High-Growth Firms and Innovation: an empirical analysis

(preliminary version)

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Abstract

This paper uses data from an extensive CIS sample of Spanish firms during the period 2004-2008 to analyze how important innovation is for high-growth firms (HGFs). In order to measure of the extent to which firm innovation affects firm growth, we apply a two-step econometric procedure to firm growth (measured in terms of employment and sales). First, a probit analysis determines whether innovation affects the probability of being a high-growth firm. And second, a quantile regression technique is applied to explore the determinants and characteristics of specific groups of firms (manufacturing versus service firms and high-tech versus low-tech firms). It is revealed that R&D plays a significant role in the probability of becoming a high-growth firm. Investment in internal and external R&D per employee has a positive impact on firm growth (although internal R&D presents a significant impact in the last quantiles, external R&D is significant up to the median). Furthermore, we show evidence that firms that cooperate present a significant and positive impact.

Keywords: high-growth firms, firm growth, innovation activity

JEL Classifications: L11, L25, O30

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1. Introduction

Firm growth and its determinants are key issues for economists. Not only can an understanding of the determinants of firm growth, survival patterns and firm decline have an impact on individual cases, it can also have implications for industrial policy. This is particularly true now when the economies have little capacity to create job opportunities. The current financial crisis has raised questions about public policy in developed economies, one of which is whether public support should be given to all firms or only to a selected group of dynamic firms. To date, some of the questions raised in this debate are still unanswered.

This paper considers the role that innovation performance has on a firm's pattern of growth or decline. In particular we analyse the organic growth of firms (hence, we do not analyse expansion by acquisition and/or mergers); the determinants of high-growth firms (henceforth HGFs) in Spain; and the link between a firm's input-output innovation strategies and growth.[1]

Recently, the empirical literature concluded that HGFs are a small group of firms that have a critical capacity for creating new jobs and economic growth (Henrekson and Johanson, 2010; Falkenhall and Junkka, 2009; Schreyer, 2000). However, very few studies have been made, perhaps because of the scarcity of representative longitudinal databases (Henrekson and Johansson, 2010). Innovative high-growth firms are of special interest since they are able to push the technological frontier but face higher risks. In this regard, R&D and innovation are generally considered to be key drivers of firm performance. However, the intrinsic risks of innovative activity may prevent firm growth in some cases and promote it in others. Innovative HGFs have different characteristics from their counterparts. For this reason, they should be monitored and their determinants analysed so that any implications for public policy can be determined.

This article, then, uses a new CIS data panel to analyse the R&D behaviour of Spanish HGFs during the period 2004-2008. Spain is a particularly interesting case because it is considered to be a moderately innovative European country (European Commission,

[1] This study does not consider the entries and exits of firms during the period 2004-2008 or firm growth by acquisition and/or merges. Recent literature has distinguished between organic and acquisition growth. Organic growth is the result of new investment and projects in the firm, while acquisition growth is the result of acquisitions and/or mergers. Organic growth and acquisition growth may also be referred to internal growth and external growth, respectively. The significance of organic and acquisition growth differs between groups of firms. In a sample of high-growth firms, Davidsson et al. (2006) find that youngest and smallest firms grow organically, but larger and older firms tend to grow by acquisition becomes.

2010) and is currently immersed in a damaging crisis. This research has three key aims. First, we apply a criterion to classify innovative HGFs in the Spanish manufacturing and service sectors over a 5 year-period. Second, we determine the factors that increase the probability of a firm becoming a high-growth firm. Third, we observe the linkages between firm growth and innovation effort (investment and cooperation) and performance (types of innovation), paying special attention to the effect of innovation activities on growth rate.

One of the most interesting contributions is the use of the Technological Innovation Panel (PITEC), which matches CIS III (2002-2004) and CIS IV (2005-2008). Hence, the final data set used here contains firm level data, with a relatively consistent data collection methodology over a number of time periods. This data comes from Community Innovation Surveys, based on the Oslo Manual (OECD, 2005), and therefore includes information about innovation activities that is comparable to the microdata on innovation of many other European countries. The main advantage of this database is that it provides a longitudinal database with an extensive set of more than twelve thousand firms for the period 2004-2008.

The paper is structured as follows: In the next section we provide a short literature survey on HGFs and innovation. Section 3 presents the CIS data and descriptive statistics. Section 4 presents empirical results showing the determinants of innovative HGFs, and gives the results of probit regressions and quantile estimations. Section 5 summarises the findings and discusses policy.

2. Literature review

2.1. A brief review of literature on high-growth firms

Firm growth studies have focused on the question of whether firm growth is independent of firm size. In general the starting point is the well-known ‘Law of Proportionate Effect’ or ‘Gibrat’s law’ (Coad, 2007). Gibrat observed that firm size distribution followed the lognormal distribution very closely, and he concluded that a firm’s rate of growth could be a random process. In particular, he reasoned that growth could not depend on the initial firm size, as this would inevitably produce a lognormal distribution.

Later Birch (1979) found empirical evidence that pointed to the stochastic nature of dynamic firm growth. However, if firm growth is a random variable, then three outcomes are excluded: first, firms of a given size will grow faster (or slower) than firms of other sizes; second, firms that grow faster (or slower) in one time period will grow faster (or slower) in a later time period; third, some factors will powerfully and consistently explain firm growth performance. Indeed, these incompatibilities were also noticed by Sutton (1997). In his review of 'Gibrat's Legacy', he found that half a century of testing had revealed several statistical regularities that were incompatible with firm growth being essentially random—most notably that small firms appeared to grow faster than large ones and that growth rates were serially correlated. In this regard, Hart and Oulton (1996) and Singh and Whittington (1968) found evidence to show that the smallest firms grew the fastest and Wagner (1992) found that those firms that grew faster in one period of time were more likely to grow faster in subsequent periods.

Also, a recent review by Coad (2009) of more than 20 studies concludes that the overall evidence on the serial correlation of growth rates, both positive and negative, is mixed. Of particular interest for the current paper is that this author finds that some firms do grow exceptionally fast and increase in size in a relatively short space of time. With reference to high-growth firms, Falkenhall and Junkka (2009) point out that high-growth firms are replaced by those that will exist in the next period. They consider that this replacement "*is a part of a natural process of ongoing structural transformation or creative destruction, where winners on the market are selected in accordance with the theory of competence blocks*". However, recent studies have shown that some high-growth firms undergo an explosive transformation at firm level in a short period in all countries, sectors and sizes. For this reason one of the key issues in the empirical literature and at policy level has been to define high-growth firms and find their determinants.

Parker et al. (2010) presented a survey on high-growth firms. First, they highlight the lack of a commonly accepted denomination used for 'high-growth' firms. In this regard, the literature has referred to fast-growth firms, high-growth impact firms (Acs et al., 2008), high-growth firms (Schreyer, 2000), "superstar" fast-growth firms (Coad and Rao, 2008), rapidly expanding firms (Schreyer, 2000), and gazelles (Birch, 1981, among others). Second, they point out that there are different definitions of high-growth firms.[2] Third, they show that the literature also uses a variety of growth indicators, of which sales, employment, profitability and market-share are the most common.[3] Some authors even apply the so-called Birch index (i.e., the combination of employment growth measured in absolute and relative terms, as a growth measurement to relate to previous literature) (Schreyer, 2000). Finally, they indicate that a size or threshold is applied. For instance, the OECD recently proposed defining HGFs as those with 10 or more employees. The term "gazelle", on the other hand, is applied to those HGFs less than five years old.

However, some empirical facts about high-growth firms have also emerged. First, they are found in all industries and in all regions (Schreyer, 2000). Second, they are more R&D intensive than growing firms and the average permanent firm. Third, high-growth firms are found in almost every sector; hence, an exclusive focus upon technology-based sectors would exclude the vast bulk of high-growth firms (Acs and Mueller, 2008). Fourth, the patterns of growth amongst HGFs are extremely volatile (Delmar et al., 2003; Garnsey et al., 2006; Acs and Mueller, 2008; Hull and Arnold, 2008). Fifth, Falkenhall and Junkka (2009) point out that this volatility is due to the replacement effect of current high-growth firms by other future high-growth firms. Sixth, a high proportion of high-growth firms are partly or wholly owned by others (Schreyer, 2000). Finally, high-growth firms tend to be younger and smaller than their counterparts (Schreyer, 2000). However, Henrekson and Johansson (2010) pointed out that "it is young age more than small size that is associated with rapid growth".

