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December 2012

Working Papers in Applied Economics

WPAE-2012-17

ECONOMÍA APLICADA II

VNIVERSITAT DE VALÈNCIA

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ISSN 2172-3036

Age and firm growth.
Evidence from three European countries

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This version: 28/11/2012

Abstract

This paper provides new insights on the firm age and growth nexus along the entire distribution of (positive and negative) growth rates. Using data from the EFIGE survey, and adopting a quantile regression approach we uncover evidence for a sample of French, Italian and Spanish manufacturing firms in the period from 2001 to 2008. After controlling for several firms' characteristics, country and sector specificities we find that: (i) young firms grow faster than old firms, especially in the highest growth quintiles (ii) young firms face the same probability of declining than their older counterparts; (iii) high growth is associated with younger CEOs and other attributes which capture the attitude of firm toward growth and change, i.e. the number of employees involved in R&D activities and the number of graduate employees; (iv) results are robust to the inclusion of other firms' characteristics like labor productivity, capital intensity, and the financial structure. Overall, our results are consistent with several theoretical arguments, like love for risk and learning.

Keywords: firm growth, age, quantile regression

JEL classifications: L21, L25, L26, L60

The authors would like to thank José Carlos Fariñas, Alexander Coad, Harald Oberhofer, Dolores Añón Higón, Silviano Esteve-Pérez, Francisco Requena-Silvente and participants at seminars and conferences in Castellón (January 2012), Valencia (Dpto. de Economia Aplicada II, April 2012; IVIE, October 2012), A Coruña (XV Encuentros de Economía Aplicada, June 2012), and Tarragona (Workshop on Firm Growth and Innovation, June 2012) for useful comments and suggestions. The usual disclaimer applies. Fabio Pieri greatly acknowledges the financial support of the Spanish Ministry of Science and Innovation (project ECO 2011-27619/ECON).

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1. Introduction

Both academic scholars (see Haltiwanger et al., 2010; Lopez-Garcia and Puente, 2011, among others) and the popular press have recently underlined the role of young firms in creating jobs. In a recent article published by *The Economist* ("Les misérables", July 28th 2012), it is claimed that:

> "Data show that continental Europe has a problem with creating new businesses destined for growth. […] [O]ne reason America has outstripped Europe in providing new jobs is its ability to produce new, fast-growing companies […]".

Thus young/fast-growing companies play a significant role for the growth of economies and their study is becoming a central topic in current economic research[1].

That young firms grow more than older counterparts is a well-established empirical regularity. This result has been found in a large number of studies across countries and sectors, which have flourished since the seminal papers on the U.S. manufacturing by Evans (1987a, 1987b) and Dunne, Roberts and Samuelson (1988, 1989).

However, at least two aspects of the relationship between age and growth have not been adequately explored yet. The first one is that little attention has been devoted to exploring asymmetries in upsizing and downsizing processes. Many firms experience a reduction in size, which in the last decade in Europe has been an equally likely episode as upsizing[2]. In this paper we therefore investigate the relationship between age and growth along the entire growth spectrum (positive and negative) that a firm may experiment. We find that asymmetric patterns do in fact emerge. Age has a negative effect on growth for upsizing firms, while it does not have any significant impact for downsizing ones. Turning the argument around, older firms are less likely to grow fast, but they experience the same probability of shrinking than their younger counterparts. Interestingly, we find that the negative effect of age is particularly large and significant in the fastest rising group of firms

Second, what factors drive this relationship between age and growth, it is not a fully empirically explored issue. One recurrent explanation links age to learning processes[3], which may deter growth (Jovanovic, 1982), but it may also stem from the combination of firm attributes, willingness-to-grow, abilities, and opportunities (Stenholm and Toivonen, 2009). This paper, by combining age with several other potentially correlated observable drivers of growth, is at least able to restrict the size of the black box. Age keeps a large and robust explanatory power, even after controlling for: factors related to a risk loving attitude (age of CEO), and an attitude toward change (number of graduates in the workforce and employees involved in R&D activities); self-selection factors (productivity, capital intensity, profitability); other factors in themselves conducive to growth (financial structure).

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[1] See, among others, the meta-analysis conducted by Henrekson and Johansson (2010).

[2] Recent evidence on downsizing has been provided by Bravo Biosca (2010) for manufacturing industries in several European countries and by Braguinsky, Branstetter and Regateiro (2011) for Portuguese companies.

[3] Jovanovic (1982) learning theory is that young firms face higher uncertainty about their ability to compete in the market, so they adjust employment more than more experienced firms. As they get older, firms learn and this translates in smaller change in size. So younger firms grow more because they are unable to identify their optimal size.

