BEES OR BUTTERFLIES? WHEN CONSISTENT STRATEGIES IN R&D PAY OFF.

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Abstract

We derive insights from the Resource-Based View literature to assess the effects of different R&D strategies on firm´s performance in terms of growth of firm's size (measured by total sales) and profitability (growth of returns on sales (ROS), and returns on assets (ROA)). In particular, a firm can: never invest in R&D; occasionally invest or persistently invest in R&D. Using dynamic panel-data models, we analyse the impact of the three different strategies on the performance of Spanish manufacturing firms during the period 1990-2013. The results suggest that firms which always and occasionally invest in R&D have better performance in terms of ROS growth than those who never invest in R&D. However, R&D strategies that affect positively ROS growth sometimes have a negative influence on sales growth and on ROA growth depending on initial conditions and firms heterogeneity.

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1. INTRODUCTION.

Innovation plays an important role for firm's performance. Innovation is one of the major competitive resources within the firm, but uncertainty and dynamism of markets do not always assure the conversion of R&D in firm's performance. For many companies, the struggle to maintain a sustainable performance while controlling costs has resulted in inefficient R&D decisions that have conducted to inadequate results.

Recent literature suggests that the competitive positions of firms are only in part a function of the level of resources they posses (Newbert et al., 2008), while the strategic management of them is the necessary complement to achieve the success. Although R&D is an essential resource in the first steps of the innovation process, it is not always guaranteed that it enables organizations to improve their capabilities and gain more competitive advantage. From this perspective, firms handle R&D in different ways and subsequently develop distinct capabilities and performance. That means that firms' performance differs according to the heterogeneity of resources and capabilities across firms (Hoopes et al., 2003). Firm's strategies and innovation processes are interdependent and complementary to ensure good performance within firms under challenging and changing conditions of the environment (Miller, 1987). The dynamic interaction between technology and strategy at the firm level is based on the premise that strategy should make the best possible use of technology currently or potentially available to the firm (Itami and Numagami, 1992). Moreover, R&D investments imply explicit managerial intentions and a clear planning. Companies are required to pursue a coherent technology strategy to articulate its plans to develop, acquire and deploy technological resources if they want to achieve superior performance (Zahra, 1996).

There exist a growing body of literature that maintains that firms with significant R&D perform better than other firms, that is, firm´s performance is positively correlated with the level (or the intensity) of the R&D investment (Klette and Griliches, 2000; Del Monte and Papagni, 2003; Blanchard et al., 2005; Tsai and Wang, 2005; Adamou and Sasidharan, 2007; Filatovchev and Piesse, 2009; Artz et al., 2010; Bogliacino and Pianta, 2011). However, the contributions that study the effects of a specific R&D strategy on firms' performance are scarcer. In this paper we focus on the effect on firms' performance of three different R&D strategies that regards the frequency, or, in other words, the persistence with which firms do R&D investments.

A substantial research effort has been devoted to examine the persistence in innovation activities at the firm level. Among the most recent researches, we find Raymond et al. (2010), Peters (2009) and Roper and Hewitt-Dundas (2008). In addition, Cuervo-Cazurra and Un (2010) study the determinants of the frequency of formal R&D investments indentifying five strategies: never, always, start, stop, and vary investing in R&D. They link real option theory to the knowledge-based view to explain why many firms never invest in R&D. Nevertheless, to the best of our knowledge, there are very few studies that focus on the effect of innovation persistence on firms´ performance (Cefis, 2003; Cefis and Ciccarelli, 2005). These studies show that firms develop distinct capabilities and competencies when innovate persistently, and that the differences in profitability between innovators and non-innovators become more prominent in case of persistent innovators. The importance of adopting a long-term perspective in R&D strategy for firm´s performance has not been largely analyzed. Most of the empirical literature has studied this relationship in a cross-section framework (see, e.g., Klette and Kortum, 2004; Johansson and Lööf, 2008, and 2010) or it has not focused in a particular R&D strategy (Hall, 2007).

We drive insights from the RBV literature that consider firm resources, capabilities and competitive actions as drivers of superior performance (Sirmon et al., 2007, 2010; Ndofor et al., 2011), to assess the effects of the frequency of the R&D efforts on firm´s performance. In particular, we distinguish three different R&D strategies: a firm can i) never invest in R&D; ii) occasionally invest; iii) persistently invest. Our aim is to measure the impact that this three different strategies have on firm´s performance in terms of firm's and profitability.

The analysis is carried out at firm-level, covering the Spanish manufacturing industry over a period of 23 years, 1990-2013. The data come from ESEE (*Encuesta sobre Estrategias Empresariales*) compiled by the Spanish Ministry of Science and Technology. The panel data is an unbalanced panel that include all the industrial sectors.

We chose as proxies of firm´s performance three different variables: growth in firm's size measured by total sales, and firm's profitability measured by ROS - Return On Sales and ROA – Return An Assets With regard to the research objectives, we employ a measure based on the estimation of Transition Probabilities Matrices (TPM) for each firm for two purposes: to calculate the persistence degree of firm's R&D investments and to distinguish between persistent, occasional and non- R&D strategies.

We estimate dynamic random effects models that control for the initial condition problem and for the firms unobserved heterogeneity (Wooldridge, 2005). We introduce the R&D intensity in the first year in which the firms appear in the dataset as the initial condition, taken into account the importance of the sunk costs in the R&D decision.

Furthermore, we introduce as controls some variables referred to the market dynamism in order to reflect the influence of demand and changing environment conditions as well as the control variables referred to firms characteristics like size, age, export, and a dummy variable to the firms that have foreign ownership participation (at least 50%). Finally, we include Pavitt taxonomy classification to capture technological differences and year dummies to consider economy-wide influences on firm behaviour.

The results suggest that R&D efforts are an important innovation source for firms´ performance and consistent strategies in R&D pay off. Firms that always and occasionally invest in R&D have better performance in terms of ROS growth than those who never invest in R&D. However, R&D strategies that affect positively ROS growth sometimes have a negative influence on sales growth and on ROA growth depending on initial conditions and firms heterogeneity.

The rest of this article is organized as follows. In Section 2, the theoretical background and main hypotheses are introduced. In Section 3, the data, variables and methodology used to contrast the importance of R&D strategy as a capability to improve firm's performance are presented. Based on this approach, we present the main results obtained after the random effects estimation of three different models that link R&D strategy and firm´s performance in section 4. Finally, conclusions and discussion are proposed in Section 5.

