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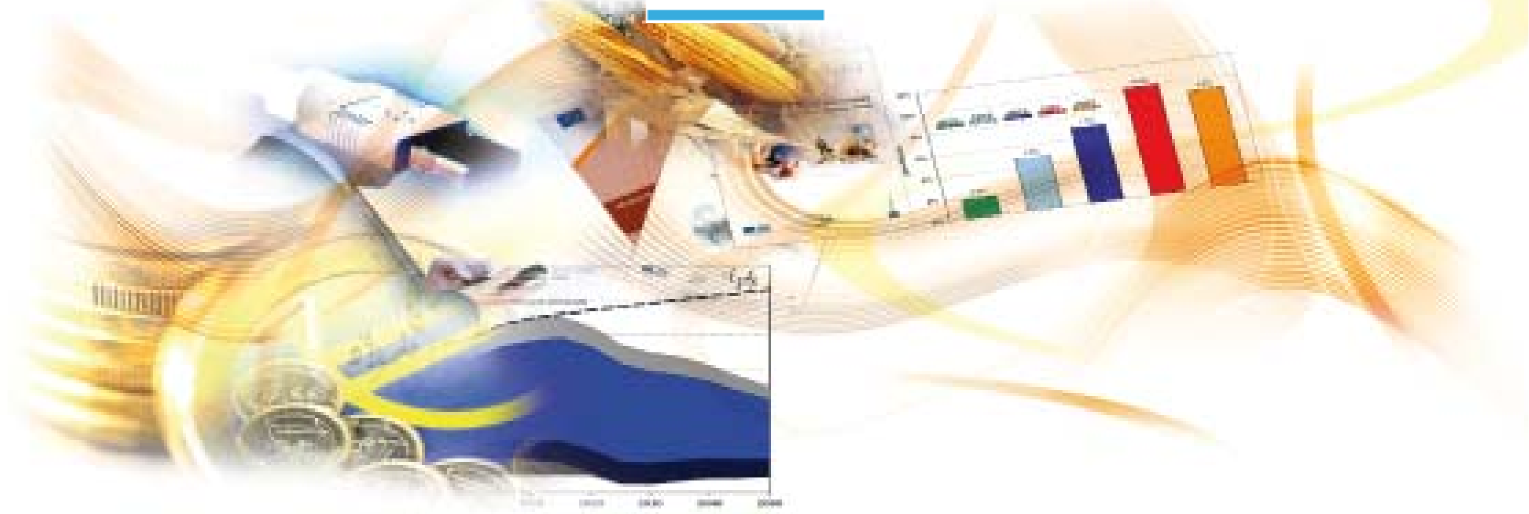

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Does size or age of innovative firms affect their growth persistence?

– Evidence from a panel of innovative Spanish firms –

Daria Ciriaci, Pietro Moncada-Paternò-Castello
and Peter Voigt

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Abstract

This study examines serial correlation in employment, sales and innovative sales growth rates in a balanced panel of 3,300 Spanish firms over the years 2002-2009, obtained by matching different waves of the Spanish *Encuesta sobre Innovacion en las Empresas*, the Spanish innovation survey conducted annually by the Spanish National Statistics Institute (INE). The main objective is to verify whether the changes (increase/decrease) in these figures are persistent over time, whether such persistence (if any) differs between SMEs and larger firms, and if it is affected by a firm's age. To do so, we adopted a semi-parametric quantile regression approach. This methodology is well suited to cases where outliers (high-growth firms) are the subject of investigation and/or when they have to be assumed as being very heterogeneous.

Empirical results indicate that among those innovative firms experiencing high employment growth, the smaller and younger grow faster than larger firms, but the jobs they create are not persistent over time. However, while being smaller and younger helps growing more in terms of employment and sales, it is not an advantage when innovative sales growth is considered: in this case larger firms experience faster growth.

Keywords: Serial correlation; quantile regression model; Spanish firms; firm size, firm age; job creation; fast growing firms.

JEL codes: L11; L25

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Non-technical summary

Problem and Research question:

The paper contributes to the new European research and innovation policy agenda by broadening the understanding about the contribution of innovative firms to EU competitiveness and job creation. In particular, it aims to verify whether changes (increase/decrease) in employment figures, total sales and innovative sales of a sample of innovative Spanish firms over the period 2002-2009 are persistent over time, whether persistence (if any) differs between SMEs and larger firms, and if it is affected by firms' age. To do this, we adopted an econometric technique (quantile regressions) which is particularly appropriate for dealing with very heterogeneous observations.

Findings:

The findings of the study complement the current knowledge in the relevant thematic area, in particular by making the following observations:

(1) Smaller and younger innovative firms in Spain tend to grow faster in terms of employment and total sales than larger firms, but the jobs they create are not proved to be persistent over time.

(2) Among the fastest growing Spanish firms, the smaller and younger innovative companies have some difficulties to innovate at a later business stage, therefore being unable to base their sales on successive waves of innovations. The latter, in contrast, was found to be the strength of larger innovative companies.

(3) The larger innovative firms in Spain were found to grow more gradually in employment, but with less discontinuity than smaller innovative firms.

Implications:

Our results suggest that, to enhance the growth potential of the Spanish economy, a well concerted mix of policies is needed to enable all sorts of companies to fully exploit their development capacity with more persistency and dynamicity.

In particular, the following policy implications arise:

(i) Policies need to address possible specific barriers and market failures which prevent smaller and younger innovative firms from sustaining the jobs they create.

(ii) There might be a rationale for policies to encourage smaller and younger firms in Spain to keep/increase their knowledge generation and accumulation and to support the use of this capacity. For instance, measures aiming to foster firms' innovation capacity building, support university-firm collaboration, and second-phase business cycle financing of technology innovation appear promising in this regard.

(iii) Larger innovative firms in Spain might be supported to develop steadily and thus create persistent jobs. Corresponding policy measures include, for instance, tax incentives, increasing the availability of highly qualified personnel, and introducing labour market reforms towards more flexibility and stability.

This study also demonstrates the feasibility of gathering firm-level data across EU countries, and that the related analyses can provide EU policy-makers and other stakeholders with a better understanding of the growth dynamics of innovative firms – as the "Innovation Union initiative" claims – on which to base future policy initiatives.

1 Introduction

One of the main objectives of the new European research and innovation policy agenda is to favour the creation and growth of EU companies operating in new and knowledge-intensive industries. There is a common understanding that these companies play an important role in shaping the dynamism of the economy's sectoral composition by favouring the transition towards more knowledge-intensive activities and contributing to overarching economic growth objectives (i.e. "EU 2020 Strategy") through the creation of more and better jobs.

This study aims to contribute to the corresponding debate and enrich knowledge on the matter. In particular, we wish to verify whether the changes in terms of employment, total sales and innovative sales of a panel of innovative Spanish firms over the period 2002-2009 are persistent over time. In other words, our aim is to investigate whether the growth and jobs created by innovative firms are sustainable –i.e. persistent over time– or whether these jobs and/or the competitive advantages obtained through introducing new/innovative products to the market tend to disappear in the following period. Thus, it shall be tested whether such persistence (if any) differs between SMEs and larger firms and whether it is affected by a firm's age.

Conceptually, the study analyses how serial correlation changes with a firms' size and growth rate. In fact, the *autocorrelation* of growth rates may provide valuable information concerning firms' growth trajectories (Hölzl, 2008) insofar as the empirical evidence may confirm that firms which are growing in a given year can repeat this performance in the following year(s) (Bottazzi and Secchi, 2003). One would expect a positive correlation of a certain firm's growth rates; however, corresponding evidence is not always found (Almus and Nerlinger, 2000). One of the possible explanations for the latter is that serial correlation may change according to firm size (Coad, 2006a, 2007a). Small firms are typically subject to a negative correlation of growth rates whereas larger firms display a positive correlation which suggests that persistent growth patterns are more likely to be observed in larger firms. The fact that 80% of new jobs in Europe over the last five years have been created by SMEs[1] explains why there is such great interest from a policy perspective to analyse the extent to which SMEs are capable of repeating their positive growth performance over time and whether the jobs created are persistent over time.

This paper has five sections. The introduction is followed by a section providing a brief review of the relevant literature on innovative firms' growth (SMEs in particular). The methodology and database are then presented. Section four gives an overview of the empirical results. The final section provides conclusions, discussing policy implications and indications for future research.

2 Literature review

Research into firms' growth and the role of innovative activities has been growing at a remarkable pace. Seminal works include those by Gibrat (1931), Schumpeter (1942), Penrose (1959) and Marris (1964). In the literature, innovation is generally perceived as one of the most important investments that affects a firm's growth[2], productivity, and survival.[3]

1 Structural Business Statistics Database (EUROSTAT). However, SMEs are in general considered to be one of the main sources of economic growth and job creation in the EU since they represent 99% of European businesses and providing two out of three private sector jobs.

