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Does the intensity in R&D generate start-up's growth?

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Abstract

Existing literature is not conclusive regarding the effect that R&D activities exert on a firm's performance and growth. Furthermore, this issue is unexplored in the literature stream of new venture growth. We shed light on this issue by proposing a mediation model. Building on previous literature, we predict that R&D intensity indirectly and positively affects the growth of new ventures through the mediation of patents. The analysis is conducted from primary survey data which contains information for 87 new ventures belonging to the Basque innovation ecosystem. According to the results, patents significantly and positively mediate the relation between R&D intensity and new venture growth.

Resumen

La literatura existente es aún inconclusa en lo que se refiere a los efectos que las actividades de I+D tienen sobre el rendimiento y el crecimiento de las empresas. Además esta relación esta inexplorada en la literatura relacionada con nuevas empresas. Basándonos en literatura previa postulamos que la intensidad en I+D indirecta y positivamente afecta el crecimiento de las nuevas empresas a través de la mediación de las patentes. El análisis está basado en un cuestionario a 87 nuevas empresas que operan en el ecosistema de innovación vasco. Los resultados indican que las patentes positiva y significativamente median la relación entre la intensidad en I+D y el crecimiento de las nuevas empresas.

Laburpena

I+Gko jarduerek enpresen errendimenduan eta hazkundean duten eragina aztertzen duen literatura amaitu gabe dago oraindik. Harreman hori, gainera, aztertu gabe dago enpresa berriekin lotutako literaturan. Aurretiko literatura oinarri hartuta, esan dezakegu I+Gko intentsitateak zeharka eragin positiboa duela enpresa berrien hazkundean, patenteen bidetik. Gure analisian EAEko berrikuntza ekosisteman dauden 87 enpresa berriri galdesorta bat egin diegu. Emaitzek adierazten dute patenteen bidez daudela harremanetan, modu positiboan eta esanguratsuan, I+Gko intentsitatea eta enpresa berrien hazkundea.

1. INTRODUCTION

Firms increasingly face market dynamics (Teece, 1998) which make difficult sustaining their competitive position. Grant (1996) asserts that innovation must be the driver that allows firms to maintain such competitive advantage. Thus, Innovation is an important element within all the parameters that constitute the firm strategy (Cooper, 1985; Dwyer and Mellon, 1993). Indeed, it is quite common to find a positive premium for those firms that decide to be innovative (Olson and Bokor, 1995; Roper, 1997; Cefis and Marsili, 2006a, 2006b).

Knowledge management is a core activity inside innovative firms (Nonaka et al., 2000) since they must invest in creating and processing new knowledge to survive and grow. It is common agreement that investment in research and development (R&D) activities is a key-element in creating new knowledge. However, financing such activities is complex and expensive, and they become a more acute problem among new, almost always small, start-up ventures (Hall, 2002). So, as start-ups rely on limited resources, it is especially important to know how the intensity on R&D activities is related to growth and/or performance.

Existing evidence in this regard is inconclusive for established firms and scarce for young firms (see Table 1). Actually, not all new knowledge is economically relevant (Arrow, 1962), which suggest that R&D activities do not automatically lead to improvements in performance, but instead they have an indirect effect (through an innovation output) on it. Although this indirect effect has been tested in established firms (Diaz-Diaz et al., 2008), we are unaware that previous studies analyze other effects than merely direct effects of R&D investment (i.e. Stam and Wennberg, 2009) and product innovation (i.e. Freel and Robson, 2004) on start-up's growth.

We contribute to the literature stream on innovation strategy and new venture growth by analyzing empirically both (*i*) the direct effect of R&D intensity, and (*ii*) the indirect effect of R&D intensity through the mediation of patents, on employment growth in new ventures. Data were collected in a cross sectional setting between February and April of 2008, through a survey addressed to 87 start-ups located in the Basque Country (Spain)

The following section analyzes in depth the literature concerning the direct and indirect effects of R&D on performance and growth. Our empirical hypothesis is outlined according to such literature. Section 3 presents the data, variables and model. Section 4 and 5 show the results and conclusions of the work, respectively.