2. THEORETHICAL BACKGROUND AND HYPOTHESES.

The development and application of innovative capabilities are central to the definition of an innovation strategy. Since the seminal contribution of Barney (1991), the resource-based view (RBV) suggests that possessing valuable, rare, inimitable and non-substitutable resources provides the basis for value creation through the development of competitive advantage (Barney, 1991). However, merely performing R&D activities does not guarantee the generation of value or getting a competitive position. R&D is not "*valuable, rare and, inimitable*" (VRI) *per se*. Organizational capabilities must be also considered because some firms are enabled to make the best use of these resources to maximize their performance (Mahoney and Pandain, 1992; Peteraf, 1993; Henderson and Cockburn, 1994). In this sense, Barney´s VRI resources emerges as a more completed theoretical approach pondering the resources´ level inside an appropriate dynamic capability or organizing context (Newbert, 2007). Thus, processes in which resources are exploited must be considered. A firm needed to be organized in such a manner (strategy) that it could exploit (utilize) the full potential of those resources to attain a competitive advantage (Barney, 2001; Newbert, 2007).

Indeed, the competitive dynamics perspective relay on actions or strategies. Specifically, this approach focuses on actions (and reactions) that firms initiate to enhance their competitive position and improve performance (Ndofor et al., 2011). The "dynamic capabilities" approach is also considered highlighting the importance of internal and external firm-specific competences to deal with changing environments (Teece et al., 1997). For a long time the innovation process and management of technology have been studied separately, but strategy-making and technological processes are interdependent and complementary to ensure good performance within firms under challenging conditions of environment (Miller, 1987). Combining organizational and environmental factors allows for a dynamic strategic fit, which has been considered necessary to improve firm performance (Zajac et al., 2000). A firm's ability to adapt to shifting knowledge environments is central to ensure competitiveness and survival (Eisenhardt and Martin, 2000). In particular, it conceives that actions can enhance or create the competitive advantages of the firm and undermine the advantages of competitors (Sorenson, 2000; Katila and Chen, 2008).

The competitive positions of firms are only in part a function of the level of resources they posses (Newbert et al., 2008). Individually, the RBV and the competitive dynamics approaches provide a partial picture of performance drivers (Achidi et al., 2011). RBV refers to resources and competitive dynamics to actions, but resources and actions are intimately related. Sirmon et al. (2007) suggest the resource management theory that relies on linking firms' actions with firms' resources to explain the value creation in dynamic environmental contexts. Components of this theory include structuring the resource portfolio;

bundling resources to build capabilities; and leveraging capabilities to gain a competitive advantage, providing value to customers, and creating wealth for owners (Sirmon et al., 2007). The recent theoretical and empirical literature associated to resource management is capable to consider jointly the significance of resources, capabilities and actions (Sirmon et al., 2011).

In this paper, we focus on the effect of a formulated leveraging R&D strategy on firms´ performance where leveraging refers to the application of a firm's capabilities to improve the firm´s performance. Concretely, we concern about how firms bundle these technological input resources into valuable capabilities and their influences on performance.

In a R&D strategy, the first step is possessing and coordinating R&D and the second step is deploying to enable to implement it inside the firm (Sirmon et al., 2007). Deploying is the process of physically using capability configurations to support the R&D chosen leveraging strategy. This deploying process involves using individual capabilities to support the chosen strategy. The strength (or the potential) of the firm's capabilities to improve firms´ performance via a particular resource (R&D) and a specific action (invest always, sometimes or never in R&D) shape a particular deployment (strategy) that influences performance reflecting the success of this resource deployment. In this way, we consider how the "match" between capabilities and actions explains performance. Not just the availability of capabilities (RBV) or only the fit between actions (competitive dynamics) affects performance (Ndofor et al., 2011). Combining both approaches, we aim to explain different firms' performance depending on different uses (actions) of R&D (resource).

Within a sample of heterogeneous firms, the likely existence of significant cross-sectional and longitudinal differences in capabilities (firms´ heterogeneity) will lead also to different actions (heterogeneous strategies). Consequently, firms conduct diverse exploitation of R&D (heterogeneous dynamic resource management) that will result in dissimilar firms' performances.

Respect to our research interest, empirical studies have mainly implemented a variance approach considering resources and/or capabilities as the unique explanatory variables and different measures of performance as the dependent variable. Such research attempts have concluded that while superior resources or capabilities are usually necessary to get a better performance o competitive advantage. However, these studies are not enough to explain the processes taking place between resources and performance (Crook et al., 2008; Ndofor et al., 2011). One of the main aims of this work is to try to give a possible explanation for why firms spending the same money or having similar R&D intensity levels -even facing comparable market environments- can experience different performances depending on their particular R&D strategy. Namely, we consider in the following hypotheses the influence of R&D decision, frequency and deployment on firm´s performance.

The R&D strategies.

The R&D firms' decision depends on internal and external firms' characteristics. Internal characteristics are directly related to firms' capabilities (financial resources, human capital, etc). These are clearly pre-conditions to decide to invest in R&D. Firms decide to do R&D only if they reach a sort of minimum "status" defined by minimum knowledge base (skilled people), minimum financial resources, minimum infrastructure (R&D laboratories). Only those firms that arrive to this minimum state are those that have better capabilities and so can have better performance

In this sense, R&D has traditionally been associated with competitive advantage and productivity because R&D efforts are fundamental to get innovations and develop new products, processes or entry in new markets (Ettlie, 1998). Researchers have largely examined the factors associated with increased or decreased firm R&D spending but less has been done to examine separately the factors that determine the R&D decision-making to the R&D intensity. Factors guiding the R&D decisions can differ to reasons to do more or less R&D. Firm´s financial resources (Helfat, 1997; Cuervo-Cazurra and Un, 2010), past R&D experience and organizational learning or adjustment costs (Helfat, 1997), human capital and relationships with customers, suppliers or parent company (Cuervo-Cazurra and Un, 2011) could explain why a firm decides to do or not to do R&D. A firm's strategy also must contemplate a set of diverse competitive actions it carries out to attract new clients and defend its market share (Miller and Chen, 1994) and within these choices R&D is usually contemplated. Thus, we hypothesize that:

Hypothesis 1a: Firms that always invest in R&D have better performance than those who never or occasionally invest in R&D.

