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Analysis of the Technological Innovation Process: Determinants, Consequences and Efficiency

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ABSTRACT

Despite the great importance attributed to technological innovations as the main source of competitive advantages and as the driver of firm performance, a comprehensive picture of the techniques and approaches for understanding firms' R&D behavior has not yet emerged and several issues require further investigation. In this context, the aim of this dissertation is to analyze, in a broader sense, the technological innovation activities following a process-based perspective. Categorizing innovation as a process which embraces the phases of searching, selecting, implementing and capturing, this dissertation develops four empirical studies in order to capture and understand each of the innovation process phases.

The first empirical Chapter accounts for the searching and selecting phases of the innovation process and aims at increasing our knowledge of firm innovative behavior by analyzing the factors that determine firm R&D strategy selection. Three R&D strategies are defined and represent the internal development of R&D (*make*), the externalization of R&D (*buy*) and the combination of internal and external R&D (*make-buy*). Contrary to previous studies, we consider the joint effect of firm internal resources, industry characteristics and appropriability conditions as determinants of R&D strategy selection. The second empirical Chapter also explains the determinants of the R&D strategy selection but with an emphasis on public R&D funding. The third empirical Chapter aims at ascertaining the effects of the different R&D strategies on firm innovative performance, which accounts for the selecting and implementing phases. In order to evaluate RDSs effects in a broader sense and looking for robust results, we consider different measures of product and/or process innovations as indicators of firm innovative performance. Finally, the fifth chapter accounts for the implementing and capturing phases of the innovation process. It proposes a new approach to tackle the innovation-performance relationship; its objective is to cope with the, so far, mixed and inconclusive results of studies analyzing this relationship. We argue that the indistinctly use of the innovation inputs or outputs in order to measure firm

innovativeness is not trouble-free; they should be, rather, jointly considered from a productive perspective.

All empirical studies are carried out using the Survey of Business Strategies of Spanish manufacturing firms which is a panel dataset from 1992 to 2005. Results show that the *buy* strategy is mainly selected by young firms lacking organizational resources and it is avoided by firms competing in uncertain markets and characterized by major technology shifts. Its effects on firm innovativeness are weaker and last less than that of any other R&D strategy. On the opposite side, the *make-buy* strategy is selected by firms possessing high technological resources and acting in highly uncertain markets. Regarding its effects on firm innovativeness, we observe that they are stronger and last longer. In addition, we find empirical support for our proposed argument that the effects of the R&D strategies on firm innovativeness are moderated by the technological intensity level. Finally, results of the last empirical Chapter support our arguments that the better measurement of outcomes of the technological innovations is through the efficiency whereby they are developed. Moreover, we test the moderating effect of the technological intensity level and firm size on the efficiency-performance relationship.

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Table of Contents

List of Tables

List of Figures

CHAPTER I

INTRODUCTION

1. THE INNOVATION FIELD

Thanks to its impact on quality, price and sustainability, innovation is a topic that has been widely studied in the business economics literature. But, what is innovation? Drucker (1985) defines it as the specific tool used by entrepreneurs to exploit change as an opportunity to initiate a new business or service. Tidd and Bessant (2009) argue that innovation is driven by the ability to see connections, to spot opportunities and to take advantage of them; also they stress that innovation is not just opening new markets but it can also offer new ways of acting in established or mature markets.

Innovation matters at the firm level but also at the national level. Baumol (2002) pointed out that the economic growth of the last century is ultimately attributed to innovation. At the firm level, the Business Week magazine found that the median profit margin of the top 25 innovative firms was 3.4% for the period 1995-2005 whereas the average of non innovative firms was only 0.4%. Similarly, the median annual stock was 14.3% for innovators and 11.3% for non innovators (Hauptly, 2008). According to Statistics Canada (2006), innovation is the main factor in improving a company's market share, profitability and growth rate.

At this point we may wonder how do firms achieve innovations? What are the activities supporting firm innovativeness? Trott (2005) states that innovation is not simply the achievement of an invention; it also includes the critical additional step of putting it on the market and profiting from it and without this additional step it could not be considered as innovation. As defined by Freeman (1982), innovation includes the technical, design, manufacturing, management and commercial activities in which a firm engages when marketing a new, or improved, product or the first commercial use of a new process.

Several authors have argued that innovation is not just a single activity; rather, it is a complex and uncertain process, or sequence, of decisions (Veugelers and Cassiman, 1999; Terziovski, 2002). The four main cyclical stages of the innovation process, according Fleuren et al. (2004), are dissemination, adoption, implementation, and continuation. The transition from one stage to the next may be conditioned by various factors, such as the characteristics of the socio-political situation, and those of the firm, the user and the innovation.

Tidd and Bessant (2009) also identify four general phases. In phase one, firm searches in the environment for relevant signs of threats and opportunities for change. The second phase represents the strategy development, when they decide to which signs respond to. Phase three is when the germ of the original idea is developed into something new and launched onto the market. This is the trickiest step, since firms need to acquire the knowledge they need to produce the innovation and then execute the project in conditions of uncertainty. Finally, in the last phase, firms will ideally capture the value from the innovation and use what they have learned from the process to build their knowledge base.

In order to have a better understanding of the innovation process, it is important to define the different inputs and outputs that take place within this process. As for the inputs, we could mention development activities (R&D), firm creativity, high-skilled staff, leadership, willingness to innovate, ect. As or the outputs, the OECD (2005) has identified four types of innovations encompassing a wide range of changes in firms' activities: a) product innovations; b) process innovations; c) organizational innovations and; d) marketing innovations.

In this research we have special interest in the technological innovations since Bone and Saxon (2000) and Kafouros (2008) claim that technological innovations, whether in the form of products or processes innovations, are the main source of competitive advantage and are crucial to business success. Nelson and Winter (1982) define them as the search for optimal alternatives, characterized fundamentally by an intense effort to identify and solve technical problems. They also argue that technological innovations are generally dependent on R&D which is defined as the creative work undertaken on a systematic basis in order to increase the knowledge stock and use it to devise new applications (OECD, 2009).

As mentioned, the main input of the technological innovations is R&D which covers basic research, applied research, and experimental development activities, which can be managed through three different R&D strategies (RDSs): 1) performing R&D in-house (*make*), 2) outsourcing R&D to another firm or purchasing specific technology, patents or licenses (*buy*) and 3) simultaneously engaging in a degree of in-house R&D and outsourcing some activities of the R&D activities (*make-buy*).

The *make* strategy is characterized as a unique knowledge source enabling an objective valuation of real innovation needs (West, 2002). Some firms opt to achieve technological innovations through this strategy because the remarkable complexity of R&D activities requires the creation of an internal department (Dosi, 1988). It also facilitates the information flow between the R&D department and those who will be using the new technology (Fernandez, 2005). However, it is by nature more risky, less predictable, and less cost-effective, since it is a long time before the new product is marketed and could isolate the firm's efforts to a single technology (West, 2002; Perrons and Platts, 2004)

On the other hand, due to the increasing speed of new technological development, some firms prefer to outsource R&D because it is not feasible for them to develop such specific technologies in-house (Quinn, 2000). Furthermore, as stated by Barney (1999), firms are not bound to own all the resources and capacities when they can access them externally. Some of the advantages of the *buy* strategy are that it is more reliable, since the technology has already been developed and tested (Kessler and Bierly, 2002). It also enables a priori risk calculation, offers a solution to capacity problems and increases the speed of access to new technology (West, 2002). Through the *buy* strategy, firms gain access to new knowledge areas (Haour, 1992). The main limitation of this strategy is that acquiring technology in the market does not generally result in a competitive advantage per se, since the technology is also available to competitors (Barney, 1991), rendering it a short-term strategy (Kurokawa, 1997). External dependence, functional inequalities, and coordination problems are further disadvantages attributed by the literature to the *buy* strategy (Kotable and Helsen, 1999).

Combining internal and external R&D is more novel way to achieve R&D activities. Nowadays, products and processes deliver to the market demand-specific sets of technologies, each of which is the product of highly specialized knowledge and capacity, so that firms can no longer hope to do everything in-house (Iansiti, 1997). In this case, firms can resort to the *buy* strategy. However, to take full advantage of external knowledge, they must first develop the necessary absorptive capacity through their own internal R&D activity (Cohen and Levinthal, 1990). Thus, the third strategy for achieving technological innovations is the *make-buy* strategy, which appears extremely valuable, as innovations tend to emerge from a combination of ideas, resources and technologies (Fey and Birkinshaw, 2005).

Like absorptive capacity, the open innovation approach also enhances the complementarity of the *make* and *buy* strategies. This approach, coined by Chesbrough (2003), argues that firms have changed from a closed to a more open approach to innovation. In closed innovation, firms generate new ideas, convert them into innovations and then market, distribute, service, finance and support them with their own resources. The change from closed to open innovation was enabled by the growing mobility of the high-skilled staff, knowledge spillovers and the increasing demand for shorter time to market in many products and services. These factors shorten the technology cycle, making closed innovation no longer sustainable. Under the contrasting open innovation approach, the knowledge and technology flow is two-way: 1) inside-out and 2) outside-in. The flow goes from inside to out when the firm has internal ideas that can be taken to market through external channels, such as patents, licenses, or start-up companies. The outside to inside flow is the one that specifically describes the *make-buy* strategy, since it stresses that firms may actively search for new technologies and ideas beyond the firm's boundaries and combine them with internal knowledge and technologies in order to achieve new products, processes and technologies and reduce time to market (Enkel et al., 2009).

Empirical evidence capturing the effect of technological innovations on firm performance is vast but somewhat contradictory. Some authors have found positive effects of product innovation on firm performance (Soni et al., 1993; Roberts, 1999; Weerawardena et al., 2006), others report no evidence that product innovation achievements increase market and business performance (Yamin et al., 1997; Yalcinkaya et al., 2007) and in some cases product innovations appear to have a negative effect on firm profitability (Leiponen, 2000). A different perspective is given by Kleinschmidt and Cooper (1991) who demonstrate that the relationship between product innovativeness and commercial success is U-shaped. There is less discrepancy with regard to process innovations, which appear to have a positive effect on firm performance (Yamin et al., 1997; Leiponen, 2000). Recently, Rosenbusch et al. (2010) performed a meta-analysis of 45 empirical studies of the effect of innovation on firm performance. Their results suggest a context dependent relationship, where factors such as age, type of innovation and cultural context strongly moderate the impact of innovation on firm performance.

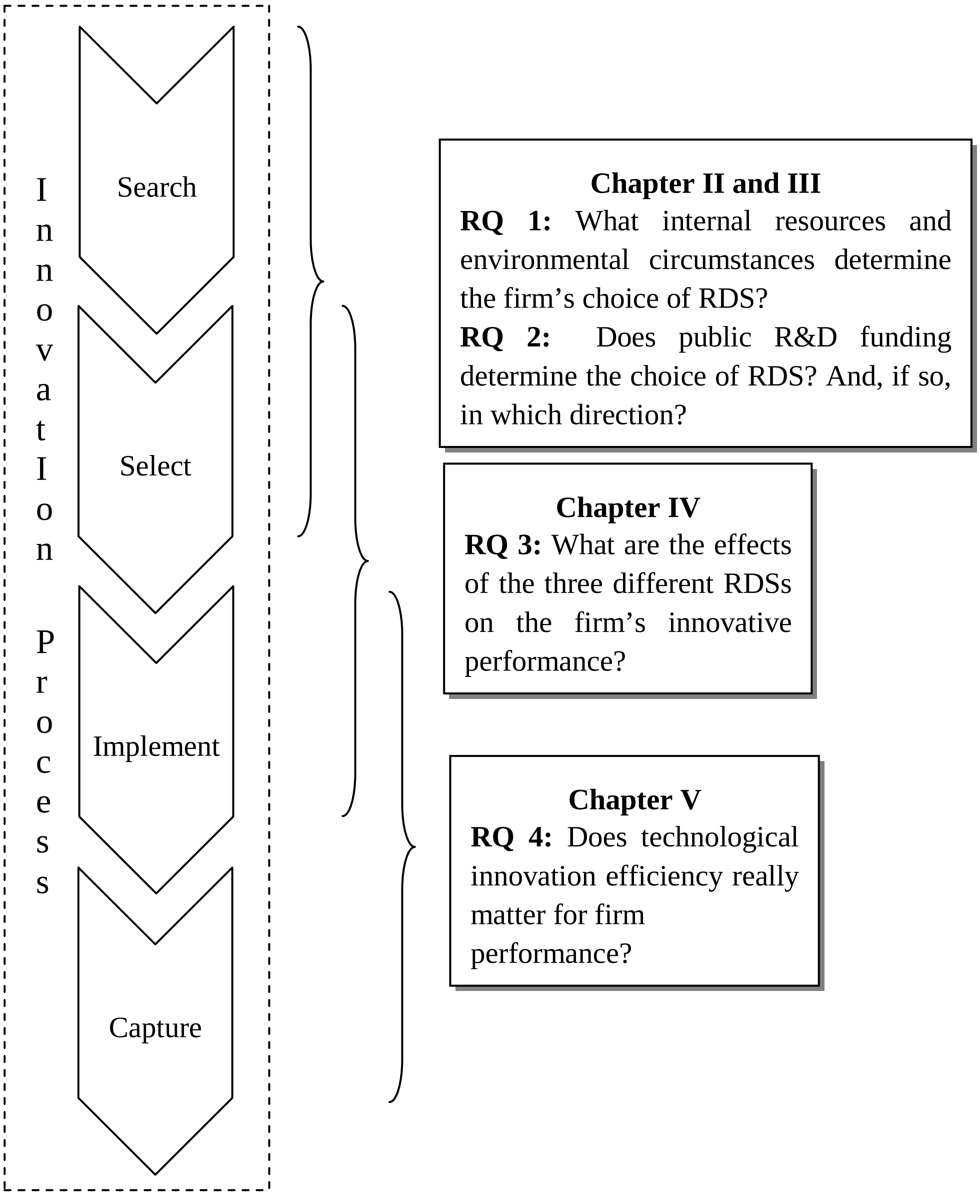
2. RESEARCH QUESTIONS AND DISSERTATION APPROACH

We turn our focus to the dissertation objective, research question and research approach for this dissertation. If the –technological- innovation is an input-output process, it is extremely important to know which the determinants of the inputs selection are and to evaluate the effect that these inputs have on the outputs achievement. Therefore, the general objective of this dissertation is to analyze the four phases of the technological innovation process (search, select, implement, capture). That is, to extend our knowledge in how and why firms decide to organize their R&D activities, the effect of R&D on firm innovativeness and the global effect of the technological innovations on firm performance.

This dissertation proposes four different empirical analyses to account for the different phases of the innovation process. The first empirical study, examines the internal and external determinants of the R&D strategy selection. The second study also deals with the determinants of the R&D strategy selection but with a clear focus on the role of public R&D funding on the decision. In the third study, we assesses the impact on firm innovative performance of the different ways of achieving R&D. The last one focuses on the final phase of the innovation process, measuring the impact of technological innovation efficiency on firm performance.

For clarifying the dissertation approach, observe Figure 1.1 where the linkage of the four empirical studies with the different phases of the innovation process is clearer. As stated, first two studies account for the search and select phases; the third one for the select and implement and the last one for the phases of implement and capture. In this way, we consider that this dissertation allows us to analyze in detail the complete technological innovation process.

Figure 1.1 Innovation as a process and dissertation approach



2.1 First empirical study

Technological innovations are mainly achieved through R&D activities and firms must select the innovation strategy that will best enable them to achieve these activities. The objective of the innovation strategy is to guide the firm in acquiring, developing and applying technology in order to generate a competitive advantage (Swan and Allred, 2003). The innovation literature has traditionally focused on the role of internal R&D as the main source of firm innovativeness (Griliches, 1979). However, scholars have increasingly recognized that the firm's ability to exploit and transform external knowledge is critical to achieving innovations (Cohen and Levinthal, 1990). Furthermore, due to dramatic changes in technology, most products and services offered in the market need to embody a specific set of technologies and knowledge, with the result that firms can no longer hope to do everything in-house, and must therefore draw on external sources of technology and knowledge (Quinn, 2000).

Despite the vast literature that has appeared in this field, there is still no clear understanding of why firms select one RDS rather than another. Most of the research published to date is limited to the dichotomous decision whether to *make* or *buy* (e.g. Kurokawa, 1997; Love and Roper, 2002) and has therefore neglected the potential complementarity between internally and externally sourcing technology (Veugelers and Cassiman, 2006). The extant empirical literature, meanwhile, has tended to focus either on internal firm resources (Prahalad and Hamel, 1990; Veugelers and Cassiman, 1999), industry characteristics (Utterback, 1994; Beneito, 2003) or appropriability conditions (Love and Roper, 2002; Teece, 2006) and has overlooked the interconnection between the internal and external circumstances under which firm set up their boundaries. This gap in the innovation literature enables us to derive the first research question for this dissertation.

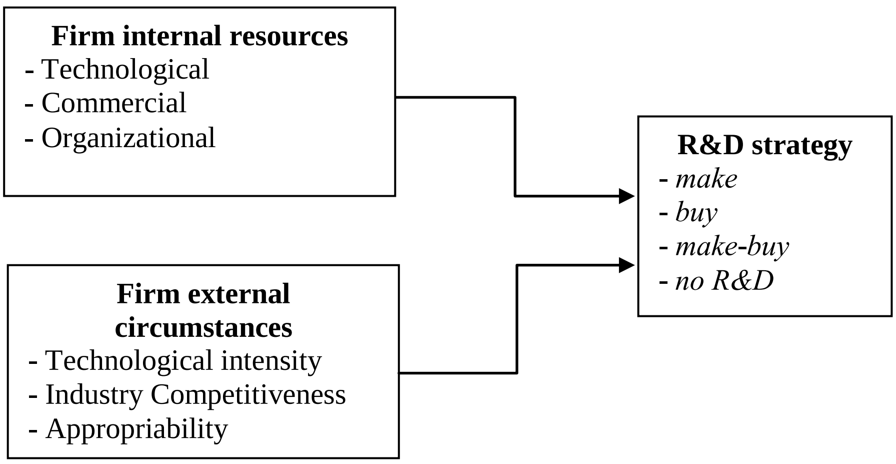
RQ1: What internal firm resources and environmental circumstances determine the choice between the three RDSs?

The aim of our first empirical study is to increase our understanding of firms' innovative behavior by answering the above research question. Drawing on the theory of the resource-based view (RBV) we evaluate the role of technological, commercial and organizational resources, as the internal determinants of the firm's choice of R&D strategy. Using the reasoning behind the absorptive capacity (Cohen and Levinthal, 1990) and open innovation (Chesbrough, 2003) approaches and previous empirical findings, we propose three hypotheses. We postulate that greater technological resources will increase the tendency of firms to select the *make-buy* strategy and reject the practice of outsourcing all R&D. Furthermore, we propose that the greater a firm's commercial resources, the more likely it is to select the *make-buy* strategy. Our last consideration in regard to internal firm resources is that firms lacking in organizational resources will prefer the *buy* strategy.

To account for external factors we consider three environmental circumstances that will condition the choice of RDS: technological intensity, market dynamism and appropriability conditions. Here, based on theoretical and empirical evidence, we present three hypotheses accounting for the external environment. First, due to its characteristics, the *make-buy* strategy will be preferred over strictly *make* or strictly *buy* by HT firms or those immersed in a highly competitive sector. Additionally, we suggest that high levels of appropriability in the sector, will encourage firms to select the *make* RDS.

The model design for answering research question 1 by testing our hypotheses is presented in Figure 1.2.

Figure 1.2 Model design for the first study



The sample used for the empirical testing of our hypothesis is taken from the SBS, which is described in the next section. The sample is an unbalanced panel because not all the firms provided answers for every year of the 16-year period, new firms are being added each year and others cease to provide information. The final sample used for this study comprises 1,539 firms. Response rate patterns vary across the panel. It is important to highlight that both innovating firms (those which achieved product and/or process innovations) and non-innovating firms are included in the analysis in order to avoid any bias in the sample selection (Miotti and Sachwald, 2003).

The dependent variable in this first study is categorical, unordered, and has four levels; 1) *no R&D*; 2) *make*; 3) *buy* and; 4) *make-buy*. The proxies for technological, commercial and organizational resources are R&D intensity, export rate and firm age, respectively. Firms are assigned to a certain technological intensity class following the Oslo Manual (OCDE, 2005). Industry competitiveness is measured by a variable for the level of market dynamism and another for the number of competitors. Due to the nature of the dependent variable, a multinomial logit model is used to estimate the model in Figure 1.2. Following Long and Freese’s (2006) recommendation, to account for non-independence of observations and to correct for heteroskedasticity, we used the Huber-White robust standard errors clustered by firm.

The results show that R&D externalization is a suitable strategy for initial engagement in technological innovations, that is, for firms that do not require cost reduction and product innovations to start activities abroad, and for young firms lacking organizational resources. We also find that externalization of R&D is not selected as a unique strategy in uncertain hi-tech market environments characterized by major technology shifts. On the other hand, firms with hi-tech resources tend to select the *make-buy* strategy since their greater absorptive capacity enables them to transform and integrate external knowledge into their routines. Finally, we also observe that the *make-buy* strategy is likely to be selected when market dynamism is high, because of the flexibility and speed provided by the *buy* strategy, so important in highly competitive industries, and because innovative firms also need the barriers to imitation that result from the *make* strategy.

2.2 Second empirical study

This second empirical study is complementary to the Chapter II. Due to the importance of the RDSs on achieving technological innovations it is fundamental to know whether the public R&D funding also determines the RDS selection and, if so, which is the strategy selected. In this sense, we present the second research question of this dissertation.

RQ2: Does public R&D funding determine the choice of RDS selection and, if so, in what direction?

Public policies play an essential role in innovation and there is a wide range of mechanisms to promote innovation in industry as a means to correct the *market failures* associated with innovation investment. Most of the research on the effectiveness of public intervention is based on the concept of additionality, that is, the extent to which public intervention gives rise to a new activity or outcome that otherwise would not have been possible (Luukkonen, 2000). Against this traditional approach, we aim to shed some light on the effect of public R&D support policies by evaluating it from a behavioural perspective.

There is little research analyzing whether government support influences the type of R&D undertaken by firms, the way R&D is carried out or whether the support generates long-term research or simply a one-off effect (Georghiou and Clarysse, 2006). This issue is particularly important because different strategies will have different effects on the innovation outcome, some of which might deviate from the objectives that the public institution had in mind when allocating the funds.

The dependent variable in this study is the unordered categorical variable with four categories, *make*, *buy*, *make-buy* and no-R&D. Different categories of public R&D funding are the main independent variables. While a large proportion of the research to date focuses on a particular country or region and a specific public initiative, this study analyzes the effect in Spanish firms receiving funding from regional governments, the state and other sources, including the European Union. These public R&D funding variables are introduced into the model at t-1 and t-2 in order to observe and account for temporal effects. We also control for technological intensity, highly-skilled staff, firm size and age.

The sample used for the empirical study is taken from the SBS filtered to include only large firms since, as observed in Table 1.3, of the next section, they are the main beneficiaries of public R&D funding. The final sample comprises 3,109 observations on 456 firms. The estimated model is a two-step multinomial logit model with random effects, which has the advantage of enabling us to control for unobservable heterogeneity and draw causal inferences. We apply the Newton–Raphson algorithm in the model to calculate maximum likelihood using first and second derivatives (Skrondal and Rabe-Hesketh, 2003). The Huber/White/sandwich estimator is used to estimate the matrix of the covariances of the estimated parameter values to obtain robust variance estimates and adjusted inter-group correlation coefficients.

Our findings tell us that R&D funding drives R&D activities. The positive effect of public funding varies according to the source of the aid, so, while State funds have a long term effect, regional or other financial aid (such as EU grants) has only a contemporaneous effect. The second relevant finding is that the source of the aid also influences whether the firm selects a *make*, a *buy* or a combined *make* and *buy* strategy.

2.3 Third empirical study

Once firms have selected one of the three RDSs, they must transform the ideas, technology and knowledge into valuable innovations. The current literature measuring the effects of RDSs on firm innovative performance has yielded mixed and inconclusive results which this study attempts to clarify. Its main contribution to the state of the art is to determine which RDS enables the highest innovation output, which leads to our second research question.

RQ3: What are the effects of the three different R&D strategies on firm innovative performance?

Some research has been conducted to evaluate the effects of internal and external R&D activities on firm performance, but there is little evidence of the relative effectiveness of the three RDSs (Veugelers and Cassiman, 2006). Past studies have measured innovation performance on a Likert scale (Haro-Dominguez et al., 2007), as the percentage of total sales due to new products (Tsai and Wang, 2009) or as the rate of new products (Chen and Yuan, 2007). We detect some drawbacks in these innovation performance measurements, since they are subjective, dependent on factors beyond R&D, such as marketing, or limited to a single output.

The aim of this study is to ascertain the effect of the *make*, *buy* and *make-buy* RDSs strategies on firm innovative performance. Based on the open innovation (Chesbrough, 2003) and absorptive capacity (Cohen and Levinthal, 1990) theories, and on empirical evidence, we propose three hypotheses regarding the influence of RDSs on firm innovativeness. We predict that all RDSs produce positive effects on firm innovativeness but that firms without the necessary absorptive capacity firms will not obtain the maximum benefit simply through external R&D. Furthermore, due to the argued complementarity of the *make* and *buy* strategies, we claim that the *make-buy* RDS will produce the highest innovative impact.

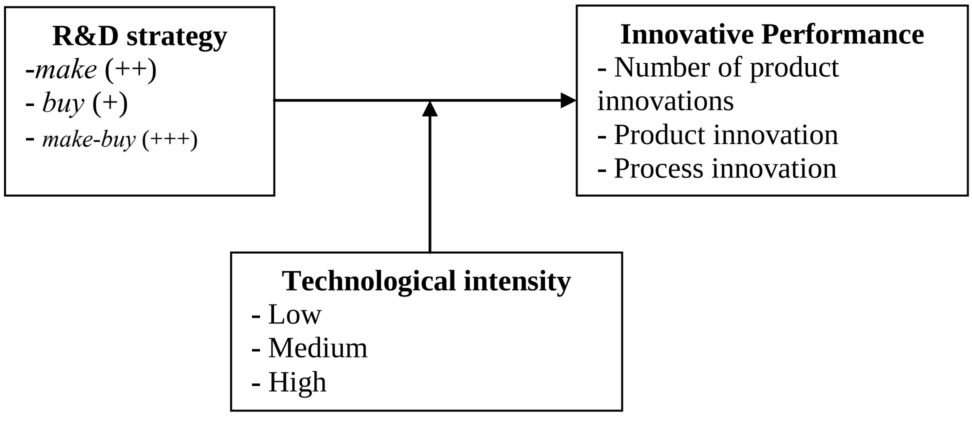
One possibility that the existing research has not taken into consideration is that, due to industry-specific differences in the technology life-cycle (Damanpour and Aravind, 2006), the knowledge environment (March, 1991), and appropriability conditions (Cohen and Levin, 1989), the effect of the RDSs might be moderated by technological intensity. Therefore, we propose that the effect of the RDSs on firm innovativeness will vary depending on the firm's technological intensity.

In contrast to previous studies, we have defined innovation outputs in terms of number of product innovations, and product and process innovations. These measures have the advantage of enabling evaluation of R&D effectiveness in achieving its main objective (OECD, 2005). It also avoids subjective perspectives and controls for the phase in the technology life-cycle (Damanpour and Aravind, 2006) since firms might concentrate their efforts to achieve product or process innovations in the early stages of the technology life-cycle or when a dominant design has emerged (Audretsch and Feldman, 1996). Due to the panel structure of the sample, we are also able to observe the lagged effects of the RDSs on firm innovative performance.

The sample used in the empirical analysis is also taken from the SBS, but the final sample is not the same as the one used in the first empirical study, since different variables are used for the models and the estimates include a two-year lag in order to observe short- and long-term RDS effects. The sample used for testing the hypotheses comprises 13,128 observations on 1,478 Spanish manufacturing firms for the 1992-2005 unbalanced panel data. As in the first study, the model includes both innovative and non-innovative firms all of which should have provided at least five consecutive responses in the survey.

As can be seen from Figure 1.3, three measurements of firm innovative performance are used: number of product innovations, product innovations and process innovations. Given that the last two variables are binary, and given the panel structure of our sample, we estimate a random-effects logit model for these two dependent variables. The rate of product innovation is a count variable traditionally estimated with the Poisson regression method, which assumes that the variance equals the mean of the dependent variable. In the absence of over-dispersion, when the variance exceeds the mean, the Poisson model fits well, but estimates may be biased if over-dispersion exists. Since this is the case in our sample, we use the alternative negative binomial regression, which follows a Poisson distribution but assumes unobservable heterogeneity (Arocena and Núnez, 2009).

Figure 1.3 Model design for the second study



As independent variables, the RDSs are included at t-1 and t-2 to enable observation of their temporal effect on firm innovativeness. The control variables are *technological knowledge* measured as the percentage of highly-skilled staff, *firm diversification* (proxied by the number of available products), *export rate* and *industry competitiveness* (number of competitors and level of market dynamism).

The estimates support our hypotheses in that all RDSs are found to have a positive influence on innovation outputs, although the highest impact is achieved by the *make-buy* strategy and the lowest by the *buy* strategy, the former with a long-term effect, the latter's being only short-term. Nevertheless, the effects of the *make-buy* and *make* strategies are time-dependent, since the greatest impact occurs after one year, and diminishes by one half in the second year. In addition, we find empirical support for our proposed argument that RDS effects on firm innovativeness are moderated by technological intensity. In this case, innovativeness in hi-tech firms does not improve with R&D externalization as a unique strategy, while low-tech firms innovate whatever their choice of RDS.

2.4 Fourth empirical study

The fourth research question presented in this research is still within the technological innovation area but is no longer related with firms' RDSs. It accounts for the ultimate goal of innovation activities, increase firms performance. Although there is a vast literature evaluating the effects of technological innovations on firm performance, empirical results are inconclusive and sometimes contradictory, since various studies have found positive, negative or no effects on performance. We attribute these inconclusive results to the lack of agreement on how to measure technological innovations and how to link them to firm performance. They have been indistinctly measured as innovation inputs (R&D expenditure or R&D intensity) (O'Regan et al., 2006) or innovation outputs (number of patents and number of products and/or processes innovations) (Akgün et al., 2009) and have been linked directly or indirectly to firm performance (George et al., 2002; Weerawardena et al., 2006).

We consider that a more integrated technological innovation indicator should include both innovation inputs and innovation outputs, always taking into consideration the lagged effect of the former on the latter. Based on previous studies (OECD, 2005; Koellinger, 2008) we believe that innovation inputs should not be directly linked to firm performance since they are only a part of the innovation process and, furthermore, they represent only those expenditures that will not improve firm performance unless they are transformed into valuable innovations. In addition, by linking innovation outputs to firm performance without taking into consideration the effort needed to achieve them, we could overestimate the effect. Therefore, we measure technological innovations as the efficiency with which the innovation inputs are transformed into innovation outputs and, by linking this technological innovation efficiency with firm performance, attempt to explain the still unclear innovation-performance relationship. This suggests our fourth research question.

RQ4: Does technological innovation efficiency really matter for firm performance?

Finding the answers to these research questions is the main objective of this research. By doing so, we aim to contribute to the current understanding of the complex process of technological innovation activity. The answers will enable us to evaluate the extent to which technological innovation activities, overall, boost firm performance.

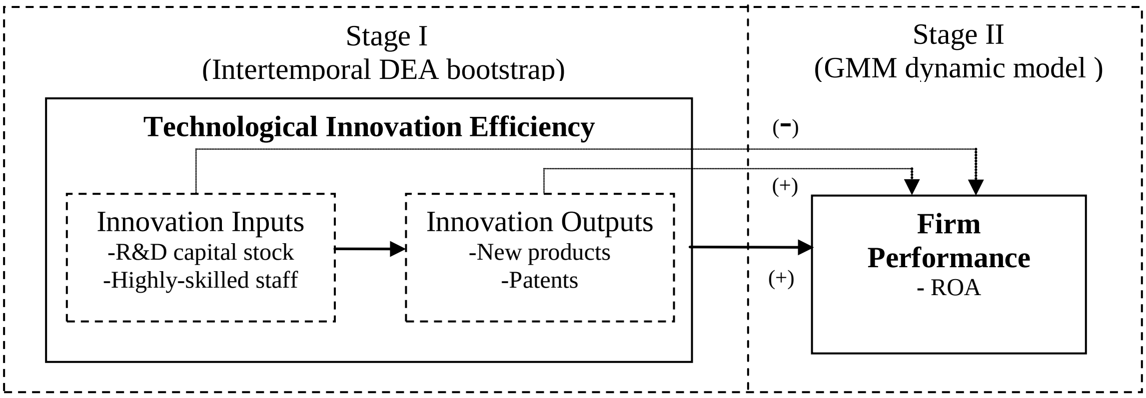
The aim of this fourth empirical chapter is to contribute to the innovation-performance literature with a proposal for a new approach to measuring the effect of the technological innovation process on firm performance. Using a thus far neglected productivity perspective, we argue that both innovation inputs and outputs should be simultaneously considered as firm performance drivers, rather than either individually, as in most previous research (Weerawardena et al., 2006; Akgün et al., 2009). We defend the idea that innovation inputs produce innovation outputs and that the key to increasing firm performance through technological innovation activities lies in the efficiency with which the innovation process is undertaken.

Our second objective is to assess the moderating effect of technological intensity and firm size on the relationship between technological innovation efficiency and firm performance. We account for this moderating effect, since previous studies have described different innovation process trajectories for low-medium- (LMTs) and hi-tech firms (HTs), and also because innovations in LMTs are not usually the result of the latest technological knowledge (Bender and Laestadius, 2005). Furthermore, we consider that due to lack of physical resources, small to medium-sized firms (SMEs) will be more dependent than large firms on technological innovation efficiency to improve firm performance.

In order to achieve our research objectives, we construct the two-stage model depicted in Figure 1.4. In the first stage, taking into consideration the causal and lagged effect of innovation inputs on innovation outputs, we estimate technological innovation efficiency for each firm based on an inter-temporal output-oriented DEA bootstrap. The estimation is carried out considering two innovation inputs (R&D capital stock and high-skilled staff) and two outputs (rate of product innovations and patents). This methodology is used because it enables a multi-dimensional evaluation of the innovation process. In the second stage, we use the technological innovation efficiency score as the explanatory variable of firm performance in the estimation of a dynamic panel data model. To verify the consistency of our arguments, we also estimate two models in which innovation inputs and innovation outputs are used to replace technological innovation efficiency as explanatory variables of firm performance. In order to achieve the second objective, we also test for the moderating effect of technological intensity and firm size in these models.

Due to methods requirements, the sample used for the first-step is carried out with a sample of 2472 observations of 415 Spanish manufacturing firms for the period 1992-2005 taken from the SBS survey. The sample for the second-stage is a little bit smaller: 2315 observations of 362 firms. As observed there is a considerable sample reduction of these samples compared with the samples of previous chapters; which obeys to the fact that, due to methodological restrictions, firms that do not declare R&D expenditures or did not achieved any innovation output were excluded firm the sample.

Figure 1.4 Conceptual framework of the fourth study



Results of the first-stage show that there is much room for improving the technological innovation efficiency of the Spanish manufacturing sector. As for the second-stage, results show support for our argument that what really affects positively firm performance is the technological innovation efficiency. On the contrary, when considering the innovation input of R&D capital stock as driver of firm performance, its effect is negative. Unexpectedly, the innovation output of number of products did not have a positive effect on firm performance but the output representing the number of patents had a negative effect on firm performance. Results also demonstrate the effect of the technological innovation efficiency is higher for HTs and SMEs firms than for their counterparts, highlighting the moderating role of the technological intensity level and firm size.

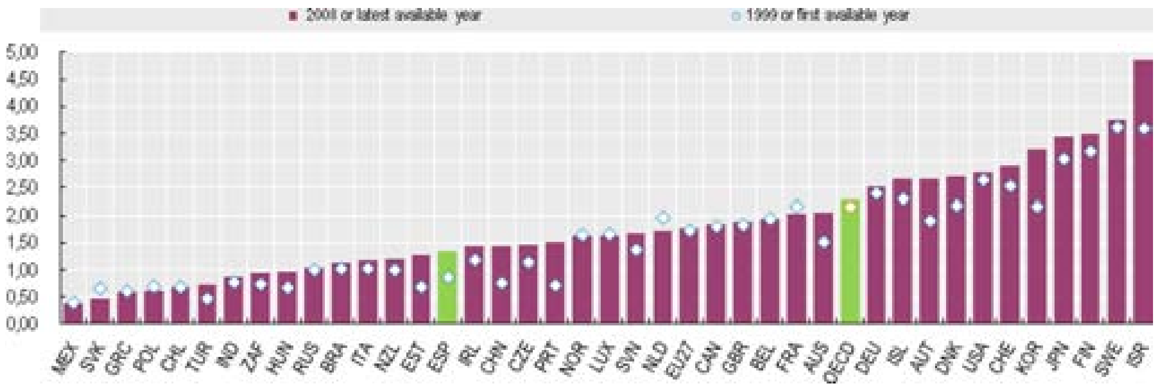
As discussed throughout this introduction, this dissertation comprises an introduction, four empirical studies and some general conclusions. We recommend detailed reading of the empirical Chapters, which provide a fuller description of the objectives, theories, hypotheses, methods and results of each study. This dissertation will provide the reader with a broad overview of the innovation process at the firm level, including an analysis of RDS choice determinants, the consequences of these on firm innovativeness, the effect of public R&D funding on firm innovative behavior and, finally, the effect of technological innovation efficiency on firm performance. We hope it makes enjoyable reading.

3. TECHNOLOGICAL INNOVATION IN SPANISH MANUFACTURING FIRMS

This dissertation is an analysis of Spanish firms in terms of their engagement in R&D activities, their innovativeness and the effect of technological innovations on firm performance. We therefore consider it appropriate to begin by describing Spain's position in relation to other OECD countries with respect to R&D expenditure, given that technological innovations depend fundamentally on R&D. Table 1.1 shows gross domestic R&D expenditure as a percentage of national GDP. From this Table it can be observed that Israel (IRS) has the highest gross domestic R&D expenditure (around 4.86 % in 2008), while Mexico (MEX) is at the other extreme with an R&D expenditure of only 0.37% of GDP.

The mean for OECD countries in 2008 is 1.82%. Thus, Spain (ESP), with 1.35%, is below the mean. In 1999, when the mean was 1.56%, Spain spent only 0.86 % of its GDP on R&D. The increase in R&D expenditure over that 10-year period highlights the Spanish Government's and Spanish firms' awareness of the importance of technological innovations for increasingly firm performance and national economic growth (Baumol, 2002). Contrastingly, countries such as Slovakia (SLV) or the Netherlands (NDL) reduced their R&D expenditures over the same period. Spain appears to be going in the right direction, but it is far from the level of engagement in R&D shown by other prosperous countries like Sweden (SWE), Finland (FIN) or Unites States (USA).

Table 1.1 Gross domestic R&D expenditure as a percentage of GDP.



Source: OECD Factbook (2010)

Having situated Spain in the international context, we focus the analysis on the situation of Spanish manufacturing firms. To obtain a detailed description and perform the empirical studies presented in this dissertation, we use a sample taken from the Survey of Business Strategy (SBS). The SBS is a firm-level panel data set of Spanish manufacturing firms covering the period from 1990 to 2005. The survey was compiled by the Spanish Ministry of Science and Technology and the Public Enterprise Foundation (FUNEP). The aim of the SBS is to document the evolution of the characteristics of Spanish firms and the strategies they use. It has the advantage of being neither focused on nor limited to innovative firms, which could have led to biased results. The SBS is a 16-page document, providing information on markets, customers, products, employment, performance outcomes, corporate strategy, human resources and technological activities.

Firms with between 10 and 200 employees were sorted by size and industry -all manufacturing firms on the NACE-Rev.1 classification- and used to select a stratified random sample. Those with more than 200 employees were surveyed on a census basis (Fariñas and Jaumandreu, 2000). In the first wave of the SBS, 2188 firms were surveyed according to the criteria mentioned above. Special interest in keeping the original firms in order to maintain a complete panel resulted in the consecutive waves of the SBS. Additionally, every year, the SBS adds to the database on all new firms with more than 200 employees and a stratified random sample of new firms with between 10 and 200 employees, which represents approximately 5% of the latter group. By the year 2005, the SBS had gathered an unbalanced panel dataset of 4500 firms.

The SBS questionnaire is presented in Annex D. As can be observed, it is has eight sections. In section A, firms are asked to answer questions relating to their activity, products and manufacturing process. This section includes questions such as the firm's year of start-up, legal structure, presence in the stock market, or production system. Section B is contains questions about the firms' clients and suppliers, such as the outsourcing of a manufacturing process or the percentage of sales to the three main clients. Section C presents questions concerning the market, such as geographic location the main market; market share and market evolution during the year and; number of competitors in the main market. Questions concerning the technological activities appear in section E, where the main focus is on internal, external, and combined R&D activities; internal and external R&D expenses; registration of patents; rate of product innovations; type of product innovations (design, materials, components, functions); public R&D funding; and so on. Section F poses questions about international markets, such as the type of internationalization mechanism or percentage of sales in international markets. Section G focuses on labor-related issues such as the number of employees; the educational level of employees or temporary workers, and Section H on accounting information, such as total sales, purchases, investments, and balance sheet information.

As observed, the SBS collects internal and external firm data, which, together, provide a broad panoramic view of the circumstances in which firms are involved. For the purposes of this dissertation, we drew mainly from section E –technological activities- but also considered information from other sections, including the market, the international market, employees and accounting. It is worth mentioning that several publications have used the SBS to examine the technological behavior of firms (e.g. Artés, 2009; Santamaría et al., 2009).

