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Why not all young firms invest in R&D

David B. Audretsch (♠), Agustí Segarra (♣), Mercedes Teruel (♣)

Abstract

This article aims to analyze the different impact that some factors may exert on the probability that a small young firm invests intensively in R&D. Recently, an increasing amount of the literature makes reference to the vital role played by a small number of young firms in generating jobs and increasing efficiency levels. However, not all new firms invest in R&D. Departing from the definition of YICs (firms younger than 6 years old, fewer than 250 employees and with more than 15% of their revenues invested in R&D activities), and with an extensive sample of the Spanish Community Innovation Survey between 2004-2010, we try to determine: i) those factors that cause firms to become YICs (innovative young small firms) or YNICs (moderately innovative young small firms); ii) what is the difference in the impact of those factors between YICs and YNICs. Our results show that factors such as initial innovation capacity and cooperation in R&D projects enhance the probability of becoming a YIC. Nevertheless, factors such as export potential and market uncertainty may influence the decision to invest moderately and become a YNIC.

Keywords: Innovation, Policy, YICs
JEL Classifications: O31, D21

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1. Introduction

The productivity gap that has existed between the United States and Europe since the seventies has drawn attention from scholars and policy-makers alike. In spite of the fact that R&D investment levels in the U.S. are similar to those in European countries, the "European Paradox" occurs due to the fact that the *Knowledge Filter* (Acs et al., 2005, 2009, 2013; Audretsch et al., 2006) does not necessarily improve competitiveness and economic growth. The reasons for this disconnection include weak links between the system of scientific research and industry (Dosi et al., 2006) and also sectoral characteristics (Cincera and Veugelers, 2013).

Recognizing the existence of this lack of knowledge, Veugelers (2008) and Schneider and Veugelers (2010) have focused their attention on Young Innovative Companies (YICs). This set of small, young and highly innovative firms have been highlighted as the main drivers for introducing new technologies and products as well as increasing long-term productivity (Aghion and Howitt, 2005). The low percentage of YICs within European industries, both manufacturing and services, has led to greater attention being paid to the determinants of this group of firms. However, the determinants that cause firms to become Young Non-Innovative Companies (YNICs are those small and young firms that invest less than 15% of their revenues in R&D) still remain unclear. While a broad range of the literature has focused on the obstacles that firms encounter, the advantages of not investing excessive economic resources in R&D and innovation have been neglected in the theoretical literature.

Consequently, the main purpose of this article is to analyze the determinants that might cause small and young firms to decide against investing intensively in R&D as opposed to those that do. We claim that there are incentives and obstacles that may cause small young firms to adopt a modest innovative profile. Our argument is in line with Carlsson et al. (2013) who state that "the essence of entrepreneurship is being different because one has a different perception of the situation". As a consequence, a diversity of strategies may appear when firms conceive differently the economic reality. If policymakers aim at providing support to the innovation activity of firms, they must take into account that this type of support might not be the best strategy for all firms. This is particularly crucial for European countries where the number of innovative firms is lower and the average size is smaller than in the U.S.

For a sample of Spanish Innovative firms between 2004 and 2010 belonging to PITEC (Panel de Innovación Tecnológica), we analyze the determinants that explain the probability of a firm not becoming a Young Innovative Company. Our results suggest that the drivers behind the probability of becoming a YIC or a YNIC are different. On the one hand, YICs are positively affected by the existence of highly skilled staff in the firm, the fact that the firm belongs to a group and if it cooperates with other agents. On the other hand, exporting to international markets has a positive effect on the probability of a firm

becoming a YNIC. These findings are consistent with the hypothesis that there are some key differences between both groups of firms. We contribute to this literature by considering YNICs as representing a rational strategy that firms may consider given their individual and sectoral characteristics. This may provide useful insights for obtaining a broader picture of the innovation activity of firms in a given industry.

The structure of the article is the following. The next section presents a review of the related literature, with particular emphasis on the incentives and obstacles that small young firms may encounter when deciding whether or not to invest in R&D. Section 3 shows the main characteristics of the database and the econometric methodology. Section 4 contains a discussion of the results. Finally, we present our main conclusions.

2. Theoretical literature

According to Czarnitzki and Delanote (2012), the fact that the characteristics of individual firms such as size and age are interrelated has given rise to the definition of a new category of firms. The appearance of Young Innovative Companies (Veugelers, 2008; Schneider and Veugelers, 2010) responds to this new category. Over the last few years, the attention of scholars has mainly focused on this category of companies. This section aims to review the different incentives and obstacles that small young firms may find when they decide to invest in innovation either intensively or moderately.

The importance of this subgroup of young small firms is due to the fact that high-growth firms are mainly young and small. During the 1980s, there was a greater interest in analyzing the role of a reduced number of firms that grow fast and generate the majority of jobs. Since the seminal work of Birch (1979) many papers have observed *ex-post* the environment that facilitates the generation of high-growth firms. High-growth SMEs are recognized as a vital source of dynamism in modern economies (Coad, 2009). When we attempt to measure the variables that define an HGF we find a diversity of situations. Scholars use different periods of observation and different measures of a firm's growth (workers, sales, turnover, etc.). In general, researchers consider HGFs to be those that grow by more than 20% every year for a period of 3 or 4 years (Henrekson and Johansson, 2010).