Actually, firms decide to experiment with novel, emerging and pioneering technologies to generate significant returns following several entrepreneurial strategies (Ahuja and Lampert, 2001). But to follow novel (imitative), adaptative (emerging) or pioneering technologies require considerable slack resources and also implies economic stakes associated with the uncertainty of breakthrough inventions or innovations (Lant and Mezias, 1990). This is one of the reasons to some firms decide not investing always money in R&D. In this way, they renounce to superior benefits (e.g., they accept to use a fixed technology in their production processes during some period) but also avoid the undesirable R&D failures associated to the existence of sunk costs and technological spillovers linked to the R&D decision. Therefore, we hypothesize that:

Hypothesis 1b: Firms that occasionally invest in R&D have better performance than those who never invest in R&D.

The dynamics of R&D strategies

The dynamics R&D strategies define the history of the firms' R&D frequency. The history affects firm´s performance because it includes firms' successes and failures related with technological capabilities. Ahuja and Katila (2004) affirm that "*the acquisition of technological capabilities is inherently evolutionary: firms experiment to find the correct investment along a given search path, and frequently make mistakes, both undershooting and overshooting the most productive levels of search*".

If a firm has been successful in R&D investments probably it is going to institutionalized the R&D. Propensities to engage in R&D differ across firms and tend to be stable within firms over time because the institutionalization of R&D (Chen and Miller, 2007). Institutionalized R&D is going to improve firms performance increasing firms capabilities. If a firm has made unsuccessful in

R&D in the past, it is probably going to review (or to revert) the decisions to do R&D and/or the frequency to do R&D. This will create a discontinuity in the R&D firm history (occasional investment in R&D). The discontinuity (or the occasionality of R&D) is a firm-specific characteristic since it depends on each firm's history.

The heterogeneity in the history of R&D leads to different firms' performances. The history of resource deployments can be particularly critical if a firm's strategic objective is to develop a distinct innovative capability (Kor and Mahoney). Furthermore, if firm has certain flexibility it would be good in more unstable markets where competitive advantage is not guaranteed (Chen, 2010). In this sense, a firm that always do R&D can be deteriorating their firm performance assuming high risks associated to the development and management of the innovative capabilities. Specifically, the appropriability problems of R&D accentuate the importance of analyzing the frequency of investments in R&D (Cuervo-Cazurra and Un, 2010).

But, what is true is that firms hold heterogeneous resource positions about their R&D decisions over time (Helfat, 1994; Knott, 2003). Zott (2003) explores how the dynamic capabilities of firms associated to timing, cost, and learning of resource deployment explain the intra-industry differences in firm performance using a simulation analysis. But firms belong to the same industry can take different decisions and with different frequencies about do or not to do R&D every year. A direct implication of this belief is that it is needed to explore how the dynamics and the history of R&D management decision of each firm affect its performance. Hence, we hypothesize that:

Hypothesis 2: The dynamics R&D strategies affects firm's performance.

In particular, this implies the following hypothesis:

Hypothesis 2a: The more frequently a firm invest in R&D the higher will be the effects on firm's performance

Hypothesis 2b: A persistent R&D strategy affects positively firm's performance.

The size of the R&D investment.

R&D efforts are made to build and/or maintain innovativeness, and firms often diverge significantly in the intensity of such R&D investments. However, science and money do not always go together (Durand et al., 2008). A precarious patent system or a low absorptive capacity can risk the appropriability of the returns to R&D. In this sense, allocation of inventive efforts is complex because the rent generation associated to the level of R&D expenditures can be minored (Ethiraj, 2007). As Cohen and Levinthal (1990) affirm ''*R&D creates a capacity to assimilate and exploit new knowledge* (p.148)". Therefore firms doing more R&D must have a better performance than firms doing less R&D.

The influence of R&D intensity on performance has been the traditional variable of interest in previous studies. Like the determinants of the frequency of R&D investments differ from the determinants of the amount invested in R&D (Cuervo-Cazurra and Un, 2010), we consider the frequency and the intensity of R&D. When a firm has an institutionalized R&D or an occasional R&D the level of R&D expenses vary depending on the aims of each firm. If the firm wants to be a leading firm in its technology field (be a pioneering in terms of technological position) it is going to (has to) chose for an higher frequency of R&D (persistent history of R&D or always invest in R&D) together with a large investment (amount) in R&D. Leading firm's R&D use more technological inputs than its lagging competitors and an adequate resource deployment must guarantee superior performance because more technological inputs are normally correlated to more innovative capabilities.

This means that a higher deployment of firms' technological resources will affect the firm's enhancing performance. The persistent and considerable efforts in R&D should positively affect firm´s performance because it should help to the firm to become a dominant firm in its industry.

The occasional are the firms that want to be laggards and they do not invest so much. This behavior should affect positively performance because they invest money in R&D but probably less than persistent firms in R&D because they tend to a non-dominant position in the market. We expect that these firms are conservative in the decision, the frequency and the level of R&D.

Several rent-generating dynamic capabilities are going to be developed over time depending on each particular firm´s resource deployment and aims. In this way, the role of history of R&D efforts could help to explain the relationship between firm-level dynamic capabilities and superior economic performance (Kor and Leblebici, 2005).

In this sense, we also expect that firms sustain heterogeneous R&D strategies over time (Helfat, 1994; Knott, 2003). Furthermore, these heterogeneous resource-action positions clarify why firms perform differently (Henderson and Cockburn, 1994; Knott, 2003; Zott, 2003; Ahuja and Katila, 2004). Examining heterogeneous R&D strategies requires research attention to both what is the frequency of R&D decisions and how much firms invest in R&D. Hence, we hypothesize that:

Hypothesis 3a: Firms with an occasional R&D strategy have a higher growth in firm's performance than firms that have never-invest R&D strategy.

Hypothesis 3b: Firms with a persistent R&D strategy have a higher growth in firm's performance than firms that have never or occasionally invest in R&D.