Table 1.2 shows the percentage of firms applying the different RDSs and the distribution of these strategies by firm size and across the different levels of technological intensity. First, it is important to highlight the fact that 65.78% of the firms in the SBS perform no R&D activities. The *make* strategy is the most widely used (17.18%) followed by the *make-buy* strategy (12.43%), while the *buy* strategy is the least used among our sample (4.61%).

Table 1.2 Percentage of R&D strategies vs. firm size and Industry

R&D Strategies	Total	Firm Size			Technological Intensity		
		Small	Medium	Large	Low	Medium	High
no R&D	65.78	87.03	61.47	28.01	77.88	67	44.34
make	17.18	7.07	18.29	35.87	11.57	16.11	27.56
buy	4.61	2.7	6.15	7.24	4.04	5.32	4.93
make-buy	12.43	3.25	14.1	28.88	6.51	11.57	23.17
Total	100	53.41	18.66	27.93	47.17	24.79	28.04

The total percentage reported for firm size represents the percentage of sample firms that belong to the size shown at the top of the column. That is, 53.41% are small, 18.66% are medium-sized, and 27.93% are large. Interesting findings emerge when the sample is disaggregated by firm size. They include a positive relationship between firm size and engagement in R&D activities. 87.03 % of the small firms apply no RDS, but this is the case for only 28.01% of the large firms. The *make* strategy is the most widely used and the *buy* strategy is the least preferred across all firm sizes, but this tendency is less marked in small firms than in medium or large firms. This evidence may indicate that small firms have no clear preference between the *buy* and the *make-buy* strategy, while large firms clearly seem to avoid the external R&D.

It can be observed from Table 1.2 that 47.17% of the firms belong to low-tech industries (LTs); 24.79% to medium-tech industries (MTs); and 28.04% are immersed in hi-tech industries (HTs). As argued in the literature, there is a positive relationship between the level of technological intensity and engagement in R&D activities. Only 22.12% of the LT firms selected some kind of RDS, the most frequent choice being the *make* strategy. 33% of the MT firms opt to perform R&D. Again, the *make* strategy is the most frequent choice, followed by the *make-buy* and the *buy* strategy. Finally, more than half of the HT firms (55.66%) have adopted some kind of RDS. Compared with the LT and MT industries, HT industries show a clearer rejection of the *buy* strategy.

R&D activities are a major drain on economic resources and some firms are unable to bear the full cost on their own. Therefore, public policies include a variety of mechanisms to correct this *market failure* in order to promote and facilitate innovations. Specifically, Spanish firms can claim public R&D funding from various sources: regional (RF), State (SF) and other (OF). Next, in Table 1.3 we present the three different types, or sources, of public R&D funding. The first block shows the mean amount of funding –in thousands of Euros- from each source to each type of RDS. That is, firms using the *make* RDS received 15.46 thousand Euros through regional funding; 111.83 thousand Euros through State funding; and 17.57 thousand Euros through other sources, including the European Union. Two points are worth highlighting. The first is that the State provides the bulk of the funding for all RDSs as can be observed from the percentages shown below. The second is that firms using the *make-buy* strategy receive the highest mean amount of funding.

The second block of Table 1.3 gives the percentage of firms receiving some type of public R&D funding. It can be appreciated at first glance that large firms are the most favored in terms of public funding. Only 0.89% of small firms received any regional funding, while this form of aid benefited 9.83% of large firms. This positive relationship between firm size and public R&D funding is apparent also in the case of funding from the State and other sources. In terms of mean amounts, more firms appear to benefit from State funding than from regional or other types of funding.

Table 1.3 Public R&D funding by R&D strategy and firm size

Public R&D funding	R&D strategy*			Firm Size**		
	make	*buy*	*make-buy*	Small	Medium	Large
RF	15.6410 (10.78%)	3.1229 (7.08%)	29.1662 (6.93%)	0.89	4.48	9.83
SF	111.8345 (77.10%)	39.6033 (89.78%)	360.5697 (85.65%)	0.98	5.26	15.22
OF	17.5700 (6.93%)	1.3837 (3.14%)	31.2341 (7.42%)	0.4	1.42	6.48

* Thousands of Euros received by RDS; ** Percentage of firms receiving public R&D funding.

Having established some aspects of the relationship between the size and technological intensity of the firm and its choice of RDS, it is worth exploring how its innovation capacity affects this choice. Table 1.4 shows the percentages of achievement/non-achievement of product and process innovations and patents for each RDS. Not all innovations or patents are dependent on R&D activities. As the Table shows, of the firms with no RDS, 11.59% obtained product innovations; 20.13% process innovations; and 2.32% registered patents. However, these percentages are lower than for firms applying some RDS, which highlights the importance of R&D activities for achieving innovations. Note that the patent and product and/or process innovations are not mutually exclusive. That is, the “yes” and “no” row sum for every innovation or patent is 100% for each RDS.

These descriptive statistics show that the *buy* strategy produces less product and process innovations and patents. Only 32.97% of the firms using the *buy* strategy obtained product innovations, versus 50.38% and 52.42% of those using, the *make* and *make-buy* RDS, respectively. A similar pattern is observed for process innovations and for patents, although the difference seems to be smaller for process innovations and even higher for patents. In addition, the *make-buy* strategy shows the highest percentages both of innovations and of patents, suggesting a better performance.

Table 1.4 R&D strategies and percentage of innovative results

R&D Strategies	Product Innovation		Process innovation		Registered Patent	
	yes	no	yes	no	Yes	no
no R&D	11.59	88.41	20.13	79.87	2.32	97.68
make	50.38	49.62	52.34	47.66	12.9	87.1
buy	32.97	67.03	41.52	58.48	6.22	93.78
make-buy	52.42	47.58	56	44	17.19	82.81

Finally, in Table 1.5, we present the descriptive statistics for the mean of Return on Assets (ROA) and total sales across firms reporting achievements in product and process innovations and patents. No clear relationship can be observed between ROA and firm innovativeness. The ROA of firms achieving product innovations is just slightly higher than for firms with no product innovations (16.55% and 16.25% percent, respectively). The difference is slightly greater for process innovations than for product innovations, but still too small to support the thesis that innovating firms achieve a higher ROA. For patents achievement, the rate is even lower, that is, on average, firms achieving patents register a lower ROA than firms that do not.

Table 1.5 Firm innovativeness and performance

Firm performance	Product Innovation		Process innovation		Patent achievement	
	yes	no	yes	no	yes	no
ROA	16.55	16.25	16.76	16.12	15.6	16.37
Sales*	79400	35600	85000	28800	113000	41900

* Thousands of Euros

A completely different panorama emerges when we turn to the sales variable, where innovating firms and those achieving patents report double the sales figures of their counterparts. Firms obtaining product innovations report average annual sales of 79400 thousand Euros versus 35600 thousand Euros for non-innovating firms. A similar pattern emerges in the case of process innovations, but the difference is greater when it comes to registered patents. Sales increase to 113000 thousand Euros for patenting firms, while decreasing to a mean of 41900 thousand Euros for non patenting firms. We might ask why this difference in performance between innovating and non-innovating firms is not evident when firm performance is measured in terms of ROA and emerges only when total sales are considered. A possible explanation might lie in the Schumpeterian (1934) hypothesis that large firms are more innovating than small firms and therefore register considerably higher sales figures, but a much more modest difference in ROA.

So far we have learned that there is a positive relationship between firm size, technological intensity and engagement in R&D activities. That is, large and HT firms are more prone to achieve innovations through the development of R&D. LT firms and small firms, in contrast, are more reluctant to engage in R&D and their preference for one RDS or another is less evident than for their counterparts. With respect to the effects of R&D activities it has been shown that not all innovative firms perform R&D activities and that not all firms engaged in R&D obtain product or process innovations. Nevertheless, the descriptive statistics provide some support of the fact that most innovations come from some form of RDS, principally the *make-buy* strategy. Finally, there appears to be a positive relationship between innovativeness and firm performance, but it is evident only for sales.

CHAPTER II

MAKE, BUY OR BOTH? R&D STRATEGY SELECTION

1. INTRODUCTION

Given the current market pressures and that the economy is increasingly based on technology, firms see technological innovations as the source of competitive advantage. However, due to dramatic technological changes, most products and services offered in the market need to embody a specific set of technologies and knowledge, and as a result firms can no longer hope to do everything in-house (Quinn, 2000) and may require external sources of technology and knowledge.

Thus, firms set their boundaries by deciding on an R&D strategy: internal (*make*); external (*buy*) or a combination of both (*make-buy*)[1]. The *make* strategy is a high-cost approach whose results cannot be clearly foreseen; however, it gives rise to a unique source of knowledge and enables innovative responses to the firm's real needs. On the other hand, although the *buy* strategy is relatively less expensive and solves the capacity problems, it does not in itself yield competitive advantage, since what is bought on the market is also available to the firm's competitors. Nowadays, due to product complexity, even the largest innovative companies can no longer rely on doing everything on their own (Chesbrough and Crowther, 2006). Consequently, the twofold *make-buy* strategy brings together both the advantages and disadvantages of *make* and *buy*.

[1] R&D cooperation could be considered another R&D strategy, but due to its specificity in the theoretical specifications –such as trust, behavioural integration, personal commitment- and different types of collaboration, such as cooperation agreements with universities, competitors, users and joint ventures, we decided not to include it in the analysis. Additionally, the variable of cooperation agreements was compiled in the SBS after 1998 which would have considerably reduced our panel.

Although some studies are aware of the three different R&D strategies, the majority of the studies analyzing the determinants of R&D strategy selection have focused in the dichotomous decision between *make* or *buy* (e.g. Kurokawa, 1997; Love and Roper, 2002; Huang et al., 2009) and has neglected the potential complementarity between internal and external technology sourcing (Veugelers and Cassiman, 2006). On the other hand, the existing empirical literature has tended to focus either on firm internal resources (Prahalad and Hamel, 1990; Veugelers and Cassiman, 1999), industry characteristics (Utterback, 1994; Beneito, 2003) or appropriability conditions (Love and Roper, 2002; Teece, 2006) and has overlooked the interconnection between internal and external circumstances under which firms set their boundaries.

The aim of this Chapter is to advance our knowledge on innovation firm behavior based on two main aspects. First, we jointly consider the internal firm resources, industry characteristic and appropriability conditions. Second, we compare the selection of three different models of R&D strategies – *make*, *buy*, and *make-buy* – against *no_R&D* and between them.

Thought this research is not the first one in this field, it extends previous literature (e.g. Veugelers, and Cassiman, 1999) in the next issues. Veugelers and Cassiman (1999) have a similar research question but the way to treat it is different. They consider internal firm characteristics but these make reference only to the importance given to certain information sources –two sources are analyzed from six available in the dataset they use- and one objective of the innovation activities. We consider that a problem of endogeneity might emerge when using these variables. For example, how could a firm value as important the internal source of information if it does not achieve internal R&D, or contrarily, how is possible that a firm that exclusively achieves internal R&D could valuate as the external source of information as important? In this sense, our analysis uses objective measures of firm internal resources –commercial, technological and organizational- that are not considered in previous literature. Regarding the external determinants Veugelers and Cassiman (1999) only include in the model the industry sector to which firms belong while in ours we also include the market dynamism and number of competitors as measurements of industry competitiveness.

Contrary to Veugelers and Cassiman (1999) study, this research permits to analyze which strategy is preferred over the others, that is, it could assess whether *make* is preferred over *buy* and *make-buy* or *make-buy* over *make*. Previous literature were limited to indicate which of the strategies were preferred over no R&D, or as the first way to engaging in R&D activities, that is, they are not able to assure that *make* is preferred over *buy* when appropriability conditions are high, for example. Finally, this work overcomes another limitation present in the R&D literature: previous empirical studies have been cross-sectional, while the panel nature of our data enables us to consider the lagged determinants of R&D selection, thus improving the inference of causal effects (Baum, 2006).

Much research has empirically shown that each strategy produces different effects on firm innovative performance. Some has found that the effect of external R&D on firm innovativeness is negative (Fey and Birkinshaw, 2005), null (Schindemberg, 2008) or positive (Chen and Yuan, 2007). Other studies have found evidence that, due to its complementarity, the *make-buy* strategy produces the best innovative results (Veugelers and Cassiman, 2006). In view of these results, it is very important to analyze the internal and external factors that determine the firm’s R&D strategy selection. In the light of the foregoing discussion, the main research question may be phrased as follows: what are firm internal resources, market conditions and approachability regimens that condition the selection of one strategy rather than another?

In order to answer this question we undertake an empirical analysis based on a sample of 1,539 Spanish manufacturing firms for the period 1992–2005. The sample is taken from the Survey of Business Strategy (SBS), compiled by the Public Enterprise Foundation (FUNEP), in conjunction with the Spanish Ministry of Science and Technology.

On the basis of a multinomial logit model, we observe that R&D externalization is a suitable form for initial engagement in technological innovations for firms that do not require cost reduction and product innovations to start activities abroad, and for young firms lacking organizational resources. In addition, external R&D is not selected in isolation in high technological uncertainty markets, where technology shifts are substantial. On the other hand, firms with high technological resources opt to combine internal and external

R&D since, thanks to the gained absorptive capacity, they are able to transform and integrate external knowledge into their routines. Finally, we also observe that the *make-buy* strategy is likely to be selected when market dynamism is high because innovative firms should not only look for the flexibility and speed gained through the *buy* strategy and required in highly competitive industries, but also generate barriers to imitation by relying on the *make* strategy.

This Chapter is divided into six sections. In the next, the advantages and disadvantages of the *make* and *buy* strategies are outlined, along with a theoretical discussion of the complementarity of the two strategies. The hypotheses to be tested are set out in the third section. The fourth section comprises a description of the research sample and the variables involved. The results are detailed in the fifth section; and the final section presents the conclusions, contributions and limitations of the study.

2. R&D STRATEGIES

2.1 *Make* vs. *buy*

As mentioned above, the *make* strategy is defined as the internal development of R&D activities. By contrast, the *buy* strategy reflects the firm’s decision to externalize R&D activities to other firms. Each R&D strategy, described here in detail, has its own characteristics, advantages and disadvantages, which would condition the firm R&D strategy selection.

Due to the increasing speed of development in new technologies, some firms prefer the externalization of R&D activities, since it is not feasible for them to develop such specific technologies internally (Quinn, 2000). Badaway (2009) argues that early adoption of new technologies, available beyond firm boundaries, is an essential component for gaining competitive advantage. Furthermore, as stated by Barney (1999), firms are not bound to own all the resources and capacities when they could access them externally. From a transactional perspective, externalization occurs under low asset specificity conditions, low uncertainty and low frequency of transaction (Williamson, 1985). From the knowledge- and resource-based perspectives, external R&D is selected for those activities in which the firm is not specialized or which are non-core activities (Quinn, 2000; Mol, 2005).

Some of the advantages of the *buy* strategy are that it is more reliable since the technology has been already developed and tested (Kessler and Bierly, 2002). In addition, it allows risk calculation *a priori*, offers solution to capacity problems and increases the speed of accessing new technology (West, 2002)[2]. It also allows firms to diversify their research portfolios and to broaden their knowledge base (Li and Tang, 2010), and might determine the firm technological scope (Lai et al., 2010). Nevertheless, to a great extent, acquiring technology in the market does not result in a competitive advantage *per se*, since the same technology is also available to competitors (Barney, 1991), rendering it a short-term strategy (Kurokawa, 1997). The main problem in externalizing R&D activities is the high transactional cost which the firm could incur for specific technologies with a limited number of suppliers. Those costs could be ex-ante (searching and negotiating) and ex-post (monitoring and enforcing contracts) (Veugelers and Cassiman, 1999). However, when technology markets merge, transaction costs become less severe (Mol, 2005). Finally, externalizing R&D could lead firms to be more dependent on their suppliers and lose technological expertise in the long run (Bertrand, 2009).

On the other hand, the remarkable complexity of R&D activities requires the creation of internal departments to develop such activities (Dosi, 1988). The information flow between the R&D department and the users of the new technology could increase considerably as a result of the integration of R&D activities (Fernandez, 2005). At the same time, in-house R&D constitutes a unique source of knowledge and allows an objective valuation of real innovation needs (West, 2002). Following the transactional perspective, in the presence of asset specificity and high uncertainty, the market fails due to pressures for opportunistic behavior, leading firms to internalize those activities (Williamson, 1985).

[2] Assume that a firm without an internal R&D department aims to develop a specific R&D project. In this case it is easier and faster to outsource the project to an external firm that already has tacit and explicit knowledge, machinery and highly skilled staff than to set up an internal R&D department that could encompass all these characteristics.

An analysis of the disadvantages of this strategy suggests that it is less cost-effective, takes a long time until new product commercialization (West, 2002), is by nature more risky and less predictable, and the firm could remain isolated in only one technology (Perrons and Platts, 2004). In addition, Chakrabarti and Weisenfeld (1991) argued that firms following an aggressive technological strategy prefer in-house to external R&D.

2.2 *Make* and *buy* as complements

Due to dramatic technological changes, firms must source technology beyond their boundaries in order to provide the demanded products and services (Chesbrough and Crowther, 2006). As Lai et al. (2010) pointed out, resources available outside the firm can help to trigger a firm's technological development. Firms source external knowledge in order to diversify their research portfolio and increase their knowledge base (Li and Tang, 2010), while simultaneously reducing the lock-in effect in those less profitable technologies (Garcia-Vega, 2006). Hence, firms need to combine both internal and external R&D to achieve better results (Veugelers and Cassiman, 2006) since innovations mainly occur through the combination of ideas, resources and technologies (Fey and Birkinshaw, 2005), thus leading to the *make-buy* strategy.

Two different theoretical approaches hold that the *make* and *buy* strategies may be regarded as complements rather than alternatives. The first approach highlighting their complementarity is absorptive capacity (Cohen and Levinthal, 1990), which represents the firm's ability to recognize the value of external knowledge, assimilate it and apply it to commercial ends (Abecassis-Moedas and Mahmoud-Jouini, 2008).

Complementarity between the R&D strategies should be emphasized since firms must develop in-house R&D in order to generate or increase their capabilities to scan (acquisition-assimilation) and to integrate (transformation-exploitation) external knowledge acquired through the *buy* strategy (Zahra and George, 2002). In other words, a firm will not make the most of the *buy* strategy if it does not develop R&D activities internally (Colombo and Garrone, 1996; Steensma, 1996). Furthermore, greater knowledge gained through in-house R&D

may serve to modify or improve external technological acquisitions (Veugelers and Cassiman, 1999).

The second theoretical background underlying such complementarity is the open innovation approach developed by Chesbrough (2003). This argues that firms have changed from the closed-innovation process to a more open process of innovation, where knowledge and technology flow is twofold: 1) inside-out and 2) outside-in. The latter supports the *make* and *buy* complementarity since it stresses that firms may actively search for new technologies and ideas beyond the firm's boundaries and combine them with internal knowledge and technologies, in order to achieve new products, processes and technologies and reduce time to market (Enkel et al., 2009). The inside-out component of the open innovation is not considered in this study as it is not linked to the aim of this chapter.

Empirical evidence of the complementarity between *make* and *buy* is scarce and open to question. Some authors have noted a positive effect of the *make-buy* strategy in comparison with either the *make* or *buy* strategy alone (Veugelers and Cassiman, 2006; Cruz-Cázares et al., 2010), while others have reported non-existent (Schmiedeberg, 2008) or negative effects (Tsai and Wang, 2009).

3. HYPOTHESES

As mentioned earlier, traditionally, the innovation literature has separately considered the firm's internal resources, industry characteristics and appropriability conditions as the determinants of R&D strategy selection. We argue that previous studies have led to partial results since they do not consider the firm internal and external factors jointly, which managers take into consideration when selecting the appropriate strategy to define the firm's boundaries (Cho and Yu, 2000). Following Surroca and Santamaría (2007), the resource-based view theory (RBV) is adopted to focus on firm internal resources, while the appropriability theory accounts for intellectual property rights (IPR) (Escribano, et al., 2009).

3.1 Internal Factors

The main assumption of the RBV regarding R&D strategy selection is that externalization of R&D activities will occur either when firms need to develop a specific set of technologies for which they do not have the necessary resources to internalize the activity, or when a particular experience is scarce or is not one of the firm's core activities (Mol, 2005). The hypotheses drawn from the RBV evaluate the role of technological, commercial and organizational resources, wherein the first is regarded as tangible, and the latter two as intangible.

3.1.1 Technological Resources

In line with Tidd (2000) and Surroca and Santamaría (2007), the technological resources may be approximated in terms of R&D intensity. We consider that the higher the technological resources, the greater the probability of selecting the *make-buy* strategy. However, R&D expenditure might influence the selection of the *make* strategy. According to the traditional argument in the literature, the higher the R&D intensity, the lower the rate of externalization of R&D activities (Williamson, 1985), since scale advantages usually allow vertical integration (Harrigan, 1985) and the benefits of innovation could be harder to appropriate if they are achieved outside the firm (Pisano, 1990). Furthermore, large investments must be made in order to generate nuclear competences related to the firm's core activities, with a long-term perspective and hard to imitate (Mol, 2005). R&D intensity is considered a proxy for firm absorptive capacity (Zahra and George, 2002), which can be used as an analytical link between external technology and firms' ability to exploit and transform it (Vega-Jurado et al., 2008); consequently, that would facilitate the acquisition of external R&D since firms are more confident and willing to bear the uncertainties associated with external knowledge (Zhao et al., 2005).

Additionally, we consider that R&D intensity expresses the importance attached by firms to innovation activities and, those firms for which R&D is not a core competence – low R&D intensity – would be keen to select the *buy* strategy because it allows them to achieve specific innovations without incurring the additional expenditure of establishing a costly R&D department (West, 2000).

Previous empirical studies have produced inconclusive results about R&D intensity and strategy selection. Cesaroni (2004) and Gooroochurn and Hanley (2006) found that firms with higher R&D intensity internalized the R&D activities, while Beneito (2003) showed the tendency to opt for the *make-buy* strategy when R&D intensity is high.

Hypothesis 1*: The higher the technological resources, the lower the probability of selecting the buy strategy and the higher the probability of selecting the make-buy strategy.*

3.1.2 Commercial resources

As Teece (2006) argued, the firm's commercial resources might become a complementary resource required for suitable exploitation of the innovations achieved within the firm. One component of the firm's commercial capacity is the reputation and relationship it has with foreign clients, which may be represented by the firm's degree of internationalization (Surroca and Santamaría, 2007). Based on the putative mutual relationship between innovations and internationalization (Zou and Ozsomer, 1999; Filipescu et al., 2009), we postulate that firms are likely to adopt the *make-buy* strategy when they have activities abroad.

A company which has been involved in international activity achieves experience and knowledge of the international markets, including the competitors and suppliers from those markets. This knowledge allows the firm to understand easily the behavior of its competitors, properly interpret the feedback of the customers and therefore, continuously update its products, creating barriers to imitation through the development of *make* strategy and aiming at maintaining its competitive advantages (Kumar and Saqib, 1996; Filipescu et al., 2009).

However, when a firm becomes international, it creates new networks and, at the same time, gains access to foreign knowledge and technologies, as well as production methods (Tomiura, 2007), which could reduce business transaction costs with potential suppliers, facilitating the *buy* strategy. In order to assimilate correctly, and transform the external knowledge into innovations, firms need first to develop the absorptive capacity through the development of internal R&D activities (Cohen and Levinthal, 1990). The limited empirical evidence on this point shows that export intensity reduces external R&D selection (Veugelers and Cassiman, 1999).

Hypothesis 2: *The greater a firm's commercial resources, the greater the probability of selecting the make-buy strategy.*

3.1.3 Organizational Resources

Firms' organizational resources may also be regarded as a determinant of R&D strategy selection since they reflect the efficiency and synergy between the departments involved in the R&D process (e.g. R&D, production, and marketing). These resources also embody management and organizational excellence and enable the integration of internal and external knowledge (Bughin and Jacques, 1994; Dyerson and Mueller, 1999), enhancing absorption capacity. Thus far, these internal resources have been analyzed as a fostering factor in the innovation of activities (Bughin and Jacques, 1994; Galende and De la Fuente, 2003), but not as a determinant of R&D strategy selection.

Although the measurement of a firm's organizational resources is a challenging task, two common measures have been established. The first is based on the firm's age, a scale which has been used in recent studies (e.g. Galende and De la Fuente, 2003 and Damanpour and Wischnevsky, 2006); it represents the firm experience, learning capacity and knowledge base and entrepreneurial behavior of firms - factors which are closely related to organizational resources (Sorensen and Stuart, 2000; Galende and De la Fuente, 2003; Santamaría et al., 2009).

Studies of organizational mortality suggest that mortality hazard rates decline steadily with age since, for younger firms, organizational politics are unstable and routines are rarely stabilized and perfected (Park and Ungson, 1997). Thus, since the *make* R&D strategy requires high organizational capabilities to control the complex process of R&D, and it is usually more risky and expensive (West, 2002), we hypothesize that younger firms with scarce experience and knowledge base tend to avoid the *make* strategy and are more likely to select the *buy* strategy, so as to externalize risk and overcome environmental uncertainties (Poon and McPherson, 2005)[3].

In addition, human capital is a substantial component of organizational resources, as it determines the firm's capacity to develop and implement R&D projects (Blanes and Busom, 2004) and is a decisive factor in regard to the type of innovation achievement (Un, 2010). It represents the firm's knowledge, enabling the generation of new ideas and the ability to scan and integrate scientific and technological knowledge beyond the firm's boundaries, fostering its absorptive capacity (Cohen and Levinthal, 1990; Schmiedeberg, 2008).

Following the RBV, it may be said that firms lacking organizational resources tend to select the *buy* strategy as internal R&D activities require experience, knowledge base and highly skilled staff.

Hypothesis 3: *The buy strategy will be selected when firms have low organizational resources.*

3.2 External Factors

As mentioned before, this study goes beyond the merely organizational determinants of R&D strategy selection analyzed in previous studies; we also incorporate the effect of technological intensity, market dynamism and appropriability conditions as external factors conditioning the firm's R&D strategy selection.

3.2.1 Technological Intensity

Arguments based principally on evolutionary theory of technological change indicate that innovation activities are driven by an industry-level clock (Sorensen and Stuart, 2000). Industries undergoing a large number of technological changes deem R&D externalization to be the better option because it does not seem right to rely on internal R&D when the market is changing substantially (Noori, 1990). Similarly, when there is great technological diversity

[3] Another possibility is that new firms in high-tech industries actively foster R&D; however, such development is controlled for in the methodology for this study by the inclusion in the model of industry technological intensity as an external factor in the explanation of R&D strategy selection.

in the market, firms are likely to externalize R&D (Cesaroni, 2004). However, given the information asymmetry between buyer and supplier, the contractual complexity of such transactions is quite high, making a balance in trade difficult to strike.

On the other hand, it is suggested that when technological changes are unpredictable, R&D integration becomes necessary (Shrivastava and Souder, 1987) so as to prevent technological innovations that dramatically threaten market stability (Cooper and Schendel, 1976). In the end, a balance between these two poles might be found in the absorption capacity and the open innovation approaches, that is, firms need to be aware of shifts in technology and gain greater flexibility through the *buy* strategy; at the same time, however, they might also develop in-house R&D in order to integrate the acquired technology efficiently and gain competitive advantage.

Hypothesis 4: *The make-buy strategy will be selected when the firm belongs to a high-tech industry.*

3.2.3 Industry Competitiveness

Swan and Allred (2003) found that external acquisition technology is positively and strongly related to high levels of competition because it enables cost reduction and a rapid entry into the market. On the other hand, Pisano (1990) argued that in sectors where competition is very high, the *make* strategy is preferred by firms so as to gain a first mover advantage. We consider both approaches to be very valuable and argue that innovative firms should not only look for the flexibility and speed gained through the *buy* strategy and required in highly competitive industries, but also generate barriers to imitation by relying on the *make* strategy. According to the open innovation approach, the significant innovations needed for survival in highly competitive markets are achieved by combining internal and external knowledge.

Hypothesis 5: *The make-buy strategy will be preferred when the firm belongs to a highly competitive sector.*

3.2.3 Innovation Appropriability

According to the appropriability theory, incentives to *make* or *buy* R&D activities are conditioned by the extent to which R&D outputs may be appropriated by the firm (Veugelers and Cassiman, 1999). The degree of appropriability refers to the ability to protect the new products and process from competitors that could copy the technological knowledge at a lower cost (Teece, 2006). Primarily, the level of appropriability depends on the levels of legal protection of IPR. Under a strong protection regime, firms patent in order to prevent imitation and protect revenue streams arising from innovations (Escribano et al., 2009)[4]. A firm could limit or annul its entire investment in internal R&D if the appropriability level is very low, and also not derive any benefit from the innovations achieved (Arrow, 1962). In this regard, Veugelers and Cassiman's study (1999) concluded that the probability of externalizing R&D activities diminishes when appropriability is high. This argument was later supported by the conclusions drawn in Cesaroni's study (2004), where firms substitute internal for external R&D when appropriability is scarce. Thus, if a firm is able to appropriate R&D results, it has an incentive to opt for the *make* strategy.

Hypothesis 6: *When appropriability is high, firms will prefer to adopt the make strategy.*

3.3 Controls

3.3.1 Firm Size

The relationship between firm size and R&D strategy selection is not clear cut, leaving only chance to control the model through firm size. On one hand, following the RBV, large firms have greater resources to innovate internally: they can withstand more risky activities than small firms since they usually have greater financial resources and more highly qualified personnel (Tsai, 2001). On the other hand, due to the lack of resources, small firms are likely to engage in

[4] Nevertheless, some firms prefer lead-time or product design complexity as barriers to imitation (Vega-Jurado et al., 2008).

less risky activities and tend to select the *buy* strategy (Swan and Allred, 2003). Stock et al. (2002) found that large firms tend to opt for *in-house* R&D because they want to take advantage of the economies of scale generated by internal R&D, marketing and production. However, other empirical studies (Love and Roper, 2001; Munier, 2006) have reached opposing conclusions. Finally, Veugelers and Cassiman (1999) argued that small firms restrict their R&D strategy to either *make* or *buy* R&D, while large firms usually combine both strategies simultaneously.

3.3.2 Financial Aid

The effectiveness of government financial aid for R&D is very significant as its purpose is to encourage innovation so as to compensate for market failure[5] (Arrow, 1962). The literature on public innovation policies has thoroughly investigated how public support stimulates additional R&D spending (Almus and Czarnitzki, 2003), and how such subsidies impact on the outcomes of the innovation process (Bayona-Sáez and Garcia-Marco, 2010). However, this study attempts to analyze whether public support affects firm innovative behavior. It is very important to examine the role of public financial aid in firms' R&D strategy selection, given that such aid should aim to maximize its utility and it is argued in the literature that the *make-buy* strategy outperforms the others (Veugelers and Cassiman, 2006). Furthermore, as stressed in OECD (2006), it is essential to investigate whether financial aid affects firms' organizational behavior and delimits their boundaries.

4. DATA AND VARIABLES

4.1 The Sample

The Survey of Business Strategy (SBS) used in our empirical analysis is an annual firm-level panel dataset of Spanish manufacturing firms covering the period from 1990 to 2005. The survey is compiled by the Spanish Ministry of Science and Technology and the Public Enterprise Foundation (FUNEP). The

[5] Market failure is said to exist when private R&D investment is lower than optimal social benefits.

aim of the SBS is to document the evolution of the characteristics of Spanish firms and the strategies they use. The SBS have the advantage of being neither focused on nor limited to innovative firms, which could have led to biased results. Firms with between 10 and 200 employees are classified according to size and industry - all manufacturing firms on the NACE-Rev.1 classification - and selected into a random and stratified sample. Those with more than 200 employees are surveyed on a census basis (Fariñas and Jaumandreu, 2000)[6]. It is worth mentioning that several publications have used the SBS to address the technological behavior of firms (e.g. Artés, 2009; Santamaría et al., 2009).

The sample consisted of an unbalanced panel since not all firms responded throughout the 16 years, as new firms were added each year and others ceased to provide information. Our analysis covers a period of 14 years (1992-2005); some of the variables were included in the survey only up to 1991, so this year was excluded when generating lagged variables. Outliers[7], firms with missing values and firms without a continuous period were likewise excluded from the panel. Firms are considered to have a continuous period of analysis over the 14-year period if, and only if, the period during which the firm was surveyed is continuous for at least five years. Finally, given that some lagged (*t-1*) variables are used, the smallest number of observations a firm can have is four. Following Miotti and Sachwald (2003), innovative and non-innovative firms are included in the panel so as to preclude bias in the sample. The final sample comprises 13,948 observations of 1,539 firms over 14 years. The properties of the sample remain quite similar to the original sample.

Innovative firms – those participating in the SBS that have achieved product and/or process innovations at time *t* – comprise 41% of the total sample.

[6] The SBS is a 16-page document, which provides information on markets, customers, products, employment, outcome results, corporate strategy, human resources and technological activities. In the first wave of the SBS, 2188 firms were surveyed according to the criteria mentioned above. Special interest in keeping the original firms to maintain a complete panel has motivated the consecutives waves of the SBS. Additionally, each year, the SBS adds to the database information on all new firms with more than 200 employees and a random and stratified sample of new firms with between 10 and 200 employees, which represents approximately 5% of the latter group. For the year 2005 the SBS had an unbalanced panel of 4050 firms surveyed. The annual response rate is around 90% (see http://www.funep.es/esee/sp/sinfo_cobertura.asp for detail information of the SBS).

[7] Those firms with values ± 5 standard deviations were considered outliers. In addition, firms with percentage values higher than 100 or firms that declare positive R&D expenditures but reported no R&D strategy were also eliminated from the original sample.

It is worth pointing out that not all innovative firms undertook R&D activities (42.49%). This clearly shows that many activities involved in the development of innovations, such as design, engineering, and setup and trial production, are not included in the R&D activities (OECD, 2005). On the other hand, not all firms developing R&D activities at time *t* achieved product and/or process innovations (10.64%) in the same period.

4.2 Variables

4.2.1 Dependent Variable

R&D strategy (RD_ST) is the dependent variable in the model, defined in terms of four levels: 1 = no R&D, 2 = make, 3 = buy, and 4 = make-buy. This variable is not ordered categorically and was taken directly from the database, corresponding to activities at time t. Firms were asked to answer the following question: Mark below if the firm carried out R&D internally or contracted out R&D activities. The different levels are, by definition, mutually exclusive. Following Parmigiani (2007), in order to ensure that the make-buy strategy truly represents the combination of both strategies and to guarantee that it is a third choice distinct from either only make or buy, the original data were recoded as follows: those firms who achieved make-buy and had less than 10% of the total R&D expenses due to external R&D at time t were recoded as firms pursuing only the make strategy; the same less than 10% criterion was applied to internal R&D expenses. Firms for which both internal and external R&D expenses were higher than 10% remained within the make-buy category. Even though this 10% threshold might cause some loss of information, the remaining information is more accurate and robust (Parmigiani, 2007).

4.2.2 Independent Variables

The fixed part of the model includes contextual and firm-specific variables. Firm technological resources are approximated through firm innovation intensity (RDSL1), which is calculated as the total amount of R&D expenses divided by total sales. The variable is included in the model using the first lag (*t-1*) because we believe that current strategy is conditioned by the preparations or planning carried out in the previous year. With regard to firm commercial resources, firm internationalization level is measured by the percentage of the total sales achieved through the firm's export activities (EXP). To measure organizational resources, we used the firm's age at time *t* (AGE), as well as the level of highly skilled staff (HS_S). To calculate firm age, we subtracted the year of the firm's foundation year from the current year *t*. The level of highly skilled staff is measured as the percentage of total employees holding a university degree at time *t*.

In order to test H4 we grouped the industries as low, medium and high technological intensity sectors following the Oslo Manual (OECD, 2005)[8]. Hence, the industry effect is captured via three variables: high-tech (H_TECH); medium-tech (M_TECH); and low-tech (L_TECH) industries. To measure industry competitiveness we used market dynamism (MK_D) and the number of competitors (CO_N) in the main market of firm *i* at time *t*. For both variables the firm must respond according to the values previously defined by the SBS. The former could take values of 0 = recessive, 0.5 = stable or 1 = expansive. The latter is measured as a four-level ordinal variable taking values of 1 = less than 10; 2 = from 11 to 25; 3 = more than 25; and 4 = atomized. Following previous studies (e.g. Veugelers and Cassiman, 2006; Artés, 2009), we measured the appropriability level as the average of national patents at sector level at time *t* (APPR)[9] since the literature shows important differences in IPR across sectors.

As previously mentioned, firm size and the amount of financial aid received for R&D by each firm are controlled for in this model. For firm size, three dummy variables are included for small, medium and large firms (SM, MED,

[8] The Oslo Manual proposed the classification of technological intensity based on R&D intensity, measured as the ratio between R&D expenditures and sales. It is a common measurement in the innovation literature to account for the industry effect (e.g. Tsai and Wang, 2009; Santamaría et al., 2009).

[9] The SBS provides information about the number of patents registered in Spain and the patents internationally registered. The information in the SBS does not allow us to identify whether the patents registered nationally are also registered internationally. Consequently, in order to avoid double counting we have used only the Spanish patents, since firms usually register the invention with the national bureau, and after obtaining the patent, they extend it to the international market (OECD, 2009).

LARGE, respectively). Small firms are those with less than 50 employees; medium, between 50 and 200 employees; and large firms, more than 200 employees.

Table 2.1 Means, standard deviations and variables correlation

Variables	Mean	Std. Dev.	1	2	3	4	5	6
1. RDSL1	0.65	2.025	1					
2. EXP	17.039	24.855	0.163*	1				
3. AGE	2.848	0.862	0.108*	0.152*	1			
4. HS_S	4.074	6.561	0.252*	0.123*	0.142*	1		
5. L_TECH	0.471	0.499	-0.175*	-0.211*	-0.060*	-0.161*	1	
6. M_TECH	0.247	0.431	-0.073*	0.048*	-0.026	-0.079*	-0.542*	1
7. H_TECH	0.28	0.449	0.265*	0.188*	0.092*	0.255*	-0.589*	-0.358*
8. MK_D	0.085	0.684	0.050*	0.071*	-0.009	0.086*	-0.105*	0.070*
9. CO_N	1.851	1.145	-0.091*	-0.102*	-0.155*	-0.123*	0.136*	-0.013
10. TPATL1	0.158	0.184	0.071*	-0.001	-0.015	0.041*	-0.094*	-0.106*
11. SM	0.534	0.498	-0.178*	-0.425*	-0.358*	-0.203*	0.198*	-0.041*
12. MED	0.186	0.389	0.056*	0.094*	0.104*	0.039*	-0.086*	0.034*
13. LARGE	0.279	0.448	0.150*	0.390*	0.307*	0.191*	-0.145*	0.016
14. InFARDL1	0.41	1.414	0.440*	0.254*	0.135*	0.216*	-0.167*	-0.024
VIF			1.32	1.3	1.17	1.14	-	1.19

Variables	7	8	9	10	11	12	13	14
8. MK_D	0.049*	1						
9. CO_N	-0.138*	-0.054*	1					
10. TPATL1	0.207*	-0.026	-0.004	1				
11. SM	-0.180*	-0.075*	0.277*	-0.006	1			
12. MED	0.062*	0.007	-0.086*	0.003	-0.512*	1		
13. LARGE	0.146*	0.077*	-0.233*	0.003	-0.666*	-0.298*	1	
14. InFARDL1	0.210*	0.038*	-0.108*	0.028*	-0.263*	-0.01	0.302*	1
VIF	1.36	1.11	1.02	1.05	-	1.26	1.7	1.18

** Significance level at 0.01*

The second control variable represents financial aid received by a firm for developing R&D activities at *t-1* (InFARDL1). Firms were specifically asked about the amount of money received from local and state governments, as well as other funding resources, for developing R&D activities. In order to reduce the differences among firms the natural logarithm of this variable was used for estimation. So as to control for temporal effects, year dummies were included in the model. Means, correlations, standard deviations and VIF values for each variable are presented in Table 2.1[10]. See Annex A for a summary of the variables' description.

5. RESULTS

5.1 Descriptive

As mentioned above, the final sample comprises 13,948 observations of 1,539 firms over a panel of 14 years; 394 firms responded throughout the panel (25.60%), while the remainder follow different continuous patterns. Table 2.2 shows the descriptive for R&D strategies by firm size. Within the whole sample, 65.78% of the firms did not develop R&D activities at time *t*. Table 2.2 suggests that there is a direct relationship between firm size and the development of R&D activities. There is clear evidence that small firms tend not to develop R&D activities (87.03%). On the other hand, almost 40% of medium-sized firms undertake R&D, as do nearly 72% of large firms. The latter are more likely to adopt the *make* strategy (35.87%). Finally, the *buy* strategy is the least pursued by all firms, 4.61% in total. As observed, 53.41% of the total sample is made up of small firms, while 27.93% are large and 18.66% are medium-sized.

Table 2.2 Percentage of R&D strategies vs. firm size

R&D Strategies	Small	Medium	Large	Total
no R&D	87.03	61.47	28.01	65.78
make	7.07	18.29	35.87	17.18
buy	2.7	6.15	7.24	4.61
make-buy	3.25	14.1	28.88	12.43
Total	53.41	18.66	27.93	100

Table 2.3 presents the descriptive for R&D strategies by industry characteristics. As observed, 47.17% of the sample corresponds to low-tech industries, while 24.79% and 28.04% belong to medium and high-tech industries,

[10] As the VIF values (< 1.70) shown in Table 1 are considerably lower than 10 (Baum, 2006), we can assume that multicolinearity is absent from the model. In addition, the largest correlation coefficient is lower than .70 and relates to large and small firms, which are mutually exclusive variables and do not affect the model estimates.

respectively. High-tech firms are more involved in R&D activities (55.66%), especially in the *make* strategy (27.57%), while only 33% and 21.12% of medium and low-tech firms are developing R&D activities, respectively. The *make* strategy is more commonly selected at all levels of technological intensity.