However, here we adopt a complementary *ex-ante* analysis of new and small innovative firms as a more appropriate viewpoint from which to design public policies. Recently, the European Commission has offered a new concept of young innovative companies (hereafter, YICs) that remarks on the *ex-ante* characteristics of new firms related to growth. The European Commission defines YICs as those firms that are less than 6 years old, have fewer than 250 employees and spend at least 15% of their operating expenses on R&D.

2.1. The incentives to become a YIC firm

The literature discussing the relationship between entrants and innovation dates back to Schumpeter. On the one hand, the so-called Schumpeter Mark I (Schumpeter, 1934) defines a system characterized by "creative destruction" where new firms introduce innovations into the market in order to pressurize incumbents. On the other hand, the so-called Schumpeter Mark II (Schumpeter, 1942) defines a system of "creative accumulation" where incumbents are more prone to introduce innovations into the market. Both frameworks seem to coexist in industry and, depending on the entry threats and the market structure, one system will be more predominant than the other.

Under both hypotheses, YICs find advantages and disadvantages for investing in R&D. On the one hand, YICs may have some advantages in the race for innovation since they may have a better managerial control and lower bureaucratization of innovation activity (Schneider and Veugelers, 2010) in comparison with incumbents. On the other hand, YICs may find more difficulties in comparison with incumbents since they will not be able to take advantage of economies of scale and scope and complementarities with other competences needed to commercialize their innovations. In that sense, less concentrated industries, industries with fewer sunk costs and in the early stages of the life cycle favour the appearance of small innovative entrants (see e.g. Acs and Audretsch, 1987, Utterback, 1996, Malerba, 2004).

More recently, a set of models rooted in the distance-to-frontier theoretical tradition have appeared. The "Schumpeterian effect" remarks that competition decreases the monopoly rents of prospective innovative firms, thus reducing their incentive to engage in R&D activities (Scherer 1967; Geroski 1990; Nickell 1996). In contrast, the "escape-competition effect" argues that competition increases incremental profits derived from innovative activities resulting in a positive relationship between competition and R&D. Aghion et al. (2009) suggest the idea of the "escape-entry effect" in line with the idea of the "escape-competition effect" as developed in Aghion et al. (2001). Those authors show that the threat of entrants induces incumbents in sectors that are initially close to the technological frontier to innovate more, but the threat of entrants may reduce the rents expected from carrying out R&D activities for incumbents in sectors far away from the frontier. Thus the threat of entrants to incumbents differs according to the distance of industries from the technological frontier. According to Schneider and Veugelers (2010), "the fear of cannibalization of existing profits restricts the incumbent's incentives to innovate (Reinganum, 1983), while the incentive to pre-empt entry pushes incumbent's innovations (Gilbert and Newbery, 1982)". Recently, Aghion et al. (2005) integrate these two contrasting forces and remark on the presence of an inverted U-shape relationship between market competition and innovation.

Within this framework, YICs may encounter a competitive reaction from incumbents in sectors which are near the technological frontier, while this reaction may not be as pronounced in sectors far away from the technological frontier. However, there might be

small market niches in sectors that incumbents may not be interested in occupying, while YICs might be interested in entering due to their greater flexibility and low scale. Conversely, YICs might encounter a fear of competition by incumbents who may opt to introduce their products into every market even if they are not profitable. As a consequence, the impact of the market might not be well-defined.

Another branch of the literature suggests that incumbents may or may not be better at innovating than entrants, depending on the nature of the innovation process (Abernathy and Clark, 1985; Tushman and Anderson, 1986; Henderson and Clark, 1990; Henderson, 1993). This line of research suggests that incumbents may have advantages in introducing incremental innovations but less so when the new technology requires a significant departure from their core capabilities. For instance, Henderson and Clark (1990) showed that architectural innovations tend to destroy the existing knowledge embedded in the structure and systems of established firms. Thus, in this type of innovation, incumbents may actually prove less innovative than entrants[1].

Considering this framework, YICs aspiring to obtain a larger market share might be more prone to invest in R&D and to introduce radical innovations to improve their market position in relation to their counterparts. Baumol (2002) and Vaona and Pianta (2008) argued that firms not concerned with safeguarding existing skills or their market position are more inclined to introduce radical innovations. Similarly, Veugelers (2008) argues that YICs tend to exploit a newly found concept while incumbents mostly introduce incremental innovations because they want to safeguard existing profits.

Furthermore, the literature has highlighted differences in the type of innovation introduced in the market. Along these lines, YICs are more prone to introduce product innovations since novelties are usually adopted in niche markets. Given that YICs are more flexible and quicker to respond to market needs, they may enter niche markets more easily than incumbents, while incumbents will be more prone to introduce process innovations (Cohen and Klepper, 1996; Vaona and Pianta, 2008; Schneider and Veugelers, 2010).

However, the threat of entrants to incumbents depends on a set of variables. Schneider and Veugelers (2010) point out several characteristics that may cause small young firms do not innovate: the licensing possibilities (Gans and Stern, 2000), the strength of intellectual property protection (Anton and Yao, 1994), the stage in the industry life cycle (Klepper, 1996), the effectiveness of the market for ideas, the control over complementary assets, the association with venture capital, the likelihood of cooperation between entrants and incumbents, among others (Gans et al., 2002).

2.2. YNICs: incentives and obstacles

[1] For instance, empirical evidence from the photolithographic equipment industry confirms that for incremental innovations, incumbents spend significantly more on R&D; while for radical innovations entrants are more successful (Henderson, 1993).