3. Data and methodology

3.1. Sample and data description.

All of the variables used in this study were derived from ESEE (Encuesta Sobre Estrategias Empresariales). It is a panel of firm-level data compiled by the Spanish Ministry of Science and Technology from 1990 to 2008. The survey covers a wide range of Spanish manufacturing firms operating in all industry sectors. It is an unbalanced panel, since for various firms, observations are missing for some years due to several reasons, like mergers, changes to non-industrial activity, cession of production, or, non-response. Furthermore, new companies enter the survey each year to maintain the representativeness of the industry over the whole population. For the data collection, a questionnaire with direct interviewers was used. The coverage of the data set is mixed. A random sample is drawn for small companies (with less than 200 employees), keeping the sample representative of the industrial distribution, whereas the sample is complete for large firms (more than 200 employees). Since data for R&D expenditures are available from 1990, we will use data from 1990 to 2008.

On the basis of ESEE dataset, we define three dummies to distinguish between Non-R&D firms, Occasional-R&D firms and Always-R&D firms. Of the firms in the sample, 2,208 firms never do *R&D* and 2,219 have carried *R&D* activities in sometime. 'Occasional R&D' includes 1,285 firms that engaged in *R&D* activities in some year but not always. Finally, 934 R&D performers always do R&D. Table 1 reports the number and share of firms for each group among manufacturing industries in Spain.

Table 1. Non-R&D, Occasional R&D and Always-R&D firms.

Average in the whole period (# of firms)		
Non-*R&D*	**R&D**	**Total**
2408	2219	4627
52.04%	47.96%	100.00%
Occasional-*R&D*	**Non Occasional-*R&D***	**Total**
1285	3344	4629
27.76%	72.24%	100.00%
Always-*R&D*	**Non always-R&D**	**Total**
934	3693	4627
20.19%	79.81%	100.00%

Source: Survey on Business Strategies (ESEE). The share of the number of firms for each category is shown in parentheses.

The characteristics of each category of firms are reported in the Appendix with the means and standard error of all dependent and explanatory variables. Performance of firms can be measured in different ways. From an organizational focus, the growth of employees has been widely used in management and economics literature as a performance measure (Coad 2009). However, we will not call attention to changes in number of employees. We focus on real economic impact on firm´s performance outputs (mainly, sales and profits)[1].

[1] Although we know that employment growth could be another alternative measure, we

We use three performance measures: sales growth, returns on sales (ROS) growth and returns on assets (ROA) growth. Sales growth is defined by the ratio between the sales of the firm in the period t+1 minus sales in the period t over the total sales in period t. Sales growth is one of the most commonly used performance measures (Kelm et al., 1995; Lee et al., 2001; Artz et al., 2010; Filatotchev and Piesse, 2009; Hall et al., 2009; Parmigiani and Holloway, 2011). ROS growth is defined in similar terms using the growth of gross operating margin over sales between the period t+1 and t. ROS is also used as a proxy for performance ROS. Although it could be correlated to the sales growth some studies confirm that is more stable to variation considering the accounting procedures than other measures (Ray et al., 2004). For these reasons, ROS has been used as a measure of firm performance in some studies related to the relationship between R&D strategies and firm´s performance (e.g., Lichtenthaler, 2009)

Finally, ROA growth is the ratio between the gross operating profit over assets between the year t+1 and the gross operating profit over assets in the year t minus one. ROA resume the efficiency of resource utilization. From our point of view, this measure can be a central concern to measure the effectiveness of an R&D strategy taken into account the increase of assets that usually is associated to R&D. ROA is one of the most used financial performance used for evaluate the effects of R&D investments and technological resources (Miller, 2004; Artz et al., 2010; Ndofor et al., 2011).

Next to these variables, we included a set of control variables in the vector to take into account the importance of other firm level resources. A variety of resources could be distinguished, among which we use firm size, firm age, export intensity and foreign capital participation. Firm size is measured as the natural logarithm of the number of employees. Firm age is the number of years since firm was born. Size and age were controlled in the current analyses because larger and older firms may possess more fully developed capabilities. Also, exporters firms will be more likely to overcome performance (Ito and Pucik, 1993; Beneito, 2003). Finally, a organizational characteristic is

believe that investigating the potential changes in performance measured by sales or returns is a forward step in the current literature and the R&D strategy affects mainly these kind of financial measures.

considered and firms with a more foreign capital participation could be more prone to innovative activity (Roper and Hewitt-Dundas, 2008) and hold better performance than locally owned firms.

R&D expenditures are also controlled because of their possible effects on the manufacturing capabilities herein examined. The R&D expenditure ratio is measured by the ratio of R&D expenditures to total sales and serves as the indicator of input of firm innovativeness.

In addition, because performance effects may be time dependent, all the models include year fixed effects. Finally, we include industry dummies to control the differential in technological opportunities and competitive conditions in each industry. Industry dummies for the principal activity of the firm are defined following an aggregation of 3-digits CNAE-93 that classify 20 manufacturing sectors.

In general terms, variables used as controls (size, age, export intensity and foreign participation) are higher among occasional-R&D and always-R&D performers and lower among non-R&D. However, the dynamics of each firm´s performance measure inside each group of firms is different. The average value of sales growth and ROS growth for the whole sample are 0.203 and -0,311 while the ratios corresponding to R&D performers are better (0.292 and -0.282) than the values associated to non-R&D (0.072 and -0.356, respectively). But the mean value related to ROA growth is higher for non-R&D than for R&D firms (8.338 versus 3.289).

If we compare the behaviour of occasional and non-occasional R&D firms, the Sales growth of occasional-R&D performers is higher than the average size related to non-occasional R&D firms (0.361 vs 0.09). Nevertheless, the ROS growth and the ROA growth for the firms that only do R&D sometimes is worse than the mean related to non-occasional R&D firms. Finally, the mean of sales growth and ROA growth is be larger in the firms that always invest in R&D – 0.220 and 5.544 -. But the average ROS growth is worse (-0,430) than mean corresponding to the whole sample and the non-always R&D firms (0.311 and 0.226, respectively).