2. THEORETICAL FRAMEWORK

Regardless of the existence of an innovation premium, there is a widespread support for the idea that the key input for generating valuable knowledge for innovation is the investment on R&D. Accordingly, the analysis of the impact exerted by R&D intensity on firm's growth and/or performance is interesting by itself. In order to make theoretical predictions about such impact, we build on previous literature to disentangle *direct* and *indirect* effects R&D efforts.

Direct effect of R&D efforts

A variety of theoretical argumentations has been proposed about the role of R&D investment on firm's performance. The main perspectives thereof are shown at the top of Table 1.

- Insert Table 1 about here -

The resource based view (Barney et al., 2001) considers that firm's intangible assets -knowledge in particular- are the basis for obtaining and sustaining a competitive advantage. In our research context, which is focused on new ventures, this competitive advantage may be translated into a greater capacity for growing. Certainly, R&D activities conducted internally involve the need to hire high skilled employees and hence to grow. In contrast, according to the absorptive capacity view (Cohen and Levinthal, 1989), internal generation of knowledge helps firms to develop the ability to identify, assimilate and apply external knowledge in an easier way. In other words, it enhances the likelihood of identifying new opportunities for growth in the market.

The investment in R&D also has an important theoretical drawback. As Nonaka et al. (2000, p. 14) pointed out, "…there is a cost involved in acquiring and retaining the knowledge as inputs…". The main reasoning behind those costs is that the generation of knowledge is a costly process that takes time and may last several years (Zahra and Nielsen, 2002). As a result, R&D may delay the growth of new ventures.

Altogether, theoretical argumentations in the existent literature are not clear enough in order to predict a concrete sign about the direct relationship between R&D investment and growth. Previous evidence could help to incline the balance one way or another. Unfortunately, as far as we know, only Stam and Wennberg (2009) provide evidence regarding the relationship between R&D intensity and growth in new ventures. Their evidence seems conclusive only for a small set of firms. They found a direct and positive relation between R&D activities and high-tech firm's growth. The effect disappears for medium and low tech firms. Recent studies on this issue focus on established firms instead. As it can be observed at the bottom of the Table 1, most of these studies analyze the returns on assets (ROA) as dependent variable. Among the six works identified, three of them found a negative impact of R&D investment on performance (Le et al., 2006; Díaz-Díaz et al., 2008; Coad and Rao, 2008), whereas the rest found a positive impact (Kotabe et al., 2002; Carayannis and Alexander, 2002; Lin et al., 2006). Therefore, both previous theoretical literature and empirical literature are inconclusive. They do not allow us to propose a hypothesis regarding the direct effect of R&D intensity on growth. In this sense, we will take an empirical-driven view in order to attempt to disentangle such debate.

Indirect effect of R&D efforts through patents

Clarysse et al. (2007) and Helmers and Rogers (2009) found that patents help high technology start-ups to grow their assets. Besides, according to the knowledge production function (KPF) a positive relationship exists between R&D intensity and patents and/or new product generation (Griliches, 1979). In fact, Freel and Robson (2004) provide evidence that generating product innovation enhances employment growth of new ventures. This reasoning brings us to the existence of an indirect relationship between R&D intensity and growth, which is mediated through patents. In other words, we consider patents as an endogenous variable in order to explain growth. Previous literature has suggested similar indirect effects for established firms. For example, Dröge (2003) argues that production technology routineness and technological turbulence have a total positive indirect effect on financial performance through the mediation of new knowledge creation and applied knowledge. Similarly, Díaz-Díaz et al. (2008) proves that R&D intensity has a positive partial indirect effect on the ROA through the mediation of new product generation.