While there is a common understanding of the importance of innovation to survive, little attention has been devoted to small young firms that decide not to innovate or to innovate moderately. According to Katz et al. (2000, 8), small young firms are similar to fruit flies 'because they live and die quickly.' These high mortality rates are often attributable to their inability to adapt to change. Nevertheless, there is a large portion of small young firms which decide not to innovate in order to avoid the inherent risks of R&D activities.

Although risks associated with R&D activities are common to all firms regardless of their size and age, young small firms may face even higher barriers. We can highlight the following obstacles: lack of financial resources (asymmetric information is very accurate among young small firms, so small innovators are more likely to be financially constrained both internally and externally, see Segarra et al., 2013; Schneider and Veugelers, 2010), lack of human resources (incumbents may attract highly-skilled human resources), lack of absorptive capacity (incumbents may invest in internal R&D which increases their absorptive capacity, while small young firms may have more difficulties in attracting more skilled workers and as a consequence may have more difficulties in dealing with complexity[2]) and lack of the appropriation of benefits from innovation (appropriation requires complementary strategies to patents, such as trademarks, secrecy, lead time and complexity, all of which might require a critical scale that SMEs may lack (Teece, 1986; Cassiman and Veugelers, 2002)).

> **Hypothesis 1.** Knowledge barriers increase the likelihood that a firm remains as aYNIC.

Furthermore, although innovations may increase profits by increasing sales or reducing costs, the evidence is not conclusive. On the one hand, Geroski and Machin (1992) note relatively large and persistent differences in the profits of innovators and non-innovators. On the other hand, innovations may be associated in the short-term with lower profits (see Heunks, 1998, p. 266). Lower profits may be related to the sunk cost of innovations that firms must absorb and also to the dynamic nature of innovation since its success may be unlikely to manifest itself in increased profits until some years after product launch. Furthermore, in order to secure long-term profits derived from innovation, firms must be able to exert property rights or effectively employ other appropriability devices – e.g. learning curve effects, secrecy, first mover advantages, etc. (Dosi, 1998)[3].

Taking into consideration all these factors, firms may consider not becoming an intensively innovative firm and adopt a more conservative strategy in terms of R&D. To that effect, young small firms may opt for alternative strategies in order to enter the marketplace without having to invest in innovation. On the one hand, small young firms may adopt a

[2] Also there some interlinkages may appear between these factors. For instance, skilled workers are more likely to 'absorb' knowledge and consequently to reinforce absorptive capacity (Cohen and Levinthal, 1990).
[3] Recent evidence may be found in Helmers and Rogers (2010) who find that patenting increases the likelihood of survival in some sectors.

low-cost strategy. However, small young firms lack economies of scale to compete with incumbents. Furthermore, a lack of reputation may increase the difficulty in getting into a particular market given that customers may have a certain level of loyalty to more experienced firms (Segarra and Gombau, 2013). However, it may be the case that small young firms handle a small market which is not covered by incumbents and, as a consequence, they may survive by covering the needs of a specific market.

> **Hypothesis 2.** Market barriers increase the likelihood that a firm remains as aYNIC.

On the other hand, firms may adopt a quality strategy. Small young firms may try to increase customer satisfaction. One of the characteristics of small young firms is their flexibility and their capacity to respond to customers' needs. As a consequence, they may try to put greater effort into satisfying the needs of their relatively few customers in order to develop long-term relationships. Obviously, at the same time, firm size may also be a limitation since smaller firms often lack the ability to offer a wide variety of products. Hence, those firms with a developed market strategy will have less incentive to become an intensive young innovative company.

> **Hypothesis 3.** Firms with a market strategy will be more likely to remain as aYNIC.

Recently, Thomason et al. (2013) remark that small young firms may adopt cooperative behavior in order to compete with incumbents. Within this framework, small young firms collaborate with a competitor in order to overcome financial and technological deficiencies, and also in order to cover gaps in their product range. Moreover, when new firms invest in internal R&D activity, it increases their ability to generate 'absorptive capacity' and to capture external knowledge (Cohen and Levinthal, 1990) and to cooperate in R&D projects (Segarra and Arauzo, 2008). Here we expect the YNIC firms to have a moderate incentive to cooperate in R&D activities with other partners, while the YIC firms have more incentive to cooperate in R&D projects, especially with scientific partners, in order to increase their potential for creative destruction in new markets.

> **Hypothesis 4.** Firms that cooperate in R&D have fewer possibilities of remaining as a YNIC.

3. Database and descriptive statistics

3.1. Database

Our database belongs to the Spanish Technological Innovation Panel (henceforth, PITEC). PITEC is the result of the collaboration between the Spanish National Statistics Institute and the COTEC foundation. In accordance with the Oslo Manual (OECD, 2005), PITEC

contains information about Spanish innovative firms during the period 2004-2010. The main advantage of CIS data is that it contains a broad range of information on innovation behavior at firm level. PITEC includes innovative firms in the manufacturing and service sectors. However, CIS data has several constraints. First, it does not offer information on firms' balance sheets, which would allow us to assess the effect of internal or external finance on the behavior of R&D investment. Second, financial constraints and the innovation pattern at firm level are of a dynamic nature where time may be a relevant dimension. Nevertheless, Spanish PITEC overcomes this factor through offering panel data while the rest of European CIS datasets offer a cross section. In spite of all these disadvantages, PITEC is the best database for observing the innovation behavior of Spanish firms over a period of time (Barge-Gil, 2010).