Evidence is based on a sample of French, Italian and Spanish manufacturing firms with 10 or more employees in the period from 2001 to 2008. A new database, obtained from the merge of Bureau Van Dijk's Amadeus with the EU-EFIGE[4]/Bruegel-Unicredit (EFIGE) survey, combines information on the year of establishment, and many other economic, financial and qualitative characteristics such as productivity, capital intensity, profitability, financial structure, human capital, attributes of the CEO, involvement in R&D and innovation activities.

In order to analyze the effect of age and that of other drivers of growth along the entire growth rates distribution, thus being able to see if different behavioral patterns can be related to upsizing and downsizing, we use quantile regressions.

The rest of the paper is structured as follows: section 2 critically overviews the main theoretical and empirical contributions on the link between age and firm growth. Section 3 describes the data used in the analysis and provides some descriptive statistics. Section 4 presents the econometric framework and discusses the results. Section 5 concludes.

2. The role of age in shaping firm dynamics: theory and evidence

2.1 Theory

Why should firm age have an effect on size dynamics[5]?

If a learning-by-doing process is at work (Arrow, 1962), age may definitely play a role and younger firms may be disadvantaged with respect to older counterparts in terms of efficiency, and thus, growth possibilities. In an evolutionary setting (Nelson and Winter, 1982; Winter, 1984), age may affect growth in different directions, depending on the underlying process of innovation in the industry: in a "routinized regime", age may have a positive effect on growth, given that innovations tend to be generated by accumulated non-transferable knowledge, while in an "entrepreneurial regime", age may be negatively correlated with growth, given knowledge is not of a routine nature.

Dynamic competitive models explicitly take into account the role of age in shaping firms' growth. In particular, some of them consider a process of learning, which takes some time to evolve. In Jovanovic (1982) model of passive learning, firms do not know their (in)efficiency level (their 'type') with certainty, but they know the distribution of such parameter. So a firm sets its output (and employment) based on guess about its efficiency. If at the end of the period profits are larger than expected, the firm infers it is more efficient than it guessed in the period before. If this is the case, firms update their guess and increase their output (and employment). Since younger firms experiment more uncertainty about their type (i.e. they face higher variance in efficiency level), they are more likely to make mistakes and set their

[4] EFIGE is the acronym for "European Firms in a Global Economy: internal policies for external competitiveness", which is a project funded by the European Union under the FP7 framework.

[5] Admittedly, several strands of the literature do not assign any role to age in the process firms' growth. For example, in neoclassical models of perfect competition (profit maximizing) firms tend to the unique optimum size in the industry, the minimum efficient scale (MES) and, after that, growth stops; a similar picture can be observed in settings characterized by imperfect competition. Age continues to be "silent" in models which contemplate technical economies of scale: they mostly focus on the role played by size as an advantage for large firms, both in the possibility of exploiting increasing returns to scale (IRS), and in coping with the existence of fixed factors of production (like management or capital equipment indivisibilities). Large firms may also have non-technical advantages, i.e. pecuniary economies of scale, such as lower constraints in the access to financial markets, bargaining advantages in obtain lower input prices and political lobbying.

size at lower (higher) level that their level of productivity would require, so the update is stronger and hence growth rates are larger (see Jovanovic, 1982, p. 656) for younger firms[6]. In the Ericson and Pakes (1995) active learning framework, firms decide whether to exit the market or to operate in each period, and in the second case, the level of exploratory investment in order to maximize expected profits: higher levels of investment ensure more favorable distribution of the efficiency level in the future. The model predicts that firms will stop investing after reaching some level of efficiency and that younger firms, as in the passive learning model, will show higher growth rates (see, respectively, Pakes and Ericson, 1998, p. 17 and p.19).

The competitive equilibrium models discussed above suggest that firm growth is mainly the result of different efficiency/productivity levels (Jovanovic, 1982, Hopenhayn, 1992, Ericson and Pakes, 1995)[7] and age is negatively correlated with growth, since it captures the role of learning. However, subjective-motivational characteristics of the firms seem to have an important impact on their growth (see Sargant Florence, 1934; Baum, Locke and Smith, 2001, among others). As noted by Stenholm and Toivonen, (2009) growth may stem from the combination of firm attributes, willingness-to-grow, abilities, and opportunities. In this perspective, the risk-loving attitude of the entrepreneur (Cucculelli and Ermini, 2012) human capital and innovation (Arrighetti and Ninni, 2009) can certainly play a key role. According to Penrose (1959) the lack of managerial skills may hinder the firm growth, especially in small-sized firms, even if intentions for growth would exist. Access to finance is also clearly related to growth opportunities (Cooley and Quadrini, 2004), and it may well be that young firms obtain less long-term bank debt and show lower levels of equity capital, while mostly hold on internal cash-flow and commercial debt.