Hsu and Ziedonis (2008) present another argumentation that holds with the idea that R&D intensity has an indirect effect on start-ups' growth. Their reasoning is specific for entrepreneurial ventures. They found strong evidence that patents portfolio increase the investor's estimation of a start-up valuation. This is due to a signaling role. In particular, their results show that a doubling in the patent application stock of a new venture is associated with a 24% increase in their valuation. These results are consistent with the view that patents provide a vehicle for overcoming early-stage disclosure problems in the market (e.g. debt, Venture capital funding…) for new ideas (Arrow, 1962; Arora et al., 2001; Gans et al., 2002), which streamline the process of growth. Lemley's (2000; p.143) words strength the signaling role of patents for new ventures using the example of venture capitalists:

"If you ask venture capitalists what they think of patents, and in particular, of patent litigation, they'll tell you it's awful. "This is a terrible thing: leave us alone and let us innovate," they will say. And then if you ask them how their companies are doing in the marketplace, they will answer you in reference to patents: "Our company has patented this model"; "our company got twelve patents this year"; "our company has a patent application that cover this, that, and the other things".

- Insert Figure 1 about here -

Figure 1 shows our conceptual model about the mediation effect of patents in the relationship between R&D efforts and growth. While R&D intensity has an inconclusive direct relation to growth (Arrow X), theoretically they should have a strong indirect and positive effect on growth through patents (Arrows Z and Y). This mediation is conducted by two effects, namely KPF and signaling. In order to simplify the analysis we will test the role of patents as a mediator and we will estimate the relative total weight of such effects in explaining such result. Overall, the argumentations aforementioned bring us to the empirical hypothesis of the paper.

- **Hypothesis:** *The relative intensity in R&D activities has a positive and indirect effect on new venture growth through patenting.*

3. DATA, VARIABLES AND METHODOLOGY

3.1 Data construction

The regional government in the Basque Country (One of the 17 Spanish autonomous regions) provide potential innovative entrepreneurs with a series of specific services to develop their new ventures (i.e. specialized assistance programs, network of business and innovation centers, venture capital with public funds, etc.). All entrepreneurs who benefit from such services and their business projects are tracked in different directories, which allowed us to identify a regional population of potentially innovative new ventures. Accordingly, we defined as unit of analysis the group of new ventures created with the support of a regional Business Innovation Center (BIC), as well as, those participated by a public venture capital fund at regional level. To be precise we focused on the entrepreneurial initiatives that, having been created with the support of a BIC or participated by a public venture capital fund, were set up in the region during the period 2000-2005.

According to information provided by the network of BICs[1] operating in the Basque Country, 378 potentially innovative firms were started up on their premises during the period 2000-2005. Additionally, we identified 55 new ventures set up outside the BICs' premises that were participated by public venture capital funds at regional level[2]. We

[1] The network of regional BICs is made up of the following centers:: BEAZ, BIC BERRILAN, CEDEMI, CEIA and SAIOLAN.

[2] These firms were participated by one of the following institutions: Gestión de Capital Riesgo del País Vasco, SGECR (www.gestioncapitalriesgo.com), Seed Capital Bizkaia (www.seedcapitalbizkaia.com), Sortek (www.inasmet.es/home.aspx?tabid=32) and Hazibide (www.hazibide.es).

were unable to find the contact information for 37 out of the 433 new ventures identified. Thus, 396 structured questionnaires were sent by mail between February and April 2008 to one of the entrepreneurs of each new venture. The monitoring of those questionnaires was conducted by a market research firm (Datakey).

By May 2008, 129 responses were available. The total answer rate was 32.5%. While 113 survey responses came from the new ventures created in the BICs' premises (33.1% of answer rate), 16 survey responses came from the new firms participated by public venture capital funds (29% of answer rate). Due to missing data, only 87 observations will be used in our empirical analysis. Among these observations, 77 belong to the group of new ventures set up in the BICs' premises.

3.2 Descriptive statistics

Table 2 shows the descriptive statistics and measurement details for the dependent and explanatory variables used in the empirical analysis.

- Insert Table 2 about here -

Dependent variables

The main purpose of the paper is to explain the heterogeneity in new venture growth. According to Delmar et al. (2003), the relative employment growth is an appropriate measure for determining a start-up's growth. Besides, previous studies consider this measure as a good predictor of future economic profits (Storey, 1994). Consequently, new venture *Growth* is measured as follows:

$$Growth = \frac{\ln(Current\ employees) - \ln(Initial\ employees)}{Age}$$

The overall growth mean is situated at a 17.25% annual growth, and the median at 13%. The descriptive statistics identify a huge diversity in start-ups growth in employment since the minimum is negative (-22%) and the maximum almost duplicates the amount of employees each year (98%).