3.2. Methodology.

In estimating the influence of R&D strategy on firm´s performance, we correct for firms´ unobserved heterogeneity. The firm´s performance measure is explained by:

$$FPM_{it}^{*} = X_{it}\beta + \varepsilon_i + u_{it} \quad [1]$$

Being *i* =1,…, *N and t*= 1,…,*T* where the subscript *i* corresponds to firms and *t* to time periods. In equation (10), X_{it} is a vector of explanatory variables and ε_i are individual-specific time-invariant terms. Following Chamberlain (1984), correlation with the observed characteristics is allowed by assuming a relationship $\varepsilon_i = \overline{X_i}a + \alpha_i$, where α_i~ *iid N(0,* σ^2_α*)* and independent of X_{it} and u_{it} for all *i*, *t*. Equation (1) can be rewritten as:

$$FPM_{it}^{*} = X_{it}\beta + \overline{X_{it}}a + \alpha_i + u_{it} \quad [2]$$

We also consider an assumption about the influence of initial condition level of R&D. Following Wooldridge (2005), the initial condition of R&D intensity is introduced as explanatory variable and the final model is specified as:

$$FPM_{it}^{*} = X_{it}\beta + \overline{X_{it}}a + b_0 + b_1 RD\,\mathrm{int}_{i1} + u_{it} \quad [3]$$

In regard to contrast the hypotheses 1a and 1b, we employ different specifications of equation [3] to address the relevancy of R&D strategies as possible drivers of firms´ performance. Specifically, to test the hypothesis 1, we distinguish between: (1) Persistent- R&D firms (2) Occasional - R&D firms and (3) Non-R&D firms and we estimate the Model 1 [Dep(firm's performance)= dummy(decision: persistent) + dummy(decision: occasional) + controls]. The following regression is run considering random effects using panel data for the period 1990–2008:

FPM$_{it}$ = α + β_1DPERSIST$_i$ + β_2DOCARD$_i$ + β_3Age$_{it}$ + β_4Size$_{it}$ + β_5Export-intensity$_{it}$ + β_6Foreign-participation$_{it}$ + $\overline{X_{it}}a + b_0 + b_1 RD\,\text{int}_{i1} + u_{it}$ [4]

where DPERSIST is a dummy variable taking the value of one if the company exhibited persistence in R&D over the whole period and zero otherwise; DOCARD is a dummy variable taking the value of one if the company is an occasional R&D performer over the whole period and zero otherwise.

Another way of dealing with persistence is to consider the dynamic behavior and the cross-section variation of the R&D decisions. For that, it has been developed in the economic literature a prolific econometric strategy based in the markovian processes. A markovian process is a sequence of states where the probability of an event to happen (to do or not to do R&D) depends on previous states. Future events are conditioned by current states. Markov processes are heavily used in other economics fields, such as the study of poverty and income mobility, and also have been applied to patent distributions and survival firms (Cefis, 2003, 2006).

The formal argument goes as follows: in a sequence of events $X_1, X_2, X_{3\ldots}$, the value of X_n is the state in time n. The probabilities of every event may be defined then as:

$$\begin{aligned}\Pr\left(X_{n+1}=x_{n+1} \mid X_n=x_n, X_{n-1}=x_{n-1},\ldots,X_1=x_1\right) &= \Pr\left(X_{n+1}=x_{n+1} \mid X_n=x_n\right)= \\ &= \Pr\left(X\left(t_{n+1}\right)=x_{n+1} \mid X\left(t_n\right)=x_n\right) \quad ,\forall n\in N\end{aligned} \quad [5]$$

$$\begin{aligned}&where: \\ &X_i = X(t_i) \quad , \quad \forall i=1,2,\ldots,n+1,\ldots \quad \rightarrow \quad \text{Markov Chain in the i-th moment} \\ &t_i = t_{i-1}+t=\ldots=t_1+(i-1)\cdot t \quad , \quad \forall i=1,2,\ldots,n+1,\ldots \quad \rightarrow \quad \#\text{ of time moments} \\ &x_i \in E \quad , \quad \forall i=1,2,\ldots,n+1,\ldots \quad \rightarrow \quad \text{Event in the i-th moment} \\ &E=\{e_1,e_2,\ldots e_r\} \quad \rightarrow \quad \text{Set of possible states}\end{aligned}$$

then:

$$\begin{aligned}\Pr\left(X_{n+1}=e_j \mid X_n=e_i\right) &= \Pr\left(X\left(t_{n+1}\right)=e_j \mid X\left(t_n\right)=e_i\right)= \\ &= \Pr\left(X\left(t_n+t\right)=e_j \mid X\left(t_n\right)=e_i\right)=p_{ij}(t) \quad ,\forall n\in N, \forall e_i,e_j\in E\end{aligned} \quad [6]$$

From expression [6] we may estimate the transition probability $p_{ij}(t)$ to reach state (j) from an initial state (i) at time (t). The set of transition probabilities constitutes the Transition Probability Matrix (TPM), *P = [pij]*. The TPM is a stochastic *r*r* matrix, r being the number of possible states.

The estimation of transition matrices requires observations for states in at least two periods. Transition probabilities may be determined by changes in values between periods and it may be estimated from a contingency table. The main diagonal of the TPM shows the probability of permanence in the initial states, and it gives an idea of the degree of persistent conduct. Although the two-fold nature of panel data (time series and cross section) allows identifying the dynamics of R&D each year using markovian processes, we are interested only in a particular probability transition of each firm. The TPM is the matrix measuring the probability of each firm moving from state i to state j in the whole period. This TPM offers useful information for analyzing the influence of dynamics of R&D on performance since it measures the probability that a firm goes from a state —do or not to do R&D — to another state (also, do or not to do R&D) in the whole period.

A TPM with four states is computed for each firm. The first state corresponds to events succeed when firm neither do R&D in t+1 nor in t (the "non-R&D" state). The second one takes into account the events in which the firm does not R&D in t but does R&D in t+1 (the "occasional R&D" state) while in the third one, we count the number of times in which firm does R&D in t but not does R&D in t+1 (also another "occasional R&D" state). Finally, in the fourth state, we consider the events where the firm does R&D in t and in t+1. The matrix computed in this way provides different information of each firm depending if the firm is non-R&D, occasional R&D or always persistent in R&D (see Table 2.). Although the analysis also could focus on the dynamics of transition from being non-R&D to being R&D performer ("occasional state"), we use only the information contain in the state e_4 as a synthetic measure of frequency of R&D decision (persistence) of firm i. This measure reports the joint probability of each firm from being R&D in t to being R&D in t+1 (four state). This methodological choice ables us to contrast the hypotheses 2, 2a and 2b. We consider two interaction terms: [(1+TPM)*DPERSIST] and [(1+TPM)*DOCARD]; these variables capture the frequency of R&D decision relative to always-persistent R&D firms and occasional-R&D firms. Specifically, we estimate the Model 2 that considers the dynamics of R&D decisions [Dep (firm's performance) = [(1+TPM)*dummy(decision:occasional) + (1+TPM)*dummy(persistent) + controls]. The correspondent specification is the following:

FPM_{it} = α + β_1[(1+TPM)*DPERSIST] $_i$ + β_2 [(1+TPM)*DOCARD]$_i$ + β_3Age$_{it}$ + β_4Size$_{it}$ + β_5Export-intensity$_{it}$ + β_6Foreign-participation$_{it}$ + $\overline{X_{it}}a + b_0 + b_1 RD\text{int}_{i1} + u_{it}$ [7]

Table. 2. Transition probability matrix by type of firms.