The procedure employed for filtering our sample is that we drop firms that have suffered a process of mergers. For the definition of the YICs we adopt the European interpretation laid down in Article 35 of the General Block Exemption Regulation (GBER). The European Commission defines YICs as firms that are younger than 6 years old, have fewer than 250 employees and that spend at least 15% of their operating expenses on R&D. We also adopt the criteria of Schneider and Veugelers (2010) who define R&D intensity in terms of revenues (sales) rather than expenditure.

3.2. Descriptive statistics

Table 1 shows the distribution of our sample. Although initially the PITEC database contains 12,817 firms observed over a period of time, our database has 5,516 firms after the process of filtering. The percentage of YICs represents around 2% of our sample at the beginning of the period of observation, while this value reduces to 0.22%. With respect to YNICs, the starting value is around 4.5%, and at the end of our period of observation it is equal 0.53%. PITEC is mainly a balanced panel data and, as a consequence, the number of young firms shrinks over time.

Table 1.
Distribution of firms over time.

	YICs (%)	YNICs (%)	Others (%)	Sample (firms)
2005	2.27	4.50	93.23	4,091
2006	2.64	4.16	93.19	5,068
2007	1.88	2.56	95.56	5,047
2008	1.18	1.79	97.03	5,087
2009	0.56	0.94	98.50	5,130
2010	0.22	0.53	99.25	4,937

Source: PITEC

Table 2 shows the main characteristics of our three groups of firms: YICs, YNICs and other firms. We observe differences between YICs and their counterparts both in profiles and patterns of growth.

First, with respect to the pattern of innovation, YICs invest more in innovation in absolute terms than YNICs, while the value is similar to the other firms. However, if we observe the value of R&D intensity relative to sales, we observe that the effort of the YICs is substantially greater than its counterparts. Hence, in spite of the smaller size of the YICs, they invest much more in R&D than their counterparts.

Table 2.
Descriptive analysis. Mean and standard deviation in brackets

	YIC	YNIC	Others
R&D and Innovation investments (% on total investments)			
Innovation investments (thousands €)	1268.3 (1964.6)	258.2 (384.0)	1259.0 (1.12e+04)
R&D /Sales (%)	54.56 (13.19)	4.34 (4.05)	5.56 (14.68)
Growth pattern (%)			
Growth of sales (annual average rate)	28.24 (55.05)	22.49 (42.27)	7.37 (25.89)
Growth of workers (annual rate)	15.99 (32.78)	12.16 (33.50)	2.8 (17.60)
Firm characteristics			
Sales (thousands €)	2144.5 (3797.4)	2.16e+04 (8.32e+04)	5.34e+04 (2.58e+05)
Employees	30.13 (30.87)	61.00 (60.35)	203.02 (640.34)
Age (years)	4.38 (1.33)	4.45 (1.74)	27.37 (20.42)
Internal Financial Constraint (% firms)	41.18 (49.40)	35.06 (47.82)	25.86 (43.79)
External Financial Constraint (% firms)	37.50 (48.59)	36.36 (48.21)	24.70 (43.13)
Regional R&D subsidies (%)	66.18 (47.48)	30.74 (46.24)	25.76 (43.74)
Spanish R&D subsidies (%)	47.79 (50.14)	21.21 (40.97)	20.73 (40.54)
European R&D subsidies (%)	25.00 (43.46)	2.60 (15.94)	4.40 (20.51)
Knowledge barriers (%)	91.18 (28.47)	90.04 (30.01)	83.31 (37.29)
Market barriers (%)	91.91 (27.37)	89.61 (30.58)	81.17 (39.10)
Firm exports (% firms)	38.24 (48.77)	60.17 (49.06)	63.04 (48.27)
Cooperation in R&D projects (% firms)	64.71 (47.96)	30.74 (46.24)	30.53 (46.06)
Location in parks (% firms)	21.32 (41.11)	7.79 (26.86)	2.81 (16.52)
Belong to a group (% firms)	30.15 (46.06)	35.06 (47.82)	35.22 (47.78)
Researchers/Total (%)	55.66 (32.50)	44.51 (37.04)	29.92 (33.51)
Technicians / Total (%)	32.00 (28.26)	25.40 (29.40)	21.65 (27.77)
Firms in High-tech manufacturing industries (%)	12.50 (33.19)	34.20 (47.54)	35.64 (47.90)
Firms in Low-tech manufacturing industries (%)	6.62 (24.95)	39.39 (48.97)	44.49 (49.70)
Firms in Knowledge-intensive services (%)	77.94 (41.62)	21.64 (41.27)	10.52 (30.69)

Source: PITEC database

However, although YICs invest much more in R&D, their growth rates (in terms of sales and workers) are not significantly higher than YNICs, while young and small firms grow more than other firms. These results highlight that the different strategies employed by YICs and YNICs do not always increase the expected levels of profit and growth. Hence, this result questions the empirical results put forward in a wide range of literature that found a strong positive association between [product] innovation and turnover growth (Roper, 1997; Wynarczyk and Thwaites, 1997). Here, for a group of small firms and small young firms, they show the same profit in spite of having different intensities of R&D investment.

With respect to their profile, YICs are smaller than YNICs, while the mean size of the other firms has the highest value regardless of whether we consider the number of employees or sales. Furthermore, a larger percentage of small young firms state that they suffer financial constraints (internal and external); however, a larger percentage of YICs state that they receive R&D subsidies. With respect to firms that state they perceive market or knowledge barriers, the percentage is quite similar, although it is worth noting that the percentage of YICs that export is significantly smaller (38.24%) when compared with YNICs and other firms (around 60% of firms state that they export).