2.2 Innovation and high-growth firms

The effect of innovative activity on firm performance has received a great deal of attention (Segarra and Teruel, 2010). Recently, the literature has emphasized the existence of "absorptive capacity" (Cohen and Levinthal, 1989), a phenomenon that is the result of the complementarities between internal and external R&D. First, investment

[2] Authors have used different period of observation. For instance, Henrekson and Johansson (2010) consider high-growth firms those that grow more than 20% every year for a period of 3 or 4 years, while Fritsch and Weyh (2006) used the longest time 8 period, 18 years.

[3] Daunfeldt et al (2010) present an exhaustive panel of growth indicators and growth measurements used in empirical literature. They define HGFs by employment and sales and add definitions of value added and productivity.

in internal R&D activity leads to innovation, but it also leads to indirect effects related to the exploitation of the knowledge developed outside the firm (Fabrizio, 2009; Catozzella and Vivarelli, 2007). This result has also been emphasized by Stam and Wennberg (2009) where R&D efforts capture external knowledge.

Empirical evidence about the effect of innovation activity on firm growth is mixed, however. Stam and Wennberg (2009) hypothesize that innovation activity does not improve the performance of the average firm but "only has a positive effect on the growth rate of fast-growing firms". According to these authors, R&D and innovation effort are a key determinant of high-growth firms. For example, Smallbone et al. (1995) showed that the management of product and market development most consistently distinguished HGFs from other firms. For these authors, although "*it is true that a few firms could survive for ten years without paying some attention to product and market development, to achieve high growth firms need to be particularly active in this respect*". In line with these results, in a sample of 1,480 growing Canadian SMEs Baldwin (1994) found that 30% of firms considered that their success was down to their innovation strategy.

However, there are some differences between countries. For a sample of SMEs from 16 countries using CIS data, Hölzl (2009) finds that R&D effort and innovativeness are higher for high-growth SMEs in countries close to the technological frontier. According to these results, there are interactions between the effort of innovation, the returns on innovation and the technological level of the country.

Coad and Rao (2008) also analysed the relationship between innovation and sales growth for incumbent firms in high-tech sectors. Using a quantile regression approach, they observe that innovation is of crucial importance for a handful of 'superstar' fast-growth firms. They pointed out the existence of a "paradox". On the one hand, there is a wide range of theoretical and empirical contributions that highlight the importance of innovation for firm growth. On the other hand, there is a scarcity of strong results showing that innovation and firm growth are associated. In line with Coad and Rao (2008), Stam and Wennberg (2009) also find that R&D is an important determinant for new high-growth firms.

These difficulties may be due to the fact that the innovation process is rather complex: converting R&D into innovation, and finally contributing to the firm's performance may take a long time (Coad and Rao, 2008). In general, the innovation process is rather risky and uncertain. Hence, an in-depth study into the relationship between innovation activity and firm growth needs to be made (Cefis and Orsenigo, 2001; Coad and Rao, 2010). In line with this, Cainelli et al. (2006) analysed a set of service firms and found that innovation has a positive influence on growth and productivity. In fact, productivity enhancement acts as a self-reinforcing mechanism to encourage more innovation. Their results suggested that "embarking on long-lasting, costly and risky innovation projects requires a 'healthy' economic structure and is facilitated by fast-growing markets".

Furthermore, Parker et al. (2010) using a novel British data set containing information on more than 100 gazelles found that HGFs that had developed new products for introduction to the market after 1996 were significantly less likely to survive and less likely to be acquired than to be liquidated. This finding might reflect the risk of new product development.

Although analysing the effect of innovation activity on high-growth firms is of considerable interest, to the best of our knowledge no studies have yet investigated the effect of innovation activities (innovation effort and innovation performance) on the growth of innovative high-growth firms.

3. Descriptive

3.1. PITEC and the measure of high-growth firms

The CIS is a firm level survey conducted by the European Union and several non-EU countries. It aims to provide a sound source of statistical data on innovation by using a stratified sample of firms, in which the stratification of the sample (by size-class and sector of activity) should ensure that the samples are representative. We use PITEC panel data which integrates information from CIS-4 and CIS-5.

The main advantage of the PITEC data is that it contains detailed information from the CIS on innovation behaviour at the firm level and the use of panel data for the period 2004-2008 data makes it possible to make a detailed study of the innovation behaviour of high-growth firms. PITEC overcomes the main drawback of the CIS data because it enables the evolution of the individual firm to be analysed during the period 2004-2008.

We should also point out that it has some drawbacks itself: for example, there is little financial information, which is a crucial variable for firm growth, and some questions are “subjective”. In this regard, the assessment of the innovative character of a particular activity is at least partially dependent on the views of the entrerpeneur. However, the evidence provided by Mairesse and Mohnen (2004) suggests that the subjective measures appear to be consistent with more objective measures of innovation, such as the probability of holding a patent and the share in sales of products protected by patents.

Our final database was subject to a process of filtering. First, we selected firms from the manufacturing and service sectors (including high-tech and low-tech sectors). Second, we excluded firms with 3 or fewer years of observation. Third, firms that had experienced a sudden change such as a merger or an acquistions are not included in our sample. Fourth, we restrict to those observations with a growth or decline of sales and employees smaller than 250% in order to control the presence of outliers. With this process the sample gained in the consistency of the data. However, the initial base was reduced from 12,813 to 5,017 firms.

From this final selection of firms, we found those that are high-growth. Our definition of high-growth firms is based on the growth experienced by firms in terms of number of employees or sales, or both simultaneously.[4] We consider a firm to be high-growth when it grew by 80% between the year 2004 and 2008. Therefore, there are two groups of high-growth firms: employee high-growth firms and sales high-growth firms. Our final panel data has 5,017 firms, of which 495 (9.86%) were HGFs from the sales point of view and 265 (5.28%) were HGFs from the employee point of view.

Hence, our dependent variable is sales and employment growth. There are numerous ways in which firm size can be measured empirically. Employment and sales are the most frequent indicators, but sometimes assets are used (Coad and Hölzl, 2010). Delmar (1997) points out that little congruence is to be found among the growth measures used across studies. Both of the most frequently used measures—sales and employment growth—have advantages and disadvantages. One drawback of the sales variable is

[4] Recently OECD and Eurostat l'any 2008 in the *Manual on Busines Demography Statistics* high-growth enterprises can be defined both in terms of employment (number of employees) and in terms of turnover. The definition of HGF is as follows: “*All enterprises with average annualised growth greater than 20% per annum, over a three year period should be considered as high-growth enterprises. Growth can be measured by the number of employees or by turnover*”.

inflation (Delmar et al., 2003), so we deflated it, and the rest of the monetary variables, by the industrial price index. Given that policy makers are concerned with reducing the unemployment rate, employment is generally considered to be an interesting measure of firm growth (Storey, 1994). However, employment growth is highly affected by increases in labor productivity (Delmar et al., 2003).

In recent decades, firm innovation strategies have surpassed the limits of product and process innovations. Therefore, the third edition of the Oslo Manual (OECD, 2005) has expanded the old frame and has added two additional types of innovation: organizational innovation and marketing innovation. This is of particular interest in our work, because high-growth firms—specially small, young firms—may start their innovation trajectory by introducing product and process innovation, and some years later invest in organizational innovation and internal skills in order to improve the governance and management of the firm.

Table 1.
Size and growth rate in manufacturing and service firms. Deciles for firm size measured by number of employees.

Deciles	Manufacturing firms		Service firms	
	Number of employees	Growth in the number of employees (%)	Number of employees	Growth in the number of employees (%)
1	98.35	-25.29	108.84	-32.74
2	138.89	-9.81	263.38	-10.31
3	180.79	-5.01	1124.75	-2.71
4	328.75	-1.93	63.45	0.00
5	88.97	-0.01	558.37	0.60
6	197.67	0.24	677.46	3.42
7	250.52	2.69	437.95	6.93
8	186.76	5.89	377.87	12.24
9	152.91	11.03	218.68	21.21
10	140.12	33.38	169.27	57.01
Total sample	**176.37**	**1.12%**	**400.00**	**5.57%**

Source: PITEC and authors.