Table 2.3 Percentage of R&D strategies vs. industry

R&D Strategies	Technological Intensity			Market Dynamism		
	Low	Medium	High	Recessive	Stable	Expansive
no R&D	77.88	67	44.34	69.01	69.33	56.9
make	11.57	16.11	27.56	16.91	15.35	20.77
buy	4.04	5.32	4.93	3.9	4.43	5.44
make-buy	6.51	11.57	23.17	10.18	10.88	16.89
Total	47.17	24.79	28.04	19.5	52.44	28.06

Table 2.3 also shows that firms in expansive markets tend to develop more R&D activities (43.1%) than firms in stable or recessive markets (31%). Again, the *make* strategy is more commonly used by firms at all levels of market dynamism, and the *buy* strategy is the least pursued.

5.2 Estimates

A multinomial logit regression model was estimated, since the dependent variable is not ordered categorically, that is, all levels within the variable are equivalent in terms of importance[11]. Following Long and Freese's (2006) recommendation, to account for the non-independence of the observations and to correct for heteroskedasticity, we used the Huber-White robust standard errors clustered by firm[12]. Table 2.4 (a/b/c) shows the estimates.

Traditionally, the determinants of R&D strategy selection have been analyzed up to the level of Table 2.4(a), considering *no R&D* as the reference variable and where the estimates are interpreted as the probability of selecting one of the strategies over the reference category, given X_i, *ceteris paribus*.

[11] The independent and irrelevant alternatives test (IIA) was conducted using the Small-Hsiao test. Results are available from the authors upon request.

[12] Clustered sandwich estimator specifies that standard errors allow for intra-group correlation, relaxing the usual requirement that the observations be independent. In other words, the observations are independent across the clusters defined but are not necessarily within clusters.

Table 2.4 Estimates of the multinomial logit model, changing the reference variable

		Variables	a. *No_R&D* as ref.			b. *make* as ref.		c. *buy* as ref.
			make	*buy*	*make-buy*	*buy*	*make-buy*	*make-buy*
Internal Factors	Technological resources	1. RDSL1	1.1721*** (0.1728)	1.1208*** (0.1736)	1.2052*** (0.1759)	-0.0513 (0.0427)	0.0330* (0.0182)	0.0843* (0.0445)
	Commercial Resources	2. EXP	0.0147*** (0.0023)	0.0064** (0.0029)	0.0120*** (0.0025)	-0.0083*** (0.0029)	-0.0027 (0.0022)	0.0055* (0.0029)
	Organizational Resources	3. AGE	0.1868*** (0.0682)	-0.0715 (0.0772)	0.2271*** (0.0769)	-0.2584*** (0.0901)	0.0402 (0.0775)	0.2987*** (0.0927)
		4. HS_S	0.0323*** (0.0086)	0.0191 (0.0122)	0.0369*** (0.0095)	-0.0131 (0.0118)	0.0046 (0.0072)	0.0178 (0.0122)
External Factors	Technological Intensity	5. M_TECH	0.1609 (0.1504)	0.1724 (0.1934)	0.3346* (0.1734)	0.0115 (0.2198)	0.1736 (0.1737)	0.1621 (0.221)
		6. H_TECH	0.5228*** (0.1573)	0.1233 (0.2063)	0.7523*** (0.17)	-0.3995* (0.2285)	0.2295 (0.1574)	0.6290*** (0.2249)
	Industry Competitiveness	7. MK_D	0.1291** (0.0592)	0.1855** (0.0852)	0.2427*** (0.0633)	0.0563 (0.0937)	0.1135* (0.0641)	0.0571 (0.0927)
		8. CO_N	-0.2075*** (0.0527)	-0.1707** (0.0794)	-0.2099*** (0.0579)	0.0368 (0.0916)	-0.0023 (0.0619)	-0.0392 (0.0917)
	Appropriability	9. TPATL1	0.4363** (0.1895)	0.0485 (0.3486)	0.0793 (0.261)	-0.3877 (0.3767)	-0.3569 (0.2353)	0.0308 (0.4167)
Control Variables	Size	10. MED	0.6877*** (0.154)	0.8383*** (0.2185)	1.1237*** (0.1899)	0.1506 (0.2493)	0.4360** (0.2019)	0.2854 (0.2599)
		11. LARGE	1.9501*** (0.1524)	1.7163*** (0.2033)	2.3743*** (0.1878)	-0.2338 (0.2319)	0.4242** (0.1931)	0.6580*** (0.2364)
	Financial Aid	12. InFARDL1	0.3488*** (0.0517)	0.2407*** (0.0651)	0.4951*** (0.0553)	-0.1081** (0.047)	0.1463*** (0.0256)	0.2544*** (0.047)
	years	13. YEAR	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Constant		βo	-3.498*** (0.2575)	-3.780*** (0.3412)	-4.740*** (0.3299)	-0.2814 (0.3831)	-1.241*** (0.3382)	-0.959** (0.4237)

*log likelihood: -9578.8502; Pseudo R2: 0.2986; * p <0.1; ** p <0 .05; *** p < 0.01; observations: 13948; standard errors in brackets.*

This approach did help us to find the strategy selected when moving from a *no R&D* state to an active R&D state. The only straightforward result is that when appropriability conditions are high (APPR), firms would prefer to start developing R&D internally, bearing out H6. However, for the remaining variables, we have positive and significant coefficients for at least two strategies, which would invalidate that interpretation; we have to mention that Veugelers and Cassiman (1999) failed to do this.

For example, we can say that the *make-buy* strategy is preferred to *no R&D* when firms are older, but we cannot say that *make-buy* will also be preferred to *make*, because we do not know if the difference in the coefficients is significant (0.1868 *vs*. 0.2271 for *make* and *make-buy*, respectively for AGE). To solve this problem presented in the literature and correctly test the validity of the hypotheses, the model is rerun changing the reference category until all the possibilities have been explored. Table 2.4(b) and 2.4(c) show estimates that consider the *make* and *buy* strategies as the reference variables, respectively[13]. Note that the large log-likelihood (-9578.8502) and the pseudo R2 (.2986) show a desirable goodness of fit for the model.

From Table 2.4(a) we can see that almost all the coefficients on the variables are positive and significant for at least two strategies, indicating that all of them influence the decision to develop R&D activities. Note that selecting the *buy* strategy against *no R&D* is not conditioned by firm age (AGE), percentage of highly skilled staff (HS_S), appropriability conditions (APPR) and technological intensity levels; rather, it seems that firms opt to *buy* in preference to *no R&D*, based on their technological (RDSL1) and commercial resources (EXP), and industry competiveness (MK_D; CO_N).

The negative signs for all strategies indicate that, contrary to expectation, firms with a high number of competitors (CO_N) are less keen to engage in R&D than their counterparts. In the same way, given the positive and significant coefficients for medium (MED) and large (LARGE) firms, we may assume that small firms (the reference variable) are less likely to embark on R&D activities.

[13] Note that some estimates are not shown because the inverse relationship is already included in a previous estimation.

To test the validity of the remaining hypotheses, we must focus on Tables 2.4(b) and 2.4(c). The estimates show partial support for hypothesis 1: due to the absence of a significant coefficient for the *buy* strategy in 2.4(b), we cannot state that the *buy* strategy is the least preferred, since it is not statistically significant different from *make*. However, observing both positive and significant coefficients on *make-buy* in Tables 2.4(b) and 2.4(c), we can assert that this strategy is more likely to be selected when technological resources (RDSL1) are high. On the basis that R&D expenditure reflects the importance given to the R&D activities, this result suggests that those firms for which these activities are very important tend to select the *make-buy* strategy, since it is through the combination of technologies, knowledge and ideas that the main innovations are achieved (Quinn, 2000; Chesbrough 2003). Moreover, higher technological resources ensure the absorptive capacity needed to integrate and transform external knowledge (Cohen and Levinthal, 1990).

In hypothesis 2 we argued that the greater the commercial resources (EXP), the higher the probability of selecting the *make-buy* strategy. The results of the model enable us partially to corroborate this hypothesis. The positive and significant sign on *make-buy* in 2.4(c) shows the preference for this strategy over buying. However, there is no clear preference of *make-buy* over *make*. In other words, the higher the commercial resources, the lower the probability of externalizing R&D activities. We could venture to argue that merely buying R&D is not enough to achieve the products and process innovations needed to compete in international markets (Tomiura, 2007).

Hypothesis 3 is supported for organizational resources approximated by firm age (AGE). The negative and significant coefficient in 2.4(b) and positive and significant coefficients in 2.4(c) show that firms with constrained organizational resources tend to prefer the *buy* strategy as a means of externalizing risk and overcoming environmental uncertainties (Poon and McPherson, 2005), since they do not have the organizational capabilities to control the complex process of R&D. Furthermore, there is no significant difference between choosing *make* or *make-buy* strategies when organizational resources are high (2.4(b)). When approximating the organizational resources as the level of highly skilled staff (HS_S), we can observe that *make* and *make-buy* are both preferred to *no R&D* in 4(a). Although human capital represents the firm's capacity to develop and implement R&D projects (Blanes and Busom, 2004), it does not influence the selection of one R&D strategy over another.

As expected, contextual factors also encourage firm engagement in R&D activities and determine the way these activities are developed. We argued in hypothesis 4 that due to the uncertainties facing high-tech firms, they would prefer to combine *make* and *buy* in order, simultaneously, to create a competitive advantage and gain flexibility. This argument is partially supported, since Table 2.4(c) shows that *make-buy* is preferred to solely *buy*, but it is not significantly different from *make*. In 2.4(b) it can be observed that *make* is also preferred to *buy*. In other words, firms in high-tech industries appear to avoid buying external R&D in isolation. This behavior is understandable since firms in sectors experiencing high technological changes need to achieve in-house R&D in order to generate the absorptive capacity required to assimilate the extensive technology available in the market (Cohen and Levinthal, 1990). Moreover, high uncertainty, information asymmetry and the specificity of assets traded in these sectors might discourage external R&D (Williamson, 1985; Mol, 2005). Firms in medium-tech industries seem not to be affected by this high transactional cost, since there is not a preference for a specific strategy in these sectors.

The results show that industry competitiveness is a clear determinant of the decision to engage in R&D activities and they partially support our hypothesis. The analysis of 2.4(b) and 2.4(c) indicates that, when market dynamism (MK_D) is high, *make-buy* is preferred to *make* but the former is not significantly different from buying. This suggests that the key component of the *make-buy* strategy under these market conditions is external R&D, since it enables cost reduction and quick entry into new markets (Swan and Allred, 2003), necessary in high dynamic environments. As mentioned earlier, a high number of competitors (CO_N) discourages firms from developing R&D and does not determine R&D strategy selection. This behavior supports the Schumpeterian hypothesis that in concentrated markets, with many competitors, firms will not have incentives to innovate, due to the difficulty of appropriating the returns on innovation (Schumpeter, 1943).

In relation to the control variables, Table 2.4(a) shows that medium (MED) and large (LARGE) firms are more involved in R&D activities than small firms (the reference category), since the signs on the coefficients are positive for all strategies. The poor participation of small firms in R&D activities may be due to the fact that they usually have limited financial, human and physical resources, and R&D activities are resource-consuming. The results provide evidence of a linear relationship between size and R&D involvement, given that, for all strategies, the coefficients for large firms are greater than for their medium-sized counterparts.

Our results support Tsai's argument (2001) that large firms prefer the *make-buy* strategy because they have the necessary physical resources. The positive and significant coefficients for *make-buy* in 2.4(b) and 2.4(c) indicate that large firms in our sample tend to select this strategy over either *make* or *buy*. As for medium-sized firms, the *make-buy* strategy is only preferred to *make*.

The positive and significant coefficients in 2.4(a) show that financial aid to R&D activities (InFARDL1) does encourage involvement in these activities, since all strategies are preferred to *no R&D*, completing its objective. Moreover, the results show that financial aid also influences the selection of R&D strategy - *make-buy* is preferred to the others and *make* is preferred to *buy*. Based on previous argument in the literature that the *make-buy* strategy produces higher innovative results, and that the *buy* strategy has a minor effect and in the short term (Veugelers and Cassiman, 2006; Cruz-Cázares et al., 2010), we are able to argue that the effect of financial aid on R&D strategy selection is optimal because firms would maximize their use.

6. CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH LINES

In the new era of open innovations, the traditional dichotomous decision of *make* vs. *buy* R&D has shifted to the combination of internal and external sources of knowledge since, due to the increasingly specialized products and processes, firms can no longer develop everything internally (Chesbrough and Crowther, 2006). Furthermore, firms might have incentives to combine internal and external R&D, since the main innovations occur with the combination of technologies, knowledge and ideas (Fey and Birkinshaw, 2005). Despite this fact, numerous firms still follow a close form of innovation, relying solely on internal R&D, while others confine R&D to a secondary level, externalizing these activities.

In this context, this Chapter aims to augment our knowledge of the firms' innovative behavior by analyzing the internal and external driving forces that encourage firms to select one of the three different R&D strategies – *make*, *buy*, and *make-buy*. We found that the *buy* strategy is less likely to be selected by international and older firms and by those in high-tech industries. This shows how R&D externalization is a suitable form of initial involvement in technological innovations for firms that do not require cost reduction and product innovations to start activities abroad, and for young firms lacking organizational resources. In addition, this strategy is not achieved in isolation in high technological uncertainty markets, where technology shifts are high, and the transactional costs might be higher, due to the specificity of assets.

This study shows that the experience and knowledge acquired in international markets lead firms partially or totally to develop R&D activities in-house, since this might be the key to achieving the differentiated products needed to compete successfully in international markets.

We can conclude that under high technological resources, firms opt to combine internal and external R&D since, thanks to technological resources and their absorptive capacity, they are able to transform and integrate external knowledge into the firms' routines. In addition, our results support the open innovation approach, in that the *make-buy* strategy is likely to be selected when market dynamism is high and when firms are immersed in high-tech industries, indicating that innovative firms should not only look for the flexibility and speed gained through the *buy* strategy and required under these circumstances, but also generate barriers to imitation relying on the *make* strategy.

We are also able to ascertain that small, low-tech firms and those in sectors where the number of competitors is high are discouraged from involving in R&D activities. The fact that high numbers of competitors discourage firms from engaging in R&D activities is highly significant. On one hand, this gives support to the Schumpeterian (1943) hypothesis of monopolistic conditions and innovation. On the other hand, it might be assumed that the mode of competition in such markets is not based on R&D achievement, but rather on marketing or organizational innovations. We also observed that high appropriability conditions encourage firms towards internalizing R&D because strong protection of IPR enables the appropriation of the outcome of these activities.

The contribution of this study to the literature is threefold. First, based on the interconnection of internal and external circumstances under which firms set their boundaries, we combine the industry characteristics (Utterback, 1994), appropriability (Teece, 2006) and firm internal resources (Prahalad and Hamel, 1990) to explain R&D strategy selection, overlooked in previous research. Second, this study goes beyond the simple dichotomous decision of *make* or *buy*, extensively analyzed in the literature, and based on potential complementarity between internal and external technology sourcing we define three R&D strategies. Third, contrary to previous cross-sectional studies, due to the panel nature of the sample, this study analyzes the determinants of R&D strategy selection, thereby improving the inference of causal effects.

The findings of this study have managerial and policy implications. First, managers should be aware of the main characteristics associated with each R&D strategy, as well as their main advantages. For policy makers, this study confirms that public R&D financial support encourages firms to become involved in such activities and, interestingly, shows that it influences the selection of the *make-buy* strategy, claimed by some authors to be the one producing the greatest innovative results.

There are certain limitations and further research lines (FRL) for the present study that should be addressed. First, due to a data constraint, this study is unable to test empirically the importance of the transactional cost, and cost reduction goal, in the selection of R&D strategies. Second, based on the information available, in this study we compare an aggregate form of external R&D, but it would be academically and practically interesting to compare the determinants of different types of external knowledge sources. Third, although standard errors of the estimates of the multinomial logit model are clustered by firms, we are not able to deal satisfactorily with the violation of the independence of observations.

Including random effects in the model would be a suitable solution but statistical software to estimate these models is still under development and results are unstable.

ANNEX A. **Variables description**

VARIABLES	DESCRIPTION	CODE	TYPE OF VARIABLE	VALUES
Dependent Variable				
R&D Strategy	Firm R&D activities	RD_ST	Categorical	1= *no R&D* 2= *make R&D* 3= *buy R&D* 4= *make-buy R&D*
Independent Variables				
Internal Factors				
Innovation Intensity (*Technological Resources*)	R&D expenses /total sales at *t-1*	RDSL1	Continuous	0-100%
Firm Internationalization (*Commercial Resources*)	International sales / total sales at *t*	EXP	Continuous	0-100%
Firm Age (*Organizational Resources*)	Logarithm of firm age at *t*	AGE	Continuous	0-N
High-Skill Staff (*Organizational Resources*)	Percentage of engineers and graduate staff	HS_S	Continuous	0-100%
External Factors				
Medium Technological Intensity	Firm industry classification based on CNAE 93. Rev1 at *t*	M_TECH	Binary	0 = no 1= yes
High Technological Intensity	Firm industry classification based on CNAE 93. Rev1 at *t*	H_TECH	Binary	0= no 1= yes
Market Dynamism	Market dynamism of the main firm market at *t*	MK_D	Ordinal	0 = Recessive 0.5 = Stable 1= Expansive
Number of Competitors	Number of competitors in the main firm market at *t*	CO_N	Ordinal	1= Less than 10 2= From 11 to 25 3= More than 25 4= Atomized
Patents	Mean of patents granted per industry at *t-1*	APPR	Continuous	0-N
Control Variables				
Medium sized	Firm size at *t*	MED	Binary	0 = no 1= yes
Large sized	Firm size at *t*	LARGE	Binary	0 = no 1= yes
Financial Aid	Logarithm of financial aid received for R&D projects at *t-1*	InFAIDTL1	Continuous	0-N

CHATPER III

PUBLIC R&D FUNDING:

DOES THE SOURCE DETERMINE THE

STRATEGY?

1. INTRODUCTION

Public policies on innovation play an essential role in the long-term growth and prosperity of any region. Public administrative bodies have designed a wide range of mechanisms to promote innovation in firms as a mean to correct the *market failures* typically associated with innovation. Different levels of government put great effort into implementing measures to improve the economic performance of the firms and other social objectives under their jurisdiction. However, as recent papers have reported,[14] the discussion has become focused on the need to assess the effectiveness of these measures.

Most of the research on the effectiveness of public intervention is based on the concept of additionality (Luukkonen 2000), that is, measuring the extent to which public intervention gives rise to a new activity or outcome that would not otherwise have come into being. Most of this work adopts one of three analytic approaches: the influence of policies on R&D input levels (Branstetter and Sakakibara 1998; Almus and Czarnitzki 2003; García-Quevedo 2004), the influence on innovation behaviour (Huggins 2001; Polt and Streicher 2005; OECD 2006) and the influence on the outcome of the innovation process (Branstetter and Sakkibara 1998; Klette and Moen 1999; Huggins 2001; Benfratello and Sembenelli 2002; Bayona-Sáez and García-Marco 2010).

[14] Georghiou and Roessner (2000); Klette, Moen and Griliches (2000); Luukkonen (2000); Salter and Martín (2001); Jaffe (2002) Almus and Czarnitzki (2003); Roper et al. (2004) OECD (2006); Bayona-Saéz and García-Marco (2010) among others.

Against this background, this paper sets out with the main purpose of shedding some light on the effect of public R&D support policies by evaluating additionality through behaviour indicators. There has been little research on issues as crucial as how to tell whether government fund influences the type of R&D undertaken by firms, or the way R&D is carried out or whether the support generates long-term research or simply has a one-off effect (Georghiou and Clarysse 2006). In this sense, we aim at answering whether public funding influences the R&D strategy selection, assuming three possible strategies: in-house R&D (*make)*, outsourced R&D (*buy),* or the combination of both (*make-buy)*. This issue is particularly important because, as previous literature has shown, each strategy has different effects on the innovation outcome. Previous evidence appears to suggest that the *buy* strategy is a less effective driver of innovation, and sometimes has a negative influence on firm innovativeness. According to the evidence analyzed in this paper, however, the *make* strategy has a positive impact on innovation output, while the *make-buy* strategy seems to generate the best innovative results (Veugelers and Cassiman 2006, Cruz-Cazares, Bayona-Sáez and García-Marco 2010) Therefore, it is crucial for policy makers to evaluate whether the public funds foster the correct strategy according to the objectives pursued.

The contribution of this study is twofold. First, while a large proportion of the research focuses on a particular country or region and a specific public initiative, there have been few attempts performing simultaneous analysis of the additionality effect that fund coming from different government levels has on innovation behaviour This paper, in contrast, studies the effect that funds from Regional governments, State and other sources, including the European Union have on Spanish firms. We consider important to evaluate the behavioural effect of different public funds in the R&D strategy selection as innovations are the main source of social and economical wealth (Baumol, 2002).

Second, methodologically, the related literature is often based on case studies or interviews with firms, or the results come from cross-sectional and relatively small samples. Our contribution in this respect is to use a panel data set for the 1992-2005 period containing information on 457 Spanish firms with over 200 workers. The data were drawn from the *Encuesta de Estrategias*

Empresariales (Business Strategy Survey). Furthermore, the technique used, multinomial logit model with random effects, allows us to overcome endogeneity problems and control for the unobserved heterogeneity, obtaining a more accurate approximation, and drawing causal inferences.

The Chapter is structured as follows. The next section describes the theoretical framework and the different types of funding available to Spanish firms and briefly presents the evidence on the repercussions of different R&D strategies on innovation behaviour. Section 3 describes the database, variables and methodology issues. The results are discussed in section 4, and the main conclusions are summarized in the final section.

2. THEORETICAL BACKGROUND

2.1 Public R&D funding and the behavior perspective: a review of the literature

The proliferation of public initiatives to support innovation has stimulated interest in assessing its effectiveness. The effect of public innovation policies on business is usually analyzed through three different perspectives: the impact on R&D inputs, innovation behaviour and the output achievement.

The most thoroughly investigated aspect is the impact of public funding for R&D expenditures. Research has been conducted at sector, region and business level using a variety of methods. Among the many findings, some cases have showed complementarity and others substitution between public and private funds. An exhaustive review of the related literature can be found in David, Bronwyn and Toole (2000), García-Quevedo (2004) and Lööf and Hesmati (2005).

From an output perspective the existing literature is also patently diverse both in terms of the findings and the output measures used. A survey of this research is reported in Klette, Moen and Griliches (2000), which is an analysis of evaluative studies of the effect of various public initiatives on a number of firm performance measures, such as sales growth, investment in physical assets, return over assets or sales, labour productivity, and factor productivity growth.

This paper focuses on the third of these perspectives: innovation behaviour, aiming to explore the effect of three different public R&D funding as drivers of the R&D strategy selection. In this respect, additionality in behaviour is defined as the differences taking place in the firm's innovation behaviour after receiving public funding. This is the least common approach in econometric studies dealing with the effects of public R&D funding. However, for politicians attempting to compare the effectiveness of different policy instruments, it will be useful to see how the government program has affected firms' R&D behaviour and management.

Most of the studies on additionality in behaviour are based on firm-survey responses (see Polt and Streicher 2005; and OECD 2006). Many of the cited firms state that without public funding some projects would never have got underway, or at least not on the same scale or at the same speed. The surveyed firms also claim to have acquired skills and competencies that can be exploited in future innovation projects, and also to have strengthened their networks and collaboration with other firms (Georghiou and Clarysse 2006).

Specifically, some of the studies listed in the OECD publication, such as Australian Department of Industry, Tourism and Resources (2006), have found that those firms that had received a government subsidy had increased their R&D commitment, carried out larger-scale projects requiring consultants (R&D outsourcing), and had developed a more rigorous, well-planned R&D management method Falk (2006) stresses that participation in a government-funded initiative helped firms to increase their R&D skills, allowing them to take on new projects in the future. The Austrian firms surveyed by Steyer (2006) modify their R&D strategy: they increased the percentage of their outsourcing R&D expenditure from 10% to 22% in four years. Hyvärinen (2006) observed that Finnish firms receiving public funding engaged in higher-risk and longer-term projects, and increased their R&D capacity through more highly skilled personnel.

2.2 Public innovation support programs for Spanish firms

In the Spanish context, there are three sources to which firms can apply for aid; Regional (Autonomous Community) governments, the State and other public authorities, including the European Union. The different levels serve different objectives, so it is likely that the impact of the funding will vary with the source.

Some of the state funding programs have existed over 20 years[15]. Various initiatives have coexisted in Spain, with a range of objectives including the promotion of basic and precompetitive research as part of the National R&D Plan, which calls for sustained in-house R&D and has sometimes resulted in collaboration between firms and universities or research centres. There have also been initiatives on the part of the Ministry of Industry and Energy to encourage innovation, technological development and the incorporation of advanced technology into the industrial fabric (Acosta and Modrego 2001). This funding is aimed at growing markets and enabling firms to compete technologically (Heijs et al. 2005).

The range of Regional governments programs is very wide and very difficult to generalize. Nevertheless, some studies (Blanes and Busom 2004) report that the selection criterion for funding is not very strict, but their predominant targets are SMEs. This Regional funding sometimes tends to favour firms in shrinking markets (Heijs et al. 2005) and provides a full range of support and beneficiaries firms are less experienced or less active in innovation than the type of firm targeted by State funding.

Finally, a feature that distinguishes the European funding from those described above is that they require mandatory developing in-house R&D since only purchasing or outsourcing R&D is not allowed. When collaborating, the European programs demand that the participant firms should be from a least two different EU countries. In other words, EU funding is intended for cooperative, international research, something which is more feasible for larger firms. The European funds focus on frontier technology in basic R&D projects; the requirements are formal and the candidates are leading firms with sufficient

[15] In fact, the first National R&D Plan ran from 1988 to 1991 and each three years the Plan is rebuilt according to the new technological demands.

technological skills to ensure the technological success of the projects (Heijs et al. 2005). Firms with high innovation capability usually are the receipt of these funds.

2.3 R&D strategy selection and innovation performance

R&D strategy aims to guide the firm in acquiring, developing and applying technology to generate a competitive advantage. Therefore, firms have to select the strategy best suited to their technological requirements. Traditionally, studies have analyzed three R&D strategies commonly called *make, buy* and, the combination of both, *make-buy*. As described in some papers, each of them has its advantages and disadvantages (Veugelers and Cassiman 1999; Cho and Yu 2000; Mol 2005).

Theoretical arguments indicate that the *buy* strategy outperforms the *make* strategy since it allows risk calculation a priori, offers solutions to capacity problems and increases the speed to access to new knowledge (West, 2002). Nevertheless, it implies high transactional cost, high risk of opportunistic behaviour, external dependences and coordination problems that might reduce its impact on firm innovativeness (Kotable and Hensen 1999; Narula 2001). On the other hand, in-house R&D facilitates the information flow between the involved departments, constitutes a unique source of knowledge, allows an objective valuation of the problems and reduces transaction costs (West, 2002). Perrons and Platts (2004) argue that the *make* strategy is more risky and results are less predictable and the firm could remain isolated in one specific technology.

Empirical evidence shows that the *buy* strategy usually has negative effects on product and process innovations (Kessler, Bierly and Gopalakrishnan 2000; Lanctot and Swan 2000; Jones, Lanctot and Teegen 2001; Fey and Birkinshaw 2005). However, some others studies found positive effects of outsourced R&D on product innovation but the *make* strategy presented a higher impact (Chen and Yuan 2007; Haro-Dominguez et al. 2007; Santamaría, Nieto and Barge-Gil 2009).

The open innovation and absorptive capacity approaches stress that combining internal and external creates synergies that ends with a better innovative performance rather than solely making of buying. The open innovation approach indicates that due to the complexity of current products it is no feasible to develop everything in-house and argues that the main innovations come from the combination of internal and external knowledge (Chesbrough 2003). On the other hand, Cohen and Levinthal (1989) defend the idea that a firm is not able to assimilate and integrate external knowledge if it does not have the absorptive capacity gained through the internal R&D. Empirical evidence is not conclusive since Schmiedeberg (2008) did not observed better performance of the *make-buy* strategy and Tsai and Wang's (2009) results through a negative effect but on the other hand, Veugelers and Cassiman (2006) and Cruz-Cázares, Bayona-Sáez and Garcia-Marco (2010) found that the *make-buy* strategy produces a better innovative performance.

In a broad consensus, it seems that the *buy* strategy produces the lower innovative results and that the *make* strategy outperformers the *buy* strategy. Theoretically, and supported with some empirical evidence, it is supposed that combining in-house and external R&D is the best R&D strategy. Therefore, we consider crucial to observe whether, for the Spanish case, the public R&D funds encourage firms to select those strategies with a larger effect on firm innovativeness.

3. DATABASE, VARIABLES AND METHODOLOGY

The Spanish Business Strategy Survey (henceforth SBS) used in our empirical analysis is a firm-level panel dataset of manufacturing firms covering the period from 1990 to 2005. The survey is compiled by the Ministry of Science and Technology and the Public Enterprise Foundation (FUNEP). It is random and stratified by industry sector and firm size (Fariñas and Jaumandreu 2000). It provides information on markets, customers, products, employment, outcome results, corporate strategy, human resources and technological activities. The aim of the SBS is to document the evolution of the characteristics of Spanish firms and the strategies they use. For the purposes of our analysis we have selected the data pertaining to large firms with over 200 workers.

We selected large firms since several studies have found that large firms are the principal ones in receiving public R&D funding (Wallsten 2000; Lach 2002; Czarnitzki and Hussinger 2004; Madrid and García 2009). In fact, in SBS sample the percentage of medium and small firms receiving public R&D funding is very low, (2.07% and 9.2%, respectively). According Blanes and Busom (2004) and Czarnitzki and Hussinger (2004), large firms receive more funding because they are more willing to undertake innovations projects since they can afford the fix costs associated to those projects. Additionally, they are more prone to apply for public funding as they have larger organizational resources to face the bureaucracy and paperwork inherent to the process when requesting the public funds (Czarnitzki and Hussinger 2004). Moreover, some public administrations might prefer to support large firms as they believe that their projects have more possibilities of success (Blanes and Busom 2004).

The final sample comprises 3941 observations for 457 firms, 72 of which (16 %) presented a complete panel[16]. 72.36% of these 457 firms performed some sort of R&D in at least one year of the period considered, from which 50.11 % had adopted the *make* strategy, 39.37 %) the *make-buy* ; and 10.52 % the *buy* strategy.

R&D strategy (RD_ST), which is the dependent variable in the model, is defined in terms of four levels: 1 = *no R&D*, 2 = *make*, 3 = *buy* and 4 = *make-buy*. This is a categorical unordered variable, taken directly from the SBS representing activities at time *t*. Firms were asked to answer the following question: *Mark below if your firm performed in-house, outsourced R&D or combined both.* The different levels are, by definition, mutually exclusive. Following Parmigiani (2007), in order to ensure that the *make-buy* strategy truly represents the combination of both strategies, it was recoded from the original data as follows: firms that had opted for *make-buy* and had assigned less than 10% of their total R&D expenditure to outsourced R&D at time *t*, were recoded as adopters of the *make* strategy; the same less than 10% criterion was applied to in-house R&D expenditure. Firms whose in-house and outsourced R&D

[16] The panel data is not balanced since some firms ceased to provide information and some others were added. Due to the availability of information, our sample covers the period from 1992 to 2005. Firms included in the final sample had to be in the panel for at least four consecutive years.

expenditures were both greater than 10% of the total remained within the *make-buy* category.

We have three independent variables which capture each of the public R&D funding: the Neperian log of R&D funding, Regional funding (*RF*), State funding (*SF*) and funding from other levels of governance, including the European Union (*OF*). These variables were calculated as the Neperian log of R&D funding and are included in the model at *t*, *t-1* and *t-2* aiming to determine whether the receipt of funding has a long- or short-term effect in determining the R&D strategy selection.

The first control variable is human capital which is measured as the percentage of engineers and graduates among the total number of workers (*GP*). It is one of firm's internal resources that will influence its capacity to design and implement R&D projects (Blanes and Busom 2004) and whether the R&D can be performed in-house, using ideas proposed and developed by the firm's own employees and could also facilitate the acquisition and assimilation of external knowledge.

The second control variable is the technological intensity which captures whether firms belong to a sector with high (HTI), medium (MTI) or low technological intensity (LTI). This variable was recoded as in the SBS the industrial sector variable is divided into 20 different industries based CNAE-93 classification.

The remaining control variables are age (AGE_t), and firm size (*SIZE*). The first one captures demographic organizational characteristics such as leadership capacity, entrepreneurship, etc… and derived from the difference between the year the firm was founded and time *t*. Firm size was calculated from the Neperian log of total turnover. All control variables were included in the model, presented below, at time *t* and time dummies representing each year of the data are also included

$$RDS_{it} = \beta_1 RF_{it} + \beta_2 RF_{it-1} + \beta_3 RF_{it-2} + \beta_4 SF_{it} + \beta_5 SF_{it-1} + \beta_6 SF_{it-2} + \beta_7 OF_{it} + \beta_8 OF_{it-1} + \beta_9 OF_{it-2} + \beta_{10} GP_{it} + \beta_{11} Size_{it} + \beta_{12} Age_{it} + \beta_{13} MTI_{it} + \beta_{14} HTI_{it} + \gamma_i + \varepsilon_{it} \qquad (1)$$

The panel structure of the sample allows the use of panel data estimation techniques. Although observations tend to be correlated, the problem can be solved by introducing random effects. In our case, the appropriate model is the multinomial logit model[17] with random effects, which has the advantage of allowing for control of unobserved heterogeneity and stronger causal inference (Hsiao 1985).

The model is estimated using gllamm, a Stata module for maximum likelihood estimation of generalized linear latent and mixed models. This software has the capacity to estimate multi-level, mixed, and hierarchical regression models with binary or ordinal dependent variables and possible latent (unobserved) variables and random effects at any level. The Newton–Raphson algorithm is implemented in gllamm to calculate maximum likelihood using first and second derivatives (Skrondal and Rabe-Hesketh 2003). The best way to integrate the random effects, in order to obtain the marginal response distribution, is using the Gaussian adaptive quadrature (GAQ) method, which improves the robustness of the results when working with large numbers of observations and between-group correlation (Rabe-Hesketh, Skrondal and Pickles 2004). The Huber/White/sandwich estimator is used to estimate the matrix of covariance of the estimated parameter to obtain a robust variance and adjusted between-group correlation coefficients.

4. RESULTS

Table 3.1 gives the descriptive statistics and correlations of the variables used in the models. As the table shows, most of the firms (38% approx.) belong to the high-tech sectors; the next group are the firms from the low-tech sector (36%) and the last are those from the medium-tech sector (25%). The average age of the firms is high (about 35 years).

With respect to average funding received, a few remarks are due regarding the data in Table 3.2, which, unlike those in the previous Table, are expressed in thousands of Euros rather than Neperian logs. The means and standard deviations

[17] Where level one represents total observations that are nested in level 2, firms.

shown on the left-hand side of Table 3.2 refer to the whole sample of firms, receivers and non-receivers of funding alike, while the figures that appear on the right-hand side of the table refer exclusively to receivers, thus enabling us to calculate average funding received.

Table 3.1 Means, standard deviations and correlations among variables

Variable	Mean	Std. Dev	RDS	RF_t	SF_t	OF_t
RDS	2.3697	1.1644	1			
RF_t	0.3993	1.3004	0.2568*	1		
SF_t	0.7068	1.7828	0.2812*	0.3410*	1	
OF_t	0.2813	1.1456	0.1284*	0.2111*	0.2612*	1
LTI	0.3623	0.4807	-0.2108*	-0.1519*	-0.1669*	-0.1052*
MTI	0.2552	0.436	0.018	0.025	0.0116	0.0318
HTI	0.3823	0.486	0.1923*	0.1278*	0.1547*	0.0755*
GP	6.2022	7.5099	0.1669*	0.0391	0.1933*	0.0708*
SIZE	18.04	1.0728	0.1391*	0.0427	0.1248*	0.0887*
AGE	35.851	25.6966	0.0255	-0.0278	0.0385	-0.0327
Variable	**GP**	**SIZE**	**AGE**	**LTI**	**MTI**	**HTI**
LTI	1					
MTI	-0.4413*	1				
HTI	-0.5931*	-0.4607*	1			
GP	-0.1253*	-0.1457*	0.2546*	1		
SIZE	-0.0972*	-0.0416	0.1335*	0.2764*	1	
AGE	0.0776*	-0.0611*	-0.0219	0.1319*	0.0896*	1

* significance at 0.05

Focusing on those firms that received funding, it can be seen that the most frequent source is the State (582 assignations in all). It is also the most generous, with a mean payout of nearly 360 thousand Euros. The next most frequent sources are the Regional funding (375 assignations). Other sources, including the European Union, come last with 246 assignations. In terms of mean amounts, other sources surpass the Regional funding. These results are in line with those obtained (also for the Spanish context) by Blanes and Busom (2004).

The results of the estimation the multinomial logit model with random effects of equation (1) are given in Table 3.3.

Table 3.2 Total sample and firms that received funding

	Total number of firms			Firms that received funding		
	Observations	Mean	Standard deviation	Observations	Mean	Standard deviation
RF*	3941	15.5	101.02	375	162.91	288.86
SF*	3941	53.11	410.1	582	359.63	1014.93
OF*	3941	14.56	129.41	246	233.25	467.01

* Thousands of Euros

We perform our first estimation, leaving *no R&D* as a reference category. Thus, the results that appear in the first three columns of Table 3 shows that, when taking *no R&D* as a reference, R&D funding, whether it is from the Regional (RF), State (SF) or any other public (OF) body, has a positive effect in that it is associated more strongly with the *make*, *buy* or the combined *make-buy* R&D strategies than with the *no R&D* strategy. In other words, the receipt of R&D funding, as might be expected, encourages any R&D strategy. But, aiming to answering our question whether the source determine the strategy we re-estimate the model changing the reference variable twice for *make* and *buy* instead of *no R&D*, as can be observed for models (4), (5) and (6) of Table 3.3[18]. The purpose of this was to test for significant differences between the estimated coefficients and the coefficients for the reference category in each case.

As the data show, Regional funding appears to increase the firm's probability of selecting the combined *make-buy* strategy rather than the *make* strategy, but no significant differences can be observed between *make* versus *buy* and *make-buy* versus *buy*. Thus, Regional funding appears to make a firm slightly more likely to adopt the combined strategy than to opt for in-house R&D alone, but makes no difference otherwise.

State funding, meanwhile, increases the firm's probability of selecting the combined *make-buy* strategy rather than either of the others. This finding is in-line with that of Steyer (2006) where, following participation in a State program, firms could be seen to increase their external R&D expenditure by up to 22%, which places them by our criteria in the combined *make-buy* category.

[18] Estimates of the re-estimation are only presented for those strategies not already included in the previous estimations.

Table 3.3 Estimates of multinomial logit model with random effects

Variables		*no R&D* as reference			*make* as reference		*buy* as reference
		make (1)	*buy* (2)	*make-buy* (3)	*buy* (4)	*make-buy* (5)	*make-buy* (6)
Funding	RF_t	1.3696* (0. 728)	1.4256* (0. 737)	1.4930** (0. 728)	0. 0500 (0. 072)	0. 1359** (0. 054)	0. 0005 (0. 078)
	SF_t	0. 982*** (0. 288)	0. 8446*** (0. 297)	1.0543*** (0. 289)	-0. 1115 (0. 077)	0. 1040*** (0. 038)	0. 2186** (0. 107)
	OF_t	2.4342*** (0.000)	2.0770*** (0. 505)	2.3697*** (0. 478)	-0. 336*** (0.111)	-0. 0018 (0. 035)	0. 3064*** (0. 069)
Funding $_{-1}$	RF_{t-1}	0. 1359 (0. 174)	0. 1471 (0. 184)	0. 1893 (0. 176)	-0. 0011 (0. 070)	0. 0390 (0. 049)	0. 0279 (0. 085)
	SF_{t-1}	0. 3287** (0. 151)	0. 3076** (0. 155)	0.3687** (0. 150)	-0. 0103 (0. 058)	0. 0550* (0. 031)	0. 0173 (0. 073)
	OF_{t-1}	0. 1327 (0. 207)	-0. 0830 (0. 225)	0. 0869 (0. 209)	-0. 233*** (0. 086)	-0. 0548* (0. 032)	0. 1784** (0. 083)
Funding $_{-2}$	RF_{t-2}	0.1034 (0. 133)	0. 1902 (0. 164)	0. 2559* (0. 132)	0. 0734 (0. 079)	0. 1476*** (0. 049)	0. 1315 (0. 095)
	SF_{t-2}	0. 1975 (0. 121)	0. 0681 (0. 133)	0. 2266* (0. 121)	-0. 1108 (0. 081)	0. 0576 (0. 039)	0. 1090 (0. 074)
	OF_{t-2}	0. 3180 (0. 246)	0. 1983 (0. 262)	0. 3144 (0. 249)	-0. 0595 (0. 079)	0. 0492 (0. 032)	0. 0953 (0. 063)
Tech. Intensity	MIT	0. 9865* (0. 543)	1.4414*** (0. 554)	1.2756** (0. 558)	0. 4051 (0. 464)	0. 1710 (0. 336)	-0. 5734 (0. 464)
	HIT	2.3373*** (0. 539)	2.5886*** (0. 564)	2.4820*** (0. 552)	-0. 2008 (0. 420)	-0. 2530 (0. 318)	-0. 1742 (0. 431)
Percent. Graduates	GP	0. 0574* (0. 031)	0. 0608** (0. 033)	0. 0741** (0. 030)	0. 0247 (0. 025)	0. 0345** (0. 017)	0. 0006 (0. 029)
	Size	0. 747*** (0. 226)	0. 8997*** (0. 238)	0. 835*** (0. 229)	0. 02340 (0. 302)	-0. 0735 (0. 251)	0. 0329 (0. 625)
	Age	0. 0012 (0. 007)	-0. 0115 (0. 008)	0. 0025 (0. 007)	-0. 0140** (0. 007)	-0. 0007 (0. 004)	0. 013** (0. 006)
Number of level 1 units		3109			3109		3109
Number of level 2 units		456			456		456
Condition Number		31420.069			16009.559		25003.975
Log likelihood		-3008.705			-3012.1596		-3330.8177
Variance (std. error)		12.637 (1.961)			6.935 (0.925)		5.597 (1.12)

*p<0.1; ** p<0,05; *** p<0.01

Finally, the receipt of aid from other sources, including the European Union, increases the firm's probability of selecting either of the other two strategies rather than the *buy* strategy on its own. This result may be consonant with the typology of European projects, which are undertaken on a cooperative basis and therefore require participating firms to perform in-house R&D and not rely on outsourcing alone.