Furthermore, a larger percentage of YICs state that they cooperate in R&D projects and that they are located in scientific and technological research parks. Obviously, the percentage of researchers and technicians is significantly higher among YICs. Finally, we observe a lower presence of YICs in high-tech and low-tech manufacturing, while there is a larger presence in KIS industries. This sectoral structure is different for YNICs and the other firms, since they have a larger presence of manufacturing firms.

To sum up, the R&D strategies of firms seem to be closely related to their other strategies and also to sectoral characteristics and the market in which they operate. Therefore, YICs are represented less in high-tech manufacturing industries and more in KIS services, they are located in scientific and technological parks and they have more technical staff as well as cooperating more frequently in R&D programs. Conversely, YNICs employ strategies aimed at productivity gains per worker, are located outside the parks, tend to export more and register a lower percentage of research staff.

4. Econometric methodology and variables

The main purpose of this article is to analyse the determinants affecting the probability of remaining a YNIC. Our model is the following:

$$\Pr(\text{being a YNIC} = 1) = \Pr(\text{invest in R\&D} = 1, \text{invest moderately} = 1 \mid x)$$
$$= \Pr(\text{invest moderately} = 1 \mid \text{invest in R\&D} = 1, x) \cdot \Pr(\text{invest in R\&D} = 1, x)$$

Hence, we apply a probit model correcting by sample selection. The main idea is that, in each particular market, small young firms adopt two decisions. First, they decide to invest or not in R&D. Second, those firms that decide to invest in R&D have to decide to invest intensively in R&D or not.

Our first equation considers the probability that a firm decides to invest in R&D. We will consider the following equation:

$$y_{1i} = \begin{cases} 1 & if \quad y_{1i}^{*} = f(x_{1i}\beta_1 + u_{1i}) > 0 \\ 0 & otherwise \end{cases}$$

where y_{1i} is a dummy variable which indicates that a young small company (less than 6 years old with fewer than 250 employees) decides to invest in R&D. Here, y^*_{1i} is a latent dependent variable, x_{1i} are the determinants of the firm's decision to invest in R&D, β_1 corresponds to the vector of coefficients to be estimated and u_{1i} is the error term which follows $N(0, \sigma_1^2)$. Firm "i" will invest in R&D if y^*_{1i} is positive. Equation (1) will depend on the following set of explanatory variables (x_{1i}): *internalFC, externalFC, Size, Age, RegionalSubs, SpanishSubs, EuropSubs, HTmanuf*, *LTmanuf* and*KIS*.

The second equation is the probability that an innovative small young firm invests more or less than 15% of his revenues on R&D; in other words, the probability that a firm becomes a YNIC or a YIC. The dependent variable y_{2i} is a dummy variable that takes a value equal to 1 when a firm decides to invest moderately in R&D activities. This second equation will have the following form:

$$y_{2i} = \begin{cases} 1 & if \quad y_{2i}^{*} = f(x_{2i}\beta_2 + u_{2i}) > 0 \\ 0 & otherwise \end{cases}$$

where y^*_{2i} is the latent dependent variable, x_{2i} are the determinants of the decision to invest moderately, β_2 corresponds to the vector of coefficients to be estimated and u_{2i} is the error term which follows $N(0, \sigma_2^2)$. y^*_{2i} may be observed only when y^*_{1i} is equal to 1. Equation (2) will depend on the following set of explanatory variables (x_{2i}): *Size, Age, Researchers* and *Technicians, Export, Group, ScPark, Coop, Know*, *KnowStaff*, *KnowTech*, *KnowMarket*, *KnowPartner, Market*, *MarketEstabl*, *MarketUncert, HTmanuf*, *LTmanuf* and *KIS,*

Table 3.
Independent variables

Variable	Description
Size	ln(sales). Variable lagged one period.
Age	ln(age). Variable lagged one period.
Researchers and *Technicians*	Percentage of researchers and technicians working in a firm which is a proxy of the capacity of the firm to intensify its R&D activity
Export	Dummy variable with a value equal to 1 in the case that the firm exports.

Group	Dummy variable with a value equal to 1 in the case that a firm belongs to a group.
ScPark	Dummy variable with a value equal to 1 in the case that a firm is located in a scientific or technological park that facilitates cooperation with public research centres and universities.
Coop	Dummy variable with a value equal to 1 when a firm cooperates with other agents to carry out R&D activity.
Know, *KnowStaff*, *KnowTech*, *KnowMarket*, *KnowPartner*	Dummy variable that indicates the difficulties that a firm suffers of knowledge barriers (*Know*). *KnowStaff* indicates there is a lack of knowledge by the staff, *KnowTech* indicats there are difficulties in knowing the technology, *KnowMarket* indicates a lack of information about relevant markets and *KnowPartner* indicates difficulties in locating a partner with whom to cooperate.
Market, *MarketEstabl*, *MarketUncert*	Dummy variable which indicates the perception of barriers due to the fact that the market is dominated by established firms (*MarketEstabl*) or due to uncertainty (*MarketUncert*). The variable *Market* is equal to 1 in the case that the firm perceives either or both of previous barriers.
HTmanuf, *LTmanuf* and *KIS*	Dummy variables that indicate if a firm belongs to a high-tech manufacturing industry, to a low-tech manufacturing industry or to a knowledge-intensive service.
internalFC and *externalFC*	Dummy variable which indicates if a firm suffers from internal or external financial constraints.
RegionalSubs, *SpanishSubs* and *EuropSubs*	Dummy variables that indicate if a firm has received R&D subsidies at regional, Spanish or European level.