Non-R&D performers		
	$R\&D_{t+1}=0$	$R\&D_{t+1}>0$
$R\&D_t=0$	1	0
$R\&D_t>0$	0	0=TPM_i
Occasional R&D performers		
	$R\&D_{t+1}=0$	$R\&D_{t+1}>0$
$R\&D_t=0$	e_1	e_2
$R\&D_t>0$	e_3	e_4 = TPM_i
Always invest in R&D		
	$R\&D_{t+1}=0$	$R\&D_{t+1}>0$
$R\&D_t=0$	0	0
$R\&D_t>0$	0	1= TPM_i

Finally, the last specification considers the performance effect of R&D strategy including the interaction term [Occasional R&D-Dummy * (1+TPM)* R&D Intensity] and the interaction term [Persistent R&D-Dummy * (1+TPM) * R&D]. Specifically, the Model 3 related to R&D Strategy [Dep (firm's performance) = [[(1+TPM)*dummy (occasional)] * R&D intensity] + [[(1+TPM)*dummy(persistent)]*R&D intensity]+ controls]. Thus, the third model specification is the next:

FPM_{it}=α+β_1[(1+TPM_i)*$DPERSIST_i$*R&$Dint_{it}$]+β_2[(1+TPM_i)*$DOCARD_i$*R&$Dint_{it}$]+β_3Age$_{it}$ +β_4Size$_{it}$+β_5Export-intensity$_{it}$+β_6Foreign-participation$_{it}$+ $\overline{X_{it}}a + b_0 + b_1 RD\text{int}_{i1} + u_{it}$[8]

4. MAIN RESULTS.

Table 3 presents the coefficient estimates and values of standard errors (in parentheses) that have been estimated by running the model 1 Eq. [4], when the dependent variable equals sales growth, ROS growth and ROA growth.

Table 3. The influence of R&D strategy (to do or not to do R&D) on firm´s performance.

Performance measures	Sales growth	ROS growth	ROA growth
DPERSIST (1)	-1.945***	4.239***	-10.794**
	-0.343	-0.698	-4.297
DOCARD (1)	-0.590***	1.427***	-6.696**
	-0.227	-0.463	-3.079
Age	0.153	-0.109	1.664
	-0.095	-0.192	-1.278
Size	-1.224***	0.855	-0.328
	-0.316	-0.649	-4.237
Export intensity	-7.449***	-6.799***	-13.032
	-0.912	-1.865	-11.499
Foreign capital Participation	0.328	0.156	1.019
	-0.702	-1.426	-8.351
Initial condition of R&D Intensity	0.847***	-1.848***	1.453***
	-0.035	-0.073	-0.429
Constant	0.88	-1.254	19.628
	-1.159	-2.363	-15.905
Observations	29,552	28,995	21,957
Number of ordinal	3,876	3,856	3,328
chi2	754.6	708.6	68.19

(1) Reference category *DNONRD*.

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$; 19 industry dummies and 18 years dummies are omitted to spare space.

According to the results reported in the previous table, regressors for the persistence dummy and occasional dummy (DPERSIST and DOCARD) appear statistically significant for all the regressions. However, the signs are different depending on the performance´ measure used. In the case of the sales growth and ROA growth regressions, the persistence and occasional dummies are negative. These variables are positive and statistically significant in the ROS growth regressions, providing an indicator of better performance of profitability by the R&D performers (occasional and persistent firms). Hypothesis 1a predicts that firms that always invest in R&D get better performance than those who never or occasionally invest in R&D and hypothesis 1 b that firms that only occasionally invest in R&D have also better performance than those who never invest in R&D. Both hypothesis are confirmed in the Model I estimation because we found significantly positive impact of persistent R&D decision and occasional R&D decision on ROS growth (4.239 and 1.427 at 1% significance level). However, the positive effect on sales growth and ROA growth is not supported and we observe the contrary effect.

We also observe that, even after controlling for other variables, the initial condition in R&D/Sales variable is positive and statistically significant at 1% level in the Sales growth and ROA growth regressions, but not in the ROS regression where the R&D-intensity variable is statistically significant and affect negatively to this measure.

The influence of R&D history of each firm in the three different performance measures (Sales Growth, ROS growth and ROA growth) considering the different type of R&D performers is reflected in regression results reported in Table 4 (using Eq. [7].

As predicted by hypothesis 2, the dynamics and the history of R&D management decisions affects firm's performance. Using ROS growth as a performance measure, the interaction term [(1+TPM)*DOCARD] is significant and positive providing support for the hypothesis 2a. The more frequently a firm decides to invest in R&D the higher is the effect on its ROS growth comparing with non- persistent R&D performers (occasional and non-R&D).

In the same way, the significantly positive term, [(1+TPM)*DPERSIST], indicates that a continuous history of R&D decisions also affects positively ROS growth. However, based on results for other performance measures, we do not find support for these hypotheses. Sales growth and ROA growth are diminished (more for always-R&D firms than for occasional-R&D firms). In summary, the results suggest that the frequency of the R&D decisions affects positively ROS growth and negatively sales growth and ROA growth.

These results are not surprising. The effect on ROS growth can be viewed as clear evidence that the R&D decision and frequency contribute to the firm to gain competitive advantage through R&D and improve their performance. On the other hand, the sales reduction might be a response, at least in part, to the difficult to increase the sales every year for larger firms than hold a dominant market position. In this sense, larger firms are also the majority between the R&D performers (remember that size affects negatively to this performance´ measure). Finally, the ROA growth could decrease because R&D usually is linked to a higher acquisition of technological assets (tangible). The calculation of this measure using the gross margin over tangible assets contributes to poorest performance when we consider it.