The usual approach to input and output innovation indicators is to provide descriptive statistics (see table 1 and table 2). The information is applied to four subsamples from the manufacturing versus service firms, and high-growth versus non high-growth firms. The descriptive statistics in Table 1 provide interesting results:

a) The average growth rate is higher (5.57%) in service firms than in manufacturing firms (1.12%), and the level of dispersion between growth and decline rates is also higher.
b) The relationship between firm size and growth rates in manufacturing and service firms describes an inverted U-shape curve. In the first three deciles, both firm size and growth rates increase; in the last three deciles, firm size decreases but growth rates increase; and finally, in the intermediate deciles—5 and 6 in the manufacturing sector and 4 and 5 in the service sector—there is no clear pattern.

Table 2.
Descriptive statistics (average values) in 2004.

	Manufacturing sectors			
	Employee classification		**Sales classification**	
Innovation performance	**HGFs**	**Non HGFs**	**HGFs**	**Non HGFs**
Sales growth period	25.61%	0.36%	10.62%	0.37%
Size growth period	22.33%	2.70%	28.00%	1.33%
Firm sales (thousands of euros)	29100.00	105000.00	113000.00	91500.00
Employees	119.02	178.13	114.13	181.29
Productivity (thousands of euros)	199.48	220.07	250.56	216.99
Internal R&D (%)	58.01	49.74	56.78	49.45
External R&D (%)	9.78	8.97	9.64	8.95
Cooperation	0.38	0.31	0.38	0.31
Organization innovation	0.71	0.63	0.71	0.63
Marketing innovation	0.77	0.74	0.76	0.73
Innovation organization	0.58	0.48	0.54	0.48
Innovation market	0.34	0.28	0.29	0.28
	Service sectors			
	Employee classification		**Sales classification**	
Innovation performance	**HGFs**	**Non HGFs**	**HGFs**	**Non HGFs**
Sales growth period	26.41	2.52	14.55	3.54
Size growth period	24.02	6.00	28.81	3.66
Firm sales (thousands of euros)	29100.00	105000.00	113000.00	91500.00
Employees	165.06	434.37	439.69	391.03
Productivity (thousands of euros)	155.41	152.19	149.89	153.21
Internal R&D (%)	63.87	42.74	55.08	43.25
External R&D (%)	6.79	6.76	10.59	5.90
Cooperation	0.47	0.33	0.46	0.33
Product innovation	0.70	0.55	0.71	0.53
Innovation process innovation	0.68	0.63	0.74	0.61
Organization innovation	0.62	0.52	0.68	0.50
Marketing innovation	0.31	0.25	0.36	0.23

Source: PITEC
Notes: Firm sales and productivity in euros (thousands), Internal and External R&D are percentages over innovations. Finally, Cooperation, Product, Process, Organization and Market Innovation are dichotomic variables (these variables indicate the average number of firms that innovate or cooperate).

c) Contrasting the level of significance between the deciles and the average size confirms the results of the previous patterns (Table A-1 in the annexe). The mean test confirms that firm size is smaller in the first two deciles in manufacturing industries and in the first three deciles in the service industries. When the comparison is made in the upper deciles, the size of manufacturing firms is smaller, while the size of service firms is larger.

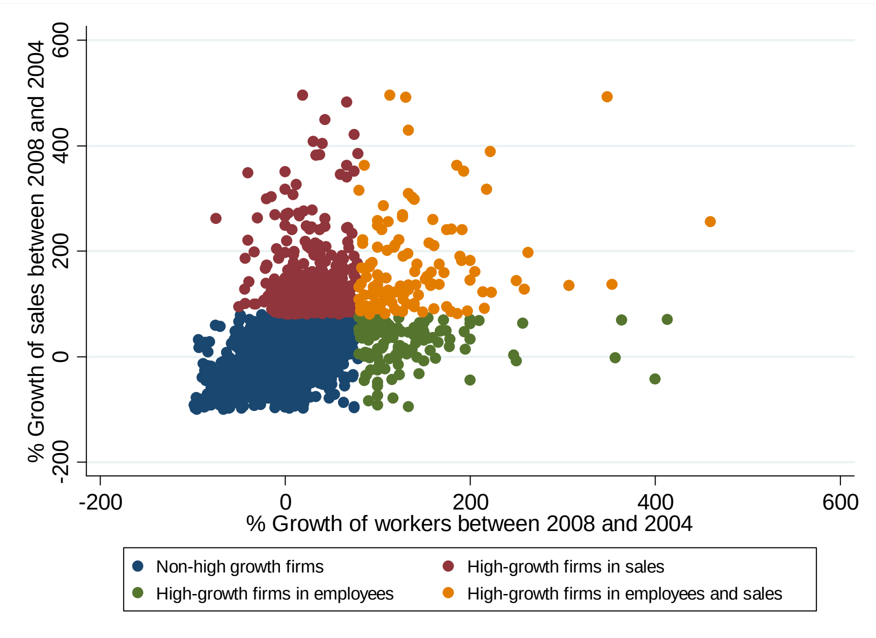
d) When we applied the mean test in input-output innovation analysis (Table 2) we obtained the following results[5]. In manufacturing and service industries HGFs growth faster than their counterparts, but have lower sales and employees (Table A-2).

e) The productivity level measured by the ratio between sales and workers is higher in non high-growth firms. This shows the scale effects and the higher ratio of capital per worker in these firms.

f) As far as the three sources of innovation are concerned (internal R&D, external R&D and cooperation), HGF's show higher investment in internal and external R&D per worker and tend to cooperate more in R&D projects than their counterparts.

g) Finally, as far as the four outputs of innovation are concerned the results obtained by high growth-firms are significantly higher than those of their counterparts.

Figure 1. Plot of growth over the 4-year period by type of firm.



Source: authors

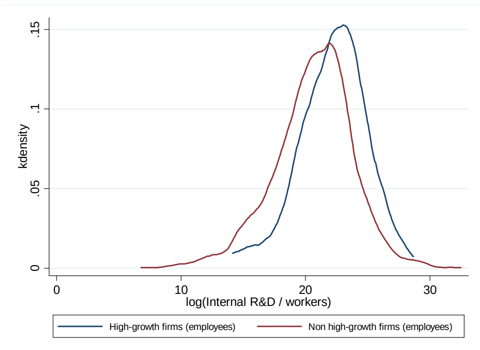
[5] Table 2 only shows firm's size and growth rate in employees, since the results obtained with sales indicators are rather similar.

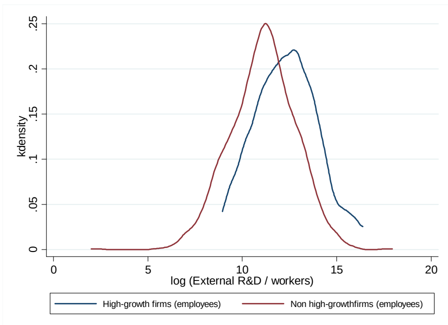
Figure 1 plots the growth of firms in terms of employment and sales during the period 2004 and 2008. The blue points show those firms that have not been classified as high-growth firms. The green and red points identify firms which are high-growth firms measured in terms of employees and sales, respectively. Finally, the group of innovative firms that have grown in both variables are coloured in yellow. This plot shows that the use of different measures will classify some of the firms as a high-growth firm regardless of the measure, while two more groups include those firms that are high-growth firms in sales or employees. Hence, we believe it is important to try to identify high-growth firms through employees and sales.

Figure 2. Kernel densities of the internal and external R&D effort per worker

High-growth firms in terms of employees

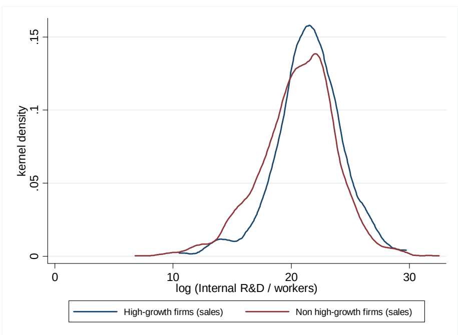
Log (Internal R&D / workers) **Log (External R&D / workers)**

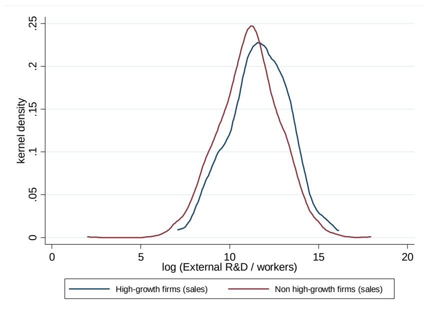




High-growth firms in terms of sales

Log (Internal R&D / workers) **Log (External R&D / workers)**





Source: authors

We also present the distribution of the internal and external R&D expenditure per employee as further evidence of the characteristics of our sample. Figure 2 shows the kernel density of these variables and distinguishes between high-growth firms (employees and sales) and their counterparts. Generally speaking, we observe that high-growth firms invest more in internal and external R&D. Although the differences in the distribution are not so clear among high-growth firms in sales, the mean tests provided in the annex show that the differences are statistically significant (see Table A.2).