2 For recent reviews on firms' growth see, for instance, Coad, 2009, and Moncada-Paternó-Castello, 2011.

3 Other economic factors determining the growth of innovative companies are e.g. intangible assets which in turn are very much dependent on firm, technological, sector and socio-economic/market environment characteristics. Furthermore, complementarities among several types of investments at firm level (such as R&D, human capital,

As regards the size of firms, already Schumpeter (1942) emphasised the positive influence of size on innovation, while a number of theoretical studies have claimed that larger companies have potential factors such as economies of scale, lower risk, a larger market and greater opportunities for appropriation (Fernández, 1996), which enables them to undertake sophisticated R&D projects and benefit from the innovations stemming from these activities. However, empirical studies often fail to provide such a clear picture. Some have found a positive relationship between size and innovation, in the sense that large-scale firm research has become the prevailing form of organisation of innovation because it is the most effective at exploiting and internalising the tacit and cumulative features of technological knowledge (Pavitt, 1986; Scherer, 1992; Scherer and Ross, 1990; Love et al., 1996; Cohen and Klepper, 1996; amongst others). However, this significant (positive) influence has not been confirmed by others (e.g. Mansfield, 1964; Griliches, Hall and Pakes, 1986; Acs and Isberg, 1991) who reported that small firms have an innovative advantage in highly innovative industries and in highly competitive markets or find that 'the pattern of R&D investment within a firm is essentially a random walk'.4 Ortega-Argilés and Voigt (2009) concluded on this point that the advantages of large-scale companies, in general, tend to be physical whereas smaller companies can capitalise more on flexibility. Furthermore, the 'relevance of R&D's role' for SME growth can only be stated clearly to a limited extent: in terms of fast growing companies, only those that operate in close proximity to the technological frontier; in terms of young firms, only the new technology-based ones (Ortega-Argilés et al., 2009). But, what is about the corresponding growth trajectories of small and large innovative firms and the persistence of job creation?[5]

The growth trajectories of small and large innovative firms together with the structural changes affecting the EU economy vis-à-vis policy targets have recently been studied by Voigt and Moncada-Paternò-Castello (2012). They investigated how sector composition and the magnitude of corporate R&D investments in the EU may differ by 2020 if top R&D-investing SMEs were assumed to be on a fast growth track while the top R&D-investing large companies continued to grow as before. The study indicates that if one expects the R&D-intensive small firms to be the engine for substantial structural change of the EU economy away from being driven by rather medium-tech sectors towards a high-tech based economy, this will require either a significantly extended time horizon of the assumed fast growth track than the simulated 10 years or small firms' growth figures will have to exceed the most optimistic scenario[6].

In another recent study, Bogliacino (2010) estimated the effect of R&D on employment at firm level, using a panel of company data from the EU Industrial R&D Investment Scoreboard. The main findings of this research confirm that R&D and innovation have a positive employment impact at firm level. This impact varies according to how much the firm invests and also to its size, in terms of sales. The main implication is that the positive job creation effect increases when the R&D intensity of the firm increases. This result has been confirmed by subsequent studies (e.g. Bogliacino, *et al.* 2012).

There is no doubt that it is crucial to get a better understanding of year-to-year growth patterns at firm-level which inter alia would also make it possible to observe the evolution of entire industries (Coad, 2007) and

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ICTs, physical capital, -international- collaboration) were identified as being very important and having higher returns than devoting resources solely to one of these activities.

4 Research has concentrated on establishing taxonomies to describe different ways of operating in terms of innovative behaviour (Pavitt, 1984; Malerba and Orsenigo, 1996; Legler, 1982; Schulmeister, 1990; Hatzichronoglou, 1997; Peneder, 1999; amongst others). However, these taxonomies focus more on the characteristics of larger firms and do not distinguish between different size segments.

5 The fastest growing firms in a certain market are not necessarily highly R&D- and/or technology-intensive / innovative companies. Indeed, high-growth potential, in principle, can be found in any sector. Accordingly, high growth in SMEs is not exclusively related to companies that are R&D-intensive and/or highly innovative. For a more detailed analysis, see, for example, OMC-SME Expert Group 2006, p. 151 ff, or the following web page: http://www.higrosme.org.

6 The main results of this study indicate that Europe needs both more top R&D investors (i.e. rather large firms) to further intensify the overall engagement in R&D (increase volume and R&D intensity; close structural investment gap e.g. to US) and more small firms (including start ups) that significantly increase their R&D activities and seek to become large firms and leading (global) R&D investors.

thus evaluate the corresponding economic theories (i.e. Gibrat's law) by comparing the hypothetical predictions about the presence and sign of the autocorrelation with the empirically observed ones.

There is indeed a series of different models that attempt to explain the skewed (heavy-tailed) distribution of annual firm growth rates (see e.g. Bottazzi and Secchi, 2006 versus Coad, 2006a).[7] Assuming that serial correlation is found to be statistically significant as a result of this study, evidence would suggest rejecting Gibrat's law of firms' growth as a purely stochastic phenomenon in which a firm's size at any time is simply the product of independent growth shocks. Consequently, the associated stochastic models of industry evolution would also come into question. At the same time, while a positive serial correlation would be compatible with the notion of increasing returns to growth (Bottazzi and Secchi 2006), finding significant negative serial correlation would point towards Coad's idea of firms' growth somehow being due to lumpy resources.

The empirical evidence in this regard is subject to a controversial discussion.[8] In his review of 'Gibrat's Legacy', Sutton (1997) found that half a century of testing had revealed a series of statistical regularities which were incompatible with a random-view of firms' growth rate. Most notably, he pointed out that small firms generally appeared to grow faster than large ones, and that growth rates were serially correlated. However, while early empirical studies into the growth of firms considered growth serial correlation over periods of four to six years, generally encountering positive autocorrelations ranging from 30% to 33% (Ijiri and Simon, 1967; Singh and Whittington 1975; Kumar 1985; and Dunne and Hughes 1994), more recent studies relying on longer time series have found more diverse annual autocorrelation patterns (Coad, 2007a). This in spite of the fact that one would expect persistence to prevail when measured over a shorter time-horizon. For instance, Chesher (1979) and Geroski et al. (1997), Wagner (1992) and Weiss (1998), Bottazzi et al. (2001) and Bottazzi and Secchi (2003) found a positive serial correlation for UK quoted firms, German manufacturing firms, Austrian firms, for the worldwide pharmaceutical industry and for US manufacturing, respectively. Negative serial correlation has been observed, in contrast, for German firms by Boeri and Cramer (1992), by Goddard et al. (2002) in the case of quoted Japanese firms, by Bottazzi et al. (2007) and by Bottazzi et al. (2005) for Italian and French manufacturing firms. Finally, a number of studies did not find any significant autocorrelation in firms' growth rates at all. For instance, Almus and Nerlinger (2000) analysing German start-ups, Bottazzi et al. (2002) for selected Italian manufacturing sectors, Geroski and Mazzucato (2002) for the US automobile industry, and Lotti et al. (2003) for Italian manufacturing firms.

According to Coad (2009), there are several reasons why these mixed results may emerge. For instance, he argued that serial correlation changes with two characteristics of the firm, namely its size and its growth rate, observing that there is no "one size fits all" serial coefficient that applies to all firms. Put simply, the differences in autocorrelation coefficients that have appeared in the literature can be explained by the different firm-size compositions of the correspondingly different datasets.

In fact, Coad (2007a) demonstrated that autocorrelation coefficients are systematically affected by the size of the firms using a seven-year balanced panel of 10,000 French manufacturing firms. Specifically, he found that typically small firms are subject to a negative correlation of annual growth rates, whereas larger firms display a positive correlation. In addition, those small firms that experience extreme positive or negative growth in a given year are unlikely to repeat this performance in the following year. Similar results were obtained by Coad and Hölzl (2009) who studied the serial autocorrelation of annual growth rates in employment for selected Austrian service industries over a 30-year period using quantile regression techniques (Koenker and Bassett, 1978). The growth patterns of micro firms were found to be markedly different from those of small, medium-sized and larger firms. In particular, the authors pointed to a positive dependency of growth on size for growing micro firms, and a negative one for the other size groups. Furthermore, growing micro firms were subject to a negative autocorrelation of annual growth rates, while larger growing firms usually displayed a positive autocorrelation, suggesting that high growth events of larger firms extend over a longer time horizon. In other words, small and large firms seem to operate on

[7] For simplification, hereafter focus is on those studies analysing positive relative growth rates.

[8] Coad (2009) stressed a lack of coherence among the empirical results on firms' growth autocorrelation.

different 'frequencies' (Coad and Hölzl, 2009): micro firms are characterized by more erratic 'start-and-stop' growth dynamics. That is to say, high growth micro firms are very unlikely to repeat their growth performance the following year, while larger firms experience a positive feedback that leads to sustained growth.

Using a database of Flemish firms over the years 2001-2008 and focusing on Young Innovative Companies (YICs), Czarnitzki and Delanote (2012) showed that size, age and innovation do matter: YICs grow more than other firms.

As far as SME growth potential and Spanish firms are concerned, a number of studies have analysed the growth persistence of SMEs (see for instance Calvo and Lorenzo, 1993) and high-growth firms (Calvo 1998; Calvo and Lorenzo 2001). Calvo (2006) focused on small, young, and innovating Spanish firms and confirmed that these companies experienced more dynamic employment growth than other Spanish firms over the period 1990–2000. Moreover, he found that firms operating in high-tech sectors experienced higher growth, thus highlighting that innovation was generally a key factor for firm survival over the period analyzed. These results are in line with a series of further empirical studies[9] and seem to vindicate the rejection of Gibrat's law of proportionate growth, which states that the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry regardless of their size at the beginning of the period.

Another interesting contribution, analysing a Spanish dataset of almost 200,000 firms, was provided by Lopez-Garcia *et al.* (2009) who investigated the contribution of small producers' to employment growth across the manufacturing and service sectors. The authors found that small firms contribute disproportionately to employment creation in Spain: in the years 1996-2003 firms with less than 20 employees were responsible for about 50% of all net job creation although they employed only a third of all workers. However, the previous finding does not imply that all small firms create jobs at a uniform rate. On the contrary, in another study based on the same dataset (Lopez-Garcia and Puente, 2009) the authors demonstrated that only 8% of small firms (less than 20 employees) – which could be classified as high-growth companies – created between 70% and 100% of all jobs within the corresponding size class. In addition, the outstanding employment performance of this company size class was due to both new and small established firms.