The likelihood of generating a patent is measured by *Patents-dummy*. It takes the value 1 when the firm has generated at least one patent since their creation and 0 otherwise. In the sample 16 firms has generated at least one patent (18.4%). Among those firms there is heterogeneity since 10 firms have created more than one patent. In particular, 2 firms generated two patents, 5 firms generated three patents, 2 firms generated five patents and lastly 1 firm generated eight patents. This distribution is measured by the variable named *Number of Patents*.

Explanatory variable

In order to explore the effort exerted in R&D activities, we compute the continuous variable *R&D effort* as the total investment in R&D over total revenues. While 26 firms did not make any investment in R&D, 48 makes a medium investment (it ranges between 0.1 to 49.9%) and the rest (13 firms) invest more than 50% of their sales.

Control variables

The topic of firm growth patterns has attracted considerable attention. Most of this literature has focused on the so-called Grilbrat's law which suggests that firm growth is independent of firm size and sector (See Sutton 1997 for a comprehensive survey). Although some evidence supports this view (Klette and Griliches, 2000; Lotti et al., 2009), other studies, both theoretical (Penrose, 1959; Shirtcombe, 1965) and empirical (Delmar et al., 2003), supports the view in which firm's growth patterns is dependent on its age, its size and its industry affiliation and hence posit that Gilbrat's law is a statistical artifact. Consequently it is clear the necessity to include as control variables firm's age, size, and sector. Given that data obtained through the survey refer to values at December 31st 2006, the *firm*'s *age* is calculated subtracting the year of creation to 2006. On average they are a bit older than 3.5 years. Size is measured through the amount of *initial employees* and the amount of *current employees* at December 31st 2006. It is worth stressing that the firms in the sample are very small. The average firm is created with 4.76 employees and at 2006 they have a bit less than 10 employees. Finally, as there is a huge heterogeneity in (the Spanish) CNAE[3] codes, we simplify their categorization in four groups which are the combination of two dichotomous variables; manufacture or services in one side, and high-technology sector or low-technology sector in the other. The most representative group is *Low-tech Services* with 42.5% of the firms. It is followed by *High-tech Services* with 33.3% and *Low-tech Manufacture* and *High-tech Manufacture* with around 12% of the observations each.

Finally, we also control for a couple of variables. In order to explain the generation of patents, we introduce into the model a variable to identify those firms selling at least

[3] CNAE for the *High-tech Manufacture*: 24, 29-34, 352-355; CNAE for the *Low-tech Manufacture*: 15-23, 25, 26, 271-274, 2751-2754, 28, 351, 361-366; CNAE for the *High-tech Services*: 64, 72, 73; and CNAE for the *Low-tech Services*: 50-52, 5, 60-63, 65-67, 70, 71, 74, 75, 80, 85, 90-93, 95, 99.

25% of their products and/or services in foreign markets (*International*). Only 10 firms have a substantial 25% (or higher) of international sales. In order to explain new venture growth, we introduce the *Number-Spinoffs* generated by those firms to control for external growth. Only 9 firms experienced this kind of external growth. While 1 firm generated seven spin-offs, 4 firms generated two spin-offs and the rest (4 firms) generated only one spin-off.

3.3 Methodology

To reach our research purpose we specify a model for jointly analyzing the direct and indirect effect of the effort exerted in R&D and start-up's growth.

$$Growth = f(R\&D\ effort, Patents, Control) \quad (1)$$

As we can see in the model specified (1), the direct effect reflects how the intensity in R&D influence a firm's growth, while the indirect effect is observed by patents, which is considered an endogenous independent variable. Accordingly, the model can be expressed as follows:

$$Growth_i = \alpha_0 + \alpha_1 Patents_i + \alpha_2 Effort\ R\&D_i + \alpha_3 Control_i + \varepsilon_i \quad (2)$$

$$Patents_i = \alpha_0 + \alpha_4 Effort\ R\&D_i + \alpha_5 Control_i + \varepsilon_i$$

The specification of the model presents and endogenous explanatory variable (Patents), and the model is estimated through a variation of the generalized two-stage least squares (Greene, 1993; pp. 682-684). Due to the characteristics of our endogenous instrumental independent variable, which may be measured as a dichotomous or a count variable (Faria et al., 2003), OLS is not an efficient procedure to estimate its predicted values. So we estimate the second stage of the specification (2) as a PROBIT (Greene, 1993; pp.