If we look more closely at the potential medium-term effect (*t-1*) of receiving R&D funding, the outcome appears to vary according to the source of the funding. First, Regional funding seems not to have any effect on the R&D strategy selection. State fund has a medium-term effect on their probability of performing R&D activities. This fund incentives firms in selecting any of the R&D strategies and seems to foster the selection of the *make-buy* strategy over *make*. However, there seems not to be a difference between *make* and *buy.* Regarding the other funding, at *t-1* interesting results appear since the *make-buy* strategy is preferred over *buy* but the *make* is preferred over *make-buy* and *buy*.

The long-term effect (*t-2*) of the public R&D funding seems to be limited to the Regional and State funding. This is interesting because we might have expected a larger effect of the State fund due to the higher amount they financed but the Regional fund has a stronger presence in the long term. It is important to highlight that both found affect in prompting the adoption of the *make-buy* strategy over the others.

In conclusion therefore, we find that the duration of the effects of financial aid on the choice of R&D strategy depends on the source. The reason for the variation may have to do with the objectives the funding is meant to target, which, as we have already mentioned, are not always the same. Thus, Regional funding , who tend to be the least selective when deciding which firms to support and also to assign lower mean amounts, has a contemporaneous and large-effect impact on R&D selection. In both contemporaneous and long-term effect seems to encourage firms in selecting the *make-buy* strategy rather than the *make*, but distinction is between *make-buy* and *buy*. State aid, involving higher mean amounts, increase the probability for selecting the complementarity strategy at a contemporaneous, medium- and long-term effect.

Finally, funding from other sources, including the European Union, has no long-term impact. Our results suggest that these sources, which provide funding for cooperative projects, do not encourage the adoption of the *buy* strategy, which, according to the evidence we have analyzed, has the least demonstrable, sometimes negative, impact on innovation output.

Our findings from the control variables show that the higher the technological intensity of the sector, the greater the firm's probability of adopting some R&D strategy, but none more than any other. In terms of the workforce skills level, a higher proportion of engineers and graduates among its employees makes a firm more likely to opt for *R&D* versus *no R&D*, while also increasing the probability of selecting *make and buy* versus *make*. We also find a significant, positive impact of firm size on the probability of selecting the *make-buy* strategy versus either of the other two and the *buy* strategy versus *no R&D*. Finally, we obtain that the probability of selecting the *buy* strategy increases with firm age.

5. CONCLUSIONS

This paper fits into the literature on the effect of public R&D funding for businesses. Its specific aim is to examine various sources of public funding from the behavioural perspective to investigate their impact on firms' R&D strategy selection and measure the possible effect over time.

While most previous literature studies the different impact of various R&D strategy options (*make, buy* and *make-buy*) have on innovation output, this study has enabled us to detect whether public institutions are fostering innovation R&D strategies according to its objectives pursued, and to assess whether public subsidies have a short- or long-term effect on commercial R&D activities.

The first significant conclusion emerging from this paper is that the source of the funding determines whether R&D support has only a contemporaneous or a more long-term effect. Thus, the impact of State aid lasts for two or three periods, depending on the firm's choice of R&D strategy,. One possibility is that the State may be directing its grants, which involve the largest sums of money, to larger-scale projects, based on the observation that the impact extends beyond two years after receipt of the funding. Another is that the State may be more successful at providing firms with the means to develop their R&D capacity through the *make-buy* strategy.

The second important finding from this study is that public funding for R&Ds, by definition, not just another factor influencing firms' decisions to undertake the type of activities that will enhance their innovation output. We have been able to confirm that the source of the funding is one of the factors that determine the firm's choice of R&D strategy, that is, whether it opts for in-house R&D, outsourced R&D or a combination of the two, a decision that will have an impact on its innovation performance.

Specifically, our results show that State funding encourages firms to opt for the *make-buy* strategy, which, despite being strongly supported by the absorption capacity and open innovation theories. Regional funding, the least significant in terms of the sums involved, presents a less obvious pattern, although there is some indication that it encourages selection of the *make-buy* strategy as opposed to an exclusive *make* strategy. A possible explanation for this result might lie in the diversity of conditions resulting from the decisions of 17 different Regional governments. Finally, the receipt of aid from other organizations, including the European Union, increase the firm's probability of adopting any R&D strategy, but the *buy* R&D strategy has the lowest probability to be selected This suggests that EU funding is having more effect as an incentive to perform in-house R&D, either exclusively or as a complement to technology outsourcing. This is consistent with the objectives and typology of European projects, which, being organized on a cooperative basis, require each participating firm to perform some activities in-house.

This study has certain limitations deriving, among other factors, from the use of a database not specifically designed for our research objective. For example, the fact that we identify each firm's adopted R&D strategy based on its responses in the SBS may compromise our findings somewhat, because we cannot know whether the respondent fully understood the distinction between *innovation strategy* and *R&D strategy;* nor are we in possession of data regarding the main purposes for which the funds are used. Finally, the main limitation of this study is that the results and conclusions draw in this study comes from a specific sample and they only apply for large Spanish manufacturing firms. In order to draw general conclusions, further studies need to be developed.

CHAPTER IV

R&D STRATEGIES AND FIRM INNOVATIVE PERFORMANCE: A PANEL DATA ANALYSIS

1. INTRODUCTION

Decisions concerning how the firm will access technology are crucial since they affect its future performance (Lanctot and Swan, 2000) and also determine business success (Fahy, 2002). Conducting exclusively in-house research and development (R&D), externalizing R&D or combining internal and external sources of technology are the main R&D strategies[19] (RDSs) by which firms realize their innovation strategy. The current literature measuring RDSs effects on firm innovative performance has yielded mixed and inconclusive results and this Chapter attempts to contribute to the existing literature.

The aim of this fourth Chapter is to ascertain the effect of the in-house (*make*), external (*buy*) and a combination of both (*make-buy*) RDSs on firm innovative performance. Based on the open innovation and absorptive capacity theoretical approaches, as well as on empirical evidence, we hypothesize that all RDSs will produce positive results on firm innovative performance, but that the *make-buy* strategy will produce the greatest impact, whereas the lowest impact will result from the *buy* strategy. We also hypothesize that the effects of RDSs are moderated by the technological intensity level; thus, these effects might vary across industries, having a lesser or greater impact on firm innovative performance.

[19] R&D cooperation could be considered another R&D strategy, but due to its specificity in the theoretical specifications (*e.g.* Bayona-Sáez *et al.*, 2001) –such as trust, behavioural integration, personal commitment- and different types of collaboration, such as R&D cooperation agreements with universities, competitors, users and joint ventures, we decided not to include it in the analysis. Additionally, the variable of cooperation agreements was compiled in the SBS after 1998. .

Some studies have measured the effect of internal and external RDSs on firms' performance using a Likert scale of global firm performance (Lanctot and Swan, 2000; Haro-Dominguez et al., 2007), others have used the firm's return on assets (Zahra et al. 1994; Diaz-Diaz, et al., 2008), sales due to new products (Veugelers and Cassiman, 2006; Tsai and Wang; 2009) or new product innovation (Poon and McPherson, 2005; Chen and Yuan, 2007). Here, we intend to evaluate their effect on different measures of firm innovative performance and have defined innovation outputs in terms of, number of product innovations, and product and process innovations (dummies).

We believe that measuring RDS effects in this way has some advantages. First, since R&D activities aim at developing new products and processes (OECD, 1997), we are measuring their efficacy. Second, it allows objective measuring of the direct effect on innovation output, avoiding subjective perspectives. Third, depending on the stage of the industry technology life-cycle, the focus of product or process innovation might vary (Abernathy and Utterback, 1978)[20]; thus we are controlling for the different stages of that cycle. This study therefore differs from previous research, most of which has only evaluated the effects of RDSs on product innovation, overlooking the need to assess the effects on process innovations.

In addition, this study provides a new understanding in that due to the inter-industry differences, like appropriability (Cohen and Levin, 1989), knowledge environment (March, 1991) and technology life-cycle (Damanpour and Aravind, 2006), RDSs effects on firm innovative performance will be moderated by technological intensity level. Most studies have focused on high-technology industries, such as biotechnology and electronics, while low- and medium-technology industries have receive little attention (Tsai and Wang, 2009); this is a problem we want to address.

The sample used for testing the hypotheses embraces 13,128 observations corresponding to 1,478 Spanish manufacturing firms for the unbalanced panel from 1992-2005. It is worth mentioning that most of the research undertaken in

[20] When new technological opportunities arise, product innovation is strongly driven by the demand for new product features, whereas process innovations follow the emergence of a dominant design.

this field has involved the analysis of cross-sectional samples (*e.g.* Veugelers and Cassiman, 2006; Schmiedeberg, 2008), while we are able to estimate panel models - due to the panel structure of the sample - allowing us to control time variation and unobserved firm-specific effects (Baum, 2006). In contrast to previous research, we took into consideration the temporal effects of RDSs and found that the *buy* strategy has a short-term effect while that of the *make-buy* strategy lasts much longer. Furthermore, the effects of all RDSs are higher at time *t-1*, diminishing at *t-2*.

The Chapter is organized as follows. In the next section we present the theoretical background and previous empirical research used to construct the hypotheses. We also discuss the role of technological intensity level and the common determinants of product and/or process innovations. Next, we describe the sample, the variables and the estimation methods to test the hypotheses. Subsequently, the analysis of the results is presented. Finally, the conclusions and implications are reserved for the fifth section.

2. THEORETICAL BACKGROUND

2.1 R&D strategies and firm innovativeness

For our purpose, the theoretical approach supporting the positive relationship between RDSs and firm innovative performance is the R&D capital stock model (Griliches, 1979). This model stresses that R&D activities have a lagged effect on innovations achievement and these innovations subsequently foster firm performance. Indeed, there are various studies analyzing the relationship between R&D, patents, spillovers, innovations and productivity performance. For example, Geroski (1991) found that innovations achieved have a long run effect on productivity growth; nevertheless, the use of innovations had a more powerful impact. Cameron (2000) observed a positive impact of R&D on total factor productivity growth, but the effects varied significatively across industries. Kafouros (2005) also found positive and direct effects of R&D on productivity growth though the effect was higher for large firms than for small firms.

Geroski (1994) asserted that although innovations have a positive effect on firm profitability the innovation process have permanent effect on firm performance since it transforms firm's capabilities making the firm less sensitive to cyclical downturns. He also emphasized that innovations produced in one sector additionally increases productivity growth in other sectors originated by spillovers since knowledge is non-excludable and has a non-rival nature.

Although there is common agreement as to the positive effects of R&D activities on firm innovativeness (Cohen and Levinthal, 1990; Griffith et al., 2004), the question of whether different RDSs have the same impact on firm innovative performance awaits a conclusive answer (Jones et al., 2001).

2.1.1 Make vs. buy effects on firm innovativeness

The *buy* strategy is supposed to have advantages over *make*, in the sense that it is more reliable (Kessler and Bierly, 2002). In addition, it allows risk calculation *a priori*, offers a solution to capacity problems, increases the speed of accessing new technology and reduces risk (West, 2002). It also allows access to new knowledge areas (Haour, 1992) through the productive networks created (Nishiguchi, 1994). On the other hand, Narula (2001) argued that *buying* implies considerable costs of negotiating and enforcing contracts. Likewise, the firm could obtain only a little amount of the codified results and not total accumulated knowledge and there is also a substantial risk of opportunistic behavior. External dependences, functional inequalities, and coordination problems are further factors affecting the *buy* strategy and reducing its impact on firm innovativeness (Kotable and Helsen, 1999).

On the other hand, developing in-house R&D facilitates the information flow within the R&D department and among those involved in the innovation process (*e.g.* manufacturing). Similarly, it allows an objective valuation of real innovation needs and constitutes a unique source of knowledge (West, 2002), with economies of scale being enhanced, transaction costs evaded and barriers to imitation constructed (Contractor and Lorange, 1988). However, the *make* strategy is risky and the results are less predictable, product commercialization is time-demanding and the firm could remain isolated in one specific technology if the R&D department is not flexible (Perrons and Platts, 2004).

Empirical evidence of the effects of the *make* and *buy* strategies upon firm innovativeness is scarce and somewhat controversial. Interestingly, the *buy* strategy has always been associated with negative effects in those studies where it was the only RDS evaluated. Kessler et al. (2000) analyzed how externalizing R&D affects new product development and found that buying during idea generation was negatively related to product competitiveness and that externalization during the technological development lowered innovation speed. Lanctot and Swan (2000) developed a scale for measuring firms' tendency to externalize technology development and discovered a negative effect of externalization of product and process technology on firm success. Finally, Fey and Birkinshaw (2005) found a negative relationship between contracting R&D and the creation of new products and technologies. Nevertheless, some authors argue that the impact of external knowledge on innovation performance varies depending on the particular sourcing method (Kang and Kang, 2009).

Results of studies where both the *make* and *buy* strategies were analyzed are quite diverse. Jones et al. (2001) observed that external R&D significantly detracted from firm performance in terms of product, market and financial measures, while the *make* strategy had a positive effect on new product development. In the study by Diaz-Diaz et al. (2008) both internal and external R&D increased the probability of achieving innovations. It is worth mentioning that although they had a panel dataset, they did not include the RDS lagged; as a result, they were unable to observe the temporal effects of R&D activities. Santamaría et al. (2009) did consider low-/medium- and high-technology industries and found that the *make* strategy was significant for both groups, while buying R&D was positive only for process innovations in the former and positive for achieving product innovations in the latter.

There is empirical evidence showing that internal R&D produces better results than external R&D. For example, Beneito (2006) found that the *buy* strategy had positive effects on incremental innovations – utility models – while the *make* strategy had positive effects on both incremental and radical innovations – patents. Haro-Dominguez et al. (2007) and Chen and Yuan (2007) observed positive effects of external and internal R&D on new product development, although the effects were higher for internal R&D.

2.1.2 Complementarity of strategies

Geroski (1994) has argued that since new external technologies could be the base for future innovations it is likely that spillovers will complement the internal R&D activities. Additionally, current products are more complex since they must be technologically feasible and economically viable and this complexity requires multidisciplinary knowledge that may sometimes be exclusively found beyond the firms' boundaries, requiring the combination of internal and external R&D (Iansiti, 1997).

The open innovation approach stresses that firms have changed from the closed innovation process to a more open one, in which knowledge and technology flows are twofold: inside-out and outside-in. On one hand, firms profit from technological innovation achievements (*e.g.* through licensing agreements and spinoffs); on the other hand, they search for new technologies and ideas beyond their boundaries (Chesbrough, 2003). According to Enkel et al. (2009), open innovation is the combination of internal and external ideas and technologies in order to achieve new products, processes and technologies and reduce time to market[21]. As a consequence, those firms acting within a closed innovation perspective will reduce their knowledge-base over the long term (Koschatzky, 2001). Interestingly, a recent study had showed how the shift from the close to an open innovation had taken place occurred in shocks, rather than a continuous process over time (Poot et al., 2009).

Finally, absorptive capacity is the most traditional theoretical approach stressing the complementarity between the *make* and *buy* strategies (Cohen and Levinthal, 1990). Abecassis-Moedas and Mahmoud-Jouini (2008) define it as the firm's ability to recognize the value of external knowledge and to assimilate and apply it to commercial ends. It is through internal R&D activities that firms enable their capabilities of scanning and integrating external knowledge (Arora and Gambardella, 1990), and without these capabilities firms will not make the most of the *buy* strategy. Additionally, Li and Vanhaverbeke (2009) empirically

[21] For example, in the automotive industry in the early 1990s, the time to complete a research project and the subsequent impact on productivity was 60 months while in the 2000s it is only 18 months (Advanced Manufacturing, 2001).

Table 4.1 Literature review comparison of RDS effect on product and process innovations

Author	*Sample*	*Estimates Method*	*RDSs Analyzed*	Product Innovation	Process Innovation
Kessler et al. (2000)	75 innovation projects of 10 large U.S. firms	First-order serial correlation	*buy*	neg, in speed neg in success	N/A N/A
Lanctot & Swan (2000)	188 MNS in U.S	OLS regression	*buy*	neg.	neg.
Fey & Birkinshaw (2005)	107 large R&D active firms in Sweden & U.K.	OLS regression	*buy*	neg.	N/A
Jones et al. (2001)	188 MNS in U.S	OLS regression	*buy* *make*	neg. pos.	N/A N/A
Haro-Dominguez et al. (2007)	110 Spanish engineering consulting firms	Structural equation model	*buy* *make*	pos. pos. & > buy	N/A N/A
Chen & Yuan (2007)	1104 Chinese high-technology firms	OLS regression	*buy* *make*	pos. pos. & > buy	N/A N/A
Diaz-Diaz et al. (2008)	1708 (6335 obs.) Spanish manufacturing firms for the 1998-2005 period	Random-effects (re) logit model & re neg. binomial	*buy* *make*	pos. pos.	N/A N/A
Santamaría et al., (2009)	1300 (6500 obs.) Spanish manufacturing firms for the 1998-2002 period	Random-effects probit model	*buy* *make*	none pos.	pos. pos.
Schmiedeberg (2008)	689 German manufacturing firms	Tobit regression	*buy* *make* *make-buy*	none pos. none	N/A N/A N/A
Veugelers & Cassiman (2006)	269 innovative Belgian manufacturing firms	OLS, two-stage Heckman, tobit, regressions	*buy* *make* *make-buy*	none pos. pos. & largest	N/A N/A N/A
Tsai & Wang (2009)	735 innovative Taiwanese firms classified as low- & medium-technology businesses	OLS-based hierarchical regression	*buy* *make* *make-buy*	none pos. neg.	N/A N/A N/A

N/A: not applicable; neg: negative; pos: positive. All RDSs analyzed were included in time t.

proved that firms with lower absorptive capacity failed to transfer technological opportunities into innovations.

Empirical evidence of complementarity between *make* and *buy* strategies on firm innovativeness is scarce. Beneito (2006) observed that external R&D had no effect on innovation output *per se*; however, when it was combined with internal R&D, positive effects arose. Adopting the supermodularity and productivity approaches, Veugelers and Cassiman (2006) found support for this complementarity. They observed that the *make-buy* strategy had the highest impact on sales due to new products. However, following the same methodology, Schmiedeberg (2008) did not observe any trace of complementarity.

Finally, interesting results have come from Tsai and Wang (2007; 2009) works. In 2007, they concluded that external R&D had no effect on firm performance when used in isolation; rather its effect depended on internal R&D efforts. Hence, the level of knowledge positively influenced inward technology for improving firm performance. Later, in 2009, they analyzed inward technology for low- and medium-technology firms and found contradictory results. Internal R&D negatively moderated the role of external R&D on sales due to new products.

Table 4.1 presents a literature review comparison of RDSs effect on product and process innovations and allows us to identify the contribution of this study alongside previous literature. Note that, among those studies comparing all RDSs (Veugelers and Cassiman, 2006; Schmiedeberg, 2008 and Tsai and Wang, 2009), the present research is the only one that considers product and/or process innovations as innovation outputs, measures the temporal effects of RDSs and addresses the moderating effects of technological intensity level.

We decided to evaluate the effects of RDSs on both product and process innovations since they are primarily meant to achieve these type innovations (OECD, 1997). Additionally, product and process innovations are deeply interrelated and, from the demand/consumer perspective, both of them are not independent phenomena (Bhoovaraghavan et al., 1996). Besides, it has been highlighted the importance of these technological innovations since they are central for business success (Bone and Saxon, 2000). Furthermore, both product and process innovations stimulate growth and productivity not only for the firms that produced them, but also for the firms that use them (Geroski, 1994).

2.2 Technological intensity level as a moderator

Zahra et al. (1994) indicate that due to rapidly changing and complex technology, acquiring external R&D is a key component of the firm strategy. The open innovation approach stresses that a combination of internal and external R&D is required for innovating when technology shifts and product complexity are high. However, do these assumptions still stand for industries where the technological shifts and uncertainty are almost imperceptible? We believe not, since appropriability conditions (Cohen and Levin, 1989) and the firm's technological trajectory[22] (Pavitt, 1984) are defined by inter-industry differences, thus affecting RDS selection (Cruz-Cázares et al., 2009) and the subsequent results. Empirical evidence has also showed different impacts of R&D on productivity growth depending on the industry type (Geroski, 1991; Kafouros, 2005).

In addition, inter-industry differences, different stages of the technology life-cycle and the economic conditions determine product and process innovations and some scholars have argued for further research covering these circumstances (Damanpour and Aravind, 2006). Certainly, the levels of change and complexity of technology depend on its life-cycle and the attractiveness to a firm of investing in technology depends on the cycle stage (Haupt et al., 2007). For example, 'the role of tacit knowledge in generating innovative activity is presumably the greatest during the early stages of the life-cycle, before product standards have been established and before a dominant design has emerged' (Audretsch and Feldman, 1996: 270).

The knowledge environment is also critical to the innovation process. The difference between a stable and turbulent knowledge environment, with significant variation across industries, depends on the importance given to exploitation and exploration activities (March, 1991). The former implies

[22] Whether a firm matches one of the four levels of Pavitt's (1984) taxonomy: supplier-dominated, scale- intensive, specialized-supplier and science-based.

refinement, implementation and efficiency of production, mostly being used for stable knowledge environments, whereas exploration implies research, rediscovery and experimentation and is preferred for unstable environments (Van den Bosch et al., 1999).

3. HYPOTHESES

Drawing on the discussion above, we have enough support for the first hypothesis. Using the R&D capital stock model (Griliches, 1979) and taking into account the existing empirical evidence, we hypothesize that all RDSs will have positive effects upon the firm's product and process innovation achievements – that is, the firm's innovative performance.

Hypothesis 1: *All R&D strategies will have a positive effect on the firm's innovative performance.*

However, we do not expect all RDSs to have the same impact on firm innovativeness. Based on the open innovation (Chesbrough, 2003) and absorptive capacity (Cohen and Levinthal, 1990) approaches and on previous empirical research (*e.g.* Veugelers and Cassiman, 2006; Schmiedeberg, 2008), we believe that the *make-buy* strategy will produce the largest effect on the firm's innovation performance because innovations mainly occur through the combination of ideas, resources and technologies (Fey and Birkinshaw, 2005).

Hypothesis 1a: *The make-buy strategy will have the highest impact on the firm's innovative performance.*

Finally, despite the flexibility gained through the externalization of the R&D activities, coordination problems, transactional costs and functional inequalities emerge when externalizing R&D (Kotable and Helsen, 1999) and researchers have found empirical evidence of these limitations (*e.g.* Kessler et al., 2000; Fey and Birkinshaw, 2005). Thus, based on theoretical and empirical evidence we would argue that the *buy* strategy will have the lowest impact on the firm's innovative performance.

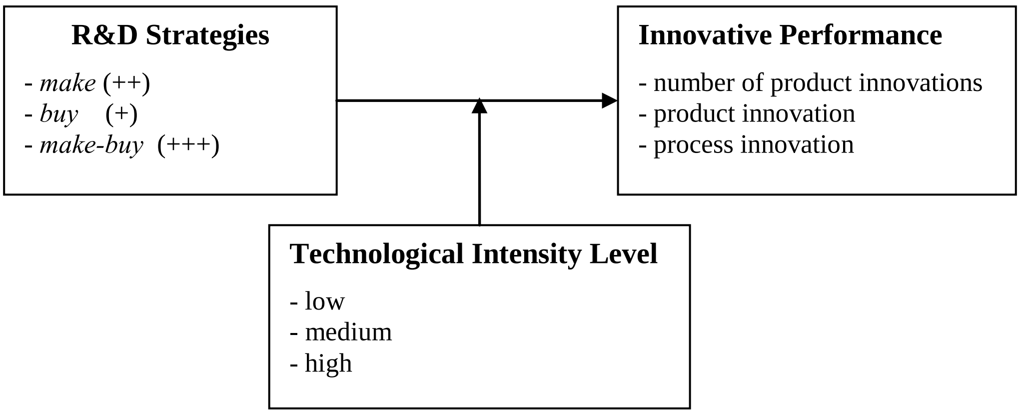
Hypothesis 1b: *The buy strategy will have the lowest impact on the firm's innovative performance.*

Our second hypothesis is driven by the inter-industry differences. We consider that the different technological life-cycle stages, appropriability conditions and technological trajectory might shape the innovation outputs. Thus, the effect of the RDSs will be moderated by different technological intensity levels.

Hypothesis 2: *The effects of the R&D strategies on firm innovative performance will be moderated by technological intensity level.*

In Figure 4.1 it can be observed the model aimed to be tested in this Chapter.

Figure 4.1 Model design



4. DETERMINANTS OF PRODUCT AND PROCESS INNOVATIONS

Apart from the RDSs, there are also organizational and environmental factors determining innovation output, which need to be controlled in the estimates.

4.1 Organizational determinants

Firm size, diversification, firm internationalization and technological knowledge are the organizational determinants most commonly used in the literature to explain product and process innovations (Damanpour and Aravind, 2006). Traditionally, it is stressed that firm size has a linear relationship with firm innovativeness (Schumpeter, 1934). However, it has been argued that small firms detect discontinuous opportunities and transform them into new products and processes (Utterback. 1994). On the other hand, large firms have more economic and organizational resources facilitating innovations (Afuah, 2001).

The degree and depth of the firm’s technological knowledge is supposed to foster innovation since diversified backgrounds and skills facilitate the understanding and creation of new ideas (Damanpour and Aravind, 2006). Clarke (1993) proposes the hypothesis that diversified firms have more incentives to innovate than their specialized counterparts because the results of R&D would be valuable for the firm, irrespective of the final result. Following Galende and Suarez (1999) we also argue that internationalization favors innovation through the increase in the firm’s market size, since firms must be more efficient – developing process innovation – and because their presence in foreign markets demands new technologically advanced products (Martinez-Ros, 2000). Additionally, when a firm is involved in international operations acquires knowledge that could be used and transformed to obtain product and/or process innovations (Filipescu et al*.*, 2009).

4.2 Environmental determinants

Market competition encourages productivity (Metcalfe, 2006) and fosters product innovations, enabling firms to enter new markets (Kraft, 1990). Schumpeter (1943) proposes that in less concentrated markets, with monopolistic conditions, firms have incentives to innovate since they can more easily appropriate the returns on innovations. By contrast, Arrow (1962) argues that firms’ gains from innovations are larger in competitive industries than in monopolistic ones. Finally, Scherer (1980) states that insulation from competitive pressure gives rise to bureaucratic inefficiency that inhibits innovation.

Demand growth is another environmental factor affecting firm innovativeness. However, due to the lack of theory and mixed empirical results, there is no common agreement favoring product or process innovations. Some authors have found that growth in demand encourages both product and process innovations (Kotable, 1990; Martinez-Ros, 2000), whereas others have observed negative effects on product innovations (Lunn, 1987).

5. DATA AND METHODS

5.1 Data

The sample used in our study was taken from the Survey of Business Strategy (SBS), which is a firm-level panel dataset of Spanish manufacturing firms covering the period from 1990 to 2005. The survey was compiled by the Spanish Ministry of Science and Technology and the Public Enterprise Foundation (FUNEP), it is random and stratified according to industry sector and firm size (Fariñas and Jaumandreu, 2000). It provides information on markets, customers, products, employment, outcome results, corporate strategy, human resources, and technological activities. The aim of the SBS is to document the evolution of the characteristics of the strategies used by Spanish firms. This survey is extremely valuable, since relatively few data sets contain information at firm level over several years (Leiponen and Helfat, 2003)[23].

The sample is an unbalanced panel since not all the firms answered throughout the 16 years, new firms are being added each year and others ceased to provide information. Our analysis covers a period of 14 years (1992-2005)[24]. A firm is included within the 14-year period if, and only if, it continuously answered the survey for at least five years. Following Fritsch and Lukas (2001) and Miotti and Sachwald (2003), innovative and non-innovative firms are

[23] Several publications have used the SBS focusing on firm technological activities (*e.g.* Santamaría and Rialp, 2007; Diaz-Diaz *et al.*, 2008; Santamaría *et al.*, 2009).

[24] Models are estimated with a maximum panel of 12 (1994-2005), since we included RDSs lagged by two years.

included in the panel in order to prevent bias in the sample. The final sample encompasses 13,128 observations corresponding to 1,478 firms, of which 312 answered throughout the whole period under analysis (21.10 %). In Table 4.2 we can observe the percentage of innovative firms grouped by technological intensity level. The percentage of firms that achieved product innovations only (22.72%) is smaller than that of those which achieved process innovations (30.96%). Note that 32.32% of high-technology firms accomplished product innovations, against only 18.65% of those in the low-technology group. A similar behavior is presented for process innovations. We are therefore able to infer a direct relationship between firm innovativeness and technological intensity level.

Table 4.2 Type of innovation by technological intensity (percent)

Type of innovation	Entire sample	Low technology	Medium technology	High technology
Product innovation	22.72	18.65	19.4	32.32
Process innovation	30.96	25.84	32.57	37.92

In Table 4.3 we present descriptive statistics for the type of innovation achieved by technological intensity level and type of RDS. Note that the mean of the number of product innovations is lower for the high- (7.44) than for the low- (10.47) and medium-technology groups (10.95). However, this does not mean that high-technology firms are less innovative than their counterparts. Almost 85% of these firms achieved product innovations, against 64% in the low-technology group.

The low number of product innovations among high-technology firms might be due to the fact that the innovations they achieved are more time-consuming and difficult to realize than innovations in low- and medium-technology firms, or, alternatively, that these firms are more focused on process innovations. As Von Tunzelmann and Acha (2005) stressed, innovations in low- and medium-technology firms are often targeted at product differentiation and marketing. For firms innovating in process we also observe a direct relationship between the use of the *make*-*buy* strategy and technological intensity level. Again, the *buy* strategy is the least pursued.

Table 4.3 Descriptive statistics for innovative firms

R&D Strategies	*no R&D*	*make*	*buy*	*make-buy*	Total
Number of Product innovations (mean)					
entire sample	9.79	8.61	7.33	9.81	9.35
low-tech	11.35	9.62	9.15	10.06	10.47
med -tech	8.19	8.84	7.59	15.27	10.95
high- tech	7.54	7.77	5.05	7.44	7.44
Product innovation (percent)					
entire sample	31.08	35,00	6.44	27.49	100
low-tech	44.64	29.7	6.94	18.72	100
med -tech	35.84	29.58	6.57	28.01	100
high- tech	15.75	42.87	5.89	35.49	100
Process innovation (percent)					
entire sample	42.83	21.67	5.39	30.11	100
low-tech	55.61	19.28	5.14	19.97	100
med -tech	47.34	18.83	5.78	28.05	100
high- tech	25.16	26.5	5.37	42.97	100

5.2 Variables operationalization

5.2.1 Dependent Variables

In order to obtain a broad measurement of the effects of RDSs on firm innovative performance we propose three different types of innovation output. We also try to establish whether, depending on the type of innovation, the RDSs will have different effects. We consider that not only the fact of innovating but also the number of innovations achieved should be evaluated. Thus, the first dependent variable is the number of product innovations achieved at time *t*. This variable is a count with a minimum value of 0. Due to the differences between the mean of the number of product innovations and the percentage of product innovations (Table 4.3), we define the product innovation variable -the second dependent variable- as dichotomous. Finally, the process innovations variable, also measured as dichotomous, takes the value of 1 if the firm achieved process innovations at *t*, and 0 otherwise.

5.2.2 Independent Variables

The three main independent variables are the different RDSs: *make*, *buy* and *make-buy*. The reference category in all models is the non-achievement of R&D activities. These variables are mutually exclusive and are coded as dichotomous since we want to know whether achieving one RDS *per se* leads to better results than other strategies. All RDSs are included in the model at *t-1* and *t-2*, to enable us to observe whether their effects persist in the short and/or long term and to validate the causal effects[25] claimed in the R&D capital stock model.

Variables with a dichotomous character are included in order to control for inter-industry differences when estimating the entire sample model. These variables capture the effect of *low*, *medium* and *high technology*. When disaggregating the sample, these variables are removed from the model.

5.2.3 Control Variables

Following Schumpeter's (1934) main hypothesis, we include *firm size* as an organizational determinant of firm innovativeness. It is included in the model as the logarithm of the number of employees at time *t*. The *technological knowledge* representing academic training, skills and capacity for creating ideas (Damanpour and Aravind, 2006) is approximated in our analysis by the ratio between R&D employees and the total number of employees at time *t*. Firm *diversification* is measured as the number of products the firm has available in the main market at time *t*. The percentage of international sales at time *t* is included to control for firm *internationalization*.

The variables used to control for environmental determinants are the number of competitors and the market dynamism in the firm's main market. The former is used as a proxy for *market competition* and takes the value of 1 if the number of competitors is less than 10; 2 if it is between 10 and 25; 3 for more than 25 competitors; and 4 if the market is atomized. *Market dynamism* represents the market demand and it takes the value of 1 if the market is recessive; 2 if it is stable; and 3 for expansive markets. Both variables are

[25] Based on the theoretical assumptions of the R&D capital stock model, the effects of the R&D activities are lagged since a particular R&D project may take more than a year to complete and, if successful, may still take some time before a decision is made to use or produce it (Griliches, 1979, p. 101). We also estimate models considering *t-3* but multicolineality problems emerged.

introduced in the model at time *t*. Finally, dummies are included for each year in order to control for temporal effects[26].

5.3 Methods

Due to the fact that we have two different types of dependent variables, we estimate two different kinds of models to test our hypothesis. Given the panel composition and binary nature of the product innovation and process innovation variables, we estimate a random-effects logit model for these variables. In respect to the number of product innovations variable, we estimate a random-effects negative binomial regression since the dependent variable is a count[27].

As we argued in the theoretical section, in order to analyze the moderating effect of technological intensity level on RDS effects, we disaggregate the sample into low, medium and high technology, following the CNAE-93 classification, and re-estimate the models for each subsample.

6. RESULTS

6.1 Product innovation

Estimates for the number of product innovations are shown in Table 4.428. Hypothesis H1 is confirmed since, for the entire sample, all RDSs have positive and significant coefficients at *t-1*. The make-buy strategy still has the largest coefficients at *t-1* (0.8468) and *t-2* (0.3946), giving support for H1a. The buy strategy has positive effects only at *t-1* and the coefficient has the lowest magnitude at *t-1* (0.4049), confirming H1b.

[26] Correlations, means, and standard deviations for the complete sample are presented in Annex B. Multicolineality is absent since the VIF coefficients are considerably low (Chatterjee *et al.*, 2000).

[27] Count data have traditionally been estimated using the Poisson regression, which assumes that the variance equals the mean of the dependent variable. In the absence of overdispersion, when the variance exceeds the mean, the Poisson model fits well, but if overdispersion exists estimates may be biased. The negative binomial regression is an alternative, since it follows a Poisson distribution but assumes that unobservable heterogeneity exists (Arocena and Núñez, 2009).

[28] The high values of the *Wald statistic* and *log likelihood* guarantee a desirable fit of the models. *Rho* is the proportion of the total variance contributed by the panel-level variance component.

Table 4.4 Estimates for the number of product innovations

Variables	Entire sample	Low technology	Medium technology	High technology
$Make_{t-1}$	0.7626***	0.7453***	0.2981	1.0099***
	(0.000)	(0.000)	(0.113)	(0.000)
Buy_{t-1}	0.4049***	0.5069***	0.4634**	0.2469
	(0.001)	(0.006)	(0.048)	(0.245)
$Make\text{-}buy_{t-1}$	0.8468***	0.7251***	0.7280***	1.0070***
	(0.000)	(0.000)	(0.000)	(0.000)
$Make_{t-2}$	0.3065***	0.4127***	0.3077	0.2040
	(0.000)	(0.002)	(0.105)	(0.154)
Buy_{t-2}	0.2174	0.3287	0.3992	0.0034
	(0.063)	(0.067)	(0.101)	(0.987)
$Make\text{-}buy_{t-2}$	0.3946***	0.4960***	0.4008**	0.2804
	(0.000)	(0.001)	(0.046)	(0.064)
Medium-tech.	-0.1499			
	(0.081)			
High-tech.	0.3717***			
	(0.000)			
Firm size	0.0470	0.1076**	-0.0430	0.0562
	(0.086)	(0.016)	(0.521)	(0.199)
Tech. knowledge	2.0921***	3.8147***	3.4442	1.3386
	(0.000)	(0.000)	(0.19)	(0.064)
Diversification	0.0289	-0.3063***	0.1252	0.1729**
	(0.604)	(0.005)	(0.315)	(0.027)
Internationalization	0.0031**	0.0023	0.0048	0.003
	(0.012)	(0.243)	(0.078)	(0.168)
Mkt. competition	-0.0307	-0.0383	0.0189	-0.0513
	(0.24)	(0.318)	(0.734)	(0.286)
Mkt. dynamism	0.0233	0.0579	0.0713	-0.0044
	(0.473)	(0.283)	(0.32)	(0.93)
Constant	-1.8210***	-1.4590***	-1.6815***	-1.9234**
	(0.000)	(0.000)	(0.000)	(0.000)
year effects (λ_τ)	*included*	*included*	*included*	*Included*
N. of observations	10085	4737	2536	2812
N. of firms	1478	689	393	426
Wald statistic	643.07***	283.78***	96.34***	206.29***
Log likelihood	-9731.46	-4037.55	-2174.09	-3488.33
X^2 *(test of rho = 0)*	2826.74***	1033.77***	588.17***	1108.85***
Dispersion (α)	0.4847***	0.6708***	0.4074***	0.2892***

**** p <= 0.001; ** p <=0.05; * p >= 0.01; p-value in parentheses*

Previous research findings that internal R&D activities increase new product development (Diaz-Diaz et al., 2008; Schmiedeberg, 2008) are supported, but only for low- and high-technology firms at *t-1*. Interestingly, this strategy has almost the same effect (1.0026) as the *make-buy* strategy (1.0004) for the high-technology group, giving us an insight into the relative importance of these strategies for high-technology firms in terms of the number of product innovations. The *make* strategy at *t-2* is only significant for low-technology firms. These findings indicate that the *make* strategy produces positive results in the short and long term for low-technology firms, while it has only a short-term effect for high-technology firms and a null effect for their medium-technology counterparts. In line with Haro-Dominguez et al. (2007), we observe a positive effect of R&D externalization on new product development for low- and medium-technology firms. However, the *buy* strategy seems not to be useful for increasing the number of product innovations for the high-technology group, and its effects are absent at *t-2*.

The complementarity between the *make* and *buy* strategies seems to be the key strategy for increasing the number of product innovations, since the *make-buy* strategy produces positive and significant effects across all technological intensity levels at *t-1*. The effects of the *make-buy* strategy endure at *t-2* only for low- and medium-technology firms. Interestingly, the effects of RDSs are absent at *t-2*, showing a short-term effect of RDSs in increasing the number of product innovations. This might help to explain why high-technology firms achieve fewer product innovations. Based on the differences mentioned above, there is clear evidence that technological intensity level is a moderator of the RDS effects, confirming H2.

The results in Table 4.4 show that the effects of firm size and technological knowledge on the number of product innovations are also moderated by technological intensity level. For low-technology firms these factors increase the number of product innovations, while for medium- and high-technology firms being large or having high technological knowledge does not increase the number of product innovations.

The assumption that firm diversification increases product innovations, since it helps to spread the risk assumed when innovations are achieved (Cabagnols and Le Bas, 2002), holds only for high-technology firms. Especially remarkable is the negative and significant coefficient obtained for low-technology firms, indicating that the more diversified a firm is, the lower the number of product innovations. This converse effect of the variable on low- and high-technology firms could have annulled its significance for the entire sample.

The effect of a firm's *internationalization* is significant only for the entire sample, but when the sample is disaggregated, this effect vanishes. Finally, the environmental variables of *market competition* and *dynamism* are not significant either for the entire sample or for the different technological intensity levels.

Table 4.5 Estimates for product innovations

Variables	Entire sample	Low technology	Medium technology	High technology
$Make_{t-1}$	1.0714***	1.0492***	0.4305	1.4702***
	(0.000)	(0.000)	(0.145)	(0.000)
Buy_{t-1}	0.5161**	0.4779	0.8058**	0.3589
	(0.01)	(0.157)	(0.029)	(0.307)
$Make\text{-}buy_{t-1}$	1.2424***	1.3956***	1.0877***	1.3309***
	(0.000)	(0.000)	(0.001)	(0.000)
$Make_{t-2}$	0.4885***	0.483	0.4567	0.4719
	(0.001)	(0.055)	(0.123)	(0.058)
Buy_{t-2}	0.1626	0.344	0.3680	-0.1502
	(0.418)	(0.315)	(0.324)	(0.66)
$Make\text{-}buy_{t-2}$	0.6393***	0.7486**	0.6575**	0.5659***
	(0.000)	(0.01)	(0.041)	(0.037)
Medium-tech.	-0.1552			
	(0.44)			
High-tech.	0.4805**			
	(0.013)			
Firm size	0.3127***	0.3986***	0.3760***	0.2558**
	(0.000)	(0.000)	(0.008)	(0.011)
Tech. knowledge	2.7135**	9.1270***	6.6144	0.7893
	(0.048)	(0.005)	(0.193)	(0.624)
Diversification	0.0126	-0.7510***	0.4598**	0.1640
	(0.91)	(0.002)	(0.036)	(0.292)
Internationalization	0.0082***	0.0132***	0.0101	0.0032
	(0.003)	(0.007)	(0.065)	(0.456)
Mkt. concentration	-0.0418	-0.0830	0.0337	-0.0288
	(0.386)	(0.256)	(0.729)	(0.749)
Mkt. competition	0.0654	0.0867	0.1912	-0.0296
	(0.274)	(0.367)	(0.12)	(0.77)
Constant	-4.6956***	-3.7515***	-5.9547***	-4.1795***
	(0.000)	(0.000)	(0.000)	(0.000)
year effects (λ_τ)	*included*	*included*	*included*	*Included*
N. of observations	10085	4737	2536	2812
N. of firms	1478	689	393	426
Wald statistic	466.84***	213.51***	109.81***	141.99***
Log likelihood	-3691.98	-1500.44	-893.61	-1271.35
X^2 *(test of rho = 0)*	1847.54***	819.12***	403.58***	565.85***

**** p <= 0.001; ** p <=0.05; * p >= 0.01; p-value in parentheses*

As mentioned before, in order to obtain robust results, we estimate the models presented in Table 4.5 considering product innovation with a dichotomous character. All the hypotheses discussed before (H1, H1a, H1b and H2) still hold for these estimates. The first difference is that the *buy* strategy is no longer significant for low-technology firms at *t-1*. The second difference is that the *make-buy* strategy becomes significant for high-technology firms at *t-2*. This clearly shows that the latter strategy encourages product innovation but does not necessarily increase the quantity of innovations achievements for high-technology firms.