These results contrast with those obtained by Farinas and Moreno (2000) for a representative panel of Spanish manufacturing firms during the period 1990-1995, although this may be partly due to differences in methodology and data. Basing their empirical analysis on the theoretical model of Jovanovic (1982), if failing firms were included in the sample the authors did not find any substantial bias in favour of a greater growth of small business with respect to larger firms. However, they found that Spanish firms' failure rates declined with size and age of firms and that the mean growth rate of successful firms declined with size and age. These results are consistent with a large body of literature that draws attention to the so-called evolutionary and learning effects, to the existence of threshold sizes, as well as ages below which smaller and younger surviving firms grow faster (Mata, 1993; Audretsch, 1995; Hart and Oulton, 1996; Geroski, 1998).

Given these somewhat contradictory empirical results (especially with regard to the evidence from Spain), the emphasis of this study and its empirical section is on the analysis of changes in the growth autocorrelation coefficients at distinct points of the employment, sales and innovative sales growth distribution for SMEs and large firms, thus relying empirically on Spanish company-level panel data. In fact, as smaller firms are commonly more flexible, less reliant on routines and less inert than larger ones, we presume that dissimilarities in the behaviour of these two classes of firms (Hannan and Freeman, 1984) will also be visible in their own growth processes (Coad, 2007), which is due to be tested empirically.

[9] For instance, Reid, 1992; Audretsch, 1995; Harhoff et al., 1998; Weiss, 1998; Audretsch et al., 1999; or Almus and Nerlinger, 2000) and Coad (2007) and Coad and Hölzl (2009),

3 Methodology

3.1 The database

This research draws on eight waves of the annual Spanish Community Innovation Survey (*Encuesta Sobre Innovación en las Empresas*),[10] conducted by the Spanish National Statistics Institute (*Instituto Nacional de Estadística, INE*) over the period 2002-2009.

Overall, the dataset contained 26,432 observations from a total of 3,304 firms over a period of 8 years (balanced panel). Since the focus of this study is on the persistence of company growth, firms that had undergone significant structural modifications were excluded, namely those firms that in any year declared an increase in turnover of 10% (or more) due to a merger with another enterprise or part of it (this is the only information provided by the survey on this point). Similarly, any firms which declared a significant decrease in turnover (10% or more) due to sale or closure of part of the enterprise were dropped. In addition, following Hall and Mairesse (1995), the dataset was 'cleaned' by removing all observations for which employment and/or sales were stated to be zero or missing. Accordingly, the total number of observations decreased from 26,432 (3,304 firms) to 25,426 (3,178 firms).

As this study focussed on the ability of innovative firms to create persistent jobs, we restricted the sample to innovative firms, i.e. firms that during the period 2002-2009, had introduced products/processes new to the market and/or new to the firm, and those which stated that they invested constantly in R&D. These represent almost 77% of the sample (i.e., 2,439 innovative firms versus 739 non innovative firms). Thus, there is a limit to how far the results of the study can be generalized in terms of the persistence of job creation in the selected sectors of economic activities because they only correspond to innovative firms. Overall, 43.6% of the sample firms were relatively large companies (non-SMEs). The remaining 56.4% were SMEs (of which 43.2% were medium size enterprises, 49% small firms, and about 7.8% micro firms)[11].

Firms were classified according to their sector of principal activity. Unfortunately, the data provided by INE were grouped according to the industry classification at a relatively high aggregation level (10 main sectors; see Table A1 in Appendix). The sectoral breakdown was as follows: 45.7% manufacturing,[12] 12.4% scientific and technical R&D, 11.1% retail trade, 5.3% construction, 4.8% finance and insurance, 3.4% transport, 2.8% water supply, and about 1% mining and quarrying. Thanks to the collaboration with INE, we were able to identify some suitable sub-sectors within the manufacturing sector, thus ensuring representativeness in each sub-sector.[13] In particular, we shortlisted those sectors[14] which: a) contained a sufficient absolute number of firms;[15] b) had a significant number of innovative firms as a share of the total number of firms operating in the corresponding sector; and c) had at an accumulated level a high share of revenues, and R&D and

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10 The information collected by this Spanish annual survey is the source of data that is then provided to EUROSTAT for the different waves of the Community Innovation Survey (CIS).

11 To define these size classes we followed Recommendation 2003/361/EC. Therefore, SMEs are defined as those firms with less than 250 employees and sales less than/equal to 50 million Euros.

12 Manufacture of food products and beverages; manufacture of chemicals and chemical products; basic pharmaceutical products and preparations; computer, electronic and optical products; electronic equipment; machinery and equipment; motor vehicles, trailers and semi-trailers; manufacture of computer, electronic and optical products.

13 Please see the Appendix for more details about the sample composition (Table A1).

14 The INE, and in particular the Subdirectorate General for Company Statistics (*Subdireccion General de Estadísticas de Empresas)*, kindly gave us access to the data and collaborated closely with us in the data processing and in matching the two different industrial classifications in use during the investigated period (i.e. NACE93 from 2002 to 2007, NACE2009 in 2009). In cases where a one-to-one matching between NACE93 and NACE2009 classification was not possible, a probabilistic matching was used (associating to the most similar category).

15 Public Administration and Defence as well as Education were excluded (zero and only four firms in the dataset, respectively). The Agriculture, Forestry and Fisheries sector had to be dropped because there was no information about R&D expenditure for 2002, 2003, 2004, and 2005.

innovation expenditures compared to the respective totals of the entire population of Spanish firms. Please see the Appendix for further details about sample composition (Table A1).

The resulting sample, compared to the data used in similar studies, had three main advantages. First, the data set included innovative firms from the manufacturing as well as the services sector and, moreover, apart from large companies it also included small and micro firms (both frequently neglected). Secondly, thanks to the merging of annual survey waves we had yearly data which, compared to other studies (e.g. relying on CIS data), is a relatively high-frequency allowing considerations of year-to-year sales and employment changes. Thirdly, the data included additional company characteristics, such as its age. This may have helped to overcome certain weaknesses which usually appear when working with anonymised data.

Unfortunately, –being a balanced panel– the dataset also had some drawbacks as it did not contain firms entering or exiting the market during the given period. In fact, by only considering firms which were already in the market at the beginning of the observed period and survived until the end, it introduced a certain bias because the negative growth rates of those firms which left the market, and the high growth rates of new born firms were both left out. However, over the analysed period the Spanish economy was characterized by a relatively low exit rate[16] which limits the corresponding bias to a certain extent[17]. Moreover, according to Lopez-Garcia *et al.* (2009), in general, Spanish start-ups tend to have a first year employment growth higher than that of subsequent years. In the empirical analysis, we controlled for the age of each firm which may have partially corrected the bias introduced due to the latter shortcoming. In addition, controlling for firm age may have compensated for the balanced nature of the panel because, for any given size of firm, the probability of exit is a decreasing function of firm age as older firms are likely to have more precise estimates about their innate efficiency, thereby reducing the likelihood of failure (Farinas and Moreno, 2000).

3.2 Descriptive statistics

Table 1 offers an overview of the evolution of innovative companies in Spain over the period 2002-2009. It is interesting to note that after a positive trend from 2002 to 2007, a data trend downturn occurred in 2009 in four of the seven parameters considered (i.e. total expenses in innovation, number of innovative enterprises, percentage of innovative enterprises, innovation density in the business sector, innovation intensity of innovative enterprises, and the percentage of turnover due to new and improved products).

Table 1: Evolution of business sector innovation in Spain (2002-2009)

	2002	2005	2007	2009
Total expenses in innovation (M €)	11,089	13,636	18,095	17,636
Number of innovative enterprises [(a)]	32,339	47,529	46,877	39,043
Percentage of innovative enterprises [(a)]	20.6	27.0	23.5	20.5
Innovation intensity in the overall business sector	0.8	0.8	0.9	1.1
Innovation intensity of innovative enterprises	1.8	1.7	1.9	2.2
Percentage of turnover concerning new and improved products in the business sector	8.6	15.6	13.5	14.9
Number of innovative enterprises with R&D activities	9,247	9,738	12,386	11,200

Note: (a) Data refers to the preceding three years

Source: "Encuesta sobre Innovación Tecnológica en las Empresas". Spanish Instituto Nacional de Estadística – INE, and EUROSTAT

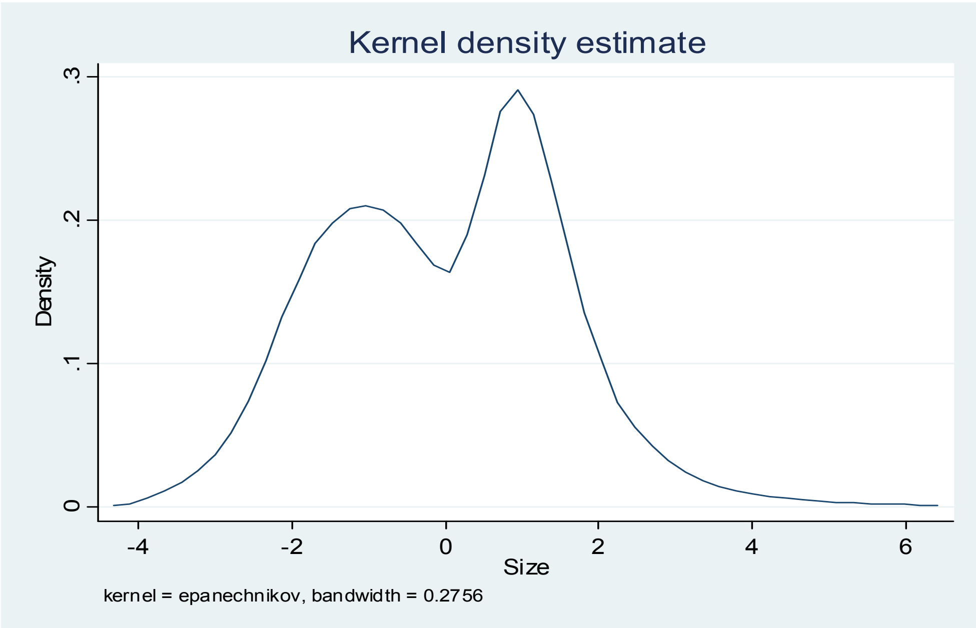
16 See, for instance, Lopez-Garcia et al., 2009; Lopez-Garcia and Puente, 2007a/b; Nunez, 2004; and Ruano, 2000.