816-821) for the dummy measure of patents (*Patents-dummy*). According to Greene (1993, pp.886-887), NEGATIVE BINOMIAL outperforms single POISSON regression when the distribution of the variable does not accomplish with the assumption that the conditional mean and variance are equal for the dependent counting variable. The assumption does not hold in our case as we have a skewed distribution. Thus, we run a NEGATIVE BINOMIAL regression for the counting measure of patents. We use the linear prediction of those models as the instrument in the First-Stage regression (*Instrumented (Patents)*). The First Stage regression is estimated through OLS due to the continuous character of the dependent variable. We correct for the variance-covariance by applying the correct mean squared error (Baltagi, 2002, p. 278)

4. RESULTS

Table 3 shows the estimates for the second-stage of the specification (2) using both a count variable (i.e. number of patents of the firm) and a dichotomous variable (i.e. the firm has one or more patents). In other words, Table 3 provide us with the coefficients α_4 (note that it is the coefficient of the arrow Z in the Figure 1) and α_5 (controls) of the specification (2). The Model A presents the results of the NEGATIVE BINOMIAL regression and the Model B the PROBIT ones. According to the Wald test (23.47 and significant at 1% level) shown in Model A, we can reject the null hypothesis that the POISSON model is efficient (Winkelman, 2008, p.114) and hence NEGATIVE BINOMIAL is the appropriate model in our context.

- Insert Table 3 about here -

The results support the expected positive relation between R&D intensity (*R&D effort*) and both the amount of patents (significant at 5% level) and the likelihood of getting patents (significant at 1% level). For instance, according to the marginal effects of

Model B, ceteris paribus, the increment of 1% of R&D intensity will enhance in 0.41% the likelihood that a firm gets at least one patent. Besides, among the control variables introduced in those models, it is worth mentioning the effect of internationalization (*International*). This variable has a positive and significant (5%) effect on firm patenting. In particular, the fact of selling internationally enhances the likelihood of having patents in 40%. Early internationalized new ventures depend on knowledge, innovation and learning advantages to compete abroad (Autio, Sapienza and Almeida, 2000; Knight and Cavusgil, 2002). Moreover, their intellectual property needs to be protected against imitation (i.e. through patents) in order to appropriate rents from such advantages and to facilitate technology transfer (Nagaoka, 2009). Note that, independently of causality problems, the correlation identified is consistent with the stream of the literature focused on international activities of young firms and their innovation outputs (Park et al., 1999; Hadjimanolis, 2000; Wong and Singh, 2004).

Table 4 shows the coefficients for the First-stage of the specification (2). While in the Models A1 and A2 patents are instrumented through the Model A (POISSON), in the Models B1 and B2 Patents are instrumented through the Model B (PROBIT). Models C1 and C2 contain as independent variable the *Number of Patents*. Among the control variables there are little significant effects. Only *Firm Age* and *Initial Employees* have significant (and negative) effect to start-up's growth. It is worth mention that neither the sector nor the amount of spin-offs has a significant effect. Notice that the results of control variables give partial evidence to Gilbrath law.

- Insert Table 4 about here -

The *R&D effort* coefficients (α_2) in the Models A1 and B1 shed light to the lineal direct effect between R&D intensity and start-up's growth (Arrow X in the Figure 1). In both cases, we cannot reject the null hypothesis that α_2 equals zero. So there is not a lineal direct effect between R&D intensity and start-up's growth. Models A2, B2 and C2 controls for a quadratic effect through the introduction of the *R&D effort squared*. Although the signs of the variables *R&D effort* and *R&D effort squared* are consistent with a quadratic direct effect their significance is very small, above all in the instrumented models (*A2* and *B2*). So, according to our results there is neither a linear nor a quadratic direct effect of R&D intensity on start-up's growth. This result adds evidence on the inconclusive direct relation between those variables.