3.2. Econometric methodology

In order to analyse the relationship between the innovation process and the behaviour of high-growth firms, we will apply a two-step procedure. First, following López and Puente (2009), we estimate a probit regression in order to determine the main determinants of the probability of being a high-growth firm. The dependent variable is a categorical variable, which adopts the value of 1 for high-growth firms according to the OECD definition and 0 for the other firms. The equation estimated will be the following:

$$P(hgf = 1)_{i,t} = \alpha_1 + \beta_1 Z_{1i,t-1} + u_{1i,t}$$

where Z_1 are lagged independent variables and α_1 and β_1 are the coefficients to be estimated and, finally, u_1 is the error term.

Second, in line with Coad and Rao (2008), we apply a quantile regression and we do not restrict the error terms to be identically distributed throughout the firm growth distribution. In order to estimate which determinants most affect the growth of the 5-year period, we first calculate the growth of the period as:

$$g_{i,2008-2004} = \ln(x_{i,2008}) - \ln(x_{i,2004})$$

The results of this latter regression will shed light on whether the explanatory variables included are important for those firms that present a higher growth during the period 2004-2008.

Here we measure firm size in sales (deflated by the industrial price index with base 100 in 2006) and the number of employees. Our equation will take the following expression:

$$g_{i,t} = \alpha_2 + \beta_2 Z_{2i,t-1} + u_{2i,t}$$

where Z_2 are lagged independent variables and α_2 and β_2 are the coefficients to be estimated and, finally, u_2 is the error term.

Finally, in spite of the fact that the main purpose of this paper is to explore the determinants and characteristics of a very specific group of firms, we shed light on the partial effects that innovation sources and types of innovation have on firm growth anually. As a measure of firm growth we calculate the log growth rate between both periods:

$$g_{i,t} = \ln(x_{i,t}) - \ln(x_{i,t-1})$$

where x is firm size of firm "i" in year "t".

We have three different sets of independent variables (Z_1 and Z_2), all of which were obtained from the PITEC database:

Firm characteristics

Firm size (*Firm size*): This variable is the firm size measured on the logarithmic number of employees in the firm. It controls for the different capacity that SMEs may have to grow. Previous evidence based on Gibrat's Law generally finds a negative relationship between firm growth and firm size (Teruel, 2010, among others).

Group (*Group*): This is a dummy variable that takes a value equal to 1 if the firm belongs to a group of firms. Falkenhall and Junkka (2009) have found major differences in firms that are part of a group in comparison to independent firms. One explanation for this could be that physical resources, knowledge and know-how can easily be transferred from one firm to other firms in the group, thus enabling rapid growth.

New (*New*): This is a dummy variable that controls for those firms that are new in the market. Although firm age may be a crucial variable in high-growth firms (Falkenhall and Junkka, 2009), results are mixed. For instance, some evidence suggests that the average HGF is a relatively mature firm, but in an older study based on Swedish data Davidsson and Delmar (2003) found that high-growth firms are clearly overrepresented among young firms. Schreyer (2000) highlights the robustness of the link between firm growth and age, but "the correlation between rapid growth and age is less clear-cut."[6]

Investment intensity (*Investment per worker*): This variable accounts for log expenditure on equipment and ICT hardware per employee.

Innovation sources

Cooperation (*Cooperation*): This is a dummy variable which has a value equal to 1 if the firm cooperates with other agents in innovative projects, and a value equal to 0 if the firm does not cooperate with other agents.

Internal R&D intensity (*Internal R&D*) and **External R&D intensity (*External R&D*)**: This variable measures the effect that the intensity of investment in internal and external R&D has on firm growth. Hence, these variables are the log expenditure on internal and external R&D divided by the number of employees.

Innovation performance

Innovation (*Innovation*): This is a dummy variable which has a value equal to 1 if the firm has innovated in at least one type of innovation (product, process, marketing or organization).

Innovation in Product (*InnProduct*): This is a dummy variable with a value equal to 1 if the firm has innovated in its product (by introducing at least one service or product onto the market).

Innovation in Process (*InnProcess*): This is a dummy variable with a value equal to 1 if the firm has innovated in its processes (by introducing at least one process innovation).

Innovation in Marketing (*InnMarketing*): This is a dummy variable with a value equal to 1 if the firm has innovated in marketing.

[6] This author, in particular, indicated that Spanish data shows that the probability of being a high-growth firm does not decline as firms get older. Although our database gives no information about firm age, we can control for the variable Newness, which controls whether the firm is new or not.

Innovation in Organization (*InnOrganization*): This is a dummy variable with a value equal to 1 if the firm has innovated in its internal organization system.

Estimations are controlled by time dummies and sectoral dummies. Additionally, the investment per employee and the innovation intensity are previously deflated with an industrial price index. Furthermore, we should note that for sections 4.1 and 4.2 the dependent variables are lagged one period.

4. Estimations

4.1. What makes a firm a HGF?

Our first aim is to show whether the effort put into innovation affects the probability that an innovative firm will become a gazelle. First, regardless of the measure (employees or sales) R&D investment shows a positive impact on HGFs. However, there are some differences between manufacturing and service sectors. In general, the impact of internal and external R&D is higher in the service sector. One exception to this is that investment in internal R& D has little impact on the probability of being a HGF in the service sectors, where the value is not significant and smaller than for the manufacturing sectors.

The variable *Innovation* controls for the impact of innovation capacity on the probability of being a HGF. Our first results for HGFs measured in terms of employees show that only manufacturing firms present a positive and significant impact, while service industries present a non-significant positive impact. As far as HGFs measured in terms of sales are concerned, our results show that innovation has a positive impact on the probability of being a HGF, in particular in service industries, which present greater sensitivity. Hence, the capacity of a firm to carry on with their innovation activity has a positive and significant impact on the probability that it will become a high-growth firm.

Firm size shows a different impact on firm growth. First we observe that the impact of firm size on the probability of being a HGF depends on which sector the firm belongs to. On the one hand, and regardless of the definition of high-growth firm, size has a negative impact on the probability of manufacturing firms being high-growth firms. On the other hand, the firm size in service industries has a positive but non-significant impact.

Table 3.
Probit estimation on the determinants of being a HGF (measured in terms of employees and sales)

	Employees			Sales		
	Whole database	**Manufacturing sectors**	**Service sectors**	**Whole database**	**Manufacturing sectors**	**Service sectors**
Firm size	-0.0882***	-0.189***	0.0026	-0.0910***	-0.160***	0.00452
	(0.0121)	(0.0185)	(0.0173)	(0.00996)	(0.0136)	(0.0159)
New	0.886***	0.864***	0.899***	0.722***	0.902***	0.513***
	(0.109)	(0.159)	(0.154)	(0.103)	(0.143)	(0.158)
Internal R&D	0.0774	0.181**	0.0360	0.184***	0.124**	0.285***
	(0.0514)	(0.0744)	(0.0759)	(0.0420)	(0.0524)	(0.0728)
External R&D	0.214***	0.178***	0.298***	0.182***	0.163***	0.265***
	(0.0430)	(0.0565)	(0.0696)	(0.0334)	(0.0408)	(0.0621)
Innovation	0.108***	0.135***	0.0894	0.107***	0.109***	0.173***
	(0.0362)	(0.0469)	(0.0601)	(0.0288)	(0.0350)	(0.0542)
Constant	-1.111***	-1.717***	-1.541***	-1.033***	-0.604***	-1.583***
	(0.0900)	(0.232)	(0.121)	(0.0785)	(0.121)	(0.114)
R^2	0.1613	0.1319	0.0835	0.1106	0.0945	0.0745
Obs.	19,430	14,901	4,211	19,758	15,167	4,211

*, **, *** *indicate levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

According to our evidence, being a new firm (*New*) shows a positive and significant impact on the probability of being a HGF. The magnitudes of the coefficients are rather similar when firm size is measured in terms of employees regardless of the sector, but when it is measured in terms of sales manufacturing firms show a greater sensitivity than service industries.

Hence, our first approach to the determinants of innovative HGFs shows that internal and external R&D in addititon to innovation activity are crucial in determining whether a firm will become a high growth firm. The section below will go deeper into the determinants of firm growth.