17 We also ran a robustness check limiting the time period analysed (2002-2007), i.e. excluding the two crisis years (2008-09). *See* section 4 and Table A3 in the Appendix.

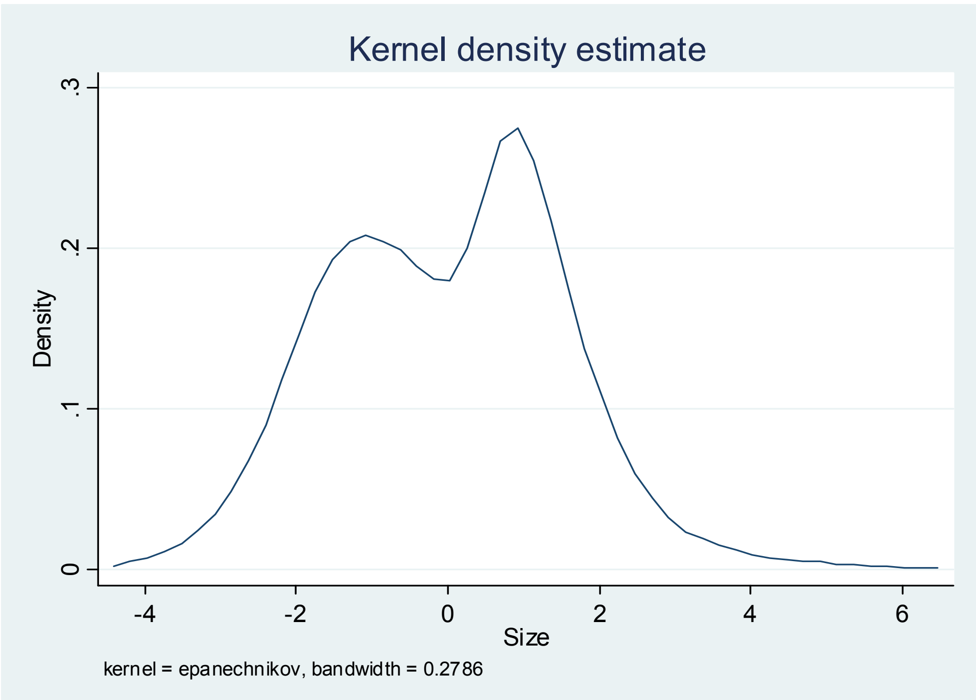
Figure 1 presents the size distribution of firms for the years 2002, 2005 and 2009, and shows bimodal density distribution skewed to the right, identifying a tail of larger firms. One should bear in mind that firm size here corresponds to the number of employees, and firms' growth is approximated correspondingly by changes in the number of employees, firms' turnover (sales) and innovative sales (amount of sales due to new products).

Figure 1: Innovative firm's size distribution (years 2002, 2005 and 2009)

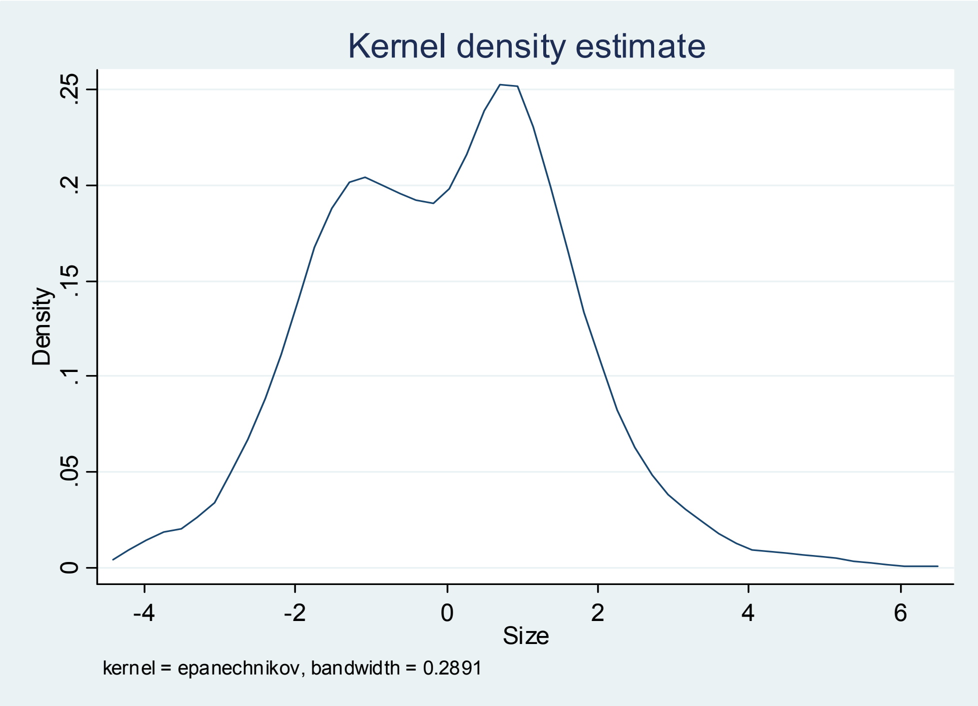
Year 2002



Year 2005



Year 2009



The univariate distribution of firms' employment growth rates and firms' growth rates in terms of sales in the corresponding years are reported in the Appendix (Figure A1 and Figure A2 respectively). In the two aforementioned cases, the growth rates have been normalised, i.e. cleaned of size dependence, serial correlation and heteroskedasticity according to the procedure outlined in Bottazzi *et al.* (2005), which is a standard approach in the relevant literature (see Coad and Rao, 2008). By applying such approach the result demonstrates that both distributions – regardless of the year considered – appear tent-shaped, i.e. characterized by fat-tails. The same applies for the innovative sales growth distribution[18] (as Figure A1 and Figure A2 in the Appendix illustrate). Hence, evidence suggests that – compared to a normally distributed variable – there is a higher probability of finding growth rates near the mean and also a higher probability of rather extreme values.

From an empirical point of view, Figure A1 and Figure A2 in the Appendix suggest that the average firm did not grow, while a minority of firms experienced very rapid growth or very rapid decline. However, these findings confirm the Laplace distribution and appear virtually the same as the empirical growth rate distribution commonly found for Community Innovation Survey data (see e.g. Hölzl and Friesenbichler, 2008).

In addition, the data confirmed a stronger propensity to innovate for SMEs. In fact, almost 85% of the SMEs in the dataset had introduced new products and/or processes and/or constantly invested in R&D, while among the non-SMEs the percentage was 62.2%, which is in line with the common understanding in the literature that it is the more entrepreneurial, smaller firms which play the crucial role in introducing new products and techniques into a market through technological innovations (Pavitt *et al.* 1987; Acs and Audretch 1990).

As expected, the average absolute company level investment in R&D (for those firms that declared a positive amount) was significantly smaller for SMEs (about 25% of the amount invested by larger firms) and, despite the greater propensity of SMEs to innovate, a look at the data reveals that their performance was not as smooth and stable as it was in case of the other firms.

18 Results are available upon request.

However, the differences between SMEs and larger firms went well beyond this. The density distribution of sales growth rates for SMEs and larger firms differed significantly which implies different growth dynamics.[19] In particular, the observed yearly growth rate distributions for SMEs had fatter tails, i.e. the probability of an extreme event – rapid growth or rapid decline – was higher than in the case of larger firms[20]. This result is in line with both Coad and Hölzl (2009) and Fu et al (2005) and with the empirical evidence on high-growth firms or gazelles (Moreno and Casillas, 2007).

In addition, the left hand side tail for SMEs was 'fatter' than the right hand side. This has a theoretical and an empirical implication. Firstly, it confirms that the Laplace distribution is somehow less appropriate for approximating SMEs' growth rate distribution, which does not appear symmetric, while it seems to be a fairly good approximation of the sales growth rate distribution for non-SMEs. This finding is again in line with Coad and Hölzl (2009). Secondly, it suggests that for SMEs rapid decline is more likely to occur than rapid growth. In addition, all these findings underline that growth rate distributions appear to be fairly stable over time and are always likely to display fat tails where outperformers and underperformers are concentrated.

From a methodological point of view, these descriptive statistics imply that regression estimates based on the assumption of normally distributed standard errors may perform poorly mainly due to the presence of (significant numbers of) 'outliers' (Coad, 2007). In addition, given the aim of this study, we decided to focus instead on those firms with higher rates of growth or contraction than the average because the reasons behind these growth patterns are of greater policy relevance. In fact, an econometric analysis focusing on the average firm would in this particular respect be of fairly limited interest. That is why the following analysis is based on the use of quantile regression techniques, which are robust to outliers and allow investigation of the autocorrelation structure across the entire distribution of employment and sales growth rates.