The (*Instrumented*) *Patents* coefficient (α_1) in Models A1 and B1 gives evidence to the Arrow Y in the Figure 1. That is the direct effect between patents and start-up's growth. These coefficients are positive and statistically significant at 1%.

Following the Sobel (1982) test[4], it is possible to calculate the indirect effect between R&D intensity and start-up's growth (the sum of Arrows Z and Y in Figure 1) and hence to test our Hypothesis. Those coefficients named $B_{mediation}$ are shown in the Table 5 with their correspondent t-student ($t_{mediation}$).

- Insert Table 5 about here -

All the coefficients are positive and significant. While the estimates from Model A (NEGATIVE BINOMIAL) are only significant at 10%, the ones from Model B (PROBIT) are significant at 5%. So according to the results we accept our Hypothesis. There exists a positive an indirect effect between R&D intensity and Start-up's growth

[4] It allows calculating the coefficient of the mediation effect and its t-value. $B_{mediation} = \alpha_1 * \alpha_4$; $t_{mediation} = B_{mediation} / s_{mediation}$; $s_{mediation} = \sqrt{\alpha_1^2 s_{\alpha_4}^2 + \alpha_4^2 s_{\alpha_1}^2}$. Where s_{α_1} and s_{α_4} accounts for the standard error for the coefficients α_1 and α_4 respectively.

mediated by patents. According to the estimates presented in the Table 5 an increment of 1% in R&D intensity enhances the start-up's annual employment growth rate in a range between 0.22% and 0.36%.

5. CONCLUSIONS

The results present an important managerial implication for entrepreneurs and promoters. The fact that the direct effect appears to be non-significant should be interpreted as *R&D does not guarantee start-up's growth by itself*. Indeed, it requires the mediation of an innovation output such as patents. In particular it is found that relative increment of R&D expenditure respect to sales of 1% indirectly and significantly enhances the annual employee growth rate of the firm in 0.22-0.36%. So according to the estimates the answer of the question opened in the title (*Does the intensity in R&D generate start-up's growth?*) would be *only when the start-up got patents.*

It is worth noting that the count-data measure of patents assumes homogeneity in their value. Although this assumption has important limitations (Grönqvist, 2009), the results clearly asserts that regardless of the patent's value, increasing their number proportionate a higher return of R&D investment (at least in terms of new venture's growth).

The idea behind the indirect effect relies on two main factors (see Figure 1). Broadly, the necessity to produce innovation output from R&D (Griliches, 1979) and the signaling role of patents for investors and debtors (Hsu and Ziedonis, 2008). Due to data constraints we cannot disentangle the relative weight of those factors in explaining the indirect effect. Further research should focus on this issue.

Obviously the fact of patenting is not necessarily the only mediator of R&D. Further research should focus on other mediators, for example those related with networking (i.e. being associated to a cluster). Besides, previous research has found moderators for R&D investment to achieve a higher performance such as marketing investment or commercial orientation (Kotabe et al., 2002; Lin et al., 2006).

Although relative annual employee growth is an accepted measure of performance for new ventures (Storey, 1994; Delmar et al., 2003), consistently with planned behavior theory (Ajzen, 1991) some authors posited that it exists heterogeneity in growth aspirations (Wiklund and Shepherd, 2003). Our data does not allow controlling for aspirations at the creation. Future robustness checks of the role of patents as a mediator should include aspirations heterogeneity.

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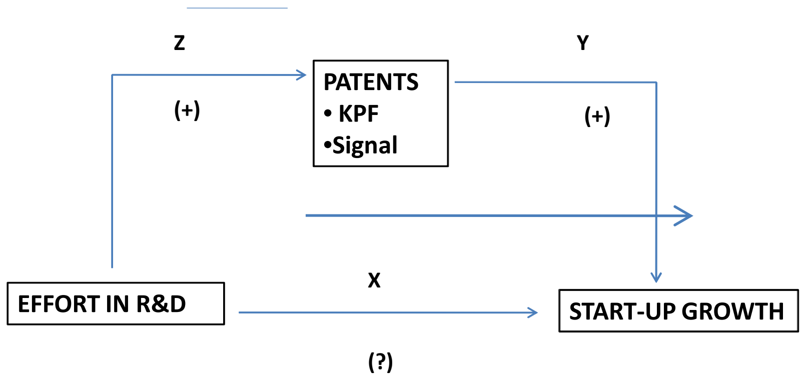
Z
(+)
PATENTS
• KPF
•Signal
Y
(+)
EFFORT IN R&D
X
START-UP GROWTH
(?)