The literature on firm growth has almost always focused on positive growth and its determinants: firms are always seen along a virtuous pattern that leads to growth[8]. Nonetheless, since negative growth (downsizing) is as likely as positive growth (upszing) (see, for example, Bravo Biosca, 2010), one may want to understand if age may have different effects on the two phenomena. One the one hand, as discussed above, higher growth rates for younger firms may be explained by a set of motivations such as "learning" processes (either passive or active), subjective firm characteristics which favor growth and different financial structures. On the other hand, the process of downsizing may be a choice which is dictated by circumstances beyond the control of the firm, such as an increased level of competition (Couke et al. 2007) or negative demand shocks. While the literature has looked into the reasons of why age should play a negative role in the process of upsizing, there is no clear *a priori* on whether young or old firms should be more likely to downsize.

[6] Jovanovic (1982, p. 655-656) clarifies that two firms with the same point estimation of their inefficiency level in period t (indicated by x_t^*), but with different precisions (i.e. different variance estimations of the x_t^* distribution) which is due to the number of years in which they are active and infer about their level of inefficiency, show different expected growth rates distributions.

[7] From a theoretical point of view, this is also in line with evolutionary tradition of growth of the fittest (Nelson and Winter, 1982; Dosi et al., 1995). However, the empirical evidence on the productivity/profitability nexus is rather inconclusive (Bottazzi et al. 2010).

[8] For example Hart (2000) and Coad (2007; p.3) are insightful surveys on firm growth which do not explicitly take into account the possibility of a downsizing pattern taken by the firm, and the possible determinants of it. Admittedly, several empirical studies in the nineties, mostly regarding the U.S., focused on the role played by downsizing in enhancing aggregate productivity (see Baily et al., 1996 among others).

2.2 Empirical evidence

The studies by Evans (1987a, 1987b) and Dunne, Roberts and Samuelson (1988, 1989) were the first studies explicitly analyzing the role played by age as determinant of growth in the U.S. manufacturing industry in the seventies and the eighties. One of the main results of these studies, which Sutton (1997; p. 46) indicates as the "The Life Cycle" regularity, is that for any given firm size, the proportional rate of growth reduces as the firm gets older. The interesting feature of these works is that even controlling for sample selection[9], which could magnify the impact of rapidly growing small/young firms showing higher growth rates than older counterparts.

Lotti et al. (2003) use quantile regression techniques to test whether the law of proportionate effects (Gibrat, 1931) holds for new-born Italian manufacturing firms in their post-entry employment from 1987 to 1993: they find that even if it fails to hold in the years immediately following the start-up, there is a convergence toward a Gibrat-like pattern of growth as time passes. In a related study, the three authors find that the negative relationship between age and growth is confirmed in the Italian radio, TV and communication equipment industry from 1987 to 1994, but it seems to lose its role as time passes (Lotti et al. 2009).

Fariñas and Moreno (2000) provide a non-parametric empirical test of Jovanovic (1982) model of noisy selection on a representative sample of Spanish firms among 10 and 200 employees from 1990 to 1995: they find that the mean growth rate of non-failing firms decreases with age, but when all firms are taken into account the relationship between growth and age is not significant. However, Calvo (2006) using the same database over a longer period of time and calculating long-run growth rate (from 1990 to 2000), find that young firms have grown more than older counterparts even after controlling for sample selection.

Geroski and Gugler (2004) indirectly investigate the relationship between firms' growth and age in a large sample of almost 65,000 manufacturing and agriculture firms in 14 European countries from 1994 to 1998, finding that the life-cycle effect significantly determines the growth process of young (and small) firms. Recently, Haltiwanger et al. (2011) using a comprehensive dataset tracking all firms and establishments in the U.S. business sector from 1976 to 2005, have found that conditional on survival, young firms grow more rapidly than mature counterparts, even if younger companies show a higher likelihood of exit, so that job destruction due to exit is very high among young firms: they call this process "up or out". More generally, young firms are more volatile and exhibit higher rates of (positive and negative) growth rates.

Overall, the negative relationship between growth rate and age seems to be a quite robust empirical regularity across many different countries and industries[10].

[9] The concept of sample selection in the literature of firm growth refers to the fact that small and young firms with lower growth rates are more likely to die and exit the market (and the sample under analysis) than larger and older counterparts.