3.3 The quantile regression approach and the estimated model

The quantile regression model is a semi-parametric technique that was first introduced by Koenker and Bassett (1978) and has been used since by many authors (e.g. Coad and Rao, 2008). The technique has several useful features which make its application especially appropriate when dealing with very heterogeneous observations whose heterogeneity, however, is of interest. Basically, when analysing firms' growth rates, outliers are carriers of fundamental information that one wants to preserve, not eliminate. As such, the quantile regression model can be used to exploit and characterise the entire conditional distribution of a dependent variable (i.e. a firm's employment growth rate) given a set of regressors and control variables.

This model allows taking into account the fact that different solutions at distinct quantiles may reflect differences in the response of the dependent variable to changes in the regressors at various points in the conditional distribution of the dependent variable itself (Buchinsky, 1998). In other words, by applying this technique we account for the fact that the autocorrelation between a firm's growth rates is not the same for all firms regardless of their size (or sector). For instance, the coefficient may differ according to the size of the firm. The model can be written as:

$$y_{it} = x_{it}^{'}\beta_{\mu} + u_{\mu it} \qquad with \qquad Quant_{\mu}(y_{it}/x_{it}) = x_{it}^{'}\beta_{\mu} \qquad (1)$$

where yit is the vector of employment or sales or innovative sales growth rates; xit is a vector of regressors; β is a vector of parameters to be estimated, and uμit is a vector of residuals whose distribution is unspecified (equation (1) assumes that uμit satisfies the quantile restriction Quant (uμit /xit) = 0 only; (see Buchinsky,

[19] After comparing the distributions of the employment growth rates of SMEs and non-SMEs it emerged that the peak of the Laplace distribution was significantly higher for non-SMEs, while the tails of the two distributions was similar. Results and details are available upon request.

[20] Results are available upon request.

1998). In this way, Quant (yit/xit) refers to the μth conditional quantile of yit given xit. The μth regression quantile, 0 < μ < 1, solves the following problem:

$$\min_{\mu}\left\{\sum_{i,t:y_{it}\geq x_{it}^{'}}\mu\left|y_{it}-x_{it}^{'}\mu\right|+\sum_{i,t:y_{it}<x_{it}^{'}}(1-\mu)\left|y_{it}-x_{it}^{'}\mu\right|\right\}=\min_{\mu}\frac{1}{n}\sum_{i=1}^{n}\rho_{\mu}(u_{\mu it}) \qquad (2)$$

where ρθ(uθit) is the so-called 'check function', which is defined as follows:

$$\rho_{\mu}(u_{\mu it})=\begin{cases}\mu u_{\mu it} & if \quad u_{\mu it}\geq 0\\ (\mu-1)u_{\mu it} & if \quad u_{\mu it}<0\end{cases} \qquad (3)$$

Equation (2) is then solved by linear programming methods. By increasing μ continuously from 0 to 1, one traces the entire conditional distribution of y, conditional on x (Buchinsky, 1998)[21].

Given that any dataset has a finite number of observations, the previous statement implies that only a finite number of quantiles will be identified and numerically distinct. As shown by equation (3), ρθ(.) is a weighted sum of absolute deviations, which gives a robust measure of location, so that the estimated coefficient vector is not sensitive to outlier observations on the dependent variable (in other words, the parameter vector estimate is robust to outliers). Therefore, when the error-term is non-normal, quantile regression estimators may be more efficient than OLS estimators (Buchinsky, 1998).[22]

The regression model to be estimated for this study can be written as follows:

$$\begin{aligned}Growth_{i,t} = {} & \alpha_0 + \alpha_1 \log(size_{i,t-1}) + \alpha_2 SME{*}Growth_{i,t-1} + \alpha_3 SME{*}Growth_{i,t-2} + \\ & \alpha_4 nonSME{*}Growth_{i,t-1} + \alpha_5 nonSME{*}Growth_{i,t-2} + a_6 SME + \\ & \alpha_7 year + \alpha_8 age_i + \alpha_9 sector_i + \varepsilon_{i,t}\end{aligned} \qquad (4)$$

phenomena common to all firms (such as inflation, market cycles, etc.), *age*$_i$ is the age of the firm (controlling for the degree of establishment of a firm), *sector*$_i$ a vector of industry dummies, and $\varepsilon_{i,t}$ a vector of residuals.[23] In addition, SME*Growth$_{i,t-1}$, SME*Growth$_{it-2}$, nonSME*Growth$_{i,t-1}$, and nonSME*Growth$_{i,t-2}$ are four interaction terms introduced to where *size*$_i$ is the logarithm of the number of employees at t-1, *year* is a vector of yearly dummies accounting for macroeconomic disentangle differences in the growth trajectories of SMEs and larger firms, and SME is a dummy identifying small and medium enterprises.

With regard to firm age, the literature suggests that for a given firm size the proportional rate of company growth decreases the older the firm (Jovanovic, 1982). The rationale behind this is the existence of diminishing returns to learning as older firms are supposed to have less scope for additional efficiency gains.

21 For a more detailed description of quantile regression techniques see e.g. Buchinsky (1998), Koenker and Hallock (2001). For the corresponding empirical application see e.g. Coad (2006) and also the special issue of Empirical Economics (Vol. 26 (3), 2001).

22 In addition, in the case of quantile regressions the error terms do not need to satisfy the restrictive assumption according to which they must be identically distributed at all points of the conditional distribution.

23 We did not insert an interaction term year*sector due to the loss of degree of freedom that it would have implied.

4 Empirical results

Five quantile regressions were computed, namely .10, .25, .50, .75 and .90, thus using the same set of independent variables in each regression and allowing two lags in serial correlation. The coefficients can be interpreted as the partial derivative of the conditional quantile of the dependent variable with regard to the specific explanatory variable. Table 2 presents the main results.

Table 2: Quantile regression estimation of equation (4), distinguished for SME and non-SMEs, 10%, 25%, 59% 75% and 90% quantiles, years 2002-2009

Explanatory variables	q10	q25	q50	q75	q90
Block A			**Employment growth**		
Lagged size	0.000365	**-0.00300****	-0.000507	**-0.00829*****	**-0.0165*****
	(0.00297)	(0.00123)	(0.000773)	(0.00197)	(0.00307)
SMEs First-order lag	-0.0377	-0.00496	**0.0123***	0.00401	-0.0455
	(0.0379)	(0.0217)	(0.00699)	(0.0233)	(0.0294)
nonSME First-order lag	0.0123	**0.0127***	**0.0375****	0.0362	-0.00810
	(0.0183)	(0.00764)	(0.0155)	(0.0315)	(0.0437)
SMEs Second-order lag	0.0128	0.0178	**0.0199***	**0.0292***	0.0185
	(0.0214)	(0.0197)	(0.0104)	(0.0171)	(0.0187)
nonSME Second-order lag	**0.0296***	**0.0473*****	**0.0391*****	**0.0550*****	**0.0490****
	(0.0165)	(0.0115)	(0.00948)	(0.0155)	(0.0235)
Age	**0.0263*****	**0.00562*****	**-0.00311*****	**-0.0210*****	**-0.0486*****
	(0.00653)	(0.00175)	(0.00109)	(0.00300)	(0.00769)
Block B			**Sales growth**		
Lagged size	**0.0129*****	**0.00770*****	**-0.00504****	**-0.0145*****	**-0.0408*****
	(0.00472)	(0.00174)	(0.00216)	(0.00276)	(0.00627)
SMEs First-order lag	**-0.229*****	**-0.131*****	**-0.0808*****	**-0.110*****	**-0.171*****
	(0.0411)	(0.0290)	(0.0164)	(0.0161)	(0.0285)
nonSME First-order lag	-0.0347	0.00122	0.00922	0.00493	-0.00236
	(0.0342)	(0.00439)	(0.00845)	(0.0166)	(0.0282)
SMEs Second-order lag	-0.0142	-0.00994	-0.00881	-0.00777	**-0.0622*****
	(0.0194)	(0.00751)	(0.00674)	(0.00816)	(0.0208)
nonSME Second-order lag	-0.00332	0.00772	0.00569	0.00229	0.0211
	(0.0145)	(0.0115)	(0.00395)	(0.00707)	(0.0173)
Age	0.0121	0.00596	**-0.00720*****	**-0.0366*****	**-0.0709*****
	(0.00825)	(0.00444)	(0.00277)	(0.00323)	(0.00834)
Block C				**Growth of innovative sales**	
Lagged size	-0.0610	0.0150	0	0.0305	**0.749*****
	(0.116)	(0.0113)	(8.54e-07)	(0.0241)	(0.198)
SMEs First-order lag	**-0.119***	**-0.0220*****	-0.000188	**-0.0373*****	**-0.467*****
	(0.0649)	(0.00220)	(0.00120)	(0.00852)	(0.0110)
nonSME First-order lag	**-0.129*****	**-0.0147*****	-0.000129	**-0.0241*****	**-0.455*****
	(0.0477)	(0.00472)	(0.000483)	(0.00667)	(0.0162)
SMEs Second-order lag	**-0.0433****	**-0.00986*****	0	**-0.0121*****	**-0.0492****
	(0.0209)	(0.00237)	(2.43e-05)	(0.00344)	(0.0193)
nonSME Second-order lag	-0.0323	**-0.00516****	0	**-0.0130*****	**-0.135*****
	(0.0240)	(0.00210)	(0.000227)	(0.00372)	(0.0329)
Age	-0.145	-0.0110	0	-0.0513	-0.433
	(0.200)	(0.0175)	(1.47e-06)	(0.0508)	(0.309)
Observations	8,063	8,063	8,063	8,063	8,063

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

In the following, the obtained estimates will be discussed along with the empirical results for employment (*see* block *A* of Table 2), sales (*see* block *B* of Table 2) and innovative sales (*see* block *C* of Table 2) growth equations. Thus, first we will comment briefly on the results at the median of the growth distribution (Q50) and then reflect whether (and how) these results may change along the other four quantiles and according to the firms' size classes. To this end, it is worth recalling that four interaction terms (SME*Growth$_{i,t-1}$; SME*Growth$_{it-2}$; nonSME*Growth$_{i,t-1}$; nonSME*Growth$_{i,t-2}$,) were introduced in the three equations to disentangle differences in first and second order autocorrelations of growth rates between these two groups of firms. Finally, we conducted several robustness checks to account for manufacturing and service firms' heterogeneity and to check whether results were affected by the time period considered. In fact, as the analysis covered two very different periods - 2002 to 2007, one of the best periods in Spanish economic growth; and 2007 to 2009, the beginning of the economic crisis - we have also circumscribed the analysis to the growth period. Results are robust (see Table A2 and A3 in Appendix).