4.2. Determinants of firm growth

4.2.1. Firm growth for the period 2004-2008

Tables 4 and 5 show the results of estimating the growth of firms in terms of employees and sales, respectively, between 2004 and 2008.[7] First of all, we should point out that our results are in line with previous results. But before we discuss the results in detail, we should mention that the magnitudes of the OLS coefficients are slightly larger than the coefficient of the median quantile. Hence, quantile estimations provide more details about the sensitivity of the determinants of growth distribution (see also the previous analysis by Coad and Rao (2010)). Finally, we observe that the estimations of the growth in terms of employees are less sensitive to the variables than the estimations of the growth in terms of sales.

Table 4.
OLS and quantile regressions of the determinants of firm growth measured by employees. 5-year growth.

		Quantile estimations				
	OLS	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**
Firm size	-0.0191***	0.0056	-0.0149***	-0.0398***	-0.0720***	-0.0826***
	(0.0057)	(0.0040)	(0.0038)	(0.0042)	(0.0102)	(0.0163)
Group	0.0151	-0.0265**	-0.0039	0.0247**	0.0454*	0.0507
	(0.0142)	(0.0108)	(0.0104)	(0.0111)	(0.0255)	(0.0423)
Investment per worker	0.0252***	0.0211***	0.0176***	0.0189***	0.0167**	0.0162
	(0.0046)	(0.0029)	(0.0027)	(0.0030)	(0.0076)	(0.0124)
Cooperation	0.1115*	-0.0159	0.0521*	0.2154***	0.3043***	0.4021***
	(0.0607)	(0.0291)	(0.0275)	(0.0285)	(0.0650)	(0.1051)
Internal R&D	0.0014**	0.0005	0.0004	0.0018***	0.0028***	0.0034**
	(0.0006)	(0.0005)	(0.0004)	(0.0005)	(0.0010)	(0.0017)
External R&D	0.0009*	0.0014***	0.0011***	0.0005	0.0001	0.0005
	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0009)	(0.0015)
InnProduct	0.0146	0.0240**	0.0175*	0.0092	-0.0099	-0.0245
	(0.0143)	(0.0114)	(0.0106)	(0.0111)	(0.0247)	(0.0397)
InnProcess	-0.0209	-0.0207*	-0.0094	-0.0267**	-0.0365	-0.0289
	(0.0144)	(0.0110)	(0.0104)	(0.0109)	(0.0250)	(0.0404)
InnMarketing	0.0115	0.0086	0.0032	0.0041	-0.0063	-0.0017
	(0.0135)	(0.0109)	(0.0104)	(0.0109)	(0.0241)	(0.0378)
InnOrganization	0.0254*	0.0074	0.0088	0.0233**	0.0122	-0.0038
	(0.0135)	(0.0102)	(0.0099)	(0.0105)	(0.0236)	(0.0366)
Constant	-1.1368***	-0.1883***	-0.0983***	-0.0387	0.1182**	0.1666*
	(0.0419)	(0.0280)	(0.0252)	(0.0259)	(0.0595)	(0.0934)
R^2	0.082					
Pseudo- R^2		0.049	0.053	0.095	0.1547	0.191
Observations				4,036		

, **, * indicate levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

One observation is that the characteristics of firms (*Firm size*, *Group* and *Investment per worker*) are in line with previous results in the literature (see for instance, Teruel (2010),

[7] Also in the Annex, there are the graph quantiles of the marginal effects of the determinants on the growth (see Graph A-1).

Coad and Rao (2010)). *Firm size* has a negative impact on firm growth regardless of the variable. Furthermore, the impact becomes more negative in those firms that grow most (top 5% and top 10%). However, for those firms that are in quantile 25 (q.25) the impact is positive (but non-significant for employee growth). The variable *Group* changes the effect on the growth: for the initial quantiles (q.25 and q.50) it has a negative effect, but at higher quantiles the impact is positive and highly significant. These results, then, show that being part of a group has a a positive impact. Obviously, the impact may be the other way round given that high-growth firms can attract the attention of other businesses who wish to invest in them. Finally, the *Investment per worker* also shows a positive influence on firm growth. However, the trend is quite different when analysing the growth rates of employees and sales. On the one hand, the impact decreases throughout the distribution for employee growth. On the other hand, investment has a greater impact on sales growth.

Table 5.
OLS and quantile regressions of the determinants of firm growth measured by sales. 5-year growth.

		Quantile estimations				
	OLS	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**
Firm size	0.0021	0.0183***	-0.0046	-0.0406***	-0.0707***	-0.0960***
	(0.0080)	(0.0066)	(0.0060)	(0.0064)	(0.0115)	(0.0164)
Group	0.0064	-0.0242	-0.0018	0.0326*	0.0733**	0.1093**
	(0.0202)	(0.0175)	(0.0165)	(0.0174)	(0.0298)	(0.0430)
Investment per	0.0095	0.0095**	0.0135***	0.0151***	0.0184**	0.0207*
worker	(0.0069)	(0.0046)	(0.00429)	(0.0047)	(0.0084)	(0.0122)
Cooperation	0.2890***	-0.0266	0.1835**	0.6013**	0.8256***	0.8909***
	(0.0965)	(0.0465)	(0.0435)	(0.0460)	(0.0767)	(0.1024)
Internal R&D	0.0013	0.0005	0.0010	0.0018***	0.0033***	0.0039**
	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0012)	(0.0017)
External R&D	0.0011	0.0017**	0.0011*	0.0012*	-0.0001	0.0005
	(0.0008)	(0.0007)	(0.0006)	(0.0006)	(0.0011)	(0.0015)
InnProduct	0.0372*	0.0532***	0.0017	-0.0098	-0.0313	-0.0429
	(0.0212)	(0.0181)	(0.0169)	(0.0175)	(0.0290)	(0.0413)
InnProcess	-0.0199	-0.0324*	-0.0124	-0.0179	0.0047	-0.0082
	(0.0201)	(0.0178)	(0.0165)	(0.0172)	(0.0284)	(0.0423)
InnMarketing	0.0277	0.0090	0.0050	0.0169	0.0061	0.0127
	(0.0186)	(0.0178)	(0.0165)	(0.0170)	(0.0284)	(0.0395)
InnOrganization	0.0088	0.0059	-0.0120	0.0055	0.0337	0.0287
	(0.0186)	(0.0168)	(0.0158)	(0.0165)	(0.0269)	(0.0388)
Constant	-4.1465***	-0.3843***	-0.2857*	-0.1931**	-0.1683**	-0.1013
	(0.0604)	(0.0444)	(0.0402)	(0.0411)	(0.0731)	(0.0962)
R^2	0.082					
Pseudo- R^2		0.048	0.057	0.095	0.151	0.177
Observations			4,036			

, **, * indicate levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

As far as innovation activity is concerned, the variable *Cooperation* has an increasingly positive impact on firm growth, except on those firms in the lowest quantile (q.25). Hence, firms which cooperate will increase their growth. Our results show that internal and external R&D per employee have a positive impact on firm growth. However, regardless of whether growth is measured in terms of employees or sales, *Internal R&D* has a significant positive impact on firms with a growth rate in the top 25%, while *External R&D* presents a significant positive impact for firms in the lowest quantiles. Furthermore, the sensitiveness of the coefficient of *Internal R&D* is larger than the *External R&D.*

As expected, our results suggest that growth in the number of employees and sales is positively associated with the initial innovation effort made by the group of firms. However, the impact of innovation effort is relatively small in comparison with the magnitude of the investment per worker.

Our estimations show that the impact of the innovation (measured on whether the firm has innovated on product, process, marketing or organization) generally has a negligible effect on firm growth performance. However, we should first point out that the results are generally positive with the exception of the variable *InnProcess,* which has a negative impact regardless of the quantile. These discouraging results may be due to the fact that we measure innovation performance using dummy variables, which cannot capture the impact on sales. And second, we should take into account that we are estimating the growth of the firm over a 5 year-period. Hence, the influence of the innovation in the initial period may have disappeared by the end. Section 4.2.2 will analyse the impact of the determinants on the following year.

Manufacturing and service industries

In order to confirm our aggregated results, we will separate manufacturing and service industries. Our results show similarities but also some important differences (see Table A-3 and Table A-4 in the Annex). First, the variable *Cooperation* shows a higher impact on the growth of sales. Second, for manufacturing firms the impact of *Internal R&D* and *External R&D* is rather similar for the aggregated results (significant positive impact of

External R&D on the lowest and highest quantile estimations). Third, we should point out that significance nearly disappears with the exception of the variable *Cooperation*.