The changes for the organizational and environmental variables are mainly observed for the *firm size*, *diversification* and *internationalization* variables. *Firm size* is now significant for medium- and high-technology firms. Firm *diversification* no longer affects those in the high-technology group but it does now affect their medium-technology counterparts. Finally, the *internationalization* variable becomes significant for low-technology firms.

6.2 Process innovation

Table 4.6 gives the estimates of the random-effects logit model for process innovation. Based on the model for the entire sample, we again find support for H1. We should point out that all RDSs have a positive and significant effect on achieving process innovations at *t-1*. Nevertheless, the *make* strategy no longer has an effect at *t-2* on process innovations, contrary to the estimates for product innovations (Table 4.4).

Hypothesis H1a is also corroborated since the *make-buy* strategy has the largest coefficient at *t-1* (0.6724) and it is the only one increasing the probability of process innovation at *t-2*. This time, however, H1b is not supported. The coefficients for the *buy* and the *make* strategies have practically the same magnitude, indicating that the two strategies have the same impact on product innovation achievement. Moreover, we are able to observe that technological intensity level moderates the effect of RDSs, supporting H2. Effects of the *make* strategy are limited to *t-1* for the entire sample, and for low- and high-technology firms. Medium-technology firms do not increase their probability of process innovation when pursuing the *make* strategy in isolation.

The *buy* strategy behaves as in the estimates for the number of product innovations. It is positive and significant only for low-technology firms. It is striking that these firms have the probability of achieving process innovations increased if they adopt the *buy* strategy, rather than *make* or *make-buy*. When the *buy* strategy is lagged by two years, there is no discernible significant effect on process innovations.

Low- and medium-technology firms benefit from the positive effect of the *make-buy* strategy one year later (*t-1*) but the effect disappears in the second year. Conversely, high-technology firms seem to receive benefits from jointly adopting *make* and *buy* strategies two years later, but there is no evidence of immediate effects (at *t-1*). This suggests that due to the complexity of the R&D activities in this sector, innovation output takes two years to emerge.

In line with the findings of Cohen and Klepper (1996), the magnitude and significance level of the coefficient on the *firm size* variable again support the Schumpeterian hypotheses that firm size is positively related to firm innovativeness - process innovation in this case. Results indicate that the greater the *technological knowledge*, the higher the probability of realizing process innovations if firms belong to low- and medium-technology industries. These findings are in line with those in Ettlie et al. (1984), even though they did not disaggregate the sample into different technological intensity levels. Contrary to Lunn (1987) and Cabagnols and Le Bas (2002), in our study it seems that low- and medium-technology firms do not achieve more process innovations if they are diversified. On the other hand, estimates in Table 4.6 show for the entire sample and for low-technology firms that process innovations are promoted by firm *internationalization*.

For the entire sample and for low-technology firms, *market competition* decreases the probability of achieving process innovations, thus supporting the Schumpeterian (1943) monopolistic hypothesis. These results are also consistent with those obtained by Martinez-Ros (2000). Finally, for the entire sample and for low- and high-technology firms, it seems that *market dynamism* encourages firms to be more efficient through the achievement of process innovations in order to meet market needs.

Table 4.6 Estimates for process innovations

Variables	Entire sample	Low technology	Medium technology	High technology
$Make_{t-1}$	0.5831***	0.6338***	0.4446	0.4433**
	(0.000)	(0.002)	(0.063)	(0.047)
Buy_{t-1}	0.5775***	1.0652***	0.3253	0.0858
	(0.000)	(0.000)	(0.279)	(0.789)
$Make\text{-}buy_{t-1}$	0.6724***	1.0071***	0.8073***	0.2347
	(0.000)	(0.000)	(0.002)	(0.344)
$Make_{t-2}$	0.2166	0.1031	0.1572	0.4083
	(0.084)	(0.62)	(0.51)	(0.069)
Buy_{t-2}	-0.0835	-0.2215	-0.0951	0.0626
	(0.615)	(0.403)	(0.757)	(0.841)
$Make\text{-}buy_{t-2}$	0.3727***	0.3248	0.3150	0.5448**
	(0.009)	(0.197)	(0.234)	(0.026)
Medium-tech.	0.0876			
	(0.524)			
High-tech.	0.0590			
	(0.671)			
Firm size	0.3818***	0.3801***	0.2935***	0.4906***
	(0.000)	(0.000)	(0.002)	(0.000)
Tech. knowledge	2.517**	5.5529**	10.2512***	0.6732
	(0.026)	(0.017)	(0.009)	(0.633)
Diversification	0.2115**	0.1353	0.1859	0.2635**
	(0.012)	(0.389)	(0.248)	(0.042)
Internationalization	0.0051**	0.0077**	0.0017	0.0047
	(0.014)	(0.032)	(0.668)	(0.184)
Mkt. concentration	-0.0803***	-0.1119**	-0.0251	-0.0489
	(0.03)	(0.037)	(0.729)	(0.521)
Mkt. competition	0.2749***	0.2560**	0.1383	0.4250***
	(0.000)	(0.001)	(0.157)	(0.000)
Constant	-3.8386***	-3.8738**	-3.2789***	-5.6547***
	(0.000)	(0.000)	(0.000)	(0.000)
year effects (λ_τ)	*included*	*included*	*included*	*included*
N. of observations	10085	4737	2536	2812
N. of firms	1478	689	393	426
Wald statistic	509.42***	222.28***	131.88***	167.41***
Log likelihood	-4866.62	-2105.87	-1271.26	-1456.96
X^2 *(test of rho = 0)*	1246.16***	564.84***	288.12***	373.91***

**** p <= 0.001;** p <=0.05; * p >= 0.01; p-value in parentheses*

7. DISCUSSION AND CONCLUSIONS

What effect do RDSs have upon firm innovative performance? Are the effects the same for all RDSs? For how long do the effects of RDSs last? Are the effects contingent on technological intensity level? Answering these questions has been the main objective of this study. Unlike previous studies, in order to evaluate the effects in a greater depth, we consider three measures of firm innovativeness: number of product innovations, product innovations and process innovations.

To answer the research questions we proposed four hypotheses and we have found support for all of them. Firstly, we observed that all RDSs – *make*, *buy* and *make-buy* – have a positive effect on firm innovativeness one year after they are achieved. Secondly, although the three RDSs produce positive effects on firm innovativeness, their impact varies. Following the absorptive capacity (Cohen and Levinthal, 1990), open innovation (Chesbrough, 2003) approaches, we hypothesized that the *make-buy* strategy would have the highest impact, and results lend support for this hypothesis. We found that this strategy has the highest impact on all innovation outputs at *t-1* and *t-2*, which helps to highlight the complementarity between *make* and *buy* since, when combined, the effects are greater and last longer.

Thirdly, the *buy* strategy, used in isolation, produces the lowest impact for all innovation outputs and it has a short-term effect. Fourthly, unlikely previous research, we considered that inter-industry differences might lead to different patterns of technology life-cycle, and higher, or lower, uncertainty and complexity of technology, as well as different conditions to the appropriability; as a consequence, we hypothesized that the effects of the RDSs on a firm's innovative performance would be moderated by technological intensity level. By disaggregating the sample into low-, medium- and high-technology firms, some remarkable changes in the effects of the RDSs emerged, confirming our hypothesis. This might indicate that previous studies were carried out with a heterogeneous mixture of technological intensity levels, and also the effects of the RDSs were overestimated. In addition, we observed that including the control variable of technological intensity level –for the entire sample model– is insufficient to correct this bias.

We are able to draw some conclusions derived from two different streams, the RDSs and the technological intensity level perspectives. As for the former, we have observed that all RDSs are more likely to achieve product innovations than process innovations, and their effects also last longer for product innovations. This behavior is only visible when the sample is disaggregated. As considered in the R&D capital stock model, the effects of the R&D activities are lagged, but we have observed that the maximum impact of the RDSs on firm's innovative performance is one year after they were achieved. In the second year, the effects are reduced to half those of the first year.

Considering product innovation as the innovation output, the *make* strategy only has a positive impact for low-technology firms two years later. This strategy, *per se*, does not produce positive results for medium- and high-technology firms; rather, they need an extra effort to maintain the effects of the R&D activities two years later. In other words, they need to look for the complementarity between the *make* and *buy* strategies.

Some studies have found that the *buy* strategy did not affect the innovation output (Schmiedeberg, 2008), or affected it negatively (Lanctot and Swan, 2000). In our study we found the former was true, but only for high-technology firms. This means that in sectors where technology shifts and uncertainty are high, the *buy* strategy, used in isolation, does not have a positive effect on the firm's innovative performance. This strategy is a complement to increase the effect of the *make* strategy in these sectors. By contrast, the *buy* strategy seems to produce positive results for markets with lower technological uncertainty. We might say that due to the lower specificity and complexity of products and processes, externalizing R&D activities is sufficient for low-technology firms to achieve innovations. The *make-buy* strategy has consistent effects for all technological intensity levels at *t-1*, but two years later the effects are moderated by industry characteristics. In terms of increasing the number of product innovations, an effect is found only for low- and medium-technology firms. Finally, as far as process innovations are concerned, this strategy affects exclusively high-technology firms.

From the technological intensity level perspective, we can conclude that high-technology firms are more innovative but their innovations are more time-consuming and difficult to achieve, and they seem to make fewer product innovations than their low- and medium-technology counterparts. Also, the scope of R&D activities seems to be wider for high-technology firms since the effects of these activities tend to last for two years. Internal R&D is the key strategy in the short term, whereas the *make-buy* strategy has a greater effect in the long term, suggesting that time is needed to codify and integrate external knowledge. For low-technology firms, where the technology shifts and uncertainty are lower, achieving product and process innovations through R&D activities becomes easier. This might be due to the fact that products and processes in these industries are less sophisticated, and innovating requires less effort in coming up with new ideas, designs and materials.

This study has important academic and practical implications. From an academic point of view, this research firstly evaluates the effects of RDSs in a broad perspective, including different innovation outputs and three scenarios based on technological intensity levels. Secondly, it has established support for the open innovation and absorptive capacity approaches, since the *make-buy* strategy produces more innovations and its effect lasts longer. Nevertheless, the contribution to the open innovation approach is limited since this research only accounts for half of the model, that is, the outside-in part. Thirdly, we have ascertained that the impact of RDSs in firm innovative performance is moderated by technological intensity level. Fourthly, the Schumpeterian hypothesis about the relationship between firm size and innovation is generally supported in this study; however, increases in the number of product innovations are not determined by firm size. Fifthly, the negative relationship between market concentration and firm innovativeness proposed by Schumpeter (1943) holds for the models for the low-technology firms and for the entire sample. Sixthly, this research shows that academics should not ignore the potential effects of RDSs on firm process innovations. Finally, most previous research used cross-sectional data, whereas the nature of our sample has enabled us to validate the causal effects of RDSs on firm innovation performance and to ascertain when RDSs produce the best results. As stress by Hsiao (1985) panel data advantages compare to cross-sectional data, include a) more accurate inference of model parameters, b) construction of more complex hypotheses as it controls for endogeneity problems and permits to observe the dynamics, c) allows controlling the impact of omitted variables and d) uncovering dynamic relationships.

From a practitioners' point of view, this research has shown that combining internal and external sources of R&D is the way to guarantee product or process innovations, and is particularly crucial for highly technological industries. In addition, practitioners should be aware that relying exclusively on external R&D will be a competitive strategy only for low-technology industries and in the short term. Finally, for policy-makers this research may help in planning the way governmental aid for R&D should be channeled, depending on the industry involved and the result sought.

This research is not extended of limitations. The main limitation would be that in the models we do not account for others complementarity activities that can lead firm to successfully innovate. That is, in our sample some firms were developing a R&D strategy but they did not innovate and, on the contrary, some firms without R&D activities successfully innovate and perhaps there are some missing variables, or innovation activities, that could explain this behavior.

ANNEX B. Mean, standard deviation, correlation and VIF values for the entire sample

Variables	Mean	Std. Dev.	1	2	3	4	5	6
1. N. Prod. Innov.	2.125	11.163	1					
2.Product innov.	0.227		0.351*	1				
3. Process innov.	0.309		0.134*	0.333*	1			
4. No R&D	0.658		-0.119*	-0.369*	-0.300*	1		
5. Make	0.171		0.100*	0.235*	0.180*	-0.632*	1	
6. Buy	0.045		-0.003	0.029*	0.040*	-0.302*	-0.099*	1
7. Make-buy	0.124		0.058*	0.242*	0.200*	-0.523*	0.171*	-0.082*
8. Low-Tech	0.464		-0.016	-0.091*	-0.103*	0.241*	-0.138*	-0.023*
9. Medium-Tech	0.252		0.001	-0.045*	0.020*	0.021*	-0.016	0.006
10. High-Tech	0.283		0.016	0.145*	0.095*	-0.287*	0.169*	0.019*
11. Firm size	4.192	1.467	0.078*	0.227*	0.273*	-0.535*	0.332*	0.099*
12.Tech. Knowl.	0.015	0.041	0.105*	0.237*	0.146*	-0.444*	0.287*	-0.030*
13. Diversific.	1.155	0.476	0.008	0.051*	0.066*	-0.090*	0.050*	0.008
14. Internationali.	17.499	25.041	0.106*	0.178*	0.166*	-0.383*	0.257*	0.049*
15. Mkt. Concent.	1.848	1.149	0	-0.091*	-0.114*	0.219*	-0.152*	-0.045*
16. Mkt. Compet.	2.092	0.678	0.024*	0.070*	0.124*	-0.084*	0.039*	0.004
VIF			-	-	-	-	2.98	1.48

Variables	7	8	9	10	11	12	13	14
8. Low-Tech	-0.173*	1						
9. Medium-Tech	-0.016	-0.540*	1					
10. High-Tech	0.207*	-0.585*	-0.365*	1				
11. Firm size	0.326*	-0.191*	0.018*	0.194*	1			
12.Tech. Knowl.	0.328*	-0.201*	-0.081*	0.300*	0.131*	1		
13. Diversific.	0.067*	-0.073*	0.024*	0.058*	0.084*	0.031*	1	
14. Internationali.	0.225*	-0.204*	0.032*	0.194*	0.449*	0.154*	0.032*	1
15. Mkt. Concent.	-0.113*	0.124*	-0.014	-0.123*	0.290*	-0.085*	-0.068*	-0.100*
16. Mkt. Compet.	0.073*	0.107*	0.076*	0.045*	0.099*	0.056*	0.028*	0.066*
VIF	2.94	-	1.19	1.37	1.77	1.46	1.02	1.35

Variables	15	16
15. Mkt. Concent.	1	
16. Mkt. Compet.	-0.050*	1
VIF	1.11	1.03

* significance at 0.05

CHAPTER V

TECHNOLOGICAL INNOVATION EFFICIENCY AND FIRM PERFORMANCE: A NEW APPROACH

1. INTRODUCTION

Most of the literature in the innovation field argues that the technological innovations are central for business success. However, empirical results are inconclusive since some studies have found positive, negative or none effects of innovations on firm performance. We consider that this controversy might have its origins in measurement of the innovation. Thus far, it has been indistinctly measured as the innovation inputs (R&D expenditure or R&D intensity) (O'Regan et al., 2006) or as the innovation outputs (number of patents and number of products and/or processes innovations) (Akgün et al., 2009). Additionally, there is a lack of agreement between authors about how to measure the effect of the innovation -inputs and/or outputs- on firm performance. Some authors focus on the short-term effect of innovation inputs on firm performance (George et al., 2002); some others seek the long-term indirect effect of innovation inputs on firm performance through the innovations outputs achieved (Balkin et al., 2000) and the third stream links innovation outputs with firm performance without considering the required innovation inputs (Weerawardena et al., 2006).

Contrary to previous studies, we propose a new approach for measuring the effects of the technological innovation activities on firm performance. From a productive perspective, innovation inputs and outputs should be jointly taken into account as determinants of firm performance since innovation is a complex and renewal process whereby firms create and exploit change as an opportunity to increase their competitive advantages (Porter, 1990; Tidd and Bessant (2009). Besides, following Koellinger (2008), we believe directly linking innovation inputs with firm performance would generate misleading results since innovation inputs –e.g. R&D expenditure- could not improve firm performance by themselves since they involve sort-term cost and, those investments that do not result in innovations are sunk cost that will not improve firm performance. Finally, we argue that linking innovation outputs with firm performance without considering the needed effort –innovation inputs- to achieve those innovations outputs would overestimate their effect on firm performance.

Derived from the above mention, the first objective of this paper is to contribute to the innovation-performance literature by proposing a new approach for measuring the effect of the technological innovation process on firm performance. Thus far neglected, following a productive perspective, we propose that both innovation inputs and outputs should be simultaneously considered as drivers of firm performance, rather than solely considering the innovation inputs or outputs. That is, innovation inputs produce innovation outputs and the key for increasing firm performance through technological innovation activities is the efficiency whereby the innovation process is undertaken. Our second objective is to assess the moderating effect of the technological intensity level and firm size on the relationship between technological innovation efficiency and firm performance.

In order to achieve the objectives of the paper we develop a two-stage model. In the first- stage, taking into consideration the causal and lagged effect of the innovation inputs upon innovation outputs, we estimate the technological innovation efficiency for each firm based on an intertemporal output-oriented DEA bootstrap. The estimation is carried out considering two innovation inputs (R&D capital stock and high-skilled staff) and two outputs (rate of product innovations and patents). This methodology is used since it allows capturing a multi-dimensional evaluation of the innovation process. In the second-stage, we take the calculated technological innovation efficiency as explanatory variable of the firm performance through the estimation of a dynamic panel data model. To verify the consistency of our arguments, we also estimate two models including the innovation inputs and innovation outputs instead of the technological innovation efficiency as explanatory variables of firm performance. In order to achieve the second objective, we also test for the moderating effect of the technological intensity level and firm size for these models.

Due to different methods requirements, further explained in the Methods section, the sample used in the first-stage is a little bit larger than the sample used for the second-stage. The analysis for the first-stage is carried out with a sample of 2472 observations of 415 Spanish manufacturing firms for the period 1992-2005. For the second-stage this sample is reduced to 2315 observations of 362 firms. Results of the firs-stage show that there is much room for improving the technological innovation efficiency of the Spanish manufacturing sector. As for the second-stage, results show support for our argument that what really affects positively firm performance is the technological innovation efficiency. On the contrary, when considering the innovation inputs as drivers of firm performance, the effect of the R&D capital stock is negative but the high-skilled staff has a positive direct effect on firm performance. Unexpectedly, but in line with some previous studies (O'Regan et al., 2006; Lichtenthaler, 2009), the innovation output of number of products did not have a positive effect on firm performance and the output of number of patents had a negative effect on firm performance. Results also demonstrate the effect of the technological innovation efficiency is higher for HTs and SMEs firms than for their counterparts, highlighting the moderating role of the technological intensity level and firm size.

Although few studies have endeavored to measure the technological innovation efficiency, most of them have mixed innovation inputs or outputs beyond the innovation process (Guan et al., 2006; Zhong et al., 2011), others have neglected the lag effect of R&D on innovation outputs (Revilla, 2003; Guan et al., 2006; Lee et al., 2010) or have used macro-level data (Lee et al., 2010). Besides, the linkage of the technological innovation efficiency with firm performance is almost inexistent. Within this context, the contribution of this paper is three-fold. One hand we estimate a technological innovation efficiency measure considering exclusively innovation inputs and outputs in the analysis. On the other hand, this paper takes into consideration the lagged effects of the innovation inputs for producing the desired outputs while estimating the efficiency. Finally, we link the efficiency of the technological innovation process with firm performance; all this at a micro-level. In addition, the nature of our sample allows us to obtain more robust results since we are able to correct for endogeneity and autocorrelation at the second-stage and also set aside us to compare the efficiency of the technological innovation process across industries.

The Chapter proceeds as follows. In the second section the theoretical framework is developed and two hypotheses are presented, the fist one sustains the effect of the technological innovation efficiency on firm performance and the second one defends the moderating effect of the technological intensity level and firm size. The data and methods for developing the empirical analysis are described in the third section. The results of the first and second-stage are showed in the fourth section while the fifth is reserved for discussion and conclusions.

2. THEORETICAL FRAMEWORK

2.1 Technological innovation efficiency concept

When evaluating the performance implications of the innovation activities some studies have focused on the short-term direct effect of innovation inputs on firm performance (George et al, 2002) while others seek the long-term indirect effect through the innovations achieved (Balkin et al., 2000) and a third stream do not take into consideration the innovation inputs and link the innovation outputs directly with firm performance. In addition, there have been used different types of innovation inputs, such as R&D expenditures (O'Regan et al. 2006), R&D intensity (Hitt et al., 1997) or R&D manpower (Wang and Huang, 2007), and a variety of innovation outputs like product innovations (Li, 2000), process innovations (Akgün et al., 2009), patents (Zahra and Nielsen, 2002) or utility models (Beneito 2006). This indistinct use of measurements and effects has lead results that are often inconclusive and ambiguous, highlighting the needed to further examine the innovation-performance relationship.

In this work we propose a new approach for measuring the effects of the technological innovation activities on firm performance. Next, we discuss several reasons that bring support our new approach instead of the traditional approaches above described.

First, linking innovation inputs to firm performance could lead to misleading results for three reasons: a) R&D expenditure –or intensity- is defined by the OECD (2005) as an involved activity in the innovation process, not the innovation outcome; b) this measurement is disconnected from the requirements of competitive advantages since it makes no reference to potential customer demand (Liao and Rice, 2010) and; c) R&D activities could not improve firm performance by themselves since they are just an input that involves sort-term cost and, those investments that do not result in innovations are sunk cost that will not improve firm performance (Koellinger, 2008).

Second, we argue that valuating the direct effect of the innovations outputs on firm performance, without considering the inputs, could overestimate their effect. For example, two firms achieve the same number of patents and products innovations but one of them consumed only the half of the innovation inputs the other firm needed. In this case, the effect of the innovation activities on firm performance should be different since once of them had a significant saving in the sum of inputs consumed, that is, this firm is more efficient in the technological innovation process. Without this information we could still assume the positive effect of innovations outputs on firm performance but we would be neglecting the effort needed to obtain the percentage of ROA growth.

Third, the technological innovations are achieved through a complex and long process, involving the phases of searching, selecting, implementing and capturing value (Tidd and Bessant; 2009) and a real valuation of the effects of the technological innovation activities on firm performance is considering the innovation process as a whole. We defend the idea that not only the innovation inputs or outputs determine the effect on firm performance; rather, the key for increasing firm performance is through the efficiency whereby the innovation process is undertaken. Maximizing the outputs achieved given a certain amount of inputs is crucial for business success since the production of the rent is dependent upon the efficiency differences among the resources in use (Peteraf and Barney; 2003:316). The resource-based view (RBV) gives us support for considering the innovation as a process and to evaluate it from an efficiency perspective since RBV supports the concept of the transformation of firm resources –R&D- into desirable outputs -innovations- through the use of the internal capabilities –efficiency. These capabilities are defined as the firm ability to use and transform the owned resources into a desired end. Furthermore, without these capabilities -efficiency- the mere possession of a large amount of resources -R&D- does not guarantee the creation of a competitive advantage -innovations- or superior performance (Song et al., 2007). Finally, as commented by Ordanini and Rubera (2010), innovations result from a complex interplay of several resources and capabilities which are accumulated over time. Chiesa and Frattini (2009:2) conceived that "… a larger availability of higher level resources does not necessarily lead to superior performance in R&D". As before commented, we define the technological innovation efficiency as the relative capability that a firm has in maximizing the innovation outputs given a certain amount of innovation inputs.

Measuring the efficiency of the innovation activities from the technical efficiency perspective (Farrel, 1957) is not new in the literature but the empirical evidence is scarce. In Table 5.1 we can observe some studies applying this efficiency measurement at micro- and macro-level. China, Japan and Spain are the countries in which the micro-level analyses have been performed. Some divergences can be observed in these studies as some of them included inputs and outputs beyond the technological innovation process (e.g. Guan et al., 2006; Hashimoto and Haneda, 2008) and some others did not take into consideration the time lag required before R&D projects are completed and innovation outputs are obtained (e.g. Revilla et al., 2003; Guan et al., 2006). Finally, those papers at a micro-level that exclusively considered inputs and outputs of the technological innovation process and controlled for the lagged effects (e.g. Wang and Huang 2007; Guan and Chen, 2010) did not linked the efficiency with firm performance.

Based on the above, there is a clear distinction of this study from the extant literature. The contribution of this work is triple. One hand in this study estimates a technological innovation efficiency measure considering exclusively innovation inputs and outputs in the analysis. On the other hand, this work takes into consideration the lagged effects of the innovation inputs for producing the desired outputs while estimating the efficiency. Finally, we link the efficiency of

Table 5.1 Literature review of innovation efficiency

Author & year	Sample	Methodology	Inputs	Outputs	Results	Link with firm perform.
Revilla et al. (2003)	118 Spanish firms carrying out 281 project of cooperation with public centers	DEA input-oriented	Firm revenue, number of employees and R&D expenditures	Total income, new employees and patents	They observed that efficiency varied depending on firm size, and the level of firm knowledge.	No
Guan et al. (2006)	182 industrial innovative firms in China	DEA input-oriented	R&D, learning , manufacturing, marketing and organization	Market share, sales growth, export rate, profit growth, productivity and new product rate	Only 16% of the firms were technical efficient	No
Wang (2007)	30 countries	SFA	R&D capital stock and number of researches and technicians (lagged effect)	Patents and papers publications	The means of efficiency scores are 0.65. R&D efficiency shows a positive correlation with income level	Yes
Wang and Huang (2007)	30 countries	DEA input-oriented	R&D capital stock and number of researches and technicians (lagged effect)	Patents and papers publications	Less than one-half of the countries are fully efficient in R&D activities	No
Hashimoto and Haneda (2008)	10 Japanese pharmaceutical firms for the period 1983-1992	(DEA)/Malmquist index input-oriented	R&D expenditure (lagged effect)	Patents, sales and profits	Japanese pharmaceutical industry has almost monotonically gotten worse throughout the study decade.	No
Guan and Chen (2010)	Twenty-six regions of China	DEA relational network output-oriented	R&D expenditures, R&D employees and patent stock (lagged effect)	Patents	The results provide evidences of China's high-tech innovations inefficiency.	No
Lee et al. (2010)	National hydrogen energy of 30 countries	DEA output-oriented	R&D expenditures, R&D human resources	Publications, patents, infrastructure of hydrogen technology	Nine nations were technically efficient.	No
Zhong et al. (2011)	30 regional R&D investments in China	DEA input-oriented	R&D expenditure, R&D personnel	Patent applications, sales due to new products, profit of primary business	Only six provinces are global technical efficient. There is no direct relationship between R&D expenditures and technical efficiency.	No

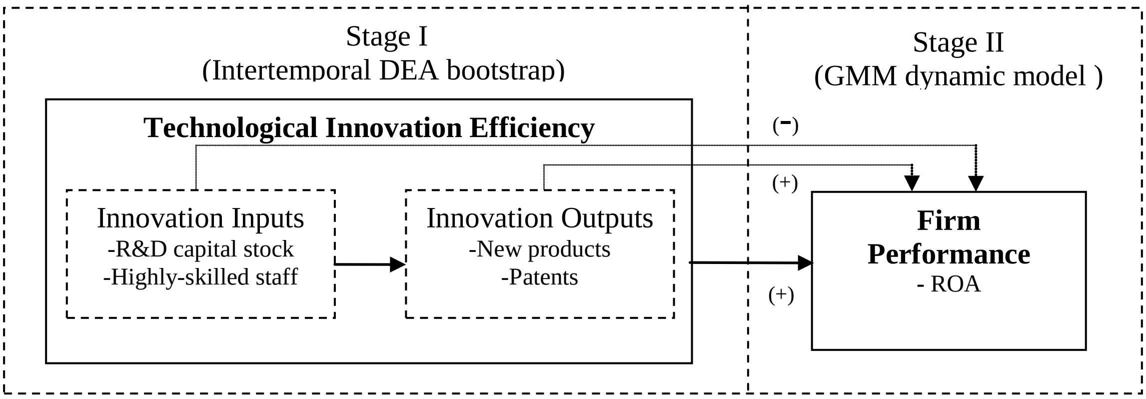
the technological innovation process with firm performance; all this at a micro-level. In addition, the nature of our sample allows us to obtain more robust results since we are able to correct for endogeneity and autocorrelation at the second-stage of the analysis and also set aside us to compare the efficiency of the technological innovation process across industries.

It is well accepted in the literature that the relationship between performance and innovation is positive since innovations are the main source of competitive advantage (Dwyer and Mellor, 1993; Bone and Saxon, 2000). In this study, we continue in the same line but proposing a different approach for measuring the technological innovation process.

Therefore, we expect that the efficiency whereby the technological process is achieved will produce a positive and significant effect on firm performance. In other words, those firms being able to efficiently transform their limited innovation resources through the use of their internal capabilities into the desired innovation outputs will register a higher performance.

The conceptual framework for the research model is presented in Figure 5.1. As observe, in the first-stage we first estimate the technological innovation efficiency by means of an intertemporal DEA bootstrap and, in the second-stage, we link the obtained efficiency score to firm performance. In order to corroborate our arguments, we additionally link innovation inputs and outputs to firm performance and expect a negative effect for the former and a positive effect for the latter.

Figure 5.1 Conceptual framework of the research model



Based on the arguments previously commented, supported on the RVB, that firms might transform in an efficiently way their resources in order to achieve the needed outputs and obtain their competitive advantage, and previous evidence supporting the positive effect of innovation activities on firm performance, we propose the next hypothesis.

Hypothesis 1: *The technological innovation efficiency will have a positive effect on firm performance.*

2.2 Moderating effect of technological intensity level and firm size

We consider that the effect of the technological innovation efficiency on firm performance will be moderated by the technological intensity level and the firm size. On one hand, the effect of the technological innovation efficiency on firm performance could be less important for LMTs since their innovations are not usually the result of the latest technological knowledge, rather they are more based on their creativity to exploit and transform their general stock of knowledge into economically useful knowledge (Bender and Laestadius, 2005). On the contrary, HTs, usually developing their activities in more turbulent environments, based their competitive advantage on technological research, rediscovery and experimentation (Van der Bosch et al., 1999), relaying more substantially on their technological innovation process.

Empirical evidence has showed that the innovation behavior varies extensively across industries. Santamaría et al. (2009) found that amount of innovation inputs and outputs were statistically significant higher for HTs than for LMTs and, Damanpour and Aravind’s (2006) results showed that the type of innovation obtained –product or process- is determined by the technology life-cycle and economic conditions of each industry. With respect of the effect of the R&D activities, Geroski (1994) showed that the impact of R&D on firm’s productivity growth varies significantly depending on the industry type. Griliches and Mairesse (1984) found a positive elasticity of R&D on firm performance for HTs while the elasticity for LMTs was negative. Similar results are obtained in the studies of Kafouros (2005) and Wang and Tsai (2003) where the effect of

R&D activities on firm performance were considerable higher for HTs than for LMTs for a sample of UK and Japanese manufacturing firms, respectively.

Based on the theoretical arguments and previous evidence we consider that the effect of the technological innovation efficiency on firm performance will be positive for both HTs and LMTs, though higher for the former.

Firm size is also considered as moderator in the technological innovation efficiency and firm performance relationship. Earlier studies have argued that large firms benefit from economies of scale and they have higher technical know-how and managerial resources that facilitate the firms' speed of response to a new technique (Mansfield, 1968). Cohen and Klepper (1996) also support the concept that the benefits for R&D activities are higher for large firms because they have larger outputs and they can apply the results of R&D to different products and processes, spreading the cost of R&D. Large firms also might have more opportunities to benefit from the R&D activities since they are usually diversified and, as Kamien and Schwartz (1982) stated, diversified firms have more opportunities to exploit the outcomes of R&D. This relates to the work of Teece (1986) who argued that large firms are more likely to have the specialized and cospecialized assets within their boundaries needed to appropriate and profit from the new technology.

Despite the theoretical arguments stated in the literature, previous empirical findings are mixed and sometimes inconsistent with theory. Some studies have found that the effect of innovation activities on firm performance is higher for large firms (Cohen and Klepper, 1996; Kafouros, 2008; Jimenez-Jimenez and Sanz-Valle, 2010), while some others did not observe any difference between large and SMEs firms (Griliches, 1980; Wang and Tsai, 2003). These inconclusive results do not allow us to venture in indicating one specific direction of the moderating effect of firm size.

These arguments, on the moderating effect of the technological intensity level and firm size, lead us to propose our second hypothesis of this study.

Hypothesis 2: *The effect of the technological innovation efficiency on firm performance will be moderated by the technological intensity level and firm size.*

3. METHODS

3.1 Data and sample

In order to empirically test the effect on technological innovation efficiency on firm performance we used the Survey of Business Strategy (SBS), which is a firm-level panel dataset of Spanish innovating and non-innovating manufacturing firms covering the period from 1990 to 2005. The Spanish Ministry of Science and Technology and the Public Enterprise Foundation (FUNEP) compiled the sample. The SBS is random and stratified according to industry sector - NACE-Rev.1 classification- and firm size (Fariñas and Jaumandreu, 2000)[29]. The aim of the SBS is to document the evolution of the characteristics of the strategies used by Spanish firms. It provides information on markets, customers, products, employment, outcome results, corporate strategy, human resources, and technological activities. This survey is extremely valuable, since relatively few data sets contain information at firm level over several years[30].

The sample consist of an unbalanced panel since not all the firms answered throughout the 16 years, that is, new firms are were added each year and others ceased to provide information[31]. After deleting observations with missing values in the variables under analysis, we considered two main aspects to restrict the firms in our data. First, firms should have answered the SBS for a least six consecutive years. Second, since the one key component of the Chapter is to calculate the efficiency of the technological innovations, those firms that did not registered any R&D expenditures during any year of the panel were excluded from the sample. As explain latter in section 3.2.1, we calculated the inputs and outputs of the technological innovation efficiency as the mean of the current year

[29] Firms with between 10 and 200 employees are selected trough a random stratified sample. Firms with more than 200 employees are surveyed on a census based.

[30] Several publications have used the SBS focusing on firm technological activities (*e.g.* Diaz-Diaz *et al.*, 2008; Santamaría *et al.*, 2009).

[31] In the first wave of the SBS, in 1990, 2188 firms were surveyed according the criteria above mentioned in footnote 3. By the year 2005, SBS had an unbalanced panel of 4050 firms surveyed. Aiming keeping the original firms during the complete panel motivated the consecutives waves of the SBS. Each year, the SBS intended to add to the sample all the new firms with more than 200 employees and a random and stratified sample which, approximately, represent the 5% of the new firms with between 10 and 200 employees. The annual response rate was around 90% (see http://www.funep.es/esee/sp/sinfo_cobertura.asp for detail information of the SBS).

plus the three previous years, leading to remain with a sample covering the period from 1994-2005. Due to the sensibility to extreme values of the program used to estimate the intertemporal DEA bootstrap, those observations that registered cero outputs were removed from the sample. In order to avoid the creation of a spurious or mediocre frontier in the first-step, we kept as much information as possible. That is, whether a firm with six observations of positive inputs had the second and fourth observations with cero outputs, we removed from the sample uniquely the second and fourth observations and kept the rest for performing the DEA bootstrap. Nevertheless, due to a restriction of the method used in the second-stage (GMM) we had to remove all observations of this example, leading a difference in the sample size between the two stages.

Then, the final sample of the first-stage consists of 2472 observations of 415 firms; from which 20.39 percent of the firms have observations for the twelve years while the 6.22 percent of the firms have the three minimum observations. The rest of the firms follow different patterns across the panel. In the second-stage analysis the sample gathers 2315 observations of 362 firms from which 11.34 percent have observations for the complete panel.

3.2 Measurement of technological innovation efficiency

The traditional cost-benefit analysis, following a parametric approach, in which the single optimized regression is assumed to apply to each firm under the analysis, has the major weakness that it requires the imposition of a specific function form and specific assumption about the error distribution. Additionally, for a standard parametric method is very problematic to jointly consider multiple inputs and multiple outputs, as the innovation activity usually embraces. Data envelopment analysis (DEA) overcomes these problems since it uses a mathematical programming model to estimate the best-practice frontier without a specific functional form assumption and, permits the evaluation of firms based on simultaneous dimensions given that it allows the use of multiple inputs and outputs. DEA can be used to calculate the maximal performance measurement of each decision making unit (DMU) -firms in this case- given a certain number of inputs, relative to all DMUs in the sample.

Farrell (1957) introduced the first systematic measurement of technical efficiency. Latter, Charnes et al. (1978) established he CCR DEA model under the assumption of that production exhibited constant returns to scale (CRS). This model was extended, by Banker et al. (1984), for the case where there are variable returns to scale (VRS). The main difference between the CRS and the VRS is that the former assumes that the plant is operating at its optimal scale or minimum average cost, while the latter avoids this assumption. Following Alvarez and Crespi (2003) we use the VRS to estimate our model since we consider it more accurate in the sense that small firms, generally, operate with a production scale lower than the optimal. Furthermore, Frantz (1992) argues that usually plants do not operate at optimal scale due to market structure and the competitive market pressures the firm are subjugated to. Additionally, the VRS allows us to exclusively measure the inefficiency caused by the suboptimal level of outputs given a certain amount of inputs and not the inefficiency caused by the inadequate plant size. We use the VRS intertemporal DEA bootstrap output-oriented since we consider that firms first establish the R&D budgets (inputs) and then seek innovation achievements, that is, output maximization.

We consider more convenient using the intertemporal estimation rather than a cross-sectional estimation because the latter assumes a yearly technical change while the intertemporal model assumes stability and comparability between firms over the years of analysis (Mittal et al., 2005). Bootstrapping the DEA scores permits to obtain bias corrected and stochastic estimates, minimizing the contamination by statistical noise the data could be subject to (Dutta et al., 1999; Simar and Wilson, 2000). Shepard's distances are employed in the model, where the efficiency score are less or equal than the unity. If a firm obtaining a score equal to the unit indicates that it is on the frontier and, thus, is efficient in the transformation of inputs to obtain the desires outputs. A value lower than the unit represents an inefficient firm and the distance up to the unit reflects the percentage in which the outputs should be increased to become efficient. The model estimation was carried out using FEAR software (Wilson, 2008). See Annex C for a description of DEA model.

3.2.1 Inputs and outputs selection

Recall that RBV considers that firms use their multiple resources (inputs) and transform them into multiple outputs through the use of their capabilities. Based on this productive perspective and on the existent literature we select the two technological innovation inputs to be transformed into two technological innovation outputs. R&D capital stock and high-skilled staff[32] are the two inputs selected. The R&D capital stock has been used in previous studies analyzing the innovative firm efficiency following the DEA approach (e.g. Wang, 2007). It was estimated using the traditional way (Griliches, 1979), where the R&D capital stock (RDCS) depends on the R&D expenditure (RD) of firm *i* at time *t* plus the previous R&D expenditures done by the firm affected by a depreciation rate (γ). The previous R&D expenditures goes up to four years before *t* (w=1…4) and the depreciation rate was set to 20%.

$$\mathbf{RDCS}_{it} = \mathbf{RD}_{it} + \textstyle\sum_1^w (1-\gamma)^w \, \mathbf{RD}_{i(t-w)} \qquad (1)$$

Since DEA methodology demands it, R&D expenditures were deflated at year 1995 before calculating RDCS. Due to the lack of a suitable deflator for R&D expenditures (Lichtenberg, 1984) we selected as a deflator the intermediate input price indices from the EU KLEMS (2008) database.

The high-skilled staff, representing the technical knowledge resources, is also considered in the literature as innovation inputs (Damanpour and Aravind, 2006). The basis of this argument is that the technical employees and employees with higher academic training, with diversified backgrounds and managerial skills, influence positively the transformation of technological investments into product and process innovation achievements through the generation of ideas (Ettlie et al., 1984; Koellinger, 2008). Thus, the second input used in this study is the mean of the current year plus three previous years of the number of high-skill staff.

As mentioned before, we selected two outputs of the innovation process that account for the number of product innovations (NPI) and the number of patents (NPAT). Some studies have considered new product rate or sales due to

[32] Some authors (Guan and Chen, 2010) also considered the number of R&D employees as an input but in our case we do not include it since the R&D expenditures also includes the salaries of the R&D personnel.

new product as the innovation output in their efficiency analysis (Guan et al., 2006; Guan and Chen, 2010) but we consider the first measurement as a better one fitting to our objective since NIP only account for the technological innovation process and not for the firm capacity to profit from the innovations. As well, the rate of patents achieved is a common innovation output used in the literature to account for innovation outputs (e.g. Revilla et al., 2003; Hashimoto and Haneda, 2008)[33]. Both rate of new products and patents were calculated as the mean of the last four years.