4.1 Companies' employment growth

The results obtained for the median firm (block A and column "Q50" of Table A2) show that employment growth is not systematically determined by firm size. However, firms' age was found to negatively affect firms' growth performance (although with a very low elasticity). This result is in line with the corresponding literature (see Coad and Tamvada, 2011).

With regard to time lags, evidence suggests positive autocorrelations of first and second order in the case of employment growth for both SMEs and larger firms. At first sight, these results would reject Gibrat's law (1931), which implies the absence of any structure in the growth process. However, these results regard firms that are at or around the median of the growth rate distribution and are of minor interest here because hardly any of them were growing at all.

Significant differences emerged regarding the impact of firm size and age on employment growth at the extreme quantiles (columns "Q10" and "Q90"). For declining firms, both size and age entered the equation with a positive sign (but size was not significant) whereas for growing and fast growing firms both variables were significant and affected firms' growth performance negatively. Stated simply, among declining firms (in terms of employment figures), age helped to limit the losses in employment growth, i.e. older innovative firms tended to decline less (i.e. laying off employees at a slower rate), whereas among growing innovative firms the smallest and youngest tended to experience a faster growth track. These results are in line with findings made in previous studies according to which smaller firms generally tend to grow faster than larger firms (Coad, 2009). Our empirical results confirm that this general hypothesis also holds for innovative companies.

As for overall employment growth patterns, in the case of SMEs a random path emerges, i.e. neither a positive nor a negative autocorrelation process was found, which would seem to confirm Gibrat's law. In the case of non-SMEs, only second-order autocorrelation was found to be positive and significant (the only exception was represented by the results for Q25, where a positive first order autocorrelation was found). The latter suggests a slightly more stable growth pattern in the longer run for larger firms**.**

4.2 Companies' total sales growth

The estimates obtained for the sales growth equation –compared at the median (block B and column "Q50" of Table A2)– are in line with those made for employment growth as far as a firm's age is concerned (see above): age entered the equation with a negative sign. However, in this case size was significant and negative and a negative first-order autocorrelation emerged in the case of SMEs.

In contrast to the results concerning employment growth, in the case of SMEs the mentioned negative first-order autocorrelation was also persistent over the entire growth rate distribution, i.e. regardless of the firm's sales growth rate. In the case of faster growing firms (column "Q90" of Table A2), for SMEs a second-order negative autocorrelation was also found to be significant. However, for all other companies (non-SMEs), a random growth path emerged in all quantiles.[24]

The main result with regard to investigating firms' sales growth was that extreme growth events were negatively correlated over time; and this seemed to be the case for smaller firms in particular. Basically, SMEs are incapable of repeating their sales growth performance year after year, across quantiles. The negative autocorrelation was even stronger in the extreme cases, especially for Q.10.

With regard to firms' age, the empirical evidence suggested again that fast growth was more likely to be found in young firms (column "Q90" of Table 2). However, for slow growth/declining firms, company age did not seem to have a significant influence.

Size mattered a lot in terms of sales growth, but the sign of its influence changed through the distribution of company growth rates. The variable had a positive impact on extreme negative growth episodes (column "Q10") and a negative impact on extreme positive growth episodes (and was found to be significant in all quantiles). In other words, larger firms were less likely to experience decline, i.e the bigger the firm the lower the rate at which sales growth was declining. Smaller firms, in turn, were more likely to experience positive and high sales growth. A positive effect of size on lower quantiles (declining firms) combined with a negative effect on upper quantiles (high growth firms) indicated that larger firms experienced a lower variance in growth rates, i.e. they were less likely to experience either fast decline or fast growth in the following years. The latter may provide a toehold for corresponding policy making aiming to accelerate the EU's overall growth patterns.

As for the controversy in the literature about firms' growth autocorrelation, our empirical results did not point towards a clear tendency. Indeed, evidence suggests that the sign and the significance of the autocorrelation process are probably affected by/dependent on sample composition. In fact, several studies have found a positive autocorrelation, while others found a negative one, and a third group of studies failed to detect any significant autocorrelation in growth rates. Overall, it looks like as if a standard specification of serial correlation of firm growth is not capable of capturing such a complex phenomenon characterised by persistent asymmetries in growth dynamics across firms.

4.3 Companies' innovative sales growth

The empirical results concerning innovative sales growth confirmed the extent to which analysing the "median" firm may be misleading (block C and column "Q50" of Table A2). In fact, if we were to comment on the results obtained for the 0.50 quantile no significant growth pattern was revealed. However, looking at the estimates across the growth distribution, more meaningful results emerged.

First of all, in contrast to the evidence found concerning employment and total sales growth patterns (as outlined above), company size only appeared to be relevant for those firms belonging to Q.90 (i.e. the fastest growing firms). In this context, fast growth and company size were apparently significantly positively correlated, i.e. bigger firms were more likely to be fast growing in terms of innovative sales than others. This result (although it contrasts with the corresponding evidence for sales and employment growth) is in line with empirical evidence on the innovative sales performance of European firms found in previous studies (see e.g. Ciriaci, 2011a; Ciriaci 2011b). Accordingly, larger firms are better at exploiting economies of scale and scope and complementarities between different departments (e.g. R&D, marketing, design) and our evidence suggests that all this is of particular importance with respect to innovative sales. In fact, some of the above mentioned studies (Ciriaci, 2011a; Ciriaci 2011b) confirmed not only that the larger the firm the greater the innovative sales, but also that returns on investment in R&D tend to be greater in larger firms. Therefore, one could argue that smaller firms face greater difficulties than larger firms to get returns from their innovation

24 Please note that we tried with higher order lags but obtained the same results, which is why we left them out of this presentation.

efforts (see e.g. Fritsch and Meschede, 2001; Bos *et al.*, 2011). That conclusion is reflected here in our empirical results concerning company growth patterns.

Once again, in contrast to the results presented above concerning the influence of firm age on growth patterns of sales and employment, the empirical evidence from analysing firms' innovative sales growth suggested that company age did not play any significant role. Moreover, comparing the growth paths of SMEs and non-SMEs, revealed negative first and second-order autocorrelations which were significant for all quantiles except the median (Q.50); and this holds for both SMEs and non-SMEs.

Summing up the overall empirical findings, two key messages arise: (1) negative autocorrelation tends to be more likely when looking at innovative sales rather than employment/total sales growth and (2) performing quantile regression may indeed provide extremely valuable insights into company growth patterns (see the non-significant parameter estimates for the median quantile).

5 Conclusions

The study investigated whether changes in employment, total sales and innovative sales of a panel of innovative Spanish firms over the period 2002-2009 were persistent over time or not, whether such persistence (if any) differed between SMEs and larger firms and if it was affected by a firm's age. To this end, it applied a quantile regression approach which is particularly suitable when the subjects of investigation are outliers (high-growth firms) and/or in the presence of high firm heterogeneity. In fact, this investigation robustly indicated that by adopting such an approach, a more comprehensive picture of company growth patterns emerged, compared to simply looking at estimates obtained for the median only.

From the individual empirical estimates, we have been able to pinpoint a bunch of stylized facts:

In general, there is evidence that autocorrelation is not systematic across all types of companies and company characteristics; instead, it appears to follow a random path. However, the following significant patterns were found:

- Smaller/younger innovative firms tend to grow more (and faster) in terms of employment and sales, but they are less likely to perform well in terms of innovative sales growth (where larger firms seem to have an advantage). At the same time, however, for both SMEs and non-SMEs a 1st and 2nd order negative autocorrelation in innovative sales growth was found which means that any high, positive growth experience in one year is unlikely to be repeated in the following years. In turn, for declining firms (quantile 10, or Q.10), evidence of significant positive growth expectations for the next two periods was found (significant 1st and 2nd order lags).[25]
- Mature (older) firms appear to be less likely to experience rapid decline in terms of employment (significant positive autocorrelation for Q.10).
- Company size matters most for those firms experiencing the fastest growth (highest elasticity). For employment and overall sales growth, the smaller the company the higher the growth rate is.
- However, this relation is inverted for innovative sales: i.e. larger firms are more likely to grow faster in terms of innovative sales than SMEs.

Some policy implications arise from the analytical results:

(1) The analysis indicates that smaller and younger innovative firms in Spain tend to grow on average with higher rates in terms of employment and sales than larger firms, but the jobs they create are not proved to be persistent over time. The reason for this needs to be investigated, raising the question: what barriers and

[25] This might be due to the nature of the dataset. One has to remember that the study relies on a balanced panel, i.e. companies experiencing persistently negative growth figures which consequently might have gone bankrupt were removed from the sample.

possible market failures are responsible? Targeted policies will have to address these barriers and possible market failures to bolster the overall growth performance of the economy.