Table 4. The dynamics of R&D strategy on firm´s performance.

Performance measures	Sales growth	ROS growth	ROA growth
[(1+TPM)*DPERSIST]	-2.001***	4.124***	-11.148**
	-0.348	-0.709	-4.341
[(1+TPM)*DOCARD]	-0.388***	0.769***	-4.185**
	-0.141	-0.288	-1.862
Age	0.155	-0.106	1.677
	-0.095	-0.192	-1.279
Size	-1.226***	0.857	-0.355
	-0.316	-0.649	-4.237
Export intensity	-7.462***	-6.775***	-13.221
	-0.912	-1.865	-11.499
Foreign capital Participation	0.327	0.159	1.006
	-0.702	-1.426	-8.351
Initial condition of R&D Intensity	0.849***	-1.846***	1.466***
	-0.036	-0.073	-0.43
Constant	0.826	-1.119	18.952
	-1.159	-2.363	-15.893
Observations	29,552	28,995	21,957
Number of ordinal	3,876	3,856	3,328
chi2	755.4	706.2	68.51

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$; 19 industry dummies and 18 years dummies are omitted to spare space.

Considering the last hypotheses formulated, the performance effect of R&D strategy will depend on whether firms are persistent, occasional or never invest R&D and their R&D intensity introduced in the model taken into account the R&D history or persistence (frequency) of R&D related to each firm of R&D.

To contrast the hypotheses 3b, we look the sign and significance of coefficients correspond to the interaction term [Always R&D-Dummy * (1+TPM) * R&D Intensity] to explain each firm´s performance measure. The results found that ROS growth is higher in firms with a persistent R&D strategy (remember that TPM_i for the firms that always do R&D is equal to one) than in firms with an occasional or a non-R&D strategy. This term captures the differences between firms with a persistent R&D strategy and firms that have never or occasionally invest in R&D confirming the hypothesis 3a. Instead of this result, this interaction term is not significant in the sales growth and the ROA growth regressions.

We also find in Table 5 that the interaction term [Occasional R&D-Dummy *(1+TPM)* R&D Intensity] is significant for two of the three performance measures. Thus, an occasional R&D strategy improves the firm´s performance measured by sales growth and ROS growth although the influence is more significant for the second firm´s performance measure (coefficients 0.034 and 0.418, respectively). In spite of these differences, these results are consistent with hypothesis 3b.

Table 5. The influence of R&D strategy and the size of R&D investment on firm´s performance.

Performance measures	Sales growth	ROS growth	ROA growth
$[(1+TPM_i)*DPERSIST_i*R\&Dint_{it}]$	-0.012	0.826***	-0.381
	-0.007	-0.078	-0.234
$[(1+TPM_i)*DOCARD_i*R\&Dint_{it}]$	0.034***	0.418***	-0.204
	-0.008	-0.076	-0.249
Age	0.03	-0.633*	1.029
	-0.036	-0.374	-1.203
Size	-0.213**	2.115**	4.014
	-0.096	-0.919	-3.232
Export intensity	-2.667***	-8.024***	-1.667
	-0.248	-2.377	-8.067
Foreign capital Participation	0.114	0.857	0.005
	-0.183	-1.738	-5.77
Initial condition of R&D Intensity	0.075***	-2.556***	0.571*
	-0.01	-0.108	-0.324
Constant	0.053	6.622*	-2.94
	-0.431	-3.893	-12.335
Observations	17,231	16,928	14,665
Number of ordinal	1,928	1,926	1,849
chi2	369.3	619.6	37.61

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$; 19 industry dummies and 18 years dummies are omitted to spare space.

The obtained results show also that the initial condition of R&D intensity is significant. The initial condition of R&D Intensity affects the three performance measure in the same direction in the three models: positively to explain the sales growth and ROA growth and negatively to explain the ROS growth (Only in the model 3, the level of significance of initial R&D intensity condition as explanatory variable of ROA growth is situated at 10% level of significance). These results are consistent with the obtained results related to the influence of R&D strategy on each measure performance. However, we notice that the influence is in the opposite direction. A higher initial R&D probably contributes to get profits in the first stages of R&D process but decreases by the pass of the time. Then, a high level of R&D intensity the first time that you do R&D decrease the probability of increase the returns to R&D over sales because the firm is assuming more sunk costs and risks associated to this investment and decrease the possibility of adapting its technological capabilities. In the opposite side, it seems that R&D intensity initial condition affects positively the sales growth and ROA growth.

Regard to control variables, only size and export intensity are statistically significant in some of the regression regression models. Concretely, size affects negatively sales growth measure. This result can be explained by the difficult that larger firms have to grow because they did before years ago. Many business strategies focus on innovation through R&D as a way of increasing sales growth but all the firms are not going to be able to increase their sales volume. Larger firms have lower sales growth (also lower return on assets (ROA)) and higher return on sales (ROS) but not significant). Also, the export intensity is statistically significant and affects negatively sales growth and ROS growth. Age and Foreign capital participation are not significant in any case. Finally, the results are robust to the addition of industry dummy variables, time-period effects and random effect estimation

5. DISCUSSION AND CONCLUSIONS.

In the current literature, there exist many studies proposing various methods for establishing and identifying the relationships between R&D or innovations and firm performance. Earlier empirical studies have examined associating R&D expenditures strongly with sales growth, profit and profit and productivity (Griliches, 1981; Dosi, 1988; Morbey and Reithner, 1990; Ito and Pucik, 1993; Long and Ravenscraft, 1993). There exist certain consensus that maintains that firms with significant R&D perform better than other firms, that is, firm´s performance is positively correlated with the level (or the intensity) of the R&D investment (Klette and Griliches, 2000; Del Monte and Papagni, 2003; Blanchard et al., 2005; Tsai and Wang, 2005; Adamou and Sasidharan, 2007; Filatotchev and Piesse, 2009; Artz et al., 2010; Bogliacino and Pianta, 2011). However, the contributions studying the effects of a specific R&D strategy on firms' performance are scarcer. In this paper we confirm the effect on firms' performance of R&D strategy taken into account the persistence with which firms do R&D investments. A substantial research effort has been devoted to examine the persistence and the determinants in innovation activities at the firm level. (Raymond et al., 2010; Peters, 2009; Roper and Hewitt-Dundas,2008; Cuervo-Cazurra and Un, 2010) Nevertheless, to the best of our knowledge, there are very few studies that focus on the effect of innovation persistence on firms´ performance. To do this, we use the resource-based view (RBV) and the competitive dynamics literature to consider jointly firm resources, capabilities and competitive actions as the main drivers of superior performance (Sirmon et al., 2007, 2010; Ndofor et al., 2011),