Table 1: Predicted Sign and previous findings of the direct effect of R&D investment on firm's performance (or firm's growth)

Theoretical reasons	Predicted Sign	Argument
Resource based view (Barney et al., 2001**)**	+	Knowledge is the basis for obtaining a sustainable competitive advantage.
Absorptive capacity (Cohen and Levinthal, 1990**)**	+	Internal effort in R&D allows absorbing external knowledge (opportunities) more efficiently.
R&D is Costly (Nonaka et al., 2000; Zahra and Nielsen, 2002**)**	-	Building technological assets involve extra-costs which delays growth.
Internal R&D requires hiring employees	+	The internal R&D generates employment (i.e. researchers).
Previous Evidence with performance	**Sign found**	
(Kotabe et al., 2002**)**	Positively related with ROA moderated jointly by internationality and marketing investment (+). Otherwise no effect.	
(Carayannis and Alexander, 2002**)**	Positive effect between R&D intensity and ROA (only 4 years-lag) (+). Otherwise no effect.	
(Lin et al., 2006**)**	R&D intensity does not affect Tobin's Q. Besides R&D is moderated positively by commercial orientation (+)	
(Le et al., 2006**)**	Negative relation between R&D expenses per employee and shareholders returns (-).	
(Díaz-Díaz et al., 2008**)**	Negative with slow significance (-).	
(Coad and Rao, 2008**)**	Negative relation for established firms between R&D investment and sales growth (-).	
(Stam and Wennberg, 2009**)**	Positive relation between R&D activities and start-up's growth in high-tech new ventures (+), no effect in the rest of technological new ventures.	
Full effect	**Inconclusive**	

Table 2: Variables definition and Descriptive Statistics

Dependent Variable	Measure	Mean	Standard Deviation
Growth	Relative annual growth in employment	0.17247	0.2093217
Patents- dummy	Dummy equals 1 when the firm has at least 1 patent, 0 otherwise	0.183908	0.03896551
Number of patents	Total amount of patents	0.4942529	1.328345
Independent Variable	**Measure**	**Mean**	**Standard Deviation**
R&D effort	(Investment in R&D*100) over total revenues	20.86678	26.33089
Initial Employees	Amount of employees at the creation of the firm	4.764368	5.702325
Current Employees	Amount of employees at the end of 2006	9.844828	17.06389
Low-tech Manufacture	Dummy equals 1 when the firm belongs to the manufacture sector and in addition does not have technological sector, 0 otherwise	0.1149425	0.3208016
High-tech Manufacture	Dummy equals 1 when the firm belongs to the manufacture sector and in addition does have technological sector, 0 otherwise	0.1264368	0.3342676
Low-tech Services	Dummy equals 1 when the firm belongs to the Services sector and in addition does not have technological sector, 0 otherwise	0.4252874	0.4972525
High-tech Services	Dummy equals 1 when the firm belongs to the services sector and in addition does have technological sector, 0 otherwise	0.333333	0.4741373
Firm Age	The age of the firm (2006- the year of creation)	3.609195	2.598552
Number-Spin-offs	Amount of Spin-offs generated by the firm	0.2183908	0.8683758
International	Dummy equals 1 when the firm sends 25% or more of its sales internationally, 0 otherwise	0.1149425	0.3208016