(2) Nonetheless, among the fastest growing Spanish firms, the smaller and younger innovative companies clearly encounter difficulties when it comes to innovating at a later business phase, affecting their ability to base their sales on successive waves of innovations. The latter in turn was found to be a strength of larger innovative companies. This suggests that there might be a rationale for policies aimed at supporting smaller and younger firms by maintaining/increasing their knowledge generation/accumulation and supporting the use of this capacity. For instance, measures aimed at fostering firms' innovation capacity, supporting university-firm collaboration, and second-phase business cycle financing of technology innovation (e.g. risk capital/equity finance) can be considered.

(3) In turn, larger innovative firms in Spain –which were found to grow more gradually, but more continuously/with less discontinuity– might be encouraged to develop steadily and thus create persistent jobs. Examples of corresponding policies are, for instance, (temporary/targeted) tax incentives, increasing the availability of highly qualified personnel, and introducing labour market reforms to increase flexibility and stability.[26]

In sum, the results of this study suggest that in order to enhance the growth potential of the Spanish economy a well concerted mix of policies is needed which, on the one hand, needs to provide favourable framework conditions to enable all companies to fully exploit their growth potential (in total sales and in particular in job creation) and, on the other, address the existing barriers and market imperfections which prevent both big and small firms from developing more persistently and dynamically. Empirically, this study revealed that the persistence of growth and job creation for small firms and the dynamics of large firms are falling short, and both of these issues require policy attention.

This study demonstrates, as another important outcome, that the elaboration of a micro-data panel of innovative firms which is representative of the national industrial structure is certainly feasible. A data gathering and processing procedure similar to the one implemented in this study, but deployed across EU countries in a coordinated manner, could certainly provide policy-makers and other stakeholders with a better "evolving picture" of the employment, sale and innovative sales growth of innovative EU firms which is one of the main objectives of the "Innovation Union initiative".

Several indications for further research arose from this study:

It would be interesting to investigate further into the relationship between R&D and firms' growth (more firm-specific variables) and also re-run the econometrics of this study based on longer time-series to include firm-data related to the years 2010 and 2011 where the Spanish economy slowed down considerably. It has to be sorted out whether this is feasible using the same panel of Spanish micro-data (additional/complementary data may be needed).

Another important line of research would be to focus on the job creation ability of both R&D investing firms and non R&D investing firms, to analyse the degree to which R&D investment influences job creation.

Finally, it would be desirable extending this analysis to companies from other EU countries, to identify similarities and differences, and analyse the possible economic and policy features underpinning them.

[26] These measures could also support medium-size companies which have the potential and seek to become large-scale (innovative) companies. However, for micro-enterprises, other issues / measures appear to be more important.

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APPENDIX

Table A1: Sample composition (by NACE 2009 sector classification codes)
Panel data of innovative firms 2002-2009, and total firms population in 2009

Sector of activities / name	Number of firms in the sample	Size	Turnover	R&D Expendi-ture intramuros	Innovation expenditure	R&D perfor-ming firms	Total number of Spanish firms in 2009	Share of firms in the sample (2002-2009) to the total Spanish firms in 2009
	Total in the sample	Total No. of employees	€ (x 1000)	€ (x 1000)	€ (x 1000)	Share over total (%)	Total	Share over total (%)
B Mining & Quarring	**32**	**7,062**	**1,091,742**	**4,644**	**4,289,730**	**0.97**	**2,916**	**1.10**
C Manufacturing (only activities' sub-sectors specified below)	**1,509**	**347,760**	**122,997,602**	**1,370,893**	**2,843,496**	**45.67**	**50,943**	**2.96**
C10 Food products	244	67,124	25,157,017	71,311	264,291	*n/a*	25,689	0.95
C11 Manufacture of beverage	47	17,681	8,804'335	10,640	52,599	*n/a*	5,216	0.90
C20 Chemicals & Chemical products	307	40,560	14,862,231	139,667	231,262	*n/a*	3,997	7.68
C21 Basic pharmaceuticals products and preparations	115	35,202	17,700,935	554,271	938,272	*n/a*	416	27.64
C26 Computer, electronic and optical products	169	17,560	3,707,637	137,436	203,844	*n/a*	3,283	5.15
C27 Electronic equipment	151	40,308	9,662,792	120,504	203,457.	*n/a*	2,984	5.06
C28 Machinery and equipment	306	33,262	5876,098	109,427	156,797		7,071	4.33
C29 Motor vehicules, trailers and semi-trailers	170	96,063	37,226,557	227,637	996,431	*n/a*	2,287	7.43
E Water supply	**92**	**80,484**	**6,664,142**	**25,077**	**41,922**	**2.78**	**5,945**	**1.55**
F Construction	**176**	**131,099**	**30,491,773**	**75,983**	**97,987**	**5.33**	**557,110**	**0.03**
G Retail	**367**	**494,714**	**132,721,519**	**118,367**	**236,692**	**11.11**	**809,290**	**0.45**
H Transport & Storage	**112**	**117,673**	**18,645,373**	**44,410**	**185,042**	**3.39**	**234,798**	**0.05**
J Information & communication	**341**	**142,329**	**42,837,605**	**437,634**	**2,319,112**	**10.32**	**51,110**	**6.67**
K Financial & Insurance	**157**	**269,159**	**122,749,085**	**137,260**	**611,406**	**4.75**	**68,306**	**0.23**
M Scientific and technical	**408**	**99,378**	**11,807,028**	**862,495**	**1,009,943**	**12.35**	**409,641**	**0.10**
Q Health	**110**	**61,301**	**3,748,580**	**10,639**	**24,383**	**3.33**	**126,986**	**0.09**
TOTAL	***3,304***	***1,437,975***	***493,754,449***	***1,553,006***	***8,816,217***	***100.00***	***2,488,473***	***0.13***

Data sources: *Instituto Nacional de Estadística* (the Spanish National Statistics Institute) – INE (2011); Unpublished anoninised micro-data and INE's Directorio central de empresas (2012) available at www.ine.es/

Figure A1: Distribution of the growth rates of employment, 2003-2009

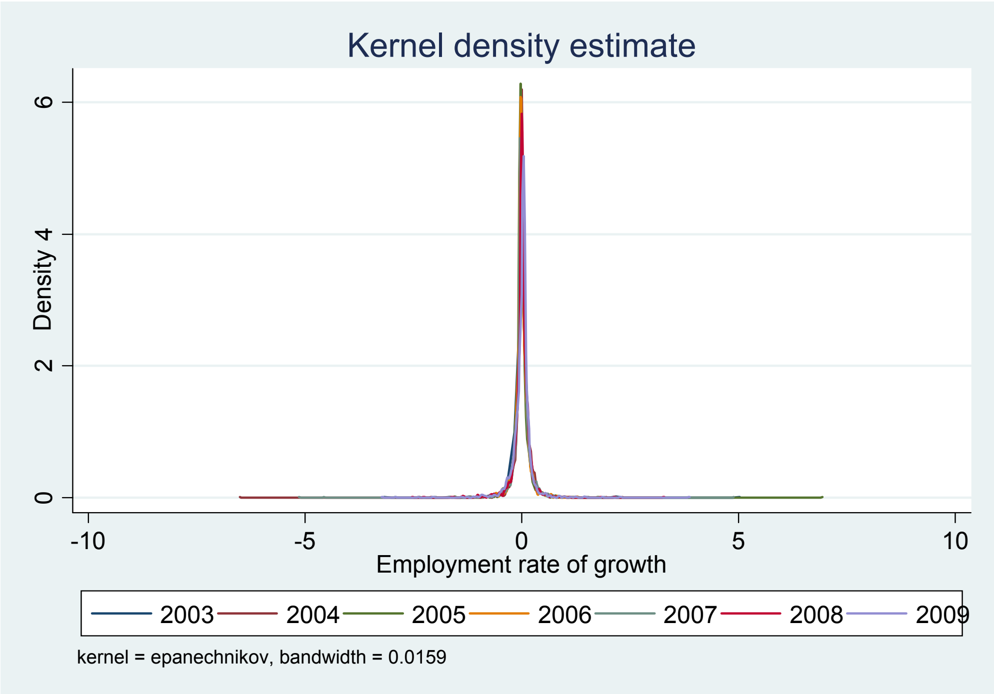

Figure A2: Distribution of the growth rates of sales, 2003-2009

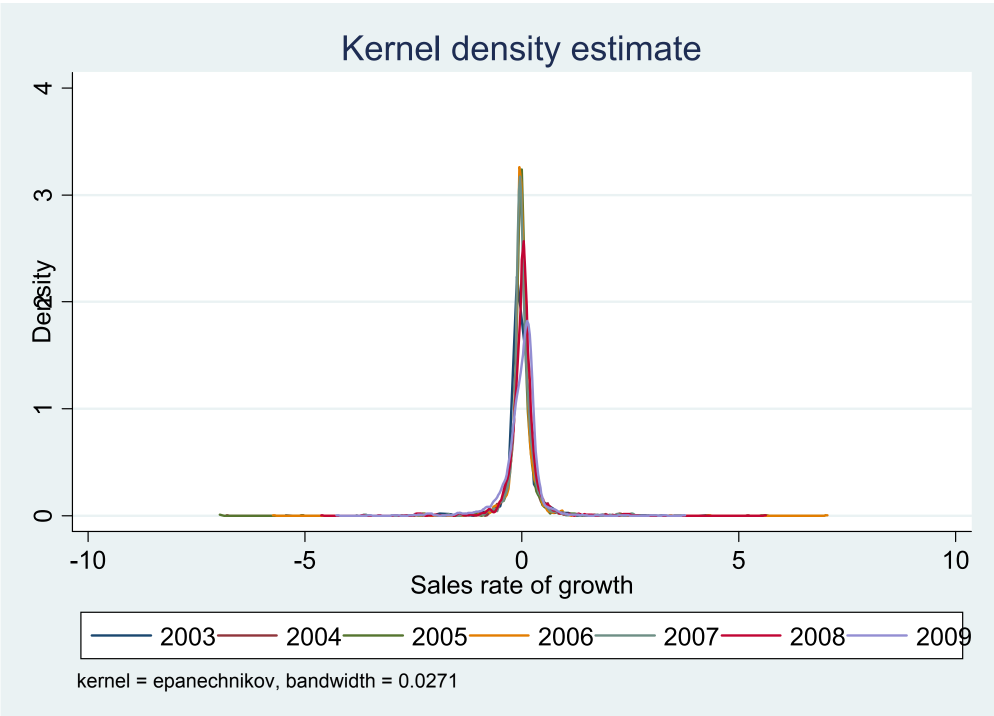

Table A2: Robustness check: Quantile regression estimation of equation (4) for manufacturing firms, 10%, 25%, 50% 75% and 90% quantiles, years 2002-2009