Equations (1) and (2) include time dummies to control for common temporal shocks since firms demonstrate procyclical behavior with regard to investing in R&D. Hence, during expansion, they invest more resources in R&D and innovation, while during a crisis investments shrink. With respect to error terms, Equations (1) and (2) might contain some commonly omitted variables and therefore the correlation term ϱ between u_1 and u_2 might be unequal to zero. This correlation between both equations may appear due to the fact that those small young firms that invest in R&D demonstrate non-unobserved characteristics which make them invest intensively in R&D. In fact, our estimation (see Table 4) of the parameter ρ indicates a significant coefficient. Consequently, there may be a sample selection bias, and the estimation of coefficients β_2 in respect of proposals only yields inconsistent estimates.

5. Results

This section presents our results. Firstly, we present the results obtained in the selection equation of those firms that decide to invest in R&D. Secondly, we compare the results obtained for the probability of becoming a YNIC or a YIC.

Regarding with the selection equation, our main results are the following. First, our proxies of financial constraints show a significant impact on the probability of investing in R&D. However, the impact is different depending on whether we consider internal or external financial constraints. While the impact of internal financial constraints has a negative impact on the probability of investing in R&D, the perception of external financial

constraints has a positive impact on the probability of investing in R&D. This result may be interpreted as the importance of having internal financial resources in order to invest in R&D projects, while the perception of lack of external financial resources may not be a limitation to carry out R&D activities. Another interpretation may be that, in spite of the fact that young small firms suffer from financial constraints, these firms will invest in R&D activities due to a need to compete in the market or due to the fact that they have been set up with the intention of investing in R&D activities.

Similar results are found in Schneider and Veugelers (2010). These authors find evidence of financial constraints for YICs in Germany. Their results show that YICs achieve significantly higher innovative sales than other innovation-active firms, but the access to financial resources is the most important factor that hampers YICs' innovation activities. Moreover, it does so significantly more than for other innovating firms. More recently, Hottenrott and Peters (2012) point out that financial constraints do not depend on the availability of internal funds, size or age, but are driven by innovation capacity that determines resource requirements. Hence, firms with a higher innovation capacity are more likely to have unexploited innovation projects. Firms with a high innovation capacity but low financial resources turn out as being most likely to be constrained. However, they also observe constraints for financially sound firms. Our results point out that, basically, the lack of internal resources will hamper R&D activity, regardless of the R&D intensity of firms. Furthermore, there is a difference between internal and external R&D financial resources.

With respect to the variables firm size and firm age, we observe that both variables show a positive sign. In this way, older and larger firms demonstrate a greater likelihood of investing in R&D activities. This result highlights that firms must increase their size and experience in order to invest in R&D activities.

Table 4.
Heckprobit estimation of the probability of being a YNIC and a YIC.

	(1)	(2)	(3)	(4)	(5)	(6)
	Probability of being a YNIC			**Probability of being a YIC**		
Size $_{t-1}$	-0.054	-0.054	-0.056	-0.522	-0.523	-0.523
	(0.029)***	(0.029)***	(0.029)***	(0.044)**	(0.044)**	(0.044)*
Age $_{t-1}$	-2.040	-2.042	-2.041	-1.716	-1.721	-1.719
	(0.081)*	(0.081)*	(0.081)*	(0.079)	(0.078)	(0.078)*
Export $_{t-1}$	0.163	0.163	0.160	-0.151	-0.146	-0.154
	(0.064)*	(0.064) **	(0.064) **	(0.077)**	(0.077)***	(0.077)**
Researchers $_{t-1}$	-0.002	-0.002	-0.002	0.003	0.003	0.003
	(0.001)	(0.001)*	(0.001)*	(0.001)**	(0.001)**	(0.001)**
Technicians $_{t-1}$	-0.003	-0.003	-0.003	0.005	0.005	0.005
	(0.001)**	(0.001)**	(0.001)**	(0.002)*	(0.002)*	(0.002)*
Group $_{t-1}$	-0.025	-0.025	-0.017	0.225	0.229	0.224
	(0.068)	(0.068)	(0.067)	(0.079)*	(0.080)*	(0.080)*
ScPark $_{t-1}$	-0.182	-0.178	-0.163	0.128	0.126	0.124
	(0.128)	(0.127)	(0.128)	(0.093)	(0.093)	(0.093)
Coop $_{t-1}$	-0.479	-0.482	-0. 469	0.448	0.454	0.456
	(0.068)*	(0.069)*	(0.069)*	(0.082)*	(0.082)*	(0.083)*
Know $_{t-1}$	0.173	0.159		0.030	0.082	
	(0.113)	(0.115)		(0.159)	(0.165)	
KnowStaff $_{t-1}$			0.169			-0.013
			(0.117)			(0.138)
KnowTech $_{t-1}$			-0.238			0.065
			(0.128)***			(0.141)
KnowMkt $_{t-1}$			0.199			0.114
			(0.118)***			(0.142)
KnowPartner $_{t-1}$			0.094			-0.091
			(0.065)			(0.102)
Market $_{t-1}$	0.154		0.205	-0.225		-0.247
	(0.112)		(0.113)***	(0.127)***		(0.135)***
Mktestablished		-0.044			0.114	
		(0.088)			(0.132)	
Mktuncertainty		0.198			-0.395	
		(0.115)***			(0.138)*	
HTmanuf	0.361	0.366	0.357	-0.891	-0.896	-0.893
	(0.135)*	(0.136)*	(0.135)*	(0.189)	(0.189)	(0.189)
LTmanuf	0.270	0.272	0.267	-0.883	-0.884	-0.898
	(0.130)**	(0.131)**	(0.131)**	(0.204)*	(0.205)*	(0.203)*
KIS	-0.228	-0.226	-0.239	0.252	0.260	0.259
	(0.144)	(0. 145)	(0. 145)***	(0.158)	(0.159)	(0.159)
Cons	2.126	2.141	2.200	2.917	2.892	2.892
	(0.280)*	(0.276)*	(0.277)*	(0.353)*	(0.347)*	(0.346)*
	Probability of investing in R&D			Probability of investing in R&D		
FC_internal $_{t-1}$	-0.048			-0.046		
	(0.023)**			(0.023)**		
FC_external $_{t-1}$	0.270			0.269		
	(0.024)*			(0.024)*		
Size $_{t-1}$	0.142			0.141		
	(0.008)**			(0.008)*		
Age $_{t-1}$	0.062			0.063		
	(0.012)*			(0.012)*		
RegionalPubSubs	1.100			1.098		
	(0.031)*			(0.031)*		
SpanishPubSubs	1.188			1.192		
	(0.036)*			(0.036)*		
EuropPubSubs	0.567			0.553		
	(0.097)*			(0.096)*		
HTmanuf	0.861			0.861		
	(0.031)*			(0.031)*		
LTmanuf	0.329			0.329		
	(0.029)*			(0.029)*		
KIS	0.659			0.657		
	(0.040)*			(0.040)*		
Cons	-1.288			-1.289		
	(0.060)*			(0.060)*		
Uncensored obs	21103			21103		
Censored obs	8630			8630		
Wald χ^2	731.45	725.31	743.33	574.03	589.00	581.36
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
Rho	0.389	0.385	0.377	-0.693	-0.685	-0.700
	(0.104)*	(0.104)*	(0.107)*	(0.102)*	(0.101)*	(0.103)*