Table 3: Determinants of start-up's patents

	MODEL A (NEGATIVE BINOMIAL)		MODEL B (PROBIT)	
	Coefficient	Marginal effect	Coefficient	Marginal effect
	β	*dy/dx*	*β*	*dy/dx*
R&D effort	0.03483**	0.009387**	0.018939***	0.004138***
	(0.01423)	(0.00474)	(0.005924)	(0.00145)
Current Employees	0.02904***	0.007827***	0.017543*	0.003833*
	(0.008637)	(0.00293)	(0.009462)	(0.00213)
Low-tech Manufacture	0.84311	0.323717	-0.040560	-0.008711
	(1.25914)	(0.68469)	(0.748739)	(0.15797)
High-tech Services	-1.42438	-0.328956	-0.860254*	-0.161437*
	(0.975388)	(0.23507)	(0.522496)	(0.09006)
Low-tech Services	0.79863	0.234552	0.067268	0.0147803
	(0.813453)	(0.27715)	(0.542216)	(0.11972)
International	1.3464**	0.65638	1.265416***	0.402067**
	(0.54286)	(0.40784)	(0.474193)	(0.17586)
Constant	-2.4407***		-1.54783***	
	(0.73873)		(0.526361)	
Observation	87	87	87	87
Pseudo-R^2			0.2418	
Wald Chi^2	23.47***		24.83***	
Log-Pseudolikelihood	-64.2334		-31.48339	

Level of statistical significance: *** 1%, ** 5%, * 10%
Standard robust errors in parenthesis

Table 4: Determinants of Start-up's growth

	MODEL A1	MODEL A2	MODEL B1	MODEL B2	MODEL C1	MODEL C2
(Instrumented) Patents	0.103512***	0.103773***	0.11695***	0.11581***		
	(0.034091)	(0.033174)	(0.041443)	(0.036618)		
Number of Patents					0.007116	0.007829
					(0.01691)	(0.019365)
R&D effort	-0.002007	0.003807	-0.000642	0.005109	0.001738*	0.007552***
	(0.002111)	(0.004948)	(0.001768)	(0.003829)	(0.000987)	(0.002669)
R&D effort squared		-0.000067		-0.000066*		-0.0000672**
		(0.000044)		(0.000035)		(0.0000264)
Initial Employees	-0.009787*	-0.009318	-0.008996*	-0.008497	-0.005832*	-0.005337
	(0.005734)	(0.007088)	(0.005464)	(0.005716)	(0.003082)	(0.003616)
Number-Spinoffs	0.006427	-0.004042	0.015337	0.005270	0.02928*	0.018587
	(0.028362)	(0.030061)	(0.024301)	(0.021803)	(0.017341)	(0.017732)
Low-tech Manufacture	-0.044942	-0.006530	0.03999	0.077319	-0.011532	0.027119
	(0.139618)	(0.133317)	(0.141174)	(0.114804)	(0.09281)	(0.087233)
High-tech Services	0.124065	0.1433359	0.071907	0.089217	-0.048046	-0.028860
	(0.192012)	(0.191696)	(0.172087)	(0.146673)	(0.101910)	(0.098616)
Low-tech Services	-0.094143	-0.058613	-0.028684	0.006151	-0.048496	-0.012697
	(0.136125)	(0.133771)	(0.135448)	(0.113362)	(0.090972)	(0.087706)
Firm Age	-0.019397	-0.015447	-0.018588	-0.014679	-0.017227**	-0.013326*
	(0.012643)	(0.011734)	(0.0117)	(0.009234)	(0.007527)	(0.006905)
Constant	0.469184***	0.383425***	0.404427***	0.318135***	0.25421**	0.16771*
	(0.142430)	(0.139608)	(0.134029)	(0.112919)	(0.101231)	(0.09383)
Observation	87	87	87	87	87	87
R^2	0.2346	0.2944	0.2169	0.2346	0.1416	0.2012

Level of statistical significance: *** 1%, ** 5%, * 10%
Standard robust errors in parenthesis

Table 5: Estimation of $B_{mediation}$

MODEL	$B_{mediation}$	$t_{mediation}$
A1	0.0036*	1.9045
A2	0.0036*	1.9282
B1	0.0022**	2.1202
B2	0.0022**	2.2554

Level of statistical significance: *** 1%, ** 5%, * 10%
Te results are calculated following the Sobel (1982) test.

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