[10] Nonetheless, some works have reported a positive relationship between firm growth and age: two interesting cases relate to developing economies. Das (1995) analyses the computer hardware industry in India, obtaining that growth increases with age, and Ayyagari et al. (2011) find that in a sample of 47,745 firms in 99 developing countries taken from the World Bank Enterprise Surveys between 2006 and 2010, small but mature firms have the largest share of job creation.

However, as discussed in the theoretical section, different effects of age on the process of upsizing and downsizing may be expected and few studies have indirectly found that the relationship between age and firms' growth may depend on the level (and sign) of growth. For example, Serrasquiero et al. (2010) use quantile regression to study the determinants of the growth of Portuguese small and medium enterprises (SMEs). They find that up to the 25th quantile of the growth rates distribution, firms' growth is negative (downsizing is a relatively frequent phenomenon), and when firms are downsizing (5th, 10th and 25th quantiles), age is not a determinant of growth, while the relationship is negative and statistically significant when firms experience positive growth. Reichstein et al. (2010) find similar results using the same methodology in a data set comprising more than 9,000 Danish manufacturing, services and construction firms. Coad et al. (2012), analyzing a panel of Spanish manufacturing firms between 1998 and 2006, take a different perspective and plot the growth rates distribution for different age categories, observing that while the left tail (decline) seems invariant to age, the right tail (positive growth) displays some negative dependence on age. Thus, these recent studies which have taken into account the possibility that positive and negative growth may be non-mirror processes seem to suggest that age lowers the probability of firms experiencing faster growth but at the same time has little effect on the probability of firm downsizing.

With respect to the existent empirical literature, this paper's contribution is twofold: first, the role of age is explicitly investigated both in the upsizing and downsizing process of the firm as the main independent variable, using a wide set of other firms' characteristics as controls; second, we take a step further and, exploiting the insightful information contained in the EFIGE survey, we investigate which firm characteristics are correlated with employment growth and the extent to which these subjective factors of growth pick-up some of the explanatory power of firm age.

3. Data and descriptive analysis

In this paper we exploit an original database which has been recovered by merging the Bureau Van Dijk's Amadeus database with the EFIGE survey. Amadeus contains economic and financial information on European companies in the period which goes from 2001 to 2008. The information contained in Amadeus has been used to build measures of performance and financial structure - such as measures of productivity, profitability, labor cost, short and long term debt - and the size of the firm. The EFIGE survey, which has been conducted on a sample of manufacturing firms with more than 10 employees in seven European countries (Italy, France, Spain, United Kingdom, Germany, Hungary and Austria) in 2008 has been used to recover qualitative characteristics of the firm, like the age of the CEO, the qualification of the labor force, its involvement in R&D activities and the propensity to innovate[11].

Given that we use the information on the number of employees as measure for the size of the firm[12], we are constrained to limit our attention to those observations which have

[11] We cross-refer the reader to the Barba Navaretti et al. (2011) and Data Appendix (A1) for more information on the Amadeus-EFIGE sample used in the analyses of the present paper.

[12] Most empirical studies (at least in the industrial economics field) measure size as the number of employees, though other measures for size may be employed. In the words of Sutton (1997; p. 40) "'Size' can be measured in a number of ways […] annual sales, […] current employment, and […] total assets. Though we might in principle expect systematic differences between the several measures, such differences have not been a focus of interest in

information on employment. In particular, we restrict our analysis to three countries, France, Spain and Italy, which have the largest number of non-missing observations. Moreover in order to observe if there are differences in the determinants of firms' size dynamics in the short-run and in the long-run, we both compute 1-year growth rates and long-run growth rates (from 2001 to 2008) in our descriptive and econometric analysis.

The 1-year and long-run growth rates can be respectively computed as,

$$g_{i,t}^{1} = \ln(SIZE_{i,t}) - \ln(SIZE_{i,t-1}) \quad (1)$$

and

$$g_{i,t}^{LR} = \ln(SIZE_{i,t}) - \ln(SIZE_{i,t-7}) \quad (2)$$

In Figure 1 we plot the distribution of growth rates in order to analyze French, Italian and Spanish firms' dynamics over the period 2001-2008: in Figure 1(a), we plot the 1-year growth rates distribution, while Figure 1(b) represents the distribution of long-run growth rates. The two plots show that both in the short-run and in the long-run most of the firms persist around the same size, showing growth rates equal to zero, which is the mode of both distributions. Furthermore, for many firms increasing the number of employees, many firms also shrink, suggesting that upsizing and the downsizing firms coexist in the three European countries[13].