3.3 The model

In order to test the first hypothesis of the effect of the technological innovation efficiency on form performance we estimate the models described in this section. The dependent variable we use in our analysis which captures firm performance is the firm ROA (Return on Assets). The main explanatory variable in our analysis is the technological innovation efficiency (EFF). The theoretical and empirical evidence offer guidance regarding what variables should also be included as explanatory variables. Firm size has been commonly considered as a control variable for firm profitability (e.g. Belderbos, 2004; Diaz-Diaz et al., 2008). We included it as a dichotomous variable indicating whether a firm is SMEs or whether it is a large one (LARGE). According to the SBS, those firms with more than 200 employees are considered as large. In addition, firm age (AGE) has been considered in the literature as an explanatory variable of firm performance since it has been suggested that firm's capabilities are formed though the experienced obtained over time (Leonard-Barton, 1995). We also controlled for the industry effects and included a dummy variable accounting for low- and medium-technology firms (LMTs) and high-technology firms (HTs). This variable takes the value of one whether a firm belongs to a HT sector.

We include in the model the lagged ROA to test for the presence of inertia and persistence. In addition, by including the dependent variable lagged, it

[33] Although, the process innovations might also derived from R&D activities, due to lack of data we could not include it in the analysis. The OECD (2005) also considers organization and marketing innovations as outcomes but they are not included in the analysis due to the fact that they might not depend on R&D activities.

permits showing the real effect of the independent variables on firm performance since the effects of the omitted variables are captured by the lagged ROA and not added to our variable of interest. To estimate the model we use a two-step generalized method of moments (GMM) system estimator applied to dynamic models, proposed by Arellano and Bover (1995) and Blundell and Bond (1998) which reduces the potential bias and imprecision associated with the usual difference estimator. GMM system uses moment restrictions of a simultaneous system of first-difference equations and the equations in levels. In the first-difference equations the lagged levels of the values of the variables are used as instruments and in the equations in levels, it uses differences as instruments. The Hansen test of over-identifying restrictions tests the validity of the instruments; with the *Ho: the instruments as a group are exogenous.* It has been argued in the literature that the standard errors of the two-step estimates of the GMM system are usually downward bias. Therefore, we apply the finite sample correction for asymptotic variance proposed by Windmeijer (2005).

The main reasons justifying the use of this estimator are that, first, explanatory variables, as innovation, are likely to be also affected by the firm ROA (Bowen et al., 2009), consequently, it seems to be desirable to control for the potential joint endogeneity. The GMM system solves this problem by incrementing the endogenous variables, and the lagged dependent one, with past observations uncorrelated with the fixed effects. Second, inertia and persistence is likely to be present in panel data and this dynamic specification allows for it. Third, this model also allows controlling for the unobserved firm-specific effects correlated with the regressors and also offers a solution to the heteroskedasdicity and autocorrelation within individuals. The first model estimated is the one measuring the direct effect of the calculated technological innovation efficiency (EFF) at *t* on firm performance[34].

$$ROA_{i,t} = \alpha_0 + \alpha_1 ROA_{i,t-1} + \beta_1 EFF_{i,t} + \beta_2 LARGE_{i,t} + \beta_3 AGE_{i,t} + \beta_4 HTs_{i,t} + \mu_t + v_{i,t} \quad (2)$$

[34] In order to avoid redundancy, we do not consider necessary to introduce the EFF variable at *t-1* since the efficiency of year *t* is given by the innovation activities of the last four years; already capturing the lagged effect.

where i = 1, …, N and t = 1, … , T represent the cross-sectional units and the time periods, respectively, while μ_t is the time-specific effect and $\nu_{it}=\varepsilon_i+\sigma_{it}$ is the error term containing an unobserved time-invariant, firm-specific effect (ε_i) that controls for unobservable heterogeneity, and a stochastic error term varying cross-time and cross-section (σ_{it}).

Complementary, aiming to demonstrate the importance of technological innovation efficiency on firm performance, following the traditional inclusion of the innovation inputs or outputs as explanatory variables of firm performance, we estimate two modes in which we substitute the EFF variable for the innovation inputs and outputs. In the second model, the R&D capital stock and the high-skilled staff would explain the firm performance. These variables are not exactly the same as those used for the estimation of the DEA since the GMM is not intertemporal and there is no methodological reason to deflate the R&D expenditure before calculating the RDCS as it was done for the DEA. Instead, we calculate the R&D capital stock relative to the firm sales (RRDCS) following (1). The HSS^ variable now represents the percentage of high-skilled staff at time *t*.

This model aims to demonstrate that the R&D Capital Stock is just an expenditure that without the subsequent innovations will sunk the costs and could not improve firm performance (Koellinger, 2008). Then in this second model we expect a negative effect of the innovation inputs on firm performance.

$$ROA_{i,t} = \alpha_0 + \alpha_1 ROA_{i,t-1} + \beta_1 RRDCS_{i,t} + \beta_2 HSS\hat{}_{i,t} + \beta_3 LARGE_{i,t} + \beta_4 AGE_{i,t} + \beta_5 HTs_{i,t} + \mu_t + \nu_{i,t} \qquad (3)$$

In the third model we consider the innovation outputs as explanatory variables of firm performance. These outputs differ from those used in the DEA since now they are included in the model as the number of product innovation (NPI^) and the number of patents (NPAT^) achieved at *t-1*. They are included at *t-1* in order to capture the lagged effect. We expect a positive effect of both innovation outputs; although, without considering the effort needed to achieve them (innovation inputs), would overestimate their impact on firm performance. The control variables remain unchanged for the three models.

$$ROA_{i,t} = \alpha_0 + \alpha_1 ROA_{i,t-1} + \beta_1 NPI\hat{}_{i,t} + \beta_2 PAT\hat{}_{i,t} + \beta_3 LARGE_{i,t} + \beta_4 AGE_{i,t} + \beta_5 HTs_{i,t} + \mu_t + \nu_{i,t} \qquad (4)$$

As for the second hypothesis, we re-estimated the same models by splitting the sample in HTs vs. LMTs and large firms vs. SMEs.

Table 5.2 Mean, standard deviation and correlations

Variables	Mean	Std. Dev.	1	2	3	4
1. ROA	0.144	0.145	1			
2. EFF	0.232	0.247	0.048*	1		
3. RRDCS	0.053	0. 078	-0.02	-0.046	1	
4. HSS^	6.546	6.841	0.085*	-0.076*	0.343*	1
5. NPI^	6.274	19.04	0.000	0.313*	0.044	0.007
6. NPAT^	0.76	3.063	-0.009	0.253*	0.083*	0.136*
7. LARGE	0.577	0.494	-0.046*	-0.121*	-0.101*	0.083*
8. AGE	33.024	22.878	-0.035	-0.012	0.018	0.102*
9. HTs	0.473	0.499	-0.059*	-0.057*	0.346*	0.271*
VIF				1.41	1.27	1.21

Variables	5	6	7	8	9
5. NPI^	1				
6. NPAT^	0.014	1			
7. LARGE	0.016	0.092*	1		
8. AGE	-0.016	0.046	0.223*	1	
9. HTs	-0.072*	0.041	-0.022	0.023	1
VIF	1.14	1.13	1.12	1.08	1.04

* p-value < 0.005

In Table 5.2 are presented the mean, standard deviation and correlations of the variables used for estimating models (2), (3) and (4). As observed, the maximum correlation coefficient is 0.346 but even at this level correlation estimates may produce good forecast (Chatterjee et al., 2000). Furthermore, the highest variance inflation factor values is 1.41 which is considerably lower than the allow level of 10 (Baum, 2006) or even 5 (Pindado and De la Torre, 2006), indicating the absence of multicolineality problems.

4. EMPIRICAL RESULTS OF THE TWO-STAGE APPROACH

4.1 Stage I: technological innovation efficiency

As mentioned before, an intertemporal DEA bootstrap output-oriented model, with 2000 replications, was used to estimate the efficiency scores of each DMU[35]. As DEA methodology demands, we estimated a separately frontier – DEA bootstrap model- for each of the 19 industries under analysis in our sample, assuming that each subsample fulfill the three necessary conditions of homogeneity (Haas and Murphy, 2003); a) the DMUs are engaged in the same process; b) all DMUs are evaluated under the same measures of efficiency and; c) all DMUs operates under the same conditions..

Recall that the efficiency scores range from 0 to 1. The interpretation of these values should be that the difference between the score obtained and the unit is the percentage of inefficiency. For example, a firm with a score of .84 would indicate that at the same level of inputs the firm is 16% inefficient, relative to its industry, due to the lack of capability to transform innovation inputs into innovation outputs. This score also indicates the firm is 84% efficient.

Due to a limitation of space, we cannot show the efficiency score for each firm under analysis, but in Table 5.3 we present the mean and median of the efficiency scores (EFF) and the percentage of efficient firms by industry. In this table there are also presented the number of firms analyzed as well as the mean of the inputs and outputs used for calculating the efficiency scores. What calls our attention is the observe heterogeneity between the different industries regarding the efficiency scores. As observed in Table 5.3, six of the industries under analysis showed a mean of the efficiency scores lower than the 20%, showing a great room for improving the technological innovation efficiency of the Spanish manufacturing firms. Nevertheless, five industries show efficiency scores averages larger than the 40%. The highest mean of the technological innovation efficiency is the one of the timber industry (66.0%), followed

[35] The correlation between the original DEA coefficients and the corrected –bootstrapped- coefficients is very high, around 0.989 (p-value ≤ 0.005). This high correlation shows the consistency of the intertemporal DEA bootstrap estimation.

Table 5.3 Number of obs.; mean of inputs and outputs and; mean, median, std. dev., of efficiency and % of efficient firms by industry

	Industries	Tech. Int.	N	Inputs		Outputs		Technological innovation efficiency			
				RDCS	HSS	NPI	PATT	EFF (mean)	EFF (median)	EFF (Std. Dev)	% of EFF =
1	Meat industry	LMTs	59	2099096	33.071	5.559	0.157	0.403	0.380	0.259	20.34%
2	Foodstuffs and tobacco	LMTs	147	1059052	18.112	3.070	0.245	0.280	0.231	0.235	11.56%
3	Beverages	LMTs	72	943752.1	32.130	1.747	0.719	0.274	0.156	0.232	22.22%
4	Textiles and clothing	LMTs	220	567941.3	5.812	13.847	0.510	0.106	0.033	0.172	5.00%
5	Leather and footwear	LMTs	45	202806.9	0.569	8.583	0.222	0.377	0.331	0.294	20.00%
6	Timber industry	LMTs	35	199460.7	5.404	1.471	0.264	0.602	0.660	0.228	28.57%
7	Paper industry	LMTs	71	810632.4	15.352	1.880	0.254	0.277	0.161	0.248	21.13%
8	Publishing and printing	LMTs	14	977823.7	120.383	0.214	0.000	0.409	0.381	0.242	35.71%
9	Chemicals	HTs	324	4720492	40.197	2.848	1.024	0.163	0.074	0.185	4.32%
10	Rubber and plastic products	LMTs	117	747858	8.321	2.778	0.442	0.163	0.052	0.208	9.40%
11	Nonmetallic mineral products	LMTs	159	3528608	21.482	5.998	0.509	0.164	0.064	0.208	4.40%
12	Ferrous and non ferrous metals	LMTs	128	1742349	18.974	11.857	0.418	0.187	0.076	0.227	10.16%
13	Metal products	LMTs	141	1170016	11.769	5.745	1.246	0.210	0.091	0.246	9.93%
14	Agricultural and industrial machinery	HTs	268	2914336	21.221	6.523	0.611	0.205	0.093	0.228	5.60%
15	Office machines and data processing	HTs	73	6341058	73.636	5.521	0.949	0.314	0.212	0.269	9.59%
16	Machinery and electrical equipment	HTs	226	2681677	25.743	5.877	0.963	0.164	0.084	0.191	5.31%
17	Motor vehicles	HTs	206	39100000	50.455	3.964	0.750	0.213	0.093	0.253	8.25%
18	Other transport equipment	HTs	72	82000000	223.398	1.438	0.580	0.476	0.474	0.276	16.67%
19	Furniture industry	LMTs	95	432820.2	12.091	8.132	2.503	0.450	0.506	0.293	16.84%

Notes: Tech. Int. accounts for technological intensity; RDCS: is the R&D capital stock; HSS: represents the mean of the number of the high-skilled staff; the % of efficiency firms = 1 was calculated based on the DEA model before estimating the bias as the corrected coefficients are lower than the unity.

by the other transport equipment industry with an efficiency average of 47.6%. Contrary, the lowest averages of the efficiency scores are those for the textile and clothing (10.6%), chemical (16.3%) and rubber and plastic products (16.3%).

Based on these results, we cannot say that one industry is more efficient than other since no common frontier has been established due to the DEA methodology requirements (Brown, 2006). But what we can learn from these results is that the uncertainty or risk associate to successful innovations outcomes is higher in those sectors with lower efficiency scores. In other words, it is easier to obtain innovations in the timber industry where technology and products are not as complex as those in chemical industries where many attempts and tests have to be performed before launching the new –or improved- product.

As commented in the theoretical framework, few attempts have been performed in the literature in order to measure the technological innovation efficiency, limiting the comparative of our results with previous results since those studies uniquely considering innovation inputs and innovation outputs were performed analyzing 30 different countries (Wang, 2007; Wang and Huang, 2007) or twenty six regions of China (Guan and Chen, 2010). If the reader claims a point of reference we could say that Wang (2007) obtain a mean of the efficiency scores of 65% and a mean of 86% for the study of Wang and Huang (2007) and for the sample of the regions of China the mean of the efficiency scores is 45.3%.

Results presented in Table 5.3 also enable us to observe the heterogeneity of firms within industries. For example, the publishing and printing industry has the highest percentage of efficient firms (35.71%) but the mean and median of the efficiency scores are not the highest but the standard deviation is among the largest. This indicates that in this industry the firms tend to be in the poles, that is, highly efficient or highly inefficient. For the textiles and clothing industry there seems to be less variation but a clear tendency to inefficiency. Observe how the standard deviation, mean and median are the lowest and the how the percentage of efficient firms is very low. That is, there are very few firms in the best practice frontier and the rest are very far from the frontier.

4.2 Stage II: effect of technological innovation efficiency on firm performance

Once the technological innovation efficiency was calculated through the intertemporal DEA bootstrap model in the first-stage of the analysis, we aim to assess its effect on firm performance in order to test hypothesis one. To do so, we use the obtained efficiency scores as an explanatory variable and, through the dynamic panel data model, regress it against firm performance, measured as the ROA. Estimates for this equation are presented in Table 5.4 as the FULL model. Additionally, as argue in section 2, we consider that the effect of the technological innovation efficiency is contingent to the technological intensity level and the firm size (LMTs; HTs and SMEs; LARGE, respectively) we re-estimate equation (2) for these subsamples in order to test our hypothesis two. These estimates are also shown in Table 5.4.

Observe that the Hansen test of over-identifying restrictions in the five models in Table 5.4 does not reject the validity of the instruments, showing the nonexistence of endogeneity problems in the model. The Arellano-Bond autocorrelation test indicates the absence of serial correlation in levels since the AR(2) tests are insignificant. The first-order autocorrelation AR(1) of the difference residuals occurs by construction. Recall that the number of observations in this second-stage is smaller than in the first-stage due to the methodological constrains. Furthermore, when introducing the ROA lagged at *t-1* the first observation of each firm was lost, leading the estimate the models with a total sample of 1953 observations[36].

From the FULL model we can see the inertia effect of the ROA at *t-1*, indicating that past performance does influence the current firm performance. This inertia effect is also observed for the LMTs HTs, SMEs and LARGE models. Observe that this effect is higher and more significant for large firms, showing a greater dependency on their past performance.

[36] Observer that the sum of the observations of SMEs and LARGE subsamples equals the number of observations in the FULL model but it is not the case for the sum of the number of firms of the same subsamples. This difference is the result of a change of the firm size during the years of analysis. That is a firm could have three observations being a SME and other three as a large firm. The same behavior is present for the technological intensity level.

Table 5.4 Estimates for technological innovation efficiency

	FULL	LMTs	HTs	SMEs	LARGE
ROA_{t-1}	0.2145***	0.3802***	0.0854*	0.1632**	0.4460***
	(0.0746)	(0.0714)	(0.0516)	(0.0746)	(0.0499)
EFF	0.1178**	0.0279	0.1817**	0.1653***	0.0088
	(0.0526)	(0.079)	(0.0801)	(0.0569)	(0.0342)
LARGE	-0.0847**	-0.0248	-0.0990**		
	(0.0381)	(0.0302)	(0.0492)		
AGE	-0.0005	-0.0004	-0.0022*	0.0002	-0.0004
	(0.0006)	(0.0005)	(0.0012)	(0.0010)	(0.0005)
High-Tech	-0.0101			-0.0143	-0.0004
	(0.0100)			(0.0178)	(0.0073)
Constant	0.1371***	0.1003***	0.1900***	0.0555*	0.0825***
	(0.0238)	(0.0312)	(0.0474)	(0.0335)	(0.0272)
YEAR	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	1953	1018	935	814	1139
Number of	362	199	166	183	212
Wald(df)LL	81.52***	138.29***	51.00***	41.66***	233.35***
N. of	149	148	119	124	122
Hansen test (p-value)	125.55 (0.752)	132.29 (0.501)	95.50 (0.712)	106.73 (0.544)	97.80 (0.726)
AR(1)	-4.27***	-4.20***	-3.51***	-3.55***	-6.32***
AR(2)	-0.11	1.00	0.76	0.22	-0.34

**** p-value <= 0.01; ** p-value <=0.05; * p-value <=0.1. Robust standard errors are in parentheses.*

Results give support for hypothesis one. As expected, the EFF variable registers a positive and significant effect of the technological innovation efficiency on firm performance, that is, the more the efficient the firm is in developing its technological innovative process, the better the firm performance. Nevertheless, as argued in hypothesis two, this effect is moderated by the technology intensity level and firm size. Observe that the EFF is positive in all cases but it is only significant for HTs and SMEs firms. In other words, LMTs and LARGE firms' performance is not dependent of the technological innovation efficiently but, on the contrary, in order to increase firm performance, HTs and SMEs might increase their technological innovation efficiency. Hence, results support our H2. This result is consistent with previous results that have showed that the effect of R&D activities on firm productivity was greater for HTs than for LMTs (Kafouros, 2005; Wang and Tsai, 2003). We consider that this behavior might be due to the fact that HTs, operating in highly turbulent environments, base their competitive advantages on the technological innovation achievements, and while the LMTs do not base their competitive advantages on the latest technological knowledge; rather, they depend on their creativity to exploit and transform their general stock of knowledge into non-science based innovations (Bender and Laestadius, 2005).

As results show in Table 5.4, the firm size also moderates the effect of the technological innovation efficiency on firm performance, giving total support for H2. The EFF variable shows a positive and significant effect for SMEs (0.1653, p-value ≤ 0.001) but for the LARGE subsample, the effect is not significant. This result indicates that due to the fact that SMEs, usually, lack of physical and economical resources and are unable to take advantage of scale economies (Alvarez and Crespi, 2003) are more susceptible to the efficiency of the technological innovation process in order to increase their performance. On the contrary, large firms have the facility to overcome the potential inefficiency without affecting –or increasing- their performance due to the large amount of resources and the scale economies generated (Damanpour, 1992).

As for the control variables we can observe from the FULL model on Table 5.4 that firm size has a negative effect on firm performance. This effect is in line with previous studies (Bayona-Sáez and García-Marco, 2010) and is partially robust to the moderating effect of the technological intensity level. As for the firm AGE variable we can observe that it does not affect firm performance in any of the models presented, except for the HTs. This is contrary to that argued by Leonard-Barton (1995) that firm’s capabilities are formed though the experienced obtained over time and that affirmed by Sørensen and Stuart (2000) that immature organizational routines of young firms might be an obstacle for increasing firm performance.

Aiming to empirically test the importance of the technological innovation efficiency instead of merely using the innovations inputs or outputs as explanatory variables of firm performance, we estimated models (3) and (4) including the innovation inputs and outputs as explanatory variables for firm performance, instead of the technological innovation efficiency.. Table 5.5 shows the estimates of model (3). As observed, in order to be consistent in the analysis, we also estimated the moderating effect of the technological intensity level and firm size between the innovation inputs and firm performance. Again, the Hansen test of over-identifying restrictions in the five models does not reject the validity of the instruments and the Arellano-Bond autocorrelation test indicates that there are no problems of serial correlation in levels.

Table 5.5 Estimates for technological innovation inputs

	FULL	LMTs	HTs	SMEs	LARGE
ROA_{t-1}	0.3930***	0.3481***	-0.1679	0.1248	0.6997**
	(0.1253)	(0.1102)	(0.1680)	(0.1342)	(0.3170)
$RRDCS_{t-1}$	-0.2894**	-0.5628	-0.7946***	-0.5762***	-0.645***
	(0.1395)	(0.3478)	(0.2494)	(0.2201)	(0.2427)
$HSS\wedge_{t-1}$	0.0027*	0.0044*	0.0161***	0.0067***	0.0057
	(0.0015)	(0.0026)	(0.0041)	(0.0025)	(0.0131)
LARGE	-0.0717**	-0.0256	-0.0286		
	(0.0287)	(0.0309)	(0.0683)		
AGE	0.0003	-0.0005	0.0003	0.0008	0.0007
	(0.0005)	(0.0009)	(0.0014)	(0.0011)	(0.0015)
High-Tech	-0.0033			-0.0156	0.0056
	(0.0103)			(0.0231)	(0.0601)
Constant	0.0957***	0.1120***	0.0711	0.0828*	-0.0053
	(0.0285)	(0.0419)	(0.0595)	(0.0480)	(0.0848)
YEAR dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	1953	1018	935	814	1139
Number of firms	362	199	166	183	212
Wald(df)LL	120.9***	54.01***	54.17***	35.80***	74.19***
Number of instruments	93	92	64	79	24
Hansen test (p-value)	63.84 (0.839)	78.11 (0.412)	44.75 (0.607)	61.50 (0.694)	8.19 (0.415)
AR(1)	-3.9***	-3.58***	-1.87**	-2.83**	-2.51**
AR(2)	0.41	-0.97	-0.42	0.17	-0.05

**** p-value <= 0.001; ** p-value <=0.05; * p-value <=0.1. Robust standard errors are in parentheses.*

In respect to the dynamic effect of ROA at *t-1* on ROA at *t,* we observe that the effect is highly significant the FULL model and for LMTs and LARGE firms. For the HTs and SMEs subsamples it is not significant. These results are mostly in line with those presented in Table 5.4.

As proposed, the RRDCS variable which accounts for the R&D capital stock has a negative and hignificant effect on firm performance. As we argued before, the merely possession of a large amount of resources does not guarantee the creation of a competitive advantage (Song et al., 2007) and, additionally, those technological investments without the subsequent innovations are sunk cost that could not improve firm performance (Kroellinger, 2008). This effect is not completely robust to the moderating effect of the technological intensity level since the RRDCS variable has a negative and significant effect on firm performance exclusively for the HTs subsample. This might be due to the fact LMTs are less dependent on the R&D activities leading to invest less in R&D reducing the negative impact. However, this negative effect of RRDCS is robust to firm size, as the effect is significant for SMEs and LARGE models.

These results bring further support to our argument that what really matters for firm performance is the efficiency whereby the R&D expenditures were transformed into innovations. In other words, it does not matter how much you invest, rather, what do to obtain with that investment.

As for the high-skilled staff (HSS^), it can be observed that its effect on firm performance is slightly positive and significant for the FULL model. Nevertheless, its effect becomes insignificant for the LARGE subsample. This general positive effect indicates that HSS^ not only foster the innovation outputs (Rothwell and Dodgson, 1991; Koellinger, 2008) but also goes beyond the innovation process and has a direct and positive effect on firm performance. Jones (2001) argues that workers' education is positively correlated with firm productivity since educated workers have valuable skills that make them more productive.

In line to the estimates of Table 5.4, the firm size is negative and significant for the FULL model presented in Table 5.5. As for the firm age, it can be observed that is no longer significant for any of the models presented in this

Table. Finally, the technological intensity level seems not to affect firm performance for any model presented.

As we have argued through this research, we consider that the merely inclusion of the innovation outputs as explanatory variables of firm performance, without considering the inputs required to achieve them, would lead to an one-eyed perspective overestimating their effect. To test our argument we proposed equation (4) where we introduce the number of product innovations (NIP^) and the number of patents achieved (NPAT^) at *t-1* as independent variables instead of the technological innovation efficiency. Estimates are presented in Table 5.6. Once more, the Hansen test of over-identifying restrictions in the five models does not reject the validity of the instruments and the Arellano-Bond autocorrelation test indicates the absence of serial correlation in levels.

First of all, we detect the same effect of the inertia effect of the firm ROA as those estimates presented in Tables 5.4 except for HTs. Unexpectedly, but in line with previous studies (Yamin et al., 1997; Yalcinkaya et al., 2007), the number of product innovations (NPI^) does not show any significant effect on firm performance for the FULL model. On the other hand, the number of patents (NPAT^) has a negative and significant effect in the FULL model indicating that the larger number of patent, the lower the firm performance. These result give support for our argument that what really influence firm performance is the efficiency whereby the innovation inputs are transformed to create innovation outputs. Interesting results emerge when analyzing the moderating effect of the technological intensity level. First, the number of product innovations becomes positive and significant for HTs, showing that usually they base their competitive advantage on technological research, rediscovery and experimentation (Van der Bosch et al., 1999).

Second, the previous negative effect of the number of patents is present for LMTs but it is positive and significant for HTs. These results are consistent with those of Lichtenthaler (2009) where, with a sample of 136 European firms, the patent portfolio size and firm technological diversification had a negative effect on firm performance for LMTs but a positive one for HTs. This negative effect could be a consequence of the limited experience LMTs have on patenting (Hall and Ziedonis, 2001) causing the excessive use of resources such as time and money (Mazzoleni and Nelson, 1998; Kortum and Lerner, 1999) that finally leads to a negative effect on firm performance.

Table 5.6 Estimates for technological innovation outputs

	FULL	LMTs	HTs	SMEs	LARGE
ROA_{t-1}	0.4957***	0.2813***	0.1349	0.2958***	0.4231***
	(0.1540)	(0.082)	(0.2098)	(0.0907)	(0.1263)
$NPI^{\wedge}_{t-1}$	0.0008	0.0003	0.0024**	0.0003	0.0010
	(0.0005)	(0.0004)	(0.0010)	(0.0009)	(0.0009)
$NPAT^{\wedge}_{t-1}$	-0.0088***	-0.0075***	0.0084**	-0.0045	0.0053*
	(0.0033)	(0.0026)	(0.0036)	(0.0069)	(0.0030)
LARGE	-0.0595*	-0.0254	-0.0803		
	(0.0320)	(0.0241)	(0.0691)		
AGE	0.0004	-0.0002	-0.0016	0.0001	-0.0010
	(0.0004)	(0.0005)	(0.0011)	(0.0010)	(0.0008)
High-Tech	0.0007			-0.0148	-0.0019
	(0.0078)			(0.0121)	(0.0082)
Constant	0.0819**	0.1111***	0.1764***	0.0820**	0.0962**
	(0.0356)	(0.0273)	(0.0589)	(0.0371)	(0.0404)
YEAR dummies	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	1953	1018	935	814	1139
Number of firms	362	199	166	183	212
Wald(df)LL	216.76***	70.92***	37.88***	44.42***	91.48***
Number of instruments	84	133	42	91	76
Hansen test (p-value)	54.91 (0.855)	109.58 (0.698)	21.71 (0.705)	75.04 (0.477)	50.20 (0.812)
AR(1)	-3.61***	-3.28***	-2.37**	-3.54***	-4.17***
AR(2)	0.55	-1.21	0.53	0.65	-0.44

**** p-value <= 0.001; ** p-value <=0.05; * p-value <=0.1. Robust standard errors are in parentheses.*

Firm size also moderates the effect of the innovation outputs on firm performance. It can be seen that the number of product innovations has no effect on firm performance for both SMEs and LARGE firms. Finally, the negative and significant effect of NPAT is also present only for SMEs but LARGE firms do not suffer these effects as they have the physical and economical resources to manage the patents control.In respect to the control variables, we can observe that, generally speaking, their effect on firm performance is the same as those presented in Tables 5.4 and 5.5. In line with previous research (Bayona-Sáez and García-Marco, 2010) firm size has a negative effect on firm performance for the FULL model. Again, firm age and the technological intensity level seems not to increase firm performance in any of the models estimated.

5. DISCUSSION AND CONCLUSION

Through this study we have argued that the, so far, unclear relationship between innovation and firm performance might be due to the lack of agreement on how to measure innovation and how to link innovation with firm performance. Most of the studies in this field used indistinctly the innovation inputs or outputs as total measure of innovativeness and linked it, directly or indirectly with firm performance. In order to cope with this theoretical and empirical problem, this study aims to contribute to the extant literature by proposing a new approach to measure the effects of the technological innovation activities on firm performance.

There are three main arguments supporting our new approach. First, as Tidd and Bessant (2009) stated, innovation is a complex process where firms create and exploit change in order to increase their competitive advantages, therefore, it should be evaluated from a productive perspective, not as a single input or output activity. Second, we consider that associating innovation inputs directly to firm performance would be misleading since without being transformed into innovation outputs, are sunk cost that could not improve firm performance (Koellinger; 2008). Third, the direct link of innovation outputs to firm performance without considering the innovation inputs would overestimate their effect.

This new approach consists in a two-stage analysis. In the first-stage we consider R&D capital stock and high-skilled staff as to innovation inputs and the rate of patents and new products as two innovation outputs and, based on a productive perspective of the innovation process we estimate an intertemporal DEA bootstrap in order to obtain the efficiency coefficient of the technological innovation activities. In the second-stage analysis we consider the technological innovation efficiency as an explanatory variable of firm performance. In addition, this Chapter aims to analyze the moderating effect of the technological intensity level and firm size on the relationship between technological innovation efficiency and firm performance.

Results support our arguments. The effect of the technological innovation efficiency on firm performance resulted positive while the R&D capital stock and the number of patents produced negative effects; product innovations had no effect on performance and only high-skilled staff positively influences firm performance. These results clearly show that what really increases firm performance is the efficiency whereby the innovation inputs are transformed in innovation outputs. As well, the mere inclusion of the R&D capital stock or the innovation outputs would have a misleading consequence in the literature.

Our analysis also shows the moderating role of the technological intensity level and firm size in the efficiency-performance relationship. The efficiency of the technological innovation activities is positive for HTs, bearing that these firms, immerse in turbulent environments based their competitive advantages in the technological innovations while for LMTs the technological innovation efficiency is tangential. As for the firm size, it is evident that large firms, the due to the large amount of resources and the scale economies, could to overcome the potential inefficiency without affecting their performance, whereas SMEs lacking of physical resources might make the most with their limited resources.

The moderating effect of these two components also is present for the innovation inputs- / outputs-performance relationship and highlights two points. First, the R&D capital stock had a negative effect for all models except for that of the SMEs, maybe, because they are less dependent of R&D activities to achieve their innovations, avoiding negative effects on firm performance. Second, patent’s rate had a negative impact on firm performance for LMTs illustrating that the pay-off for patenting in LMTs is so low that do not compensate the significant cost needed to protect the invention.

The contribution of this study to the state of the art is twofold. First, although measuring the technological innovation efficiency is not a novel concept, the empirical evidence is scarce and most of the papers have a cross-sectional sample of a single industry and have mixed, jointly with the innovation inputs outputs, other variables unrelated with the innovation process, thus, *contaminating* the technological innovation efficiency scores. In addition, contrary to most of the studies estimating the technological innovation efficiency with firm-level data, this work considers the imperative lagged effect of the innovation inputs for creating innovation outputs. Second, this is study is pioneering in the empirical examination of the relationship between the technological innovation efficiency and firm performance and in considering the moderating effect to the technological intensity level and firm size. This methodology has allowed observing the complete process of the technological innovations, permitting to improve the inference of causal effects.

For policy makers and practitioners alike, it is of a major importance to know the importance of measuring the technological innovation efficiency in order to evaluate how firms are developing one of the most important activities that are central for business success, the technological innovations.

This research is not free of limitations that could also be transformed into future research lines. First, due to the lack of information we were not able to include the process innovations as a third input in the intertemporal DEA bootstrap model. Second, some previous studies (Veugelers and Cassiman, 2006) have demonstrated that the source of the R&D activities, internal or/and external, might produce different levels of innovation outcomes and, as a consequence, could produce higher (lower) levels of inefficiency. Therefore, splitting the RDCS input into the different sources of R&D activities might shed interesting results.

ANNEX C. **Intertemporal DEA bootstrap model**

The estimation of the intertemporal DEA bootstrap output-oriented is as follows:

$$
\begin{aligned}
&\text{Max. } \beta_t \\
&\text{s.t.} \\
&\sum_{k=1}^{K} \lambda_k \cdot y_{ikt} \geq \beta_t \cdot y^{o}_{it}, \qquad i = 1 \ldots I \\
&\sum_{k=1}^{K} \lambda_k \cdot x_{jkt} \leq x^{o}_{jt}, \qquad j = 1 \ldots J \qquad (1) \\
&\sum_{k=1}^{K} \lambda_k = 1 \\
&\lambda_k \geq 0
\end{aligned}
$$

Where β_t is the efficiency coefficient of the unit under analysis in period t, y^{o}_{it} and x^{o}_{jt} are the observe outputs and inputs vectors, respectively, of the DMU under analysis in period t. y_{it} and x_{jt} represent the outputs and inputs vector for the k (k= 1…K) units composing the total sample. Finally λ stands for the activity sector.

For achieving the bootstrapped betas, we followed the method proposed by Simar and Wilson (1998). The bias of the original estimates of $\beta_1 \ldots \beta_k$ is calculated as follows: Once solve model (1), $\beta_1^* \ldots \beta_k^*$ are obtained by adjusting the smoothed sample. The, adjust the original outputs using the rations $\beta_1/\beta_k^* \ldots \beta_k/\beta_k^*$. Then solve again program (1) using the adjusted outputs to obtain $\beta_{1k}^* \ldots \beta_{bk}^*$.Once the desired number of samples is obtained (2000 for our case, which is the most common number) estimate equation (2)

$$bias\beta_k' = \frac{\sum_{b=1}^{B}(\beta_{bk}^* - \beta_k)}{B} \qquad (2)$$

Drive from (2), the bias corrected estimator of the original values of $\beta_1 \ldots \beta_k$ can be obtained through equation (3).

$$\beta_k^* = \beta_k - bias\beta_k'$$

CHAPTER VI

CONCLUSIONS

As mentioned in Chapter I, in the last decade both Spanish firms and the Spanish government have increased their R&D expenditures –as a percentage of GDP. This gives some indication of the importance given to the technological innovations. Relatedly, Bone and Saxon (2000) Kafouros (2008) defend the view that technological innovations, whether in the form of a novel product or process, are the main source of competitive advantage and are crucial for business success. Nevertheless, despite exponential growth in the attention paid by practitioners and scholars to R&D activities over the last two decades, a comprehensive picture of the techniques and approaches for understanding firms' R&D behavior has not yet emerged and several issues require further investigation (Chiesa and Frattini, 2009).

Therefore with the overall aim of contributing to the extant literature and furthering understanding of firms' R&D behavior, we pay special attention, in this dissertation, to aspects of the way firms organize their R&D activities, the subsequent effects on their innovative performance, and the joint effect of technological innovation inputs and outputs on firm performance.

Technological innovations, like any other type of innovation, are not the result of a single, isolated activity. They are rather the outcome of a complex and uncertain process involving a sequence of decisions (Terziovski, 2002). A recent classification of the activities involved in the innovation process is that of Tidd and Bessant (2009), who identify four key activities: search, selection, implementation, and capture. It is from this process-based perspective that we structure and develop the four empirical studies presented in this dissertation, which are designed to cover the entire innovation process. As illustrated in Table 6.1, Chapters II and III account for the two first stages in the innovation process, that is, search and selection. In Chapter II we aim to analyze the determinants of the selection stage, taking into consideration the firm's internal resources and external characteristics. The aim of this study is to remedy the lack of empirical studies combining data on firm resources, appropriability conditions and sector characteristics.

Table 6.1 Innovation as a process and dissertation approach

Phases of the innovation process	Research Question	Main results
Search - Select	RQ 1: What internal resources and environmental circumstances determine the firm's choice of RDS?	The *buy* strategy is mainly selected by young firms lacking organizational resources. Firms with high commercial resources tend to select the *make* strategy. The *make-buy* strategy is preferred when firms are competing in highly dynamic markets and by firms with high technological resources.
	RQ 2: Does public R&D funding determine the choice of RDS? And, if so, in which direction?	The positive effect of public funding varies according the source of aid, so, State funds have a long-term effect while regional and other funds have just a contemporaneous effect. Additionally, we observe that the source of the funding influences whether firms select the *make*, *buy* or *make-buy* strategy.
Select - Implement	RQ 3: What are the effects of the three different RDSs on the firm's innovative performance?	All RDS produce a positive influence on innovation outputs, although the highest impact is produced by the *make-buy* strategy and the lowest by the *buy* strategy. The *buy* strategy has only short-term effect while the *make-buy* has long-term effects. The effect of the RDSs on firm innovativeness is moderated by the technological intensity level.
Implement - Capture	RQ 4: Does technological innovation efficiency really matter for firm performance?	Technological innovation efficiency scores show that there is a great room for improving the efficiency of the Spanish manufacturing firms. Results also show that the technological innovation efficiency influences positively the firm performance, rather than the innovation inputs or innovation outputs.

Chapter IV covers the second and third stages of the innovation process: selection and implementation. Once the firms have selected their RDS, they have to transform and implement the knowledge and technology they have acquired in order to obtain technological innovations. The aim of this Chapter is to evaluate the effects of the choice of RDS on the firm's innovative performance. The motivation for undertaking this study came, first, from our observation that the current literature has yielded inconclusive and contradictory results and has limited its attention to product innovation achievements (Tsai and Wang, 2009) while overlooking process innovation achievements. A further motivation was that most of the existing research does not consider the possible simultaneous combination of *make* and *buy* as a third RDS.

The results obtained in Chapter II and III motivated a third research question that is addressed in a study reported in Chapter IV, which questions, also within the two first stages of the innovation process, whether public R&D funding influences the choice of RDS. This analysis is important, since there only a few studies in this domain and there is a need for further research (Georghiou and Clarysse, 2006).

Finally, to complete our analysis of the entire innovation process, we present Chapter V, which accounts for the last two stages of the process, that is, implementation and capture. These last two stages are vital for the success of the innovation process. As stated by Trott (2005), innovation is not only the achievement of an invention, it also includes the critical phase of putting the invention into the market place and making a profit from it. The inconclusive, and somewhat contradictory, findings regarding the effect of technological innovations on firm performance are our main motivations for developing a new approach to tackle this problem.

As already stated, there is a lack of comprehensive understanding of the ways in which firms structure and define their boundaries of the RDSs and the consequences of their decisions. The main reasons behind this lack of understanding include increased reliance on external sources of technology and the diversification of channels for technology exploitation, both of which are captured in the open innovation approach (Chesbrough, 2003). Therefore, although traditional innovation models have not been updated to match this new firm behavior, the new open innovation approach opens the door for further analysis of the determinants and consequences of the choice of RDS. In the new era of open innovations, increasingly specialized products and processes prevent firms from developing everything internally (Chesbrough and Crowther, 2006) forcing them, beyond the classic binary choice between *make* or *buy*, to consider a third possibility: the *make-buy* combination. Thus, firm behavior has moved forward and academic studies must be updated to accommodate this new trend.

For our main objective, which is to analyze the different stages of the innovation process, we use the SBS Spanish survey of manufacturing firms. As described in Chapter I, both innovative and non-innovative firms are included in the analysis. Despite the importance attached to technological innovations (Bone and Saxon, 2000), descriptive analysis shows that 65.78% of the firms in the SBS have no R&D activity. Although the open innovation and absorptive capacity approaches (Cohen and Levinthal, 1990) defend the idea that the best way to achieve innovations is through the combination of internal and external knowledge, our descriptive analysis shows that the most common choice of RDS is *make,* followed by *make-buy* and *buy*.

In this context, we propose two research questions, which we discuss in Chapter II and Chapter IV, respectively. The first asks which internal and external forces drive firms' choice of RDS. The second asks what effect the various RDSs have on the firm's innovative performance. Specific answers to these questions are given in detail in their respective Chapters. Here, we continue by carrying out a cross-comparison of the main findings of these studies in order to characterize each RDS in terms of its determinants and consequences.

1. SUMMARY OF RESULTS

1.1 R&D strategies

The research described in this dissertation allows us to conclude that the *buy* strategy is mainly selected by young firms lacking in organizational resources. This RDS tends to be avoided by firms in need of product and process innovations to enable them to compete successfully in international markets

(Tomiura, 2007), and by firms competing in uncertain markets, and characterized by major technology shifts. Put differently, we can assume that firms select this strategy when they have no need to create competitive advantage in order to compete in international markets, or to keep pace with rapid technological change. Why, then, do they behave in this way? Is external R&D not an effective success strategy? The results presented in Chapter IV help us to answer these questions. We find that its effect on firm innovation performance is positive but weaker and less long-lasting than that of any other RDS. Our findings for HT firms support previous studies, where the *buy* strategy was found to have no effect on firm performance (Schmiedeberg, 2008). This means that, in sectors with major technology shifts and high uncertainty, the *buy* strategy, used in isolation, does not improve firm's innovative performance. It works better as a complement to the *make* strategy in these sectors. The *buy* strategy, in contrast, seems to produce positive results for markets less marked by technological uncertainty. We might say that, since their products and processes are less specific and less complex, low-tech firms can achieve innovations simply through the *buy* strategy.