A simplistic interpretation would be that innovation is not valuable for the growth of service firms. However, we warn against putting too much faith in specific point estimates because we are analysing fewer service firms than manufacturing firms.

4.2.2. Robustness of the results: the impact of the determinants on annual growth

The regression results obtained from the quantile estimations of the annual growth rates are presented in Tables 6 and 7. It is encouraging to observe that the results obtained from these estimatios, and the regression specifications for the whole period are not too dissimilar from the estimations of the whole distribution. The major differences are the following.

Table 6.
OLS and quantile regressions of the determinants of high-growth firms measured in terms of employees. Annual growth.

		Quantile estimations				
	OLS	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**
Firm size	-0.0072***	0.0023***	-0.0007*	-0.0149***	-0.0313***	-0.0454***
	(0.0014)	(0.0009)	(0.0004)	(0.0009)	(0.0022)	(0.0039)
Group	0.0029	-0.0063***	-0.0006	0.0071***	0.0181***	0.0301***
	(0.0031)	(0.0024)	(0.0010)	(0.0024)	(0.0052)	(0.0086)
Investment per worker	0.0099***	0.0069***	0.0030***	0.0057***	0.0065***	0.0067***
	(0.0009)	(0.0006)	(0.0003)	(0.0007)	(0.0015)	(0.0025)
Cooperation	0.0381*	0.0016	0.0481***	0.1170***	0.1670***	0.245***
	(0.0221)	(0.0096)	(0.0041)	(0.0097)	(0.0200)	(0.0335)
Internal R&D	0.0004***	0.0003***	9.46e-05**	0.0002**	0.0005**	0.0003
	(0.0001)	(9.82e-05)	(4.14e-05)	(9.97e-05)	(0.0002)	(0.0003)
External R&D	0.0004***	0.0003***	0.0002***	0.0002**	0.0003	0.0004
	(0.0001)	(9.36e-05)	(3.97e-05)	(9.50e-05)	(0.0002)	(0.0003)
InnProduct	0.0016	0.0028	0.0015	-0.0002	-0.0089*	-0.0124
	(0.0032)	(0.0025)	(0.0010)	(0.0025)	(0.0052)	(0.0083)
InnProcess	-0.0039	-0.0040	-0.0022**	-0.0039	-0.0128**	-0.0089
	(0.0033)	(0.0025)	(0.0010)	(0.0025)	(0.0053)	(0.0087)
InnMarketing	0.0052	0.0055**	0.0007	0.0059**	0.0119**	0.0099
	(0.0033)	(0.0027)	(0.0011)	(0.0027)	(0.0056)	(0.0091)
InnOrganization	0.0122***	0.0058**	0.0034***	0.0079***	0.0099*	0.0134
	(0.0031)	(0.0025)	(0.0010)	(0.0025)	(0.0052)	(0.0086)
Constant	0.234	-0.0260	0.168***	0.648***	0.678***	0.697***
	(0.155)	(0.0386)	(0.0278)	(0.0390)	(0.0487)	(0.0579)
R^2	0.032					
Pseudo- R^2		0.033	0.016	0.061	0.127	0.173
Observations				19,026		

, **, * indicates levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

First, in general, the coefficients of the determinants on the dependent variable are smaller than the ones obtained for the estimation of the 4-year period. This result may be a purely statistical effect given that the increase or decrease that a firm may experience is larger during the 4-year period than one year. Hence, the magnitude of the 4-year growth is larger than for the annual growth.

Second, the significance of the variables is rather similar to our previous estimations. The exception is the impact of *Internal R&D*, which displays a significant impact for all the quantiles, regardless of whether growth is measured in terms of employees or sales.

Table 7.
OLS and quantile regressions of the determinants of high-growth firms measured in terms of sales. Annual growth.

		Quantile estimations				
	OLS	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**
Firm size	-0.0014	0.0118***	-0.0007	-0.0159***	-0.0371***	-0.0513***
	(0.0020)	(0.0012)	(0.0010)	(0.0014)	(0.0023)	(0.0051)
Group	0.0005	-0.0115***	-0.0033	0.0030	0.0221***	0.0463***
	(0.0045)	(0.0031)	(0.0026)	(0.0038)	(0.0055)	(0.0120)
Investment per worker	0.0051***	0.0052***	0.0053***	0.0063***	0.0080***	0.0101***
	(0.0014)	(0.0008)	(0.0007)	(0.0010)	(0.0016)	(0.0036)
Cooperation	0.113***	0.0445***	0.0925***	0.300***	0.437***	0.453***
	(0.0398)	(0.0123)	(0.0105)	(0.0149)	(0.0217)	(0.0457)
Internal R&D	0.0006***	0.0004***	0.0005***	0.0005***	0.0010***	0.0016***
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0005)
External R&D	0.0005***	0.0002	0.0002	0.0001	0.0004*	0.0004
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0005)
InnProduct	0.0029	0.0059*	-0.0019	-0.0055	-0.0100*	-0.0176
	(0.0049)	(0.0032)	(0.0027)	(0.0038)	(0.0057)	(0.0122)
InnProcess	-0.0066	-0.0039	-0.0043	-0.0069*	-0.0102*	-0.0260**
	(0.0048)	(0.0032)	(0.0027)	(0.0038)	(0.0056)	(0.0122)
InnMarketing	0.0032	0.0017	0.0007	-0.0045	-0.0073	-0.0109
	(0.0049)	(0.0034)	(0.0029)	(0.0042)	(0.0061)	(0.0130)
InnOrganization	0.0110**	0.0069**	0.0042	0.0088**	0.0052	0.0200*
	(0.0047)	(0.0032)	(0.0027)	(0.0039)	(0.0056)	(0.0120)
Constant	-0.0643	-0.104**	-0.0733	0.225***	0.241***	0.223***
	(0.0684)	(0.0492)	(0.0721)	(0.0599)	(0.0529)	(0.0837)
R^2	0.041					
Pseudo- R^2		0.035	0.031	0.068	0.124	0.161
Observations	19,025					

*, **, *** *indicate levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

5. Conclusions

Since the seminal work by David Birch and colleagues an increasing number of studies has focused on high-growth firms. Nowadays, we have a better understanding of how many HGFs there are, what role they play in production and employment, and the impact they have on structural change, R&D and innovation, among other things. Analyses of this sort are fundamental for countries such as Spain that need an industrial policy that will reorganize its economy and overcome the current crisis.

Here we have focused on two topics: which determinants affect the performance of high-growth firms, and how firms' effort and performance in innovation can affect firms' growth. We applied our empirical analysis to a panel of 5017 firms during the period 2004-2008, and we measured growth in two different ways: in terms of sales and number of employees. When it was measured in terms of sales, the sample contained 495 HGFs (9.86%), and in terms of the number of employees it had 265 (5.28%).

Here, for purposes of brevity and clarity, we present only the main results of our two-step econometric analysis. In the first step, a probit analysis is applied and shows that the Spanish firms that are most likely to undergo high growth are those that are small and new; innovation performance also plays a critical role in high growth. In the second step of the empirical procedure, we apply a quantile regression to measure whether the determinats affect firm growth. Our results show that firm growth is negatively affected by firm size, but positively affected by belonging to a group or investment per employee. As far as the variables that measure innovation effort are concerned, cooperation has a significant and positive impact on firm growth, and investment in internal and external R&D per employee has a positive impact (although internal R&D presents a significant impact in the highest quantiles, and external R&D is significant up to the median). Finally, innovation performance has a positive effect, but the impact is rather small and often not significant.

First, our results indicate that innovation effort is important if growth is to be high. Second, there are differences between manufacturing and service firms, and also between those firms that are high-growth and those that are not.

From a policy point of view, we cautiously suggest that to facilitate firm growth policies should encourage low-growth innovative firms to invest in external R&D, and high-growth firms to invest in internal innovation.