Explanatory variables	q10	q25	q50	q75	q90
Block A			Employment growth		
Lagged size	3.47e-05	**-0.00528*** **	**-0.00413** **	**-0.0131*** **	**-0.0263*** **
	(0.00568)	(0.00191)	(0.00180)	(0.00219)	(0.00415)
SMEs First-order lag	0.00957	0.0396	**0.0215***	0.0375	-0.00887
	(0.0439)	(0.0316)	(0.0129)	(0.0295)	(0.0257)
nonSME First-order lag	0.0352	0.0407	**0.0786*** **	**0.149*** **	0.0634
	(0.0316)	(0.0272)	(0.0284)	(0.0440)	(0.0590)
SMEs Second-order lag	0.0161	0.0420	0.0245	0.0402*	0.0279
	(0.0185)	(0.0327)	(0.0162)	(0.0240)	(0.0241)
nonSME Second-order lag	0.0135	0.0188	**0.0308** **	**0.0343** **	0.0114
	(0.0266)	(0.0121)	(0.0140)	(0.0146)	(0.0484)
Age	**0.0197** **	0.00411	**-0.00478** **	**-0.0179*** **	**-0.0386*** **
	(0.00891)	(0.00363)	(0.00196)	(0.00284)	(0.00770)
Block B			**Sales growth**		
Lagged size	**0.0141** **	0.00380	**-0.00793*** **	**-0.0219*** **	**-0.0401*** **
	(0.00645)	(0.00325)	(0.00229)	(0.00323)	(0.00809)
SMEs First-order lag	**-0.145** **	-0.0512	-0.0289	-0.0439	**-0.130** **
	(0.0620)	(0.0449)	(0.0258)	(0.0326)	(0.0545)
nonSME First-order lag	0.00171	0.0289	0.0342	0.0312	0.0331
	(0.0432)	(0.0365)	(0.0378)	(0.0452)	(0.0621)
SMEs Second-order lag	**-0.0720** **	**-0.0432***	**-0.0322** **	**-0.0483*** **	**-0.0823*** **
	(0.0350)	(0.0228)	(0.0144)	(0.0152)	(0.0252)
nonSME Second-order lag	-0.00253	0.0117	-0.00330	-0.0457	-0.0662*
	(0.0357)	(0.0196)	(0.0183)	(0.0308)	(0.0364)
Age	0.00929	0.00605	**-0.0100** **	**-0.0308*** **	**-0.0679*** **
	(0.0127)	(0.00524)	(0.00425)	(0.00659)	(0.0119)
Block C			**Innovative sales growth**		
Lagged size	-0.0950	0.0247	-0	0.0103	**0.419***
	(0.228)	(0.0218)	(0.00101)	(0.0425)	(0.253)
SMEs First-order lag	**-0.226** **	**-0.0267*** **	**-0.00403** **	**-0.0307*** **	**-0.462*** **
	(0.0891)	(0.00353)	(0.00199)	(0.0111)	(0.00870)
nonSME First-order lag	**-0.185*** **	**-0.0165*** **	**-0.00250***	**-0.0157*** **	**-0.440*** **
	(0.0464)	(0.00506)	(0.00137)	(0.00539)	(0.0201)
SMEs Second-order lag	-0.0720	**-0.0118*** **	-0.000475	**-0.0111** **	**-0.0373*** **
	(0.0451)	(0.00402)	(0.000572)	(0.00524)	(0.0138)
nonSME Second-order lag	**-0.116***	**-0.00665***	-0.000423	**-0.0104** **	**-0.0598***
	(0.0627)	(0.00340)	(0.000350)	(0.00423)	(0.0305)
Age	-0.159	0.00181	-0	-0.0732	**-0.654** **
	(0.327)	(0.0334)	(0.00243)	(0.0601)	(0.284)
Observations	4,555	4,555	4,555	4,555	4,555

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A3: Robustness check: Quantile regression estimation of equation (4), 10%, 25%, 50% 75% and 90% quantiles, years 2002-2007

Explanatory variables	q10	q25	q50	q75	q90
Block A			**Employment growth**		
Lagged size	0.00346	-0.00207	**0.00255*** **	**-0.00594*** **	**-0.0152*** **
	(0.00446)	(0.00263)	(0.000966)	(0.00211)	(0.00425)
SMEs First-order lag	-0.0410	-0.00869	0.0116	0.00456	-0.0469
	(0.0499)	(0.0254)	(0.00948)	(0.0248)	(0.0357)
nonSME First-order lag	-0.00880	0.0131	0.0378	0.0234	-0.0279
	(0.0475)	(0.0205)	(0.0381)	(0.0748)	(0.114)
SMEs Second-order lag	0.00519	0.00864	0.0148	0.0245	0.0356
	(0.0207)	(0.0131)	(0.0121)	(0.0279)	(0.0251)
nonSME Second-order lag	0.0524	**0.0487*** **	**0.0452*** **	**0.0425***	0.00879
	(0.0327)	(0.0170)	(0.0121)	(0.0231)	(0.0578)
Age	**0.0280*** **	0.00392	**-0.0051*** **	**-0.0281*** **	**-0.0529*** **
	(0.00799)	(0.00271)	(0.00145)	(0.00381)	(0.00729)
Block B			**Sales growth**		
Lagged size	**0.0144** **	**0.00565***	**-0.00555** **	**-0.0162*** **	**-0.0465*** **
	(0.00568)	(0.00328)	(0.00265)	(0.00390)	(0.00628)
SMEs First-order lag	**-0.252*** **	**-0.163*** **	**-0.129*** **	**-0.145*** **	**-0.201*** **
	(0.0594)	(0.0408)	(0.0296)	(0.0371)	(0.0477)
nonSME First-order lag	-0.00632	0.00256	0.00943	0.00403	-0.00874
	(0.0330)	(0.0156)	(0.0107)	(0.0205)	(0.0512)
SMEs Second-order lag	-0.00591	-0.00808	-0.00592	-0.00527	**-0.0650***
	(0.0189)	(0.0117)	(0.0101)	(0.0185)	(0.0357)
nonSME Second-order lag	-0.000214	**0.0103** **	**0.00704***	0.00324	-0.00282
	(0.0170)	(0.00417)	(0.00411)	(0.00777)	(0.0197)
Age	0.00933	0.00611	**-0.0111*** **	**-0.0379*** **	**-0.0707*** **
	(0.00645)	(0.00456)	(0.00330)	(0.00393)	(0.00926)
Block C			**Growth of innovative sales**		
Lagged size	-0.226	0.0361	-0	0.0254	0.384
	(0.266)	(0.0253)	(0)	(0.0890)	(0.280)
SMEs First-order lag	**-0.427*** **	**-0.030*** **	-0	**-0.0602** **	**-0.464*** **
	(0.0399)	(0.00407)	(0.000772)	(0.0247)	(0.0145)
nonSME First-order lag	**-0.355*** **	**-0.0258*** **	-0	**-0.0535** **	**-0.460*** **
	(0.0660)	(0.00633)	(0.00106)	(0.0259)	(0.0162)
SMEs Second-order lag	**-0.0878***	**-0.0166*** **	-0	**-0.0250** **	-0.0457
	(0.0448)	(0.00382)	(0.000388)	(0.0101)	(0.0311)
nonSME Second-order lag	**-0.122** **	**-0.00979** **	-0	**-0.0264***	**-0.126** **
	(0.0605)	(0.00444)	(0.000844)	(0.0155)	(0.0552)
Age	-0.263	-0.0306	-0	-0.175	**-0.542***
	(0.353)	(0.0368)	(0)	(0.111)	(0.329)
Observations	5,265	5,265	5,265	5,265	5,265

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

European Commission
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Title: Does size or age of innovative firms affect their growth persistence? - Evidence from a panel of innovative Spanish firms -

Authors: Daria Ciriaci , Pietro Moncada-Paternò-Castello and Peter Voigt

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Abstract
This study examines serial correlation in employment, sales and innovative sales growth rates in a balanced panel of 3,300 Spanish firms over the years 2002-2009, obtained by matching different waves of the Spanish Encuesta sobre Innovacion en las Empresas, the Spanish innovation survey conducted annually by the Spanish National Statistics Institute (INE). The main objective is to verify whether the changes (increase/decrease) in these figures are persistent over time, whether such persistence (if any) differs between SMEs and larger firms, and if it is affected by a firm's age. To do so, we adopted a semi-parametric quantile regression approach. This methodology is well suited to cases where outliers (high-growth firms) are the subject of investigation and/or when they have to be assumed as being very heterogeneous.
Empirical results indicate that among those innovative firms experiencing high employment growth, the smaller and younger grow faster than larger firms, but the jobs they create are not persistent over time. However, while being smaller and younger helps growing more in terms of employment and sales, it is not an advantage when innovative sales growth is considered: in this case larger firms experience faster growth.

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