Our research for this dissertation shows that the main determinants for a firm to select the *make* strategy are experience and knowledge acquired in international markets. Internal R&D activities could be the key to achieving the differentiated products needed to compete successfully in international markets. We also observe that strong appropriability conditions encourage firms to internalize R&D because strong protection of intellectual property rights (IPR) enables the appropriation of the outcome of R&D activities. Interestingly, there is no clear preference for *make* versus *make*-*buy* as far as commercial and organizational resources are concerned, but, all else being equal, either of these is preferred to *buy*. This highlights the fact that the *make* option requires the greatest amount of commercial and organizational resources. Despite similarities in the way firms set their RDS boundaries, the effect on firm innovativeness is not the same. This strategy comes somewhere between the *buy* and *make-buy* strategies in terms of its effect on firm innovativeness. The *make* RDS has a positive impact on the achievement of both product and process innovations, but the effects are long-term for products and short-term for processes.

Finally, with respect to the *make-buy* strategy, we find that firms possessing high technological resources select this option because it enables them to transform and integrate external knowledge into their routines thanks to the higher absorptive capacity derived from their technological resources (Cohen and Levinthal, 1990). In addition, our results support the open innovation approach, in the sense that the *make-buy* strategy is likely to be selected by firms in operating in highly dynamic markets and by those immersed in HT industries. This highlights the fact that innovative firms not only use the *buy* strategy to obtain the flexibility and speed required in these circumstances, but also they also use the *make* strategy to generate absorptive capacity and create barriers to imitation. These arguments hold when we analyze the impact of the *make-buy* strategy on firm innovativeness. In line with Veugelers and Cassiman (2006), our second study obtains that this strategy produces the highest impact on innovation performance. Like the *make* strategy, the *make-buy* strategy has a short and a long-term effect for product innovations, but in both cases it has a stronger effect. Interestingly, when it comes to process innovations, the *make-buy* strategy also has a stronger short-term effect than either the *make* or *buy* strategies and it is the only RDS producing long-term results.

From a general perspective, the results shown in Chapter II enable us to ascertain that small, low-tech firms and firms in sectors where the number of competitors is high are reluctant to engage in R&D activities. We could assume that this behavior stems from the fact that the mode of competition in such markets is not based on R&D achievement, but rather on marketing or organizational innovations. The results reported in Chapter IV also allow us to draw some general conclusions from the RDS perspective. Firstly, we observe that the effect of RDSs on firm innovativeness is moderated by the level of technological intensity. Furthermore, Chapter IV has brought to light that RDSs are more focused on achieving product innovations than process innovations. Finally, in line with the R&D capital stock model (Griliches, 1979), the effects of R&D activities are delayed. The maximum impact on the firm’s innovative performance occurs one year after implementation, and the impact in the second year is only half as significant.

The complementary Chapter III, aimed at analyzing whether the receipt of public funding for innovation determines the future choice of RDS, brings to light some important conclusions. First, as might be expected, receiving R&D funding encourages involvement in R&D activities, but the potential long-term outcome appears to vary according the source of the funding. Regional funding and funding from other sources –including the European Union (EU)- have only a contemporaneous effect, while State funding has a long-term effect on the probability of performing R&D activities. This suggests that State funds are channeled towards large-scale projects that take longer to complete. State funding encourages firms to select the *make-buy* strategy, which, as observed in Chapter IV, might produce the most innovative results. Regional funding presents a less obvious pattern, although there are some indications that it also encourages firms to select the *make-buy* RDS. Finally, receiving funding from other sources, such as the EU, discourages firms from adopting the *buy* strategy, which produces the fewest innovations, as observed in Chapter II.

1.2 Technological innovation efficiency

The aims of Chapter V are to analyze the effect of the technological innovation process on firm performance, propose a new approach for measuring the effect of this process on firm performance, and account for the final phases of the innovation process. Our conclusion from the production perspective is that both innovation inputs and innovation outputs must be taken into consideration when measuring firm performance effects. More specifically, we defend the idea that the efficiency gained from the technological innovation process will produce a positive effect on firm performance.

Chapter V describes a two-stage approach. The results of the first stage, the estimation of technological innovation efficiency, show that there is much room for improvement in the efficiency of Spanish manufacturing firms. The results of the second-stage enable us to defend the idea that it is neither the inputs nor the outputs of the innovation process that determine the effect of the technological innovation activities on firm performance. It is rather the efficiency with which the inputs are transformed into outputs. We test the robustness of our results by analyzing the direct effect of innovation inputs on firm performance. These prove to be negative, confirming the erroneousness of associating firm performance directly with innovation inputs, which, unless transformed into innovation outputs, are sunk costs that cannot improve firm performance (Koellinger; 2008). Interestingly, albeit in line with previous research (Yalcinkaya et al., 2007) neither product innovations nor patents had any effect on performance.

We also propose that the effect of technological innovation efficiency on firm performance is moderated by the level of technological intensity and firm size. The results highlight the fact that, although the efficiency of technological innovation activities is positive for both LMTs and HTs, the impact is higher in the turbulent environment in which HTs are immersed. Here, they form the basis of competitive advantages, while they are less tangential, albeit still important, for LMTs. As for firm size, it is evident that large firms are able to rely on large amounts of resources and scale economies to overcome potential inefficiency without affecting their performance, whereas SMEs have to make the most of their limited resources.

1.3 Technological intensity level and firm size

When the different results obtained in these four empirical Chapters are checked against technological intensity levels, interesting conclusions emerge. First, LT firms are usually reluctant to engage in R&D activities, but, once they do, they tend to prefer the *buy* strategy, a choice that yields positive results. They are less dependent on the efficiency of the technological innovation process, since their innovations are not usually dependent on the latest technological advances. Moreover, patents achieved in these industries have a negative effect on firm performance, illustrating that the economic payoff from patents is very low. HT firms, on the other hand, being immersed in environments with higher technological shifts, seem to opt for the *make-buy* strategy, which has a greater effect on firm performance in the long term, suggesting that it takes time to codify and integrate external knowledge. Finally, our study highlights that high-tech firms are more dependent on technological innovation efficiency, since, as reported in previous literature, they base their competitive advantages on technological research, rediscovery and experimentation (Van der Bosch et al., 1999).

The empirical Chapters also enable us to draw some conclusions regarding the innovation process in relation to firm size. There seems to be a positive relationship between firm size and engagement in R&D activities, which results in a positive relationship between firm size and innovativeness. That is, large firms are more prone to embark on R&D activities and, as a consequence, obtain more innovations than their counterparts. The empirical evidence points to the complementarity of the *make-buy* RDS, since large firms tend to select this as a means of achieving innovativeness. SMEs, in contrast, tend to avoid the complementary strategy and base their R&D either on bought-in or internal R&D, but not both. Furthermore, due to their lack of physical and other resources, SMEs are more dependent on technological innovation efficiency in order to profit from innovations. Large firms, in contrast, are able, due to economies of scale, to overcome inefficiencies in the technological innovation process.

Finally, we consider it important to highlight that six different methods were used in the econometric analyses reported in the empirical chapters. Chapter II estimates a multinomial logit model; Chapter III estimates random effects logit and random effects negative binomial models; Chapter IV; a random effect multinomial logit model; and Chapter V combines an intertemporal DEA bootstrap and general moments method approach.

2. CONTRIBUTIONS OF THE DISSERTATION

In the following sections, we explicitly describe the implications of this research for the innovation literature, and for practitioners and policy makers.

2.1 Contributions to the innovation literature

This dissertation has specific contributions for the innovation literature in each of the Chapters developed, which are next discussed, but, as a whole, this dissertation contributes to the innovation literature in analyzing the complete innovation process of the Spanish manufacturing firms. This dissertation permits to understand why firms select one or other R&D strategy and the effects of these strategies in the innovative performance. Finally, it makes possible to estimate the importance of the efficiency, whereby the technological innovation process is achieve, has on firm performance.

As discussed, Chapter II aimed to identify the internal and external determinants of RDS selection. By doing so, this study addresses some of the limitations present in previous empirical studies. Although some studies are aware of the three different RDSs, the majority of the studies analyzing the determinants of R&D strategy selection have focused in the dichotomous decision between *make* and *buy* (e.g. Kurokawa, 1997; Love and Roper, 2002; Hang et al., 2009) and has neglected the potential complementarity between internal and external technology sourcing (Veugelers and Cassiman, 1999; 2006).

The existing empirical literature has tended to focus either on firm internal resources (Prahalad and Hamel, 1990), industry characteristics (Utterback, 1994; Beneito, 2003) or appropriability conditions (Love and Roper, 2002; Teece, 2006), while this study considers the combination of these internal and external circumstances under which firms set their boundaries. This investigation extends Veugelers and Cassiman (1999) research in the sense that we include objective measurements of internal resources rather than the subjective valuation of the information sources, subject to endogeneity, and innovation goals as internal determinants of the RDS selection. Methodologically, and theoretically, our work extends Veugelers and Cassiman study because their work only permits to know which strategy is chosen compared to no achieving R&D. In contrast, we are able to compare which strategy is preferred over the others, including no R&D, given the independent variables. Additionally, Chapter II includes the external component of industry competitiveness as a determinant of the RDS selection, not considered in Veugelers and Cassiman analysis. Finally, while most of the studies in this field are cross-sectional, including Veugelers and Cassiman, in ours, the use of panel data enables us to consider the lagged determinants of R&D selection, thus improving the reliability of the causal inferences, and also obtaining more accurate results (Baum, 2006).

The complementary Chapter III contributes to the current literature in two different ways. A large proportion of the research focuses on a particular R&D

fund or a specific region, but there have been few attempts at the simultaneous analysis of the effectiveness of funding from different government levels. Therefore, this Chapter contributes firstly by analyzing the effect, so far neglected, of funding from regional governments, the State and other sources (including the EU) on the behavior of Spanish manufacturing firms. Secondly, while most of the research in this field is based on case studies or interviews with firms or data from cross-sectional and small samples, our empirical evidence, based on panel data on a large sample, obtains a more accurate and objective approximation by drawing causal inferences.

Our third empirical study also has some important contributions from the academic point of view. Firstly, it evaluates the effects of RDSs from a broad perspective including different innovation outputs and three technological intensity scenarios. Previous studies (*i.e.* Veugelers and Cassiman, 2006; Tsai and Wang, 2009) have considered the percentage of sales due to new products as the measure of firm innovativeness. In our case, product innovations and processes innovations were preferred since they make possible an objective valuation of the main objectives of the R&D activities. We consider important to highlight that the empirical evidence considering the process innovation as one possible outcome of the RDSs is very limited. Secondly, this Chapter is pioneering in stressing that the effect of each of the R&D strategies on firm innovativeness will be moderated by the level of technological intensity. Results of the estimates have showed that without taking into account this moderating effect, the importance of the *buy* strategy on firm innovativeness would be undervalued for medium- and low-tech firms. Thirdly, it finds support for the Schumpeterian (1943) hypothesis regarding the negative relationship between market concentration and firm innovativeness, although this effect is observed only for the overall sample and for low-tech firms. This clearly shows that firms in highly competitive markets try to become more innovative in order to survive.. Finally, as in the study described in Chapter II, while most of the previous literature is cross-sectional, ours enables us to validate the causal effects of RDSs on firm innovation performance and ascertain in which circumstances they produce the best results.

Taking the main conclusions of Chapter II and Chapter IV together, this dissertation also contributes to the extant literature by supporting the absorptive capacity and open innovation approaches, albeit with some reservations, mainly relating to the technological intensity level in which the firm is immersed. Our studies show that the *make-buy* strategy is selected mostly by firms competing in HT industries, it has largely positive results and an impact on firm performance that reaches its height two years later. This indicates two things. First, that firms require this time lag in order to absorb and integrate the knowledge acquired by external channels. . Second, as proposed in the open innovation approach, the combination of internal and bought-in knowledge has a greater effect on firm performance than either in isolation. In addition, HT firms that fail to generate further absorptive capacity through internal R&D will derive no benefit from external R&D, as far as achieving innovations is concerned. Nevertheless, the findings for the absorptive capacity and open innovation approaches did not hold in our study of LTs industries, since these are able to benefit from external R&D without developing their absorptive capacity (internal R&D). Furthermore, there is no clear distinction between the payback from *make*, *buy* or *make-buy*, forcing us to mitigate the so claimed complementarity argued in the open innovation approach.

Finally, Chapter V also makes some important contributions to the state of the art on the innovation-performance relationship. Firstly, this study proposes a new approach enabling examination of the technological innovation process and the lagged effect of its efficiency on firm performance. Secondly, although the measurement of technological innovation efficiency is not a novel concept, the empirical evidence is scarce and most papers use a cross-sectional sample of a single industry and include innovation inputs and/or outputs unrelated with the innovation process, thus, obtaining inaccurate technological innovation efficiency scores. Thirdly, in contrast to most studies estimating technological innovation efficiency with firm-level data, this Chapter considers the inevitable lagged effect of innovation inputs on the production of innovation outputs. Fourthly, this study is also pioneering in considering the moderating effect of the technological intensity level and firm size when examining the relationship between technological innovation efficiency and firm performance.

2.2 Contributions to managers and policy makers

This dissertation has explored the technological innovation process and has showed its more important characteristics, its results and its effect on firm performance. We consider that the different results obtain through the four empirical chapters have some important contributions for managers and policy makers.

For managers, this research provides some insights when setting the boundaries of their RDS as we have extensively described the characteristics and advantages associated with each RDS. Although Chapter II is interesting for managers as they can understand the firm behavior when selecting the RDS we consider that Chapter IV and V are the ones that have a greater contribution to policy makers.

Through this dissertation we have observed that, for Spanish manufacturing firms, the three types of RDSs produce positive effects on firm innovativeness one year after they are achieved. Nevertheless, the effect of the *make*, *buy* and *make-buy* strategies are not the equivalent in terms of strength and length. This is highly important for practitioners since this dissertation shows that depending on the type of innovation pursued, the strategy selected and the industry technological intensity level the effects will be different.

We have learned that combining internal and external sources of R&D is the best way to guarantee product or process innovations, and have found it to be particularly crucial for HT firms. Practitioners should also be aware that relying exclusively on external R&D proves to be a competitive strategy only for low-tech industries and that it produces only short-term effects. Considering product innovation as the innovation output, the *make* strategy only has a positive impact for low-technology firms two years later. This strategy, *per se*, does not produce positive results for medium- and high-technology firms; rather, they need an extra effort to maintain the effects of the R&D activities two years later. In other words, they need to look for the complementarity between the *make* and *buy* strategies.

Following the maxim "*you cannot manage what you cannot measure*", this research has proposed a new approach to evaluating the payoff from technological innovations. Managers need to be aware that it does not matter how much they invest in R&D or how many innovations they obtain, they need, rather, to pay more attention to the efficiency of their technological innovation processes, since this is the best way to guarantee a positive payoff from their R&D investments. Finally, managers in LMT firms should be aware that patents have a negative effect on firm performance, and that they need to seek new channels for technology exploitation in order to profit from any patents achieved.

As before commented, we consider that this dissertation also has some important contributions for policy makers. First this research has showed that R&D activities do encourage firm innovativeness and that innovations foster firm performance. Therefore, generally speaking, policy makers should be aware of the importance that public policies, such as funding, tax reduction or credits, might have in encouraging social wealth and economic growth through innovations. Second, Chapter III shows that public R&D funding has a direct impact on the RDS selection and usually the *make-buy* strategy. We may wonder whether it is good that it promotes the choice of the *make-buy* strategy. We believe that it depends on who receives the funding. It is apparently the best option for high-technology firms, but not necessarily for low-tech firms, as this strategy is more demanding in terms of economic resources and it does not seem to make a significant difference for these firms. Therefore, policy makers should channel R&D funding towards the promotion of a specific strategy, based on the desired outcome and the technological intensity of the firm.

Third, as already observed, mere investment in R&D does not guarantee a positive effect on firm performance. Policy makers should also promote public policies that could provide coaching to guarantee the efficient use of the resources granted and maximize their impact. Further analysis is required to analyze whether the high-skilled staff is more important in achieving high levels of efficiency or if the R&D capital stock is what determines the efficiency. Nevertheless, in both cases, public policies could be created in order to improve the main determinant of the technological innovation efficiency.

Finally, policy makers should create appropriate environmental and legal structures (technological centers, etc.) to promote the open innovation model in firms operating in HT industries, since, as the results show, this is the best strategy for obtaining the desired products and/or process innovations.

3. LIMITATIONS AND FUTURE RESEARCH LINES

Like all studies, this one has certain limitations, mainly relating to the sample characteristics. The sample used for the empirical work was taken from the SBS, an existing sample that was not specifically designed for the research purposes of this dissertation. This prevented us from including and measuring all the variables we would have liked to, and forced us to use some proxies. Although the SBS is random and stratified, Wooldridge (1995) sustains that that panel data surveys are prone to sample selection and attrition bias. Even we have neither collected nor managed the data, Baltagi (2007) remarks that longitudinal samples usually have problems in the design, data collection and data management; problems that the SBS could be exposed to.

A data constraint in Chapter II prevented us from empirically testing the importance of the transaction costs, and cost reduction objectives in RDS selection. Along with the previous limitation, although standard errors of the estimates of the multinomial logit model are clustered by firms, we were unable to deal satisfactorily with the violation of the independence of observations, that is, autocorrelation of observations across the panel. Furthermore, although we were able in Chapter IV to account for potential endogeneity and unobservable heterogeneity through the random effects multinomial logit model, the size of the sample made it practically impossible to apply this methodology in Chapter II.

Based on the information available, this dissertation compares an aggregate form of external R&D. However, it would be useful, both academically and practically, to compare the determinants and the effects of different types of external knowledge sources. This would contribute to our ultimate research objective, which is to explain the efficiency of the technological innovation process based on the choice of RDS, that is, determine whether firms combining internal and external knowledge are more efficient at achieving innovations.

Despite the lagged effect of the RDS observed in Chapter IV, we are unable to estimate the total lagged effect of RDS on firm innovativeness, that is, the duration, in years, of the effect on firm innovative performance. This empirical study demonstrates the effect of RDS on firm innovative performance when considered in terms of activities, using dichotomous variables. However, does commitment to the RDS (R&D expenditure) increase or decrease the effect on firm innovativeness? Finally, although our findings show that the *make-buy* strategy produces the best results, thus supporting our claims for the complementarity of internal and external knowledge, we fail to determine how long it takes to absorb and integrate the external knowledge required to produce product and/or process innovations. In other words, we still do not know how long it takes for firms switching from the *make* to the *make-buy* strategy to succeed in increasing their rate of innovations?

The main limitation in Chapter V is that, in the first-stage of the analysis, we included only R&D capital stock and highly-skilled human resources as innovation inputs and product innovation and patent rates as innovations outputs. However, we did not include among the innovation inputs other firm inputs, such as new machinery or purchased licenses, which also play a part in the technological innovation process. Similarly, although process innovation is an important outcome of the technological innovation process, data constraints prevented its inclusion in the analysis.

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ANNEX D. Survey of Business Strategy Questionnaire

MINISTERIO
DE INDUSTRIA, TURISMO
Y COMERCIO

FUNDACIÓN SEPI

INFORMACIÓN SUJETA A
SECRETO ESTADÍSTICO

PÁGINA	AA

ENCUESTA SOBRE ESTRATEGIAS EMPRESARIALES

EJERCICIO DE 2005

1	2
REFERENCIA TEMPORAL	Para remitir el cuestionario y para alguna aclaración sobre la encuesta en sí o sobre su cumplimentación, diríjase a: PROGRAMA DE INVESTIGACIONES ECONÓMICAS
Salvo que en las preguntas se especifique lo contrario, los datos van referidos al ejercicio de 2005	SRTA. HERNAIZ TEL.: 91.787.37.31 FAX: 91.787.37.37 e-mail: esee@dephimatica.es C/ Pantoja, 10. 2º 28002 MADRID

PÁGINA | AB

A. ACTIVIDAD, PRODUCTOS Y PROCESOS DE FABRICACIÓN

1

NÚMERO DE **ESTABLECIMIENTOS INDUSTRIALES** (FÁBRICAS, TALLERES, ETC.) DE LA EMPRESA

A. Una . . . . ☐ 01
B. Dos . . . . ☐ 02 A1
C. Tres . . . . ☐ 03
D. Cuatro . . . . ☐ 04
E. Cinco y más (especificar) . . . |__|

2

INSTRUCCIÓN

Especifique en la siguiente pregunta la localización geográfica y el empleo de cada uno de los **establecimientos industriales** de la empresa. Se cumplimentarán tantas filas como establecimientos industriales tenga la empresa.
(Si no hay espacio suficiente, continuar en la última hoja, de OBSERVACIONES)

3

DENOMINACIÓN, LOCALIZACIÓN GEOGRÁFICA (PROVINCIA O PAÍS EXTRANJERO) Y EMPLEO DE CADA UNO DE LOS **ESTABLECIMIENTOS INDUSTRIALES** (FÁBRICAS, TALLERES, ETC.) DE LA EMPRESA

	Denominación de la fábrica, taller, planta, etc.	Provincia o país extranjero		Empleo al 31/12/2005
1.	A3_1_1	A3_1_2	A3_1_3	A3_1_4
2.	A3_2_1	A3_2_2	A3_2_3	A3_2_4
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

4

LA EMPRESA TIENE **ESTABLECIMIENTOS NO INDUSTRIALES** SEPARADOS DE SUS INSTALACIONES FABRILES (OFICINAS, CENTROS DE DISEÑO, INSTALACIONES COMERCIALES, ETC.)

A. No ☐ 1 → 6
B. Sí ☐ 6 A4_1

|___| A4_2_1
Número de establecimientos

|______| A4_2_2
Volumen de empleo a 31 de diciembre de 2005 en estos establecimientos

5A

ALGUNOS DE ESTOS ESTABLECIMIENTOS NO INDUSTRIALES ESTÁN LOCALIZADOS EN ESPAÑA

A. No ☐ 7
B. Sí ☐ 2 A5A_1

|__| A5A_2
Número de provincias

5B

ALGUNOS DE ESTOS ESTABLECIMIENTOS NO INDUSTRIALES ESTÁN LOCALIZADOS EN OTROS PAÍSES

A. No ☐ 8
B. Sí ☐ 3 A5B_1

|__| A5B_2
Número de Países

6

AÑO DE CONSTITUCIÓN DE LA EMPRESA

A6
|____|
Año

7

FORMA JURÍDICA DE LA EMPRESA

A. Empresa individual . . . . ☐ 1 → 13
B. Sociedad Anónima . . . . ☐ 2 A7
C. Sociedad Limitada . . . . ☐ 3
D. Sociedad Anónima Laboral . ☐ 4 → 8
E. Cooperativa de trabajo . . . . ☐ 5
F. Otras . . . . ☐ 6

8

INDIQUE SI COTIZA EN BOLSA

A. No ☐ 06 A8
B. Sí ☐ 01

9

INDIQUE SI ESTÁ INTEGRADA EN UN GRUPO DE SOCIEDADES

A. No ☐ 7 A9
B. Sí ☐ 2

10

INDIQUE SI OTRA SOCIEDAD O SOCIEDADES TIENE PARTICIPACIÓN EN EL CAPITAL DE LA EMPRESA. EN CASO POSITIVO, SEÑALE EL PORCENTAJE DE LA SOCIEDAD CON MAYOR PARTICIPACIÓN EN 2005

A. No ☐ 8
B. Sí ☐ 3 A10_1

A10_2
|___|
Porcentaje

A. ACTIVIDAD, PRODUCTOS Y PROCESOS DE FABRICACIÓN (Continuación)

11	12	13
INDIQUE SI LA EMPRESA TENÍA PARTICIPACIÓN DE **CAPITAL EXTRANJERO** DIRECTA O INDIRECTAMENTE (a través de una sociedad controlada en más del 50% por capital extranjero) Y SU PORCENTAJE EN **2005**	INDIQUE SI LA EMPRESA TENÍA PARTICIPACIÓN DE **CAPITAL PÚBLICO** DIRECTA O INDIRECTAMENTE (a través de una sociedad controlada en más del 50% por capital público) Y SU PORCENTAJE EN **2005**	DESCRIBA DETALLADAMENTE LA ACTIVIDAD PRINCIPAL DE LA EMPRESA
A. No 9 / B. Sí 4 A11_1	A. No 6 / B. Sí 1 A12_1	A13_1
Porcentaje A11_2	Porcentaje A12_2	A13_2_1 A13_2_2

14

INDIQUE DETALLADAMENTE, POR ORDEN DE IMPORTANCIA, **LOS PRINCIPALES PRODUCTOS FABRICADOS** POR ESTA EMPRESA DURANTE **2005**, ESPECIFICANDO, A SU VEZ, EL PORCENTAJE QUE REPRESENTA CADA UNO DE ELLOS SOBRE EL TOTAL DE VENTAS EN EL AÑO, HASTA ALCANZAR, POR LO MENOS, EL 50% DE LA FACTURACIÓN

			% Ventas
1.	A14_1_1	A14_1_2	A14_1_3
2.	A14_2_1	A14_2_2	A14_2_3
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

15

INDIQUE, SI EN SU MAYORÍA, LOS PRODUCTOS QUE FABRICA SON O NO MUY ESTANDARIZADOS

A15

A. Los productos son muy estandarizados; en su mayoría iguales para todos los compradores . . . 9

B. Los productos en su mayoría se diseñan específicamente para cada cliente 4

16

SISTEMAS DE FABRICACIÓN Y SERVICIOS

Indique si la empresa vende productos fabricados con cada uno de los siguientes sistemas y si ofrece servicios o actividades distintas de la fabricación. En caso positivo, señale el porcentaje que representan sobre las ventas totales.

		No	Sí	% Ventas
1. Fabricación de unidades o de pequeños lotes (no superiores a 200 unidades)	A16_1_1	7	2	A16_1_2
2. Fabricación en grandes lotes o en masa (por ejemplo: líneas de montaje)	A16_2_1	6	1	A16_2_2
3. Fabricación en producción continua (por ejemplo, altos hornos, cemento, petroquímica)	A16_3_1	8	3	A16_3_2
4. Ofrece servicios o actividades distintas de la fabricación	A16_4_1	6	1	A16_4_2
9. TOTAL				1 0 0

A. ACTIVIDAD, PRODUCTOS Y PROCESOS DE FABRICACIÓN (Continuación)

17 INDIQUE SI EL PROCESO PRODUCTIVO UTILIZA CADA UNO DE LOS SIGUIENTES SISTEMAS

	No	Sí
1. Máquinas herramientas de control numérico por ordenador (A17_1)	☐ 6	☐ 1
2. Robótica (A17_2)	☐ 8	☐ 3
3. Diseño asistido por ordenador (CAD) (A17_3)	☐ 7	☐ 2
4. Combinación de algunos de los sistemas anteriores mediante ordenador central (CAM, sistemas flexibles de fabricación, etc.) (A17_4)	☐ 9	☐ 4
5. Red de Área Local (LAN) en actividades de fabricación (A17_5)	☐ 6	☐ 1

18 PORCENTAJE MEDIO DURANTE 2005 DE LA UTILIZACIÓN DE LA CAPACIDAD ESTÁNDAR DE PRODUCCIÓN

A18 |__ __ __| Porcentaje

19 INDIQUE SI ES NORMAL PARA LA EMPRESA CAMBIAR EL TIPO DE PRODUCTOS QUE OFRECEN (A19)

A. No ☐ 6 → 21

B. Sí ☐ 1 → 20

20 PERIODICIDAD USUAL DEL CAMBIO (A20)

A. Con frecuencia menor que la anual ☐ 2

B. Anualmente ☐ 3

C. Con frecuencia mayor que la anual ☐ 4

D. De forma no regular ☐ 5

21 INDIQUE SI ES NORMAL PARA SUS COMPETIDORES CAMBIAR EL TIPO DE PRODUCTOS QUE OFRECEN (A21)

A. No ☐ 6 → 23

B. Sí ☐ 1 → 22

22 PERIODICIDAD USUAL DEL CAMBIO (A22)

A. Con frecuencia menor que la anual ☐ 01

B. Anualmente ☐ 02

C. Con frecuencia mayor que la anual ☐ 03

D. De forma no regular ☐ 04

23 INDIQUE SI LA EMPRESA COMERCIALIZÓ EN **2005** ALGUNOS PRODUCTOS NO FABRICADOS POR ELLA, PROCEDENTES DEL **MERCADO INTERIOR** Y EL PORCENTAJE QUE REPRESENTÓ SOBRE LAS VENTAS TOTALES

A. No ☐ 17 (A23_1)

B. Sí ☐ 12

A23_2 |__ __ __| Porcentaje sobre ventas

24 INDIQUE SI LA EMPRESA COMERCIALIZÓ EN **2005** ALGUNOS PRODUCTOS NO FABRICADOS POR ELLA, PROCEDENTES DEL **EXTRANJERO** Y EL PORCENTAJE QUE REPRESENTÓ SOBRE LAS VENTAS TOTALES

A. No ☐ 8 (A24_1)

B. Sí ☐ 3

A24_2 |__ __ __| Porcentaje sobre ventas

25 INDIQUE SI A 31 DE DICIEMBRE DE 2005 LA EMPRESA TENÍA PARTICIPACIÓN EN EL CAPITAL SOCIAL DE OTRAS EMPRESAS LOCALIZADAS EN EL EXTRANJERO (A25)

A. No ☐ 6 → B1

B. Sí ☐ 1 → 26

26 INDIQUE LA LOCALIZACIÓN GEOGRÁFICA DE LAS EMPRESAS PARTICIPADAS

	No	Sí	Número de Empresas
1. Unión Europea (A26_1_1)	☐ 7	☐ 2	A26_1_2
2. Resto de la O.C.D.E. (Australia, Canadá, Corea, Estados Unidos, Islandia, Japón, México, Noruega, Nueva Zelanda, Suiza, Turquía) (A26_2_1)	☐ 8	☐ 3	A26_2_2
3. Iberoamérica (A26_3_1)	☐ 9	☐ 4	A26_3_2
4. Resto del mundo (A26_4_1)	☐ 6	☐ 1	A26_4_2

27 INDIQUE, PARA LA PRINCIPAL EMPRESA PARTICIPADA, LAS SIGUIENTES CARACTERÍSTICAS O RASGOS

1. Porcentaje de participación |A27_1|

2. Número de trabajadores |A27_2|

3. País |A27_3_1| A27_3_2

	No	Sí
4. La actividad de la empresa participada es únicamente de comercialización o distribución (A27_4)	☐ 7	☐ 2
5. Elaboran productos similares a los que su empresa fabrica en España (A27_5)	☐ 8	☐ 3
6. Realizan actividades de adaptación y/o montaje de componentes suministrados desde la empresa española (A27_6)	☐ 9	☐ 4

B. CLIENTES Y PROVEEDORES

1	2	3	4	5	6	7
INDIQUE SI LA EMPRESA REALIZÓ EN **2005 VENTAS A MAYORISTAS O MINORISTAS** (Intermediarios comerciales que revenden sus productos sin transformarlos)	INDIQUE SI LA EMPRESA REALIZÓ EN **2005 ACUERDOS DE COMERCIALIZACIÓN** CON MAYORISTAS O MINORISTAS	INDIQUE SI ESTOS ACUERDOS INCLUÍAN LOS SIGUIENTES ASPECTOS	NÚMERO DE INTERMEDIARIOS COMERCIALES QUE COMPRARON SUS PRODUCTOS EN 2005	INDIQUE SI LA EMPRESA REALIZÓ EN **2005 VENTAS** (Directamente o a través de su red de distribución propia o concertada, sucursales, concesionarios) **A CONSUMIDORES INDIVIDUALES O FAMILIAS**	INDIQUE SI LA EMPRESA REALIZÓ EN **2005 VENTAS** (Directamente o a través de su red propia) **A EMPRESAS INDUSTRIALES O DE SERVICIOS**	NÚMERO DE EMPRESAS INDUSTRIALES O DE SERVICIOS QUE COMPRARON SUS PRODUCTOS EN 2005
B1 A. No ☐ 6 → 5 B. Sí ☐ 1 → 2	B2 A. No ☐ 7 → 4 B. Sí ☐ 2 → 3	(No / Sí) B3_1 1. Pagos por franquicia ☐ 3 ☐ 8 B3_2 2. Límites al precio de reventa ☐ 4 ☐ 9 3. Estipulaciones de exclusividad territorial ☐ 1 ☐ 6 B3_3 4. Obligaciones de comercialización de la gama completa de productos ☐ 2 ☐ 7 B3_4 5. Obligaciones de comercialización exclusiva ☐ 3 ☐ 8 B3_5	B4 A. Entre 1 y 5 ☐ 4 B. Entre 6 y 50 ☐ 5 C. Más de 50 ☐ 6	B5 A. No ☐ 7 B. Sí ☐ 2	B6 A. No ☐ 8 → 8 B. Sí ☐ 3 → 7	B7 A. Entre 1 y 5 ☐ 4 B. Entre 6 y 50 ☐ 5 C. Más de 50 ☐ 6

8	9							
INDIQUE SI LA EMPRESA REALIZÓ EN **2005 VENTAS** (Directamente o a través de su red propia) **A ORGANISMOS DE LA ADMINISTRACIÓN PÚBLICA**	PORCENTAJE QUE SOBRE LAS VENTAS TOTALES DE 2005 REPRESENTARON LAS...							
B8		No tiene	Sí tiene	% ventas en 2005		No tiene	Sí tiene	% ventas en 2005
A. No ☐ 7	1. Ventas a minoristas B9_1_1	☐ 8	☐ 3	B9_1_2	6. Ventas a empresas industriales o de servicios a través de una red de distribución propia B9_6_1	☐ 9	☐ 4	B9_6_2
	2. Ventas a mayoristas B9_2_1	☐ 9	☐ 4	B9_2_2	7. Ventas a Organismos de la Administración Pública, directamente B9_7_1	☐ 6	☐ 1	B9_7_2
B. Sí ☐ 2	3. Ventas a consumidores individuales o familias directamente B9_3_1	☐ 6	☐ 1	B9_3_2	8. Ventas a Organismos de la Administración Pública a través de una red de distribución propia B9_8_1	☐ 7	☐ 2	B9_8_2
	4. Ventas a consumidores individuales o familias a través de una red de distribución propia B9_4_1	☐ 7	☐ 2	B9_4_2	9. TOTAL VENTAS		⇨	1 0 0
	5. Ventas a empresas industriales o de servicios directamente B9_5_1	☐ 8	☐ 3	B9_5_2				

10	11	12	13
INDIQUE EL PORCENTAJE QUE REPRESENTARON SOBRE **EL TOTAL DE VENTAS FINALES** EN **2005** LAS REALIZADAS A SUS **TRES PRINCIPALES CLIENTES**	INDIQUE SI REALIZA ACTIVIDADES DE PROMOCIÓN COMERCIAL	FINALIDAD PRINCIPAL DE LAS ACTIVIDADES DE PROMOCIÓN	INDIQUE SI LA EMPRESA PRESTA SERVICIOS AUXILIARES (INSTALACIÓN, REPARACIÓN, OTROS SERVICIOS POSTVENTA, ETC.)
B10 |___| Porcentaje sobre ventas	B11 A. No ☐ 8 → 13 B. Sí ☐ 3 → 12	B12 A. Promoción de productos concretos ☐ 4 B. Promoción de marcas ☐ 5 C. Promoción de la imagen genérica de la empresa ☐ 6	B13 A. No ☐ 7 B. Sí ☐ 2

PÁGINA	AF

B. CLIENTES Y PROVEEDORES (Continuación)

14 PORCENTAJE TOTAL DE SUS **COMPRAS** QUE EN **2005** PROVINO DE SUS TRES MAYORES PROVEEDORES

|__ __ __| B14

Porcentaje sobre compras

15 INDIQUE SI PARTE O TODAS SUS COMPRAS PROVIENEN DE OTROS ESTABLECIMIENTOS DE SU GRUPO O CORPORACIÓN Y EN CASO POSITIVO EL PORCENTAJE QUE REPRESENTAN SOBRE EL TOTAL DE SUS COMPRAS

A. No ☐ 8 B15_1

B. Sí ☐ 3

|__ __ __| B15_2

Porcentaje sobre compras

16 INDIQUE SI CONTRATÓ EN **2005** CON TERCEROS LA FABRICACIÓN DE PRODUCTOS TERMINADOS O COMPONENTES **A MEDIDA PARA SU EMPRESA.** EN CASO POSITIVO INDIQUE SU VALOR

	No	Sí	Valor en euros
1. Proporcionando su empresa los materiales (B16_1_1)	☐ 4	☐ 9	B16_1_2
2. Sin proporcionar su empresa los materiales (B16_2_1)	☐ 1	☐ 6	B16_2_2

17 INDIQUE, PARA LOS SIGUIENTES SERVICIOS EXTERIORES, CUAL HA SIDO LA PRÁCTICA DE SU EMPRESA

	No utiliza	Realizado por la empresa	Contratado parcialmente	Contratado en su totalidad
1. Asesoría jurídica . . . . B17_1	01	02	03	04
2. Asesoría económico-financiera B17_2	11	12	13	14
3. Asesoría fiscal . . . . B17_3	21	22	23	24
4. Auditoría . . . . B17_4	31	32	33	34
5. Administración (personal, pagos, cobros, etc.) . . . . B17_5	41	42	43	44
6. Selección de personal . . B17_6	51	52	53	54
7. Formación del personal . B17_7	61	62	63	64
8. Programación informática B17_8	71	72	73	74
9. Implantación de paquetes informáticos de uso común (contabilidad, etc.) . . . . B17_9	81	82	83	84
10. Mensajería . . . . B17_10	91	92	93	94
11. Alquiler de maquinaria B17_11	01	02	03	04
12. Publicidad . . . . B17_12	11	12	13	14
13. Vigilancia y seguridad . . B17_13	21	22	23	24
14. Limpieza . . . . B17_14	31	32	33	34
15. Empaquetado, envasado y etiquetado . . . . B17_15	41	42	43	44

18 INDIQUE EL USO DE NUEVAS TECNOLOGÍAS BASADAS EN INTERNET POR PARTE DE SU EMPRESA EN 2005

	No	Sí
1. Dispone de dominio propio en Internet B18_1	7 (C1)	2
2. Su página Web está alojada en servidores de su empresa . . . . B18_2	8	3
3. Realiza compras de bienes o servicios (proveedores) por Internet . . . B18_3	9	4
4. Dispone de un sistema de ventas a consumidores finales por Internet (B2C) . . . B18_4	6	1
5. Dispone de un sistema de ventas a otras empresas por Internet (B2B) . . . . B18_5	7	2

19 INDIQUE EN QUÉ MEDIDA LOS SIGUIENTES MOTIVOS JUSTIFICAN LA PRESENCIA DE SU EMPRESA EN INTERNET

	Muy importante	Importante	Poco importante	Nada importante
1. Reforzar la imagen corporativa . . . . . . B19_1	01	02	03	04
2. Ofrecer información sobre los productos y/o servicios . . . B19_2	11	12	13	14
3. Asistencia a consumidores y usuarios B19_3	21	22	23	24
4. Comercio electrónico . . . . B19_4	31	32	33	34
5. Reducción de costes de aprovisionamientos . . . . B19_5	41	42	43	44
6. Otros (especificar) B19_6_1	51	52	53	54

|. . . . .| B19_6_2

20 INDIQUE CUÁL HA SIDO LA INCIDENCIA (DIRECTA E INDIRECTA) QUE LA PRESENCIA DE INTERNET HA TENIDO SOBRE LAS VENTAS DE SU EMPRESA EN 2005

B20

A. Ninguna ☐ 61

B. Ligera ☐ 62

C. Fuerte ☐ 63

E. No es evaluable ☐ 64

C. COSTES Y PRECIOS

1

DISPONE LA EMPRESA DE UNA ESTIMACIÓN DEL COSTE POR UNIDAD DE SU(S) PRODUCTO(S)?