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Annex

Table A-1
Test of mean of the variables for manufacturing and service industries

DECIL	Prob. (H0) if	Manufactures		Services	
		Firm size	Growth size	Firm size	Growth size
1	H1 is X<µ	0.0000	0.0000	0.0000	0.0000
	H1 is X>µ	1.0000	1.0000	1.0000	1.0000
2	H1 is X<µ	0.0000	0.0003	0.0000	0.0000
	H1 is X>µ	1.0000	0.9997	1.0000	1.0000
3	H1 is X<µ	0.7149	1.0000	0.0000	0.0000
	H1 is X>µ	0.2851	0.0000	1.0000	1.0000
4	H1 is X<µ	1.0000	0.0000	0.0000	-
	H1 is X>µ	0.0000	1.0000	1.0000	-
5	H1 is X<µ	0.0000	0.9693	0.0000	0.0000
	H1 is X>µ	1.0000	0.0307	1.0000	1.0000
6	H1 is X<µ	0.8703	0.9990	0.0000	0.0000
	H1 is X>µ	0.1297	0.0010	1.0000	1.0000
7	H1 is X<µ	1.0000	0.8764	1.0000	1.0000
	H1 is X>µ	0.0000	0.1236	0.0000	0.0000
8	H1 is X<µ	0.9171	0.2638	1.0000	1.0000
	H1 is X>µ	0.0829	0.7362	0.0000	0.0000
9	H1 is X<µ	0.0005	0.0000	1.0000	1.0000
	H1 is X>µ	0.9995	1.0000	0.0000	0.0000
10	H1 is X<µ	0.0000	0.0000	1.0000	1.0000
	H1 is X>µ	1.0000	1.0000	0.0000	0.0000

Source: authors

Table A-2
Test of mean of the variables for manufacturing and service industries

	Prob. (H0) if	Manufacturing sectors		Service sectors	
		Employees classification	Sales classification	Employees classification	Sales classification
Employees growth	H1 is X<µ	0.0000	0.0000	0.0000	0.0000
	H1 is X>µ	1.0000	1.0000	1.0000	1.0000
Sales period	H1 is X<µ	0.0000	0.0000	0.0000	0.0000
	H1 is X>µ	1.0000	1.0000	1.0000	1.0000
Employees	H1 is X<µ	0.9982	0.9980	0.9982	0.1095
	H1 is X>µ	0.0018	0.0020	0.0018	0.8905
Sales	H1 is X<µ	0.9971	1.0000	1.0000	0.1853
	H1 is X>µ	0.0029	0.0000	0.0000	0.8147
Productivity	H1 is X<µ	0.9536	0.0000	0.4207	0.5949
	H1 is X>µ	0.0464	1.0000	0.5793	0.4051
Internal R&D intensity	H1 is X<µ	0.0000	0.0000	0.0000	0.0000
	H1 is X>µ	1.0000	1.0000	1.0000	1.0000
External R&D intensity	H1 is X<µ	0.1846	0.1192	0.4841	0.0000
	H1 is X>µ	0.8154	0.8808	0.5159	1.0000
Cooperation	H1 is X<µ	0.0006	0.0000	0.0000	0.0000
	H1 is X>µ	0.9994	1.0000	1.0000	1.0000
Internal R&D (%)	H1 is X<µ	0.9193	0.8711	0.3729	0.0018
	H1 is X>µ	0.0807	0.1289	0.6271	0.9982
External R&D (%)	H1 is X<µ	0.8107	0.9115	0.8949	0.2492
	H1 is X>µ	0.1893	0.0885	0.1051	0.7508
Product innovation	H1 is X<µ	0.0002	0.0000	0.0000	0.0000
	H1 is X>µ	0.9998	1.0000	1.0000	1.0000
Process innovation	H1 is X<µ	0.0580	0.0108	0.0101	0.0000
	H1 is X>µ	0.9420	0.9892	0.9899	1.0000
Innovation in markting	H1 is X<µ	0.0000	0.0000	0.0000	0.0000
	H1 is X>µ	1.0000	1.0000	1.0000	1.0000
Innovation in organization	H1 is X<µ	0.0019	0.2097	0.0004	0.0000
	H1 is X>µ	0.9981	0.7903	0.9996	1.0000

Source: authors

Table A.3.
Matrix correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
GrSales	1.000													
GrSize	**0.326***	1.000												
Firm size	0.026*	-0.025*	1.000											
Group	0.019*	0.009	**0.483***	1.000										
New	0.046*	0.043*	-0.104*	-0.012	1.000									
Investment per worker	0.038*	0.084*	0.084*	0.118*	0.031*	1.000								
Cooperation	0.046*	0.043*	-0.104*	-0.012	**1.000***	0.031*	1.000							
Internal R&D	0.059*	0.072*	-0.030*	0.047*	0.049*	0.106*	0.049*	1.000						
External R&D	0.055*	0.058*	-0.023*	0.068*	0.038*	0.111*	0.038*	**0.425***	1.000					
Innovation	0.067*	0.049*	0.046*	0.057*	0.027*	0.045*	0.027*	**0.542***	0.227*	1.000				
InnProduct	0.044*	0.033*	-0.023*	0.025*	0.067*	0.028*	0.067*	**0.506***	0.229*	**0.572***	1.000			
InnProcess	0.017	0.015	0.058*	0.057*	0.016	0.088*	0.016	0.351*	0.171*	**0.528***	**0.275***	1.000		
InnMarketing	0.017*	0.023*	0.013	0.008	0.003	0.021*	0.003	0.176*	0.093*	0.277*	**0.231***	**0.232***	1.000	
InnOrganization	0.043*	0.047*	0.067*	0.048*	-0.011	0.023*	-0.011	0.227*	0.146*	**0.461***	**0.229***	**0.323***	**0.431***	1.000

** Significant at 1%.*
Source: authors

Table A-3

OLS and quantile regressions of the determinants of firm growth measured in terms of employees and sales. 5-year growth.

	Growth in employees						Growth in sales					
		Quantile estimations						Quantile estimations				
	OLS	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**	**OLS**	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**
	Manufacturing sectors						**Manufacturing sectors**					
Cooperation	0.1235*	-0.0524	0.0161	0.2486***	0.3510***	0.6013***	0.3714***	0.1006	0.3491***	0.7052***	0.8477***	1.6744***
	(0.0679)	(0.0431)	(0.0293)	(0.0402)	(0.0700)	(0.1022)	(0.1340)	(0.0803)	(0.0525)	(0.0613)	(0.1103)	(0.112)
Internal R&D	0.0013**	0.0010*	0.0006	0.0017***	0.0031***	0.0035**	0.0014	0.0005	0.0012*	0.0024***	0.0045***	0.0038*
	(0.0006)	(0.0006)	(0.0004)	(0.0005)	(0.0010)	(0.0015)	(0.0009)	(0.0011)	(0.0007)	(0.0008)	(0.0015)	(0.0022)
External R&D	0.0011**	0.0015***	0.0012***	0.0002	0.0005	0.0007	0.0017**	0.0020**	0.0015**	0.0010	-0.0004	-0.0002
	(0.0005)	(0.0005)	(0.0003)	(0.0005)	(0.0008)	(0.0013)	(0.0008)	(0.0009)	(0.0006)	(0.0007)	(0.0013)	(0.0018)
R^2 / Pseudo- R^2	0.094	0.046	0.042	0.074	0.111	0.145	0.082	0.044	0.045	0.077	0.120	0.1553
Obs.	3,123											
	Service sectors						**Service sectors**					
Cooperation	0.1167	0.0325	0.1356**	0.2817***	0.0774	0.0351	0.2283	0.0290	0.2137***	0.2815***	0.7145***	0.7611***
	(0.1051)	(0.0488)	(0.0644)	(0.0678)	(0.1086)	(0.161)	(0.1401)	(0.0900)	(0.0694)	(0.0819)	(0.1386)	(0.2639)
Internal R&D	0.0017	0.0001	0.0001	0.0019	0.0034	0.0040	-1.01e-05	-0.0009	0.0004	-6.09e-05	0.0005	-0.0023
	(0.0014)	(0.0011)	(0.0014)	(0.0014)	(0.0024)	(0.0043)	(0.0020)	(0.0019)	(0.0015)	(0.0017)	(0.0027)	(0.0051)
External R&D	0.0011	0.0010	0.0007	0.0021	-0.0017	-0.0016	0.0001	-0.0002	0.0021	0.0010	0.0035	0.0039
	(0.0016)	(0.0011)	(0.0014)	(0.0014)	(0.0023)	(0.0040)	(0.0024)	(0.0019)	(0.0015)	(0.0018)	(0.0031)	(0.0059)
R^2 / Pseudo- R^2	0.037	0.056	0.024	0.066	0.113	0.133	0.050	0.039	0.029	0.069	0.095	0.1489
Obs.	862											