In summary, a majority of the literature has empirically demonstrated the significant impact of R&D innovation activities on the performance of firms; however, these studies did not examine whether the R&D strategy is appropriate for improve the firm´s performance. So far, empirical evidence about R&D resources deployment and performance is quite limited. R&D efforts has become an important innovation source for firms´ performance and "*variance of technological resources across firms emerges from firms' other capabilities, management, and governance, but also the inherent uncertainty in the innovation process (luck)"* (Miller, 2004, pp. 1097-98).

In this study, we confirm that the firm's capabilities can improve firms´ performance via a particular resource (R&D) and different actions (invest always, sometimes or never in R&D in a determined frequency) and strategies (actions and level of R&D intensity). Particular R&D deployment (strategy) influences each firm´ performance. We confirm that the decisions (to do always or sometimes or not to do R&D), the dynamics of these decisions: (firm´s R&D frequency history) and the R&D strategy (actions, dynamics and R&D intensity level) affect firm´s performance. First, firms that always invest in R&D and occasionally invest in R&D have better performance in terms of ROS growth than those who never invest in R&D. Second, the dynamics and the history of the firm´s R&D management decisions affects positively firm's performance measured by ROS growth. This indicator is higher for firms with more continuous and high probability to being R&D in t and being R&D in t+1 (remember that this probability is one for persistent R&D firms and higher than zero for occasional R&D firms). Thirdly, the estimations prove that ROS growth is higher in firms with a persistent R&D strategy than in firms with an occasional or a non-R&D strategy. In summary, the results suggest that the frequency of the R&D decisions affects positively ROS growth. However, more empirical research is needed because R&D deployment is reflected in different way depending to the firm´s performance measure considered. Specifically, R&D strategies that affect positively ROS growth have a negative influence on sales growth and ROA growth.

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APPENDIX:

Table A. Descriptive statistics (whole sample).

Variable	Obs	Mean	Std. Dev.	Min	Max
Sales growth	29872	0.204	15.315	-0.998	2600.990
ROS growth	29308	-0.312	30.913	-3574.325	1152.601
ROA growth	22219	4.884	171.814	-3084.486	17300.210
R&D intensity	34489	0.722	2.325	0	98.924
Size (# of employees)	34848	262	817.	1	25363
Age	75893	26.198	23.606	0	278
Export intensity	34633	0.169	0.250	0	1
Foreign capital Participation	34795	0.175	0.364	0	1
$TPM_i = e_4$	37753	0.711	0.378	0	1

Source: ESEE

Table B. Descriptive statistics by type of firm

	Non-*R&D firms*					R&D firms				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Sales growth	11985	0.072	0.631	-0.983	32.039	17887	0.292	19.784	-0.998	2600.990
ROS growth	11740	-0.356	22.947	-1653.667	1152.601	17568	-0.282	35.248	-3574.325	1028.166
ROA growth	7019	8.338	257.278	-3084.486	17300.210	15200	3.289	112.165	-1287.550	10239.360
R&D intensity	14446	0.000	0.000	0.000	0.000	20043	1.242	2.942	0.000	98.924
Size (# of employees)	14496	59	156	1	4541	20350	408	1038	1	25363
Age	38152	21	19	0	173	37722	32	26	0	278
Export intensity	14416	0.068	0.169	0.000	1.000	20216	0.240	0.273	0.000	1.000
Foreign capital Participation	14483	0.055	0.218	0.000	1.000	20310	0.260	0.419	0.000	1.000
$TPM_i = e_4$	0	0	0	0	0	37753	0.711	0.378	0.000	1.000
	Occasional-*R&D firms*					Non Occasional-*R&D firms*				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Sales growth	12564	0.361	23.537	-0.998	2600.990	17308	0.090	1.623	-0.989	198.554
ROS growth	12300	-0.500	40.744	-3574.325	726.822	17008	-0.176	21.123	-1653.667	1152.601
ROA growth	10192	3.621	123.098	-1066.045	10239.360	12027	5.955	204.192	-3084.486	17300.210
R&D intensity	13807	0.722	2.466	0.000	98.924	20682	0.721	2.226	0.000	54.546
Size (# of employees)	14011	257	576	1	10884	20837	267	946	1	25363
Age	23022	30	26	0	236	52871	25	23	0	278
Export intensity	13915	0.207	0.264	0.000	1.000	20718	0.143	0.237	0.000	1.000
Foreign capital Participation	13992	0.213	0.390	0.000	1.000	20803	0.149	0.343	0.000	1.000
$TPM_i = e_4$	22971	0.525	0.382	0.000	1.000	14782	1.000	0.000	1.000	1.000

	Always-*R&D firms*					**Non always-R&D firms**				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Sales growth	5323	0.130	2.769	-0.989	198.554	24549	0.220	16.845	-0.998	2600.990
ROS growth	5268	0.226	16.339	-303.173	1028.166	24040	-0.430	33.264	-3574.325	1152.601
ROA growth	5008	2.615	85.717	-1287.550	4120.824	17211	5.544	189.659	-3084.486	17300.210
R&D intensity	6236	2.392	3.526	0.000	54.546	28253	0.353	1.762	0.000	98.924
Size (# of employees)	6339	741	1601	3	25363	28507	156	430	1	10884
Age	14700	35	27	0	278	61174	24	22	0	236
Export intensity	6301	0.3126	0.2781	0	1	28331	0.137	0.232	0	1
Foreign capital Participation	6318	0.3634	0.4593	0	1	28475	0.133	0.324	0	1
$TPM_i = e_4$	14782	1	0	1	1	22971	0.525	0.382	0	1

Source: ESEE