C1

A. No
☐ 6 → 4

B. Sí
☐ 1 → 2

2

TIPO DE VALORACIÓN DEL COSTE UNITARIO QUE SE REALIZA

C2

A. De costes estándar en utilización normal de la capacidad ☐ 2

B. De costes reales, efectivamente incurridos en el proceso productivo . . . . ☐ 3

C. Se utilizan ambos tipos de valoraciones . . . . ☐ 4

3

SEÑALE SI SE TIENEN EN CUENTA EN LA ESTIMACIÓN DEL COSTE UNITARIO DEL (LOS) PRODUCTO(S) CADA UNO DE LOS SIGUIENTES CONCEPTOS

	No	Sí
1. Costes primarios directos (materiales, servicios industriales y mano de obra directos) . . . . C3_1	☐ 07	☐ 02
2. Costes generales de fabricación (materiales y mano de obra indirectos) . . . . C3_2	☐ 08	☐ 03
3. Costes generales no industriales (coste de administración, comerciales, financieros, etc.) . . . . C3_3	☐ 09	☐ 04

4

INDIQUE SI VARIÓ EN **2005**, RESPECTO AL AÑO ANTERIOR, EL **PRECIO MEDIO PAGADO** POR LA EMPRESA AL ADQUIRIR LOS SIGUIENTES FACTORES DE PRODUCCIÓN Y EL PORCENTAJE MEDIO QUE SUPUSO LA VARIACIÓN

	No ha variado	Sí ha variado	Signo	Variación %
1. Energía y combustibles	C4_1_1 ☐ 6	☐ 1	|__|	C4_1_2 |__|__|__|
2. Materias primas y otros aprovisionamientos .	C4_2_1 ☐ 7	☐ 2	|__|	C4_2_2 |__|__|__|
3. Servicios exteriores .	C4_3_1 ☐ 8	☐ 3	|__|	C4_3_2 |__|__|__|

5

SEÑALE LA FORMA PREFERENTE EN QUE DA A CONOCER SUS PRECIOS LA EMPRESA

C5

A. Preferentemente a través de catálogo o listas de precios
☐ 6 → 6

B. Preferentemente a través del contacto con el cliente
☐ 1 → 7

6

SEÑALE SI REALIZA POLÍTICA DE DESCUENTO

C6

A. No . . . . ☐ 01

B. Sí, para todos o casi todos los clientes . . . ☐ 02

C. Sí, para determinados clientes . . . . ☐ 03

7

INDIQUE LAS VECES QUE CAMBIÓ LOS PRECIOS A LO LARGO DEL EJERCICIO DE 2005

C7

A. Ninguna . . . . . . ☐ 04

B. Una . . . . ☐ 05

C. Dos . . . . ☐ 06

D. Más de dos . . . . ☐ 07

8

USTED CONSIDERA QUE SU INFORMACIÓN ACERCA DE LOS PRECIOS ESTABLECIDOS POR SUS COMPETIDORES ES:

C8

A. Precisa y puntual . . . . ☐ 08

B. Precisa, pero obtenida con retraso . . . . ☐ 09

C. Imprecisa . . . . ☐ 10

9

USTED CONSIDERA QUE SU INFORMACIÓN ACERCA DE LOS VOLÚMENES DE VENTAS CONSEGUIDOS POR SUS COMPETIDORES ES:

C9

A. Precisa y puntual . . . . ☐ 11

B. Precisa, pero obtenida con retraso . . . . ☐ 12

C. Imprecisa . . . . ☐ 13

PÁGINA	AH

D. MERCADOS: Defina el principal mercado o mercados servidos por la empresa de forma que:

- **Supongan en conjunto, al menos, el 50 por 100 de las ventas totales.**
- **Queden identificados por la línea de productos, el tipo de clientes a los que se venden u otras características que Ud. considere necesarias.**

	1	2	3	4	5	6	7
	RELACIONE EN CADA UNA DE LAS SIGUIENTES FILAS, POR ORDEN DE IMPORTANCIA, LOS MERCADOS SERVIDOS POR LA EMPRESA EN 2005, DE FORMA QUE ALCANCE, AL MENOS, EL 50% DE SUS VENTAS TOTALES	PORCENTAJE QUE SOBRE LAS VENTAS TOTALES DE 2005 REPRESENTARON LAS REALIZADAS EN ESTE MERCADO	ÁMBITO GEOGRÁFICO DEL MERCADO	EVOLUCIÓN DEL MERCADO EN 2005	INDIQUE SI LA CUOTA DE MERCADO DE LA EMPRESA ES SIGNIFICATIVA Y EN CASO AFIRMATIVO INDIQUE EL % QUE REPRESENTÓ EN 2005	SEÑALE LA EVOLUCIÓN DE SU CUOTA DE MERCADO EN 2005	EXISTENCIA DE COMPETIDORES CON CUOTA DE MERCADO SIGNIFICATIVA Y SU NÚMERO

SE DETALLA LA RELACIÓN DE MERCADOS DEL CUESTIONARIO DE 2004. EN CASO DE CONSIDERARLA ADECUADA, CONSIGNE EN ESTA ENCUESTA LA MISMA DEFINICIÓN

	1	2	3	4	5	6	7
M1	1er. MERCADO D1	D2 __ __ __ % Ventas totales	D3 A. ESPAÑA A.1. Local . . . ☐ 01 A.2. Provincial ☐ 02 A.3. Regional. ☐ 03 A.4. Conjunto nacional . ☐ 04 B. EXTRANJERO ☐ 05 C. ESPAÑA Y EXTRANJERO . . ☐ 11	D4 A. Expansivo ☐ 06 B. Estable ☐ 07 C. Recesivo ☐ 08	A. No significativa ☐ 09 D5_1 B. Significativa ☐ 10 D5_2 __ __ __ Porcentaje	D6 A. Ha aumentado ☐ 01 B. Se ha mantenido constante ☐ 02 C. Ha disminuido ☐ 03	A. No hay empresas con cuota significativa . . ☐ 07 D7_1 9 B. Sí hay empresas con cuota significativa . . ☐ 08 A. Menos de diez . . . . . . D7_2 ☐ 04 B. De diez a veinticinco . ☐ 05 C. Más de veinticinco . . . ☐ 06
M2	2º MERCADO	__ __ __ % Ventas totales	A. ESPAÑA A.1. Local . . . ☐ 01 A.2. Provincial ☐ 02 A.3. Regional. ☐ 03 A.4. Conjunto nacional . ☐ 04 B. EXTRANJERO ☐ 05 C. ESPAÑA Y EXTRANJERO . . ☐ 11	A. Expansivo ☐ 06 B. Estable ☐ 07 C. Recesivo ☐ 08	A. No significativa ☐ 09 B. Significativa ☐ 10 __ __ __ Porcentaje	A. Ha aumentado ☐ 01 B. Se ha mantenido constante ☐ 02 C. Ha disminuido ☐ 03	A. No hay empresas con cuota significativa . . ☐ 07 9 B. Sí hay empresas con cuota significativa . . ☐ 08 A. Menos de diez . . . . . . ☐ 04 B. De diez a veinticinco . ☐ 05 C. Más de veinticinco . . . ☐ 06
M3	3er. MERCADO	__ __ __ % Ventas totales	A. ESPAÑA A.1. Local . . . ☐ 01 A.2. Provincial ☐ 02 A.3. Regional. ☐ 03 A.4. Conjunto nacional . ☐ 04 B. EXTRANJERO ☐ 05 C. ESPAÑA Y EXTRANJERO . . ☐ 11	A. Expansivo ☐ 06 B. Estable ☐ 07 C. Recesivo ☐ 08	A. No significativa ☐ 09 B. Significativa ☐ 10 __ __ __ Porcentaje	A. Ha aumentado ☐ 01 B. Se ha mantenido constante ☐ 02 C. Ha disminuido ☐ 03	A. No hay empresas con cuota significativa . . ☐ 07 9 B. Sí hay empresas con cuota significativa . . ☐ 08 A. Menos de diez . . . . . . ☐ 04 B. De diez a veinticinco . ☐ 05 C. Más de veinticinco . . . ☐ 06
M4	4º MERCADO	__ __ __ % Ventas totales	A. ESPAÑA A.1. Local . . . ☐ 01 A.2. Provincial ☐ 02 A.3. Regional. ☐ 03 A.4. Conjunto nacional . ☐ 04 B. EXTRANJERO ☐ 05 C. ESPAÑA Y EXTRANJERO . . ☐ 11	A. Expansivo ☐ 06 B. Estable ☐ 07 C. Recesivo ☐ 08	A. No significativa ☐ 09 B. Significativa ☐ 10 __ __ __ Porcentaje	A. Ha aumentado ☐ 01 B. Se ha mantenido constante ☐ 02 C. Ha disminuido ☐ 03	A. No hay empresas con cuota significativa . . ☐ 07 9 B. Sí hay empresas con cuota significativa . . ☐ 08 A. Menos de diez . . . . . . ☐ 04 B. De diez a veinticinco . ☐ 05 C. Más de veinticinco . . . ☐ 06
M5	5º MERCADO	__ __ __ % Ventas totales	A. ESPAÑA A.1. Local . . . ☐ 01 A.2. Provincial ☐ 02 A.3. Regional. ☐ 03 A.4. Conjunto nacional . ☐ 04 B. EXTRANJERO ☐ 05 C. ESPAÑA Y EXTRANJERO . . ☐ 11	A. Expansivo ☐ 06 B. Estable ☐ 07 C. Recesivo ☐ 08	A. No significativa ☐ 09 B. Significativa ☐ 10 __ __ __ Porcentaje	A. Ha aumentado ☐ 01 B. Se ha mantenido constante ☐ 02 C. Ha disminuido ☐ 03	A. No hay empresas con cuota significativa . . ☐ 07 9 B. Sí hay empresas con cuota significativa . . ☐ 08 A. Menos de diez . . . . . . ☐ 04 B. De diez a veinticinco . ☐ 05 C. Más de veinticinco . . . ☐ 06

D. MERCADOS (Continuación)

8	9	10	11
SEÑALE, EN PORCENTAJE, LA CUOTA DE MERCADO EN 2005 DE LAS CUATRO EMPRESAS COMPETIDORAS MÁS IMPORTANTES EN EL MERCADO, EXCLUYENDO LA SUYA	INDIQUE SI LA EMPRESA VARIÓ, EN 2005, RESPECTO AL AÑO ANTERIOR, EL PRECIO EFECTIVO DE VENTA DE LOS PRODUCTOS VENDIDOS EN ESTE MERCADO Y EL PORCENTAJE MEDIO QUE SUPUSO LA VARIACIÓN	PRINCIPAL MOTIVO DE LA VARIACIÓN EN EL PRECIO (Indique un máximo de dos)	INDIQUE EL PRINCIPAL CAMBIO HABIDO EN EL MERCADO (Señale sólo uno)

M1

8	9	10	11
1er. MERCADO (%)	A. No ha variado	D10_1 D10_2	D11_1
1. 1ª Empresa .... D8_1	01 → E1	A. Cambios en el mercado . 04 → 11	A. Variación en los precios de competidores nacionales 09
2. 2ª Empresa .... D8_2	D9_1 B. Sí ha variado	B. Cambio en la calidad . . . 05 → E1	B. Variación en los precios de los productos equivalentes importados 10
3. 3ª Empresa .... D8_3	02	C. Cambio en los costes . . . 06 → E1	C. Aparición de nuevos productos o competidores 11
4. 4ª Empresa .... D8_4	D9_2 signo % de variación → 10	D. Mejoras del beneficio . . . 07 → E1	D. Incremento de la demanda 12
		E. Otros (especificar) ..... 08 → E1	E. Caída de la demanda 13
		D10_3	F. Otros (especificar) .... 14 D11_2 ....

M2

8	9	10	11
2º MERCADO (%)	A. No ha variado		
1. 1ª Empresa	01 → E1	A. Cambios en el mercado . 04 → 11	A. Variación en los precios de competidores nacionales 09
2. 2ª Empresa	B. Sí ha variado	B. Cambio en la calidad . . . 05 → E1	B. Variación en los precios de los productos equivalentes importados 10
3. 3ª Empresa	02	C. Cambio en los costes . . . 06 → E1	C. Aparición de nuevos productos o competidores 11
4. 4ª Empresa	signo % de variación → 10	D. Mejoras del beneficio . . . 07 → E1	D. Incremento de la demanda 12
		E. Otros (especificar) ..... 08 → E1	E. Caída de la demanda 13
		....	F. Otros (especificar) .... 14 ....

M3

8	9	10	11
3er. MERCADO (%)	A. No ha variado		
1. 1ª Empresa	01 → E1	A. Cambios en el mercado . 04 → 11	A. Variación en los precios de competidores nacionales 09
2. 2ª Empresa	B. Sí ha variado	B. Cambio en la calidad . . . 05 → E1	B. Variación en los precios de los productos equivalentes importados 10
3. 3ª Empresa	02	C. Cambio en los costes . . . 06 → E1	C. Aparición de nuevos productos o competidores 11
4. 4ª Empresa	signo % de variación → 10	D. Mejoras del beneficio . . . 07 → E1	D. Incremento de la demanda 12
		E. Otros (especificar) ..... 08 → E1	E. Caída de la demanda 13
		....	F. Otros (especificar) .... 14 ....

M4

8	9	10	11
4º MERCADO (%)	A. No ha variado		
1. 1ª Empresa	01 → E1	A. Cambios en el mercado . 04 → 11	A. Variación en los precios de competidores nacionales 09
2. 2ª Empresa	B. Sí ha variado	B. Cambio en la calidad . . . 05 → E1	B. Variación en los precios de los productos equivalentes importados 10
3. 3ª Empresa	02	C. Cambio en los costes . . . 06 → E1	C. Aparición de nuevos productos o competidores 11
4. 4ª Empresa	signo % de variación → 10	D. Mejoras del beneficio . . . 07 → E1	D. Incremento de la demanda 12
		E. Otros (especificar) ..... 08 → E1	E. Caída de la demanda 13
		....	F. Otros (especificar) .... 14 ....

M5

8	9	10	11
5º MERCADO (%)	A. No ha variado		
1. 1ª Empresa	01 → E1	A. Cambios en el mercado . 04 → 11	A. Variación en los precios de competidores nacionales 09
2. 2ª Empresa	B. Sí ha variado	B. Cambio en la calidad . . . 05 → E1	B. Variación en los precios de los productos equivalentes importados 10
3. 3ª Empresa	02	C. Cambio en los costes . . . 06 → E1	C. Aparición de nuevos productos o competidores 11
4. 4ª Empresa	signo % de variación → 10	D. Mejoras del beneficio . . . 07 → E1	D. Incremento de la demanda 12
		E. Otros (especificar) ..... 08 → E1	E. Caída de la demanda 13
		....	F. Otros (especificar) .... 14 ....

PÁGINA	AJ

E. ACTIVIDADES TECNOLÓGICAS

1

A. No ha realizado ni contratado actividades de I+D — 1 → 3 — E1

B. Ha realizado internamente actividades de I+D pero no ha contratado al exterior — 2

C. Ha contratado actividades de I+D pero no las ha realizado en la empresa — 3 → 2

D. Ha realizado en la empresa y también ha contratado al exterior actividades de I+D — 4

2

INDIQUE LOS GASTOS EN I+D QUE LA EMPRESA REALIZÓ EN 2005, SEGÚN EL DETALLE INDICADO

	No tiene	Tiene	Valor en euros
1. Gastos externos	6	1	E2_1_2
	E2_1_1		
2. Gastos internos	7	2	E2_2_2
	E2_2_1		
3. TOTAL GASTOS I+D			E2_3

3

INDIQUE SI LA EMPRESA REALIZÓ O CONTRATÓ EN 2005 CADA UNA DE LAS SIGUIENTES ACTIVIDADES

		No	Sí
1. Servicios de información científica y técnica	E3_1	6	1
2. Trabajos de normalización y control de calidad	E3_2	7	2
3. Esfuerzos de asimilación de tecnologías importadas	E3_3	8	3
4. Estudios de mercado y marketing para la comercialización de nuevos productos	E3_4	9	4
5. Diseño	E3_5	6	1
6. Otros (especificar) E3_6_2	E3_6_1	7	2

4

INDIQUE SI DURANTE **2005** LA EMPRESA REGISTRÓ **PATENTES EN ESPAÑA** Y SU NÚMERO

E4_1

A. No — 8

B. Sí — 3

E4_2

Número

5

INDIQUE SI DURANTE **2005** LA EMPRESA REGISTRÓ **PATENTES EN EL EXTRANJERO** Y SU NÚMERO

E5_1

A. No — 9

B. Sí — 4

E5_2

Número

6

INDIQUE SI DURANTE **2005** LA EMPRESA REGISTRÓ **MODELOS DE UTILIAD** Y SU NÚMERO

E6_1

A. No — 6

B. Sí — 1

E6_2

Número

7

INDIQUE SI DURANTE **2005** LA EMPRESA HA OBTENIDO **INNOVACIONES DE PRODUCTO** (PRODUCTOS COMPLETAMENTE NUEVOS O CON MODIFICACIONES TAN IMPORTANTES QUE LOS HACEN DIFERENTES DE LOS QUE VENÍA PRODUCIENDO CON ANTERIORIDAD). EN CASO AFIRMATIVO, INDIQUE SU NÚMERO Y EL TIPO DE NOVEDAD QUE SUPONE

		No	Sí	Nº productos
A. Innovaciones de producto	E7_1_1	7	2	E7_1_2
B. Incorpora nuevos materiales	E7_2_1	8	3	
C. Incorpora nuevos componentes o productos intermedios	E7_2_2	9	4	
D. Incorpora nuevo diseño y presentación	E7_2_3	6	1	
E. El producto cumple nuevas funciones	E7_2_4	7	2	

8

INDIQUE SI DURANTE **2005** SE INTRODUJO EN LA EMPRESA ALGUNA MODIFICACIÓN IMPORTANTE EN EL PROCESO DE PRODUCCIÓN (**INNOVACIÓN DE PROCESO**). EN CASO AFIRMATIVO, INDIQUE EN QUÉ SE HA CONCRETADO

E8_1

A. No — 8

B. Sí — 3

E8_2

C. Introducción de nueva maquinaria . . . . — 7

D. Nuevos métodos de organización de producción . . . . — 8

E. Ambas cosas . . . . — 9

9

INDIQUE SI DURANTE 2005 HA ADQUIRIDO MAQUINARIAS O EQUIPOS ESPECÍFICAMENTE COMPRADOS PARA REALIZAR PRODUCTOS NUEVOS O SENSIBLEMENTE MEJORADOS Y/O PROCESOS. EN CASO AFIRMATIVO, INDIQUE EL VALOR DE LA MAQUINARIA O EQUIPOS ADQUIRIDOS (NO INCLUIDO EN I+D, PREGUNTA E2)

E9_1

A. No — 9

B. Sí — 4

E9_2

Valor en euros

10

ORIGEN DE LOS BIENES DE EQUIPO QUE UTILIZA LA EMPRESA (en porcentaje sobre el total)

	No tiene	Tiene	%
1. De fabricación española . . .	6	1	E10_1_2
	E10_1_1		
2. De fabricación extranjera . .	7	2	E10_2_2
	E10_2_1		
9. TOTAL			1 0 0

11

INDIQUE SI LA EMPRESA OBTUVO EN 2005 RECURSOS FINANCIEROS PÚBLICOS PARA LA I + D Y SU ORIGEN Y CUANTÍA

		No tiene	Tiene	Valor en euros
1. De la Administración Central	E11_1_1	6	1	E11_1_2
2. De las Comunidades Autónomas	E11_2_1	7	2	E11_2_2
3. De otros organismos	E11_3_1	8	3	E11_3_2
9. TOTAL				E11_9

12

INDIQUE SI LA EMPRESA OBTUVO EN 2005 INGRESOS POR LICENCIAS Y ASISTENCIA TÉCNICA DEL EXTRANJERO Y SU CUANTÍA

E12_1

A. No — 9

B. Sí — 4

E12_2

Valor en euros

13

INDIQUE SI LA EMPRESA REALIZÓ EN 2005 PAGOS POR LICENCIAS Y ASISTENCIA TÉCNICA DEL EXTRANJERO Y SU CUANTÍA

E13_1

A. No — 6

B. Sí — 1

E13_2

Valor en euros

14

INDIQUE SI LA EMPRESA CONOCE Y APLICA INCENTIVOS FISCALES A I+D E INNOVACIÓN TECNOLÓGICA

1. Conoce los incentivos fiscales — E14_1

A. No — 7 → 15

B. Sí — 2

2. Ha aplicado dichos incentivos en el impuesto de sociedades — E14_2

A. No — 8 → 16

B. Sí — 3 → 15

15

INDIQUE EL VALOR TOTAL DE LAS DEDUCCIONES QUE HA APLICADO EN EL IMPUESTO DE SOCIEDADES DEL AÑO 2005. ESPECIFIQUE LAS REFERIDAS A I+D E INNOVACIÓN TECNOLÓGICA

	Valor en euros
1. Deducciones por I+D	E15_1
2. Deducciones por innovación tecnológica	E15_2
3. Otras deducciones	E15_3
9. TOTAL	E15_9

E. ACTIVIDADES TECNOLÓGICAS (Continuación)

16

INDIQUE SI EN EL AÑO 2005 LA EMPRESA DISPUSO DE LOS SIGUIENTES MECANISMOS O REALIZÓ LAS SIGUIENTES ACCIONES

	Variable	No	Sí
1. Mantuvo una dirección o comité de Tecnología o I + D	E16_1	6	1
2. Contó con un plan de actividades de innovación	E16_2	7	2
3. Se elaboraron indicadores de resultado de la innovación	E16_3	8	3
4. Se colaboró con Universidades y/o centros tecnológicos	E16_4	9	4
5. Hubo colaboración tecnológica con clientes	E16_5	6	1
6. Hubo colaboración tecnológica con proveedores	E16_6	7	2
7. Hubo colaboración tecnológica con competidores	E16_7	8	3
8. Mantuvo acuerdos de cooperación tecnológica (Joint ventures)	E16_8	9	4
9. Participó en empresas que desarrollan innovación tecnológica	E16_9	6	1
10. Incorporó ingenieros y/o licenciados de graduación reciente	E16_10	7	2
11. Reclutó personal con experiencia profesional en el sistema público de I + D	E16_11	8	3
12. Reclutó personal con experiencia empresarial en I + D	E16_12	9	4
13. Financió la innovación con créditos subvencionados	E16_13	6	1
14. Participó en algún programa de investigación de la UE	E16_14	7	2
15. Buscó sin éxito financiación externa de la innovación	E16_15	8	3
16. Utilizó asesores o expertos para informarse sobre tecnologías	E16_16	9	4
17. Evaluó tecnologías alternativas para la empresa	E16_17	6	1
18. Evaluó las perspectivas de cambio tecnológico	E16_18	7	2

F. COMERCIO EXTERIOR

1

INDIQUE SI LA EMPRESA, BIEN DE FORMA DIRECTA, O BIEN A TRAVÉS DE OTRAS EMPRESAS DE SU MISMO GRUPO, REALIZÓ EXPORTACIONES EN 2005 (Incluso a la Unión Europea) Y SU VALOR

F1_1

A. No 6 → 4

B. Sí 1

F1_2 ____________ Valor en euros

2

INDIQUE EL DESTINO DE SUS EXPORTACIONES EN 2005 Y SU DISTRIBUCIÓN POR ÁREAS GEOGRÁFICAS EN PORCENTAJE

	Variable	No	Sí	%
1. Unión Europea	F2_1_1	7	2	F2_1_2
2. Resto de la O.C.D.E. (Australia, Canadá, Corea, Estados Unidos, Islandia, Japón, México, Noruega, Nueva Zelanda, Suiza, Turquía)	F2_2_1	8	3	F2_2_2
3. Iberoamérica	F2_3_1	9	4	F2_3_2
4. Resto del mundo	F2_4_1	6	1	F2_4_2
9. TOTAL				1 0 0

3

INDIQUE SI LA EMPRESA UTILIZÓ EN 2005 CADA UNO DE ESTOS MECANISMOS COMO VÍA DE ACCESO A LOS MERCADOS INTERNACIONALES

	Variable	No	Sí
1. Dispone de medios propios (red de agentes, sucursal, delegación o empresa filial)	F3_1	1	6
2. Utiliza una empresa matriz instalada en el extranjero (empresas con capital extranjero)	F3_2	2	7
3. Utiliza un intermediario especializado establecido en España	F3_3	3	8
4. Participa en alguna modalidad de acción colectiva hacia la exportación (acuerdo sectorial de exportación, asociación de exportadores o cooperativas de exportación)	F3_4	4	9
5. Otras (especificar)	F3_5_1	1	6

F3_5_2 ....

4

INDIQUE SI LA EMPRESA, BIEN DE FORMA DIRECTA, O BIEN A TRAVÉS DE OTRAS EMPRESAS DE SU MISMO GRUPO, REALIZÓ **IMPORTACIONES** EN **2005** (Incluso de la Unión Europea) Y SU VALOR

F4_1

A. No 7 → G1

B. Sí 2

F4_2 ____________ Valor en euros

5

INDIQUE EL ORIGEN DE SUS IMPORTACIONES EN 2005 Y SU DISTRIBUCIÓN POR ÁREAS GEOGRÁFICAS EN PORCENTAJE

	Variable	No	Sí	%
1. Unión Europea	F5_1_1	8	3	F5_1_2
2. Resto de la O.C.D.E. (Australia, Canadá, Corea, Estados Unidos, Islandia, Japón, México, Noruega, Nueva Zelanda, Suiza, Turquía)	F5_2_1	9	4	F5_2_2
3. Iberoamérica	F5_3_1	6	1	F5_3_2
4. Resto del mundo	F5_4_1	7	2	F5_4_2
9. TOTAL				1 0 0

6

INDIQUE SI REALIZÓ EN 2005 IMPORTACIONES DE PRODUCTOS DE EMPRESAS EXTRANJERAS CON LAS QUE MANTIENE ACUERDOS DE COMERCIALIZACIÓN Y DISTRIBUCIÓN O QUE PARTICIPAN EN EL CAPITAL DE LA EMPRESA, Y SU PORCENTAJE SOBRE EL TOTAL DE IMPORTACIONES

F6_1

A. No 8 → G1

B. Sí 3

F6_2 ______ Porcentaje

7

INDIQUE SI DICHO PORCENTAJE SE REFIERE MAYORITARIAMENTE A PRODUCTOS SIMILARES A LOS PRODUCIDOS POR LA EMPRESA EN ESPAÑA

F7

A. No 9

B. Sí 4

PÁGINA	AL

G. EMPLEO

1

PERSONAL OCUPADO EN LA EMPRESA, AL 31 DE DICIEMBRE DE 2005, SEGÚN LAS MODALIDADES QUE SE INDICAN (En instalaciones fabriles y en establecimientos no industriales)

	No tiene	Tiene	Número
1. Propietarios y ayudas familiares			
1.1. En puestos de Dirección o Gerencia . . . . G1_1_1_1	6	1	G1_1_1_2
1.2. En otros puestos . . . . G1_1_2_1	7	2	G1_1_2_2
2. Otro personal			
2.1. Asalariado fijo (contrato indefinido)			
2.1.1. A tiempo completo . . . . G1_2_1_1	8	3	G1_2_1_2
2.1.2. A tiempo parcial . . . . . G1_2_2_1	9	4	G1_2_2_2
2.2 Asalariado eventual (contrato temporal) . . G1_2_3_1	6	1	G1_2_3_2
9. TOTAL DEL PERSONAL DE LA EMPRESA AL 31/12/2005 (Suma de 1.1+1.2+2.1.1+2.1.2+2.2)			G1_9

2

NÚMERO DE TRABAJADORES EVENTUALES EN LA EMPRESA Y VARIACIONES SIGNIFICATIVAS DURANTE EL AÑO

G2

A. No tiene eventuales 6 → 4

B. El número de eventuales no varía significativamente . . 2 → 4

C. El número de eventuales sí varía significativamente . . . . 3 → 3

3

NÚMERO DE TRABAJADORES EVENTUALES A FINALES DE CADA TRIMESTRE EN 2005

	No	Sí	Número
A. I Trimestre . . . G3_1_1	7	2	G3_1_2
B. II Trimestre . . . G3_2_1	8	3	G3_2_2
C. III Trimestre . . G3_3_1	9	4	G3_3_2
D. IV Trimestre . . G3_4_1	6	1	G3_4_2

4

CLASIFICACIÓN DEL TOTAL DEL PERSONAL DE LA EMPRESA AL 31 DE DICIEMBRE DE 2005 SEGÚN LAS SIGUIENTES CATEGORÍAS

	No tiene	Tiene	Número
1. Trabajadores de producción (obreros) . . . . G4_1_1	7	2	G4_1_2
2. Empleados y subalternos (Directivos y técnicos, personal de oficina, vendedores subalternos, limpiadores) . G4_2_1	8	3	G4_2_2
9. TOTAL			G4_9

5

CLASIFICACIÓN DEL TOTAL DEL PERSONAL DE LA EMPRESA AL 31 DE DICIEMBRE DE 2005 SEGÚN SU TITULACIÓN

	No tiene	Tiene	Número
1. Ingenieros superiores y licenciados G5_1_1	6	1	G5_1_2
2. Ingenieros técnicos, peritos y ayudantes titulados . . . . . G5_2_1	7	2	G5_2_2
3. Resto del personal . . G5_3_1	8	3	G5_3_2
9. TOTAL . . .			G5_9

6

PERSONAL DEDICADO A ACTIVIDADES DE I+D EN 2005 (Número de personas en equivalencia a jornada completa)

	No tiene	Tiene	Número
1. Titulados superiores G6_1_1	9	4	G6_1_2
2. Técnicos de grado medio . . G6_2_1	6	1	G6_2_2
3. Personal auxiliar . . G6_3_1	7	2	G6_3_2
9. TOTAL . .			G6_9

7

JORNADA NORMAL VIGENTE EN 2005 (Por legislación, convenio o pacto) PARA LA MAYOR PARTE DEL PERSONAL

G7

Horas al año por persona ocupada

8

INDIQUE SI SE REALIZARON HORAS EXTRAORDINARIAS EN 2005 Y SU NÚMERO MEDIO POR PERSONA OCUPADA

A. No G8_1 8

B. Sí 3

G8_2

Horas al año por persona ocupada

9

INDIQUE SI HUBO HORAS NO TRABAJADAS (Por regulación de empleo, conflicto colectivo, falta ocasional al trabajo, etc.) EN 2005 Y SU NÚMERO MEDIO POR PERSONA OCUPADA

A. No G9_1 9

B. Sí 4

G9_2

Horas al año por persona ocupada

10

INDIQUE SI SU EMPRESA UTILIZÓ DURANTE 2005 PERSONAL FACILITADO POR EMPRESAS DE TRABAJO TEMPORAL (ETT), SU NÚMERO Y DURACIÓN MEDIA

G10_1

A. No 6

B. Sí 1

G10_2_1

Número de personal facilitado (Media anual)

G10_2_2

Número de horas trabajadas en el año por todo el personal de las ETT

11

INDIQUE LOS GASTOS EXTERNOS EN LA FORMACIÓN DE LOS TRABAJADORES QUE SU EMPRESA REALIZÓ EN 2005, SEGÚN EL DETALLE INDICADO

	No tiene	Tiene	Valor en euros
1. Informática y tecnologías de la información . . . . . . G11_1_1	7	2	G11_1_2
2. Idiomas . . . . G11_2_1	8	3	G11_2_2
3. Ventas y Marketing . . . . G11_3_1	9	4	G11_3_2
4. Ingeniería y formación técnica . . . . . . G11_4_1	6	1	G11_4_2
5. Otros temas G11_5_1	7	2	G11_5_2
9. TOTAL GASTOS			G11_9

VALORES SIN IVA NI OTROS IMPUESTOS REPERCUTIDOS

H. DATOS CONTABLES DE 2005

PÁGINA | AM

PRE-GUNTA	H.A. RESUMEN DE ALGUNAS PARTIDAS DE LA CUENTA DE EXPLOTACIÓN	No tiene	Tiene	Signo	Valor en euros
1	**VENTAS (Plan General de Contabilidad, C.70)**				
	1. De productos transformados (C.701 + C.702)	6	1 HA1_1		
	2. De mercaderías (para revender en el mismo estado en que se adquieren) (C.700)	7	2 HA1_2		
	3. Prestación de servicios (C.705)	8	3 HA1_3		
	4. Otras ventas (envases, embalajes, subproductos y residuos, menos rappels y devoluciones de ventas) (C.703 + C.704 - C.708 - C.709)	9	4 HA1_4		
	9. TOTAL VENTAS				HA1_9
2	**VARIACIÓN DE EXISTENCIAS DE VENTAS (de productos terminados y en curso de fabricación) (C.71)**	6 HA2_1	1		HA2_2
3	**OTROS INGRESOS DE GESTIÓN CORRIENTE (arrendamientos, propiedad industrial, comisiones y otros) (C.752 + C.753 + C.754 + C.755 + C.759)**	7 HA3_1	2		HA3_2
4	**COMPRAS (C. 60)**				
	1. De mercaderías (para venderlas en el mismo estado en que se adquirieron) (C.600)	8	3 HA4_1		
	2. De materias primas y otros aprovisionamientos (C.601 + C.602)	9	4 HA4_2		
	3. Trabajos realizados por otras empresas (subcontratas) (C.607)	6	1 HA4_3		
	4. (Menos) Rappels y devoluciones de compras (C.608 + C.609)	7	2 HA4_4		
	9. VALOR COMPRAS				HA4_9
5	**VARIACIÓN DE EXISTENCIAS DE COMPRAS (de mercaderías, materias primas y otros aprovisionamientos) (C.61)**	8 HA5_1	3		HA5_2
6	**GASTOS DE PERSONAL (sueldos y salarios, indemnizaciones, cotizaciones sociales, aportaciones al sistema de pensiones y otros gastos de personal) (C.64)**	9 HA6_1	4		HA6_2
7	**SERVICIOS EXTERIORES (C. 62)**				
7.1	GASTOS ENCARGADOS A OTRAS EMPRESAS EN INVESTIGACIÓN Y DESARROLLO DEL EJERCICIO (C. 620)	HA7_1_1 6	1		HA7_1_2
7.2	GASTOS DE PUBLICIDAD, PROPAGANDA Y RELACIONES PÚBLICAS (C. 627)	HA7_2_1 7	2		HA7_2_2
7.3	OTROS SERVICIOS EXTERIORES (C. 621+622+623+624+625+626+628+629)	HA7_3_1 8	3		HA7_3_2
7.9	TOTAL SERVICIOS EXTERIORES (7.1 + 7.2 + 7.3)				HA7_9

PRE-GUNTA	H.B. INVERSIONES	No tiene	Tiene	Valor en euros
1	**COMPRAS Y GRANDES REPARACIONES DE INMOVILIZADO MATERIAL REALIZADAS EN EL EJERCICIO (incluso leasing financiero)**			
1.1	DE TERRENOS Y BIENES NATURALES (C. 220)	HB1_1_1 6	1	HB1_1_2
1.2	DE CONSTRUCCIONES (C. 221)	HB1_2_1 7	2	HB1_2_2
1.3	DE EQUIPOS PARA PROCESOS DE INFORMACIÓN (C. 227)	HB1_3_1 8	3	HB1_3_2
1.4	DE INSTALACIONES TÉCNICAS, MAQUINARIA Y UTILLAJE (C. 222 + C. 223 + C.224)	HB1_4_1 9	4	HB1_4_2
1.5	DE ELEMENTOS DE TRANSPORTE (C. 228)	HB1_5_1 6	1	HB1_5_2
1.6	DE MOBILIARIO, EQUIPO DE OFICINA (excepto para proceso de información) Y OTRO INMOVILIZADO MATERIAL (C. 225 + C. 226 + C. 229)	HB1_6_1 7	2	HB1_6_2
1.9	TOTAL COMPRAS Y GRANDES REPARACIONES DE INMOVILIZADO MATERIAL REALIZADAS EN EL EJERCICIO (Suma de 1.1 a 1.6)			HB1_9
2	**VENTAS DE INMOVILIZADO MATERIAL REALIZADAS EN EL EJERCICIO**	HB2_1 8	3	HB2_2

PÁGINA	AN

H. DATOS CONTABLES DE 2005 (Continuación)

PRE-GUNTA	H.C. DATOS DEL ACTIVO DEL BALANCE Y RELACIONADOS	DATOS						
	DATOS DEL INMOVILIZADO (Partida B), SEGÚN BALANCE DE 2005	No tiene	Tiene	Valor en euros	REGULARIZADO O ACTUALIZADO No / Sí	AÑO ÚLTIMA REGULARIZACIÓN	ANTIGÜEDAD MEDIA DE LOS ACTIVOS (En años)	ESTIMACIÓN DEL COSTE DE REEMPLAZO A PRECIOS DE 2005 (Valor en euros)
1	INMOVILIZADO MATERIAL (C.22)							
1.1	Terrenos y bienes naturales (C.220)	HC1_1_1 6	1	HC1_1_2	HC1_1_3 9 / 4	HC1_1_4		
1.2	Construcciones (c.221)	HC1_2_1 7	2	HC1_2_2	HC1_2_3 6 / 1	HC1_2_4	HC1_2_5	
1.3	Resto de inmovilizado material (C.222 + C.223 + C.224 + C.225 + C.226 + C.227 + C.228 + C.229). Instalaciones técnicas, maquinaria, utillaje, mobiliario, equipo de oficina, equipos para procesos de información, elementos de transporte y otro inmovilizado material	HC1_3_1 8	3	HC1_3_2	HC1_3_3 7 / 2	HC1_3_4	HC1_3_5	HC1_3_6
1.9	TOTAL (Suma de 1.1 + 1.2 + 1.3)			HC1_9_2				
2	GASTOS DE ESTABLECIMIENTO, INMOVILIZADO INMATERIAL E INMOVILIZADO FINANCIERO (C.20 + C.21 + C.24 + C.25+ C.26)	HC2_1 9	4	HC2_2				
3	AMORTIZACIÓN ACUMULADA Y PROVISIONES (C.28 + C.29)	HC3_1 6	1	HC3_2				

PRE-GUNTA	H.D. DATOS DEL PASIVO DEL BALANCE Y RELACIONADOS	DATOS							
	DATOS DE PARTIDAS Y CUENTAS DEL PASIVO, SEGÚN BALANCE DE 2005, Y DATOS RELACIONADOS	No tiene	Tiene	Valor en euros	COSTE MEDIO (%)	VOLUMEN DE LA FINANCIACIÓN QUE LA EMPRESA OBTUVO EN 2005: No tiene	Tiene	Valor en euros	COSTE (%)
1	FONDOS PROPIOS (Partida A). CAPITAL, RESERVAS, ETC.	HD1_1 6	1	HD1_2					
2	ACREEDORES A LARGO PLAZO (Partida D)								
2.1	Deudas con entidades de crédito (C.170) .	HD2_1_1 7	2	HD2_1_2	HD2_1_3	HD2_1_4 9	4	HD2_1_5	HD2_1_6
2.2	Otros (Resto de acreedores a largo plazo)	HD2_2_1 8	3	HD2_2_2	HD2_2_3	HD2_2_4 6	1	HD2_2_5	HD2_2_6
2.9	TOTAL (Suma de 2.1 + 2.2)			HD2_9_2				HD2_9_5	
3	ACREEDORES A CORTO PLAZO (Partida E)								
3.1	Deudas con entidades de crédito (C.520 y C.526)	HD3_1_1 9	4	HD3_1_2		HD3_1_4 7	2	HD3_1_5	HD3_1_6
3.2	Empréstitos y otras emisiones (C.50) . . .	HD3_2_1 6	1	HD3_2_2					
3.3	Otros (Resto de acreedores a corto plazo)	HD3_3_1 7	2	HD3_3_2					
3.9	TOTAL (Suma de 3.1 + 3.2 + 3.3)			HD3_9_2					

PÁGINA	AP

1	2	3	4	5
INDIQUE SI LA INFORMACIÓN SE REFIERE:	NOMBRE, APELLIDOS, CARGO, TELÉFONO Y FAX DE LA PERSONA QUE **AUTORIZA** LA CUMPLIMENTACIÓN DEL CUESTIONARIO	NOMBRE, APELLIDOS, CARGO, TELÉFONO Y FAX DE LA PERSONA **RESPONSABLE** DE LA CUMPLIMENTACIÓN DEL CUESTIONARIO	ÁREAS A LA QUE ESTÁN ADSCRITOS LOS DEPARTAMENTOS QUE HAN INTERVENIDO EN LA RESPUESTA AL CUESTIONARIO	NÚMERO DE PERSONAS QUE HAN INTERVENIDO EN LA CUMPLIMENTACIÓN DEL CUESTIONARIO
P1 A. A la empresa ☐ 6 B. A un conjunto de empresas (por no ser posible separar la información referida a cada una de ellas) ☐ 1	P2_1 Nombre P2_2 1er. apellido P2_3 2º apellido P2_4 Cargo P2_5 Teléfono P2_6 Fax: P2_7 Correo electrónico	P2_1 Nombre P2_2 1er. apellido P2_3 2º apellido P2_4 Cargo P2_5 Teléfono P2_6 Fax: P2_7 Correo electrónico	No / Sí P4_1 1. Producción ☐ 1 ☐ 6 P4_2 2. Comercial ☐ 2 ☐ 7 P4_3 3. Recursos humanos ☐ 3 ☐ 8 P4_4 4. Económico-financiero ☐ 4 ☐ 9 P4_5_1 5. Otros (especificar) ☐ 1 ☐ 6 P2_5_2	P5 Número de personas

6	7	8
DENOMINACIÓN DE LA EMPRESA	DIRECCIÓN DE LA EMPRESA	INDIQUE SI EN 2005 LA EMPRESA EXPERIMENTÓ ALGUNA DE LAS SIGUIENTES SITUACIONES
P6	A. Vial (tipo nombre vial, nº y piso) P7_1 P7_2 B. Municipio P7_3 C. Entidad P7_4 D. Provincia P7_5 E. Cód. postal P7_6	P8 A. Ha segregado alguna/s parte/s de la empresa ☐ 1 B. Ha absorbido otras empresas ☐ 2 C. Es el resultado de un proceso de escisión ☐ 3 D. Es el resultado de la fusión de varias empresas ☐ 4 E. Únicamente ha cambiado de nombre y/o forma jurídica ☐ 5 F. La empresa no ha atravesado ninguna de estas situaciones ☐ 6

9	10	11	12
INDIQUE SI A LO LARGO DE **2005** LA PLANTILLA DE TRABAJADORES FIJOS SE ALTERÓ **SIGNIFICATIVAMENTE** A CAUSA DE ALGUNA DE LAS SIGUIENTES SITUACIONES	INDIQUE SI HA RESPONDIDO **SÍ** A ALGUNA DE LAS ANTERIORES SITUACIONES	DETALLE DE LA SITUACIÓN DE LA PLANTILLA DE TRABAJADORES FIJOS A FINALES DE CADA TRIMESTRE DE 2005	INDIQUE SI LA EMPRESA DURANTE 2005 CONTABILIZÓ EN GASTOS DE PERSONAL INDEMNIZACIONES POR DESPIDOS, JUBILACIONES ANTICIPADAS O BAJAS INCENTIVADAS
No / Sí P9_1 1. Traspaso de plantilla entre la empresa y otras ☐ 1 ☐ 6 P9_2 2. Segregación o integración de colectivos en plantilla (comisionistas, red comercial, transportistas, etc.) ☐ 2 ☐ 7 P9_3 3. Expedientes de regulación de empleo con suspensión temporal de contratos ☐ 3 ☐ 8 P9_4 4. Reducción de plantilla (expedientes con extinción de contratos, jubilaciones anticipadas, bajas incentivadas, etc.) ☐ 4 ☐ 9 P9_5_1 5. Otras situaciones (especificar) ☐ 1 ☐ 6 P9_5_2	P10 A. No ☐ 7 → 12 B. Sí ☐ 2 → 11	Número 1. I Trimestre P11_1 2. II Trimestre P11_2 3. III Trimestre P11_3 4. IV Trimestre P11_4	P12_1 A. No ☐ 3 B. Sí ☐ 8 P12_2 Valor en euros

OBSERVACIONES

P13