Figure 1(a): distribution of 1-year employment growth rates.

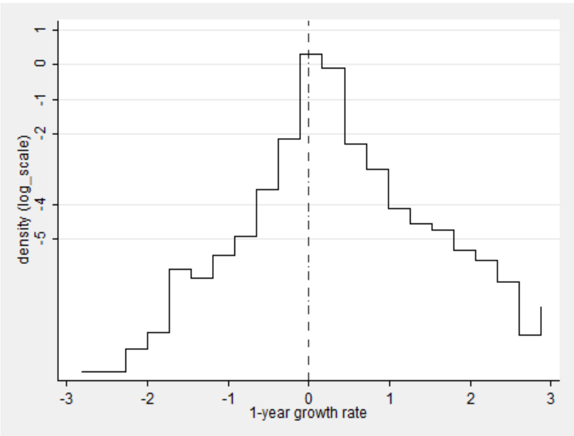
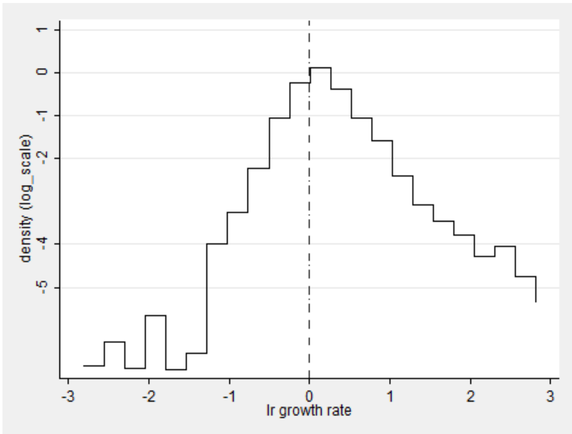


Figure 1(b): distribution for long-run (2001-2008) employment growth rates.



Note: The y-axis is on log-scale, and the Kernel density has been fitted usin an Epanechnikov kernel

These figures can be appreciated also in Table 1, showing different percentiles of the growth rates distribution. The general findings showed in Figure 1 are confirmed: the median growth rate is equal to (1-year rates), or very close to (long-run rates) zero, and upsizing firms coexist with shrinking ones. At the country level, some peculiarities can be added: Spanish firms show higher growth rates at the 50th, 75th and 90th percentiles, indicating that they have grown more from 2001 to 2008 than their Italian and French counterparts, while Italian firms show higher (in absolute values) negative growth rates at the 10th, 25th and 50th percentiles, showing that

the literature". The vast majority of studies which are cited in this section take current employment as the main measure of size in their analyses.

[13] Not surprisingly, the long-run growth rates distribution appears to be smoother than the 1-year growth rate distribution, which means that looking at a longer period of time is easier to find firms which have either increased or decreased in their size with respect to those which have persisted around the same size. The bunch of observations which are localized around a negative growth rate of -2 claims for the existence of a group of firms which have experienced a "heavy" downsizing phenomenon over the period 2001-2008.

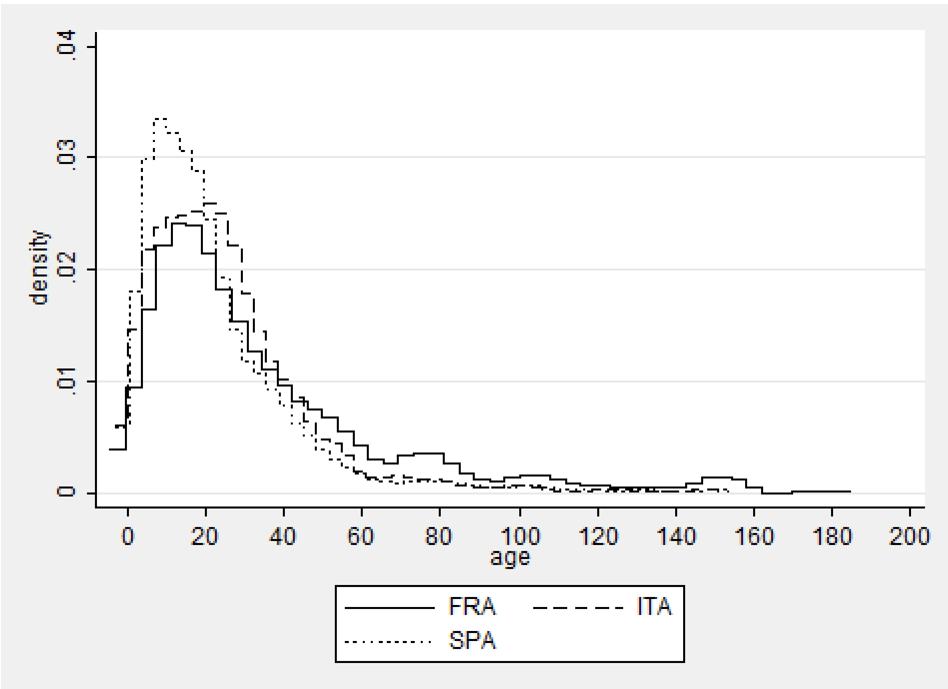
downsizing has affected them more than French and Spanish counterparts from 2001 to 2008. French firms, thus, show the lower inter-quartile range, that claims for a higher "persistence" around their size at the beginning of the period both in the short-run and in the long-run, i.e. lower size dynamics.