Time dummies included.
, ** and * corresponds at significance levels at 1%, 5% and 10%*

Regarding public subsidies, we observe that firms with access to public R&D subsidies significantly increase the probability of investing in R&D activities. However, the largest impact is obtained for firms that obtain public R&D subsidies at the Spanish level, while the lowest level is obtained by European R&D subsidies.

Finally, we must highlight that there appear to be sectoral differences. First, high-tech manufacturing industries and KIS industries are more prone to invest in R&D activities than low-tech manufacturers. However, Low-tech industries register a positive impact compared to firms belonging to non-knowledge intensive services.

With respect to our main equation, our principal results are the following. First of all, firm size and firm age show significant negative coefficients. Our findings show interesting results. While firm size demonstrates a more negative impact on the probability of becoming a YIC, the parameter approaches 0 when we consider the probability of becoming aYNIC. The coefficient of firm age shows that older entrants are more prone to making smaller efforts to invest in R&D activities, regardless of whether we consider the probability of them being a YNIC or a YIC.

With respect to the international competitiveness of the firm, we observe interesting differences between the probability of being a YIC or a YNIC. While both groups of firms register a significant impact, this impact is positive for the probability of being a YNIC but negative for the probability of being a YIC. Our results confirm that firms which export do not invest intensively in R&D. The explanation for why firms which export invest only moderately in R&D may be due to the fact that firms which compete internationally already have a competitive product or competitive productivity. Hence, we may hypothesize that innovative young small firms which export do not invest so intensively and thereby moderate the risks that R&D activities involve.

Those variables closely related with human capital show a significantly different impact between the two groups. On the one hand, firms with a higher percentage of researchers and technicians have a lower probability of becoming a YNIC. On the other hand, a higher percentage of researchers and technicians increases the probability of being a YIC. Hence, becoming a YIC, an innovative small and young firm, seems to be related to characteristics connected with absorptive capacity and the potential of the firm to design innovation projects. Firms which, since their start-up, create a highly-qualified team to develop R&D activities will invest more heavily in R&D activities. Our results are in line with Hottenrott and Peters (2012) who confirm the importance of firms having highly-skilled staff to achieve a high innovative capability.

Belonging to a group also reveals a different impact. On the one hand, it decreases the probability of being YNIC, but not significantly. On the other hand, firms belonging to a group will have a significantly higher probability of becoming a YIC. Therefore, belonging

to a group ensures the access to know-how, financial resources and other resources; and as a consequence the probability of being a YIC increases.

With respect to location, those firms situated in a scientific and technological park will have a higher probability of remaining as a YIC but less probability of becoming a YNIC. However, the impact of this variable is not significant. Similarly, the cooperation in R&D projects increases significantly by being a YIC, and negatively by being a YNIC.

The impact of barriers of knowledge produces a non-significant impact. However, when we consider the different types of barriers, we observe that lack of technological knowledge shows a significant negative impact on the probability of becoming a YNIC with market knowledge showing a significant impact on this variable. However, knowledge barriers do not show a significant impact on the likelihood of becoming a YIC. Hence, our results may indicate that the presence of new technologies plays an important role for investing moderately in R&D. In that sense, new technologies create many possibilities to develop new products. Simultaneously with the development of a new technology, many entrants are keen on exploring the possibilities that appear in a new market (Geroski and Mazzucato, 2001). This hypothesis seems to be confirmed, at least for YICs, but the impact is non-significant.