, **, * indicate levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

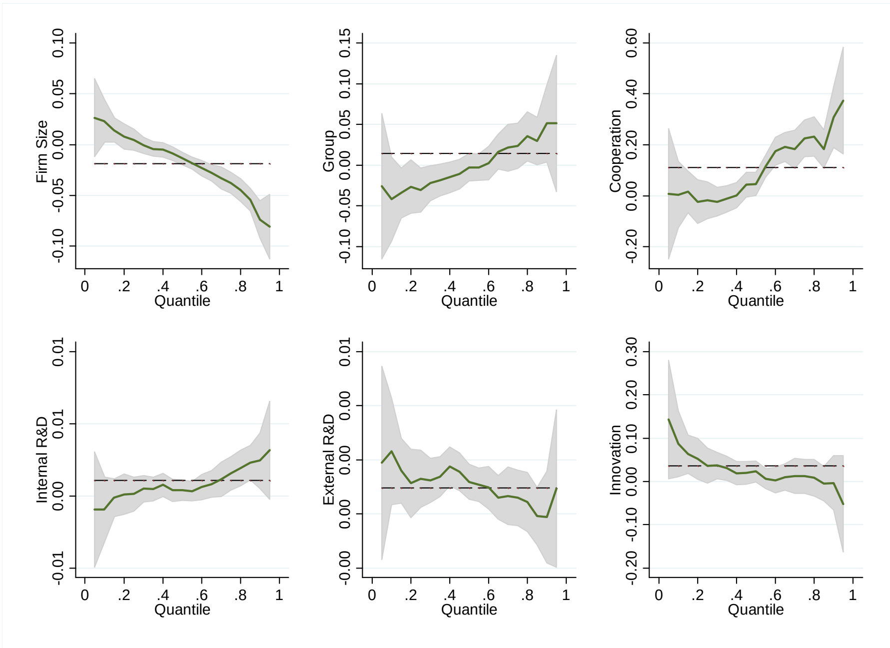
Table A-4
OLS and quantile regressions of the determinants of firm growth measured in terms of employees and sales. 5-year growth.

	Employees						Sales					
		Quantile estimations						Quantile estimations				
	OLS	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**	**OLS**	**q.25**	**q.50**	**q.75**	**q.90**	**q.95**
	Manufacturing sectors						**Manufacturing sectors**					
InnProduct	0.0088	0.0207	0.0155*	0.0124	-0.0164	-0.0384	0.0112	0.0368	-0.0048	-0.0178	-0.0600*	-0.0524
	(0.0145)	(0.0140)	(0.0092)	(0.0125)	(0.0225)	(0.0357)	(0.0219)	(0.0250)	(0.0163)	(0.0193)	(0.0351)	(0.0500)
InnProcess	-0.0177	-0.0182	-0.0153*	-0.0218*	-0.0438*	-0.0209	-0.0161	-0.0175	-0.0055	-0.0310	-0.0090	-0.0282
	(0.0143)	(0.0139)	(0.0091)	(0.0125)	(0.0228)	(0.0355)	(0.0207)	(0.0253)	(0.0163)	(0.0192)	(0.0342)	(0.0518)
InnMarketing	0.0148	0.0160	0.0096	0.0013	-0.0012	0.0095	0.0230	0.0262	0.0063	0.0076	-0.0212	-0.0106
	(0.0133)	(0.0136)	(0.0090)	(0.0125)	(0.0217)	(0.0334)	(0.0186)	(0.0248)	(0.0161)	(0.0189)	(0.0337)	(0.0476)
InnOrganization	0.0297**	0.0043	0.0108	0.0293**	0.0042	-0.0214	-0.0001	-0.0041	-0.0090	0.0117	0.0392	0.0344
	(0.0134)	(0.013)	(0.0086)	(0.0121)	(0.0212)	(0.0321)	(0.0182)	(0.0232)	(0.0153)	(0.018)	(0.0325)	(0.0479)
R^2 / Pseudo- R^2	0.094	0.046	0.042	0.074	0.111	0.145	0.082	0.044	0.045	0.077	0.120	0.1553
Obs.						3,123						
	Service sectors						**Service sectors**					
InnProduct	0.0349	0.0066	0.0036	-0.0061	0.0520	0.0937	0.1319**	0.0997*	0.0510	0.0177	0.0583	0.0955
	(0.0435)	(0.0301)	(0.0384)	(0.0395)	(0.0648)	(0.112)	(0.0615)	(0.0549)	(0.0415)	(0.0477)	(0.0794)	(0.151)
InnProcess	-0.0145	-0.0257	0.0382	-0.0543	0.0110	0.00555	-0.0221	-0.0567	-0.0532	0.0239	0.0468	0.0865
	(0.0421)	(0.0267)	(0.0353)	(0.0377)	(0.0671)	(0.121)	(0.0561)	(0.0483)	(0.0382)	(0.0459)	(0.0754)	(0.151)
InnMarketing	-0.0156	-0.0640**	-0.0441	0.0145	0.0104	-0.0260	0.0538	-0.0123	0.0011	0.0887*	0.0334	0.0911
	(0.0412)	(0.0281)	(0.0366)	(0.0377)	(0.0601)	(0.105)	(0.0550)	(0.0513)	(0.0397)	(0.0453)	(0.0767)	(0.135)
InnOrganization	-0.0010	0.0712***	-0.0011	0.0241	-0.0670	-0.0118	0.0383	0.0831*	0.0408	-0.0190	0.0517	-0.0328
	(0.0420)	(0.0273)	(0.0357)	(0.0366)	(0.0637)	(0.104)	(0.0589)	(0.0497)	(0.0387)	(0.0439)	(0.0712)	(0.135)
R^2 / Pseudo- R^2	0.037	0.056	0.024	0.066	0.113	0.133	0.050	0.039	0.029	0.069	0.095	0.1489
Obs.						862						

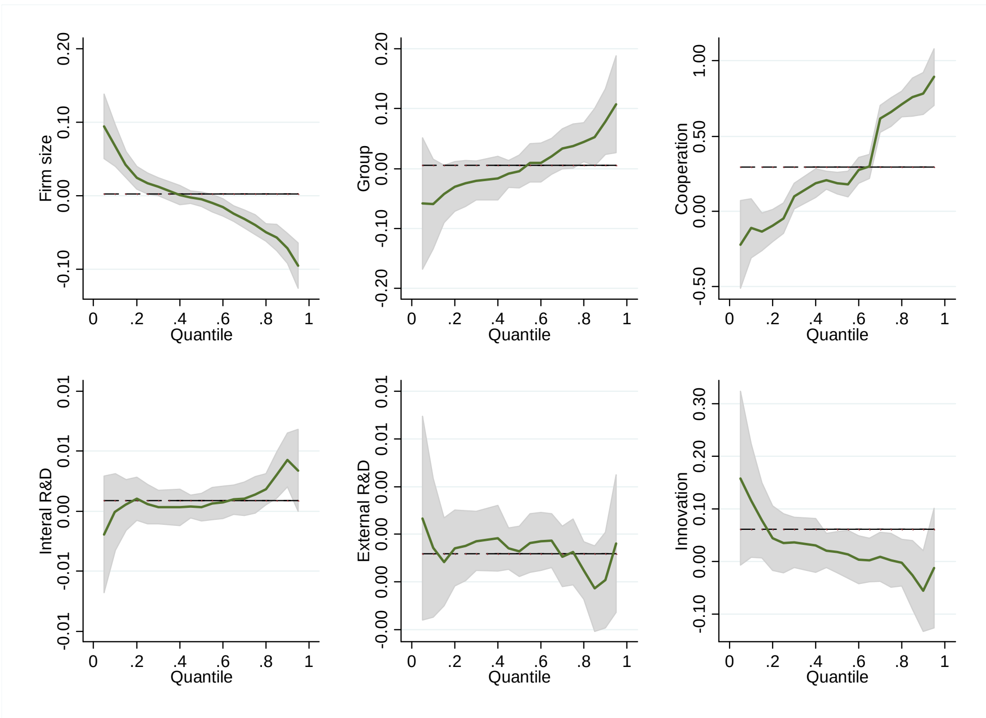
, **, * indicate levels of significance equal to 10%, 5% and 1%.*
Standard errors in parentheses.
Regressions controlled by sector and time dummies.

Graph A.1. Marginal effects of R&D on growth over the conditional quantiles. 5-year growth.

Estimation of growth in employees



Estimation of growth in employees



Source: authors