Table 1: Growth rates at different percentiles, by country

	FRA	ITA	SPA	Total
Percentile	**1 year growth rates**			
p10	-0.118	-0.169	-0.153	-0.146
p25	-0.049	-0.060	-0.050	-0.051
p50 (median)	0.000	0.000	0.000	0.000
p75	0.057	0.085	0.098	0.080
p90	0.143	0.205	0.245	0.201
Observations	10,750	12,293	15,763	38,806
Percentile	**Long-run growth rates**			
p10	-0.446	-0.529	-0.383	-0.448
p25	-0.202	-0.305	-0.140	-0.212
p50 (median)	0.000	-0.047	0.087	0.000
p75	0.202	0.274	0.421	0.304
p90	0.565	0.693	0.847	0.709
Observations	1,416	1,534	1,678	4,628

We can now turn to describe the relationship between firms' growth rates and age. We first exploit the information on the "year of establishment" provided in the EFIGE survey, measuring firm age as the difference, in each year, between the current year and the year of establishment of the firm.

Figure 2: The age distribution for the year 2001, by country



Note: the kernel density has been fitted using an Epanechnikov kernel.

The age distributions[14] of firms in the three countries in 2001[15] present some similarities (Figure 2): young firms are the most numerous in each country, and the number of firms above the mode, steadily decreases with age. Nonetheless, Figure 2 underlines also some country peculiarities. The frequency of young firms is higher in Spain, where the modal age is equal to 3 years, while France and Italy show older modal ages, respectively equal to 15 and 21 years, and France also shows a bunch of very old firms, given the higher frequency of French firms with 50 or more years with respect to their Spanish or Italians counterparts. Overall, modal ages in 2001 may suggest that young firms are under-represented in our database, especially with respect to Italy and France. This suggests caution in interpreting our results, given that the under-representation of very young firms may bring us to over-represent larger firms with above-average performance.

A useful way to further describe the age structure is to classify firms into age groups. We use the taxonomy suggested by Coad et al. (2012): we define as “Young” those firms from 0 to 10 years old, “Mature” those from 11 to 20 years old and “Experienced” those active from 21 years or more. The number of observations in each class for 2001 is showed in Table 2, splitting them by country: it is evident that, Spanish firms in the sample are more concentrated on the classes “Young” and “Mature”, while French firms are more concentrated in the “Experienced” category. Spain show higher percentages in the first two categories, suggesting that Spanish firms are significantly[16] younger than French and Italian counterparts in the sample[17]. Conversely, France shows higher percentages in the last categories, those with the oldest firms. Thus, even if the three age distributions show similarities, there are also some differences in the age structure from a cross-country perspective.

Table 2: Distribution of firms by age class and country in 2001 (observations reported as %)

Age class	**FRA**	**ITA**	**SPA**
Young (0-10)	22.48	26.19	34.42
Mature (11-20)	24.26	24.28	29.29
Experienced (21-max)	53.26	49.53	36.29
Total	100.00	100.00	100.00

Pearson’s chi-squared test
H_0: equal distribution of age classes across countries
χ_4^2= 180.3 (Critical value, 5%) = 9.49

[14] We cross-refer the reader to the Data Appendix (A3, Figure A1) for further considerations on the aggregate age distribution and a comparison with the previous literature.

[15] As pointed out by Coad (2010) when detailed information on the survival histories of specific cohorts is not available, is better to focus on the age distribution at a point in time. In our case, we show the age distribution at the beginning of the period (year 2001) but the broad picture and country specificities would not change much if we plotted the age distribution at the end of the period (year 2008).

[16] Computing the Pearson’s χ^2chi-squared (χ_4^2) statistics (--i.e. a contingency tables) in each cell of the Table, most of the differences among countries are statistically significant and contribute positively to reject the null hypothesis of equal distribution of the age classes across countries. Results are available from the authors upon request.