With respect to the perception of market barriers, we observe that the general index shows a non-significant impact. However, when we consider the different types of market barriers, we observe that the perception of market uncertainty increases the probability of becoming a YNIC, while it decreases the probability of becoming a YIC. Hence, the propensity to enter a new market and invest in R&D is closely related to technological opportunities and profit margins. We must also highlight the influence of the barrier represented by the presence of established firms. Usually, when innovation opportunities are high, the industry will be characterized by a large number of small firms and the entry rate will be high. However, when the market increases, the market concentration rises and the presence of young and small firms reduces. In our case, we observe that the presence of established firms decreases the presence of moderately innovative entrants (YNICs) while it increases the probability of YICs.

Finally, firms in high-tech manufacturing industries and low-tech manufacturing industries show a significant positive impact on the probability of being a YNIC while KIS firms show a smaller probability of being a YNIC. The impact of those variables is opposite for YICs, where KIS firms show a larger propensity to become YICs.

6. Conclusions

The aim of this article is to examine the determinants of investing in R&D moderately for the subgroup of small and young firms. Previous studies have recognized that YICs (innovative firms less than 6 years old with fewer than 250 employees and expenditure on

R&D as a percentage of sales superior to 15%) are crucial to introduce innovations in the market and that policy-makers should carefully consider their particular requirements in order to design effective support schemes. However, empirical evidence shows that a larger percentage of young small firms remain with a low percentage of expenditure on R&D. Our study takes a step further in this direction and observes the determinants that may affect the probability of becoming a YNIC (innovative firms less than 6 years old and with fewer than 250 employees and a percentage of R&D expenditure less than 15% of sales).

Our database consists of a sample with 705 young small innovative Spanish firms observed during the period 2004–2010. We estimate a probit model controlling for the sample selection since firms that decide to invest in R&D are different in comparison with the rest of firms. Our results show that when new firms enter the market they follow different paths according to the nature of their market and the technological environment. We distinguish between intensive R&D strategies (YIC companies) and non-intensive R&D strategies (YNIC companies) but the returns in terms of workers and sales growth rates are higher in both. *A priori,* non-intensive R&D strategies are not the worst ones but they are different.

Our results show that Spanish YNICs are affected by market uncertainty and also by the lack of human resources in the firm. The firms that compete in international markets are more likely to be a YNIC, which may be due to the fact that they are already sufficiently competitive and they do not feel the need to assume the larger risks associated with R&D activities. In markets with high levels of uncertainty, new firms tend to become YNICs while the probability of becoming a YIC decreases. In contrast, when new firms are located in scientific parks, have a higher number of scientific staff, belong to a group and cooperate in R&D activities with external partners, these factors increase the probability of becoming a YIC firm.

Recent years have seen a strong rise in policies aiming to promote the innovative behavior of small and young firms. While there is consensus that these policies are necessary in order to increase the number of highly innovative firms, it is less understood why some firms decide to invest moderately. The initial innovative nature of a firm and its capacity to settle down in the market will influence a firm's innovative behavior. Therefore, those policies that promote R&D activity must be aware that sectoral characteristics may raise a barrier to the market for less risky firms. Finally, we must point out that policy-makers must take into account a broader range of characteristics that may influence innovation behavior such as stability of demand and the levels of uncertainty.

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Table A.1.
Matrix of Person correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
R&D / sales	1.000															
Export	-0.154*	1.000														
Researchers	-0.001	-0.026	1.000													
Technicians	0.214*	0.095*	-0.377*	1.000												
Size	-0.319*	0.188*	-0.061	0.075	1.000											
Age	0.053	-0.055	-0.035	-0.007	-0.150*	1.000										
Group	-0.103*	0.167*	-0.069	0.080*	0.404*	-0.077*	1.000									
ScPark	0.157*	-0.022	0.090*	0.035	-0.029	-0.019	0.044	1.000								
Coop	0.153*	0.093*	-0.070	0.075	0.083*	-0.026	0.199*	0.026	1.000							
Know	0.014	-0.023	0.000	0.011	-0.095*	0.044	-0.065	0.050	0.081*	1.000						
Market	0.048	-0.023	0.043	0.038	-0.111*	-0.022	0.016	-0.005	0.014	0.340*	1.000					
FC_internal	0.000	-0.036	0.078*	-0.076*	-0.019	-0.018	-0.048	0.001	0.007	0.186*	0.098*	1.000				
FC_external	0.017	-0.095*	0.029	0.013	-0.041	0.025	-0.066	0.050	0.024	0.130*	0.007	0.481*	1.000			
RegionalPuSubs	0.207*	-0.045	-0.068	0.114*	-0.068	0.046	0.016	0.061	0.283*	0.054	0.054	-0.004	-0.010	1.000		
SpanishPubSubs	0.196*	0.036	-0.023	0.091*	0.045	-0.031	0.107*	0.039	0.219*	0.016	0.036	0.008	0.007	0.166*	1.000	
EuropeanPubSubs	0.044	-0.021	0.021	-0.002	-0.014	0.004	-0.011	0.008	0.084*	0.034	0.034	0.000	-0.064	0.036	0.020	1.000

** Significant at 1%.*
Source: autors