[17] We cross-refer the reader to the Data Appendix (A4, Tables A5 and A6), where, the number of observations in each class and each year is reported, and, as robustness check we provide, an alternative taxonomy is provided in which is made up of there are five age classes. The main evidence of youth of Spanish firms and the seniority of French ones is broadly confirmed.

Putting the two pieces of information together, we draw the growth rates distribution by age class in Figure 3(a) and Figure 3(b). In line with Coad et al. (2012), these plots on growth rates distribution suggest that younger firms have a higher probability of experiencing high growth rates, but differences in age seem not to be relevant in explaining patterns of shrinking (downsizing). The first phenomenon seems to be true both in the short-run (Figure 3(a)) and in the long-run where the 2001-2008 growth rates are computed(Figure 3(b)); however, in the long-run younger firms seem also to experience lower probabilities of downsizing with respect to older counterparts[18].

Figure 3(a): Distribution for 1-year employment growth rates, by age classes.

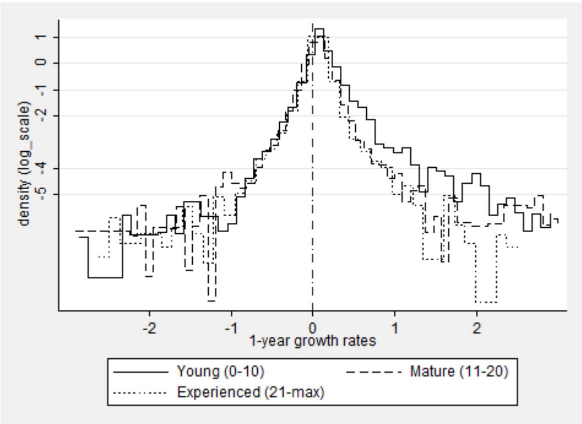
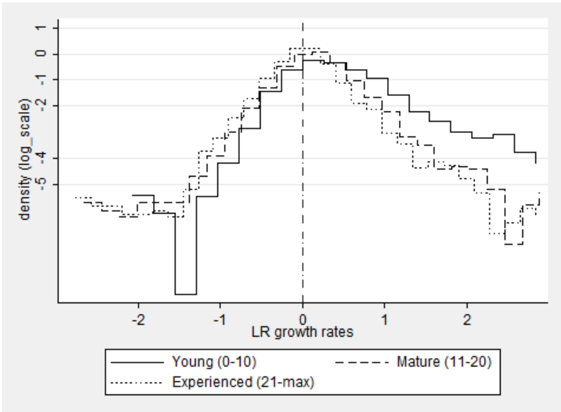


Figure 3(b): Distribution for long-run employment growth rates, by age classes.



Note: The y-axis is on log-scale, and the Kernel density has been fitted using an Epanechnikov kernel.

From this impressionistic evidence, age seems to play different roles on the process of upsizing and downsizing of the firm. Actually, the two processes may be governed by different factors, and age may be though to exert different effects on the two for several motivations. In order to (i) analyze if upsizing and downsizing are process governed by different factors and (ii) better clarify the role of age on the two processes, we move to a multivariate type of econometric analysis. In fact, in order to identify if an “age-effect” is at work, those firms’ characteristics which may be well related to age and firm growth should be included in the analysis.

In Table 3, some descriptive statistics on median values of several firm characteristics for the sample under analysis are provided[19]. In this Table, we summarize the main variables affecting the growth process of firms, which will be included in the subsequent econometric analysis. Young and old firms are clearly different in several dimensions.

[18] The evidence provided in Figure 3(b), referring to the long-run may be explained by the fact that firms which are observable both in 2001 (beginning of the period) and 2008 (end of the period) are probably the best among young firms. Thus, the result on the left tail of the growth rate distribution of “Young” firms in the long-run may be driven by a selection bias issue. For sure, long-run growth rates suffer more than 1-year growth rates of this problem. We will turn back on this issue again in the econometric part of the analysis.

[19] We cross-refer the reader to the Data Appendix (A2) for further information on how variables included in the analysis have been built.

Table 3: Descriptive statistics on the whole sample, by age class; statistics refer either to the share of firms in the sample for some variables or to the median value for others

	Measure	**Young**	**Mature**	**Experienced**	Total
Growth rate (employees)	Median value	0.04	0.00	0.00	0.00
CEO < 45 years old (2008)	Share of firms	33.87%	23.39%	21.52%	24.75%
Product innovation (2008)	Share of firms	44.91%	43.49%	48.69%	46.52%
Process innovation (2008)	Share of firms	45.39%	43.32%	44.78%	44.55%
Graduate workers (2008)	Median value	6.25%	5.88%	5.56%	5.88%
Employees in R&D activities (2008)	Median value	3.03%	3.23%	3.03%	3.13%
Labor productivity	Median value	37.29	40.45	43.60	41.60
Capita-labor ratio	Median value	16.06	16.37	18.19	17.26
EBITDA_marg_op	Median value	0.07	0.08	0.07	0.07
(average) Wage	Median value	26.42	28.40	31.76	29.65
ST_debt_share	Median value	0.59	0.52	0.49	0.51
LT_debt_share	Median value	0.02	0.01	0.00	0.01
Liquidity_ratio	Median value	0.86	1.00	1.03	0.98

The median young firm has a positive employment growth (about 4%), which instead is close to zero for median mature and experienced firm. This confirms what reported in figures 3a and 3b. For the reminder of the table the message is really two folded. On the one hand, factors clearly conducive to growth appear to be more concentrated in younger firms. These are for example more likely of being managed by a young CEO: in 33.8% of young firms the CEO is less than 45 years-old, while only 23% of mature and 21% of experienced firms have a young CEO. Furthermore, young firms have a higher proportion of graduate workers in their work-force and are more indebted.

On the other hand, factors detrimental to growth are positively correlated to age. The median young firm is less productive, less capital-intensive, pay lower wages and introduce less product innovation than the median mature or experienced firm.

Consequently, in order to assess the role of age in shaping firm size dynamics, it is necessary to conduct a multivariate econometric analysis and examine the effect of age when the moderating effect of these other variables is taken into account. This will be the focus of the next section.

4. Econometric analysis

In order to identify an age effect on the growth process of the sample of French, Italian and Spanish firms we start from a linear regression of the form:

$$gr_{i,t}^{w} = \beta_0 + \beta_1 \cdot \ln(AGE_{i,t-x}) + \boldsymbol{\delta}'\boldsymbol{Z} \quad + \mu_j + \gamma_c + \tau_t + \varepsilon_{it}, \qquad (3)$$

where $gr_{i,t}^{w}$ is the growth rate experienced by the i^{th} firm in the period of time which goes from *t-x* to *t*, and the super-index *w* can respectively be equal to 1 if the growth rate is calculated considering two consecutive year (x=1) and equal to LR (long run) if it is calculated over the entire period under analysis (x=7). $AGE_{i,t-x}$ refers to the age of the i^{th} firm at the beginning of the period (t-x) and $\boldsymbol{Z}$ denotes a vector of firm characteristics. For the time being, Z includes only the initial firm-size; μ_j is a vector sectoral dummies which are included in order to control for all time-invariant sector characteristics, γ_c is a vector of country dummies in order to control for country-specific time invariant factors and τ_t is a vector of time dummies, included in order to control for all factors affecting all firms in the same way in a given year. β_1 is the most important coefficient which captures the effect of an increase in firms' age on firm growth rate.

Columns A1 and B1 of Table 4 show the results from the estimation of equation (3) by means of OLS. The well-known negative relationship between age and growth can be appreciated: on average young firms grow more than older counterparts and this holds both for the short-term (A1) and the long-term growth (B1). The initial size has a negative relation with growth, suggesting that smaller firms grow faster. This may be the evidence of a sort of 'convergence hypothesis'. All in all, it would seem contrary to the prediction of the Gibrat law, and in line with a number of previous works (see Hall, 1987; Wagner, 1992 among others),

Given the likely event of firms experimenting negative growth rates, as we have underlined in the descriptive analysis part of the paper, it is worth asking if age may have a different effect in the event that a firm is on a path of positive growth or it is downsizing. To this end, we specify a model in which we allow the parameters of interest (β_1, δ) to vary across groups of firms (Daveri and Parisi, 2010), by interacting each regressor with a dummy which is equal to 1 if the firms experiences a growth rate which is greater or equal than 0 (specification A2 and B2). The new equation becomes:

$$gr_{i,t}^{w} = \beta_0 + \rho_0 D_{gr} + \beta_1 \ln(AGE_{i,t-x}) + \rho_1 D_{gr} \cdot \ln(AGE_{i,t-x}) + \delta \quad SIZE_{i,t-x} + \rho_2 D_{gr} \cdot SIZE_{i,t-x} + \mu_j + \gamma_c + \tau_t + \varepsilon_{it}, \qquad (4)$$

where

$$\begin{cases} D_{gr} = 1 \ \ if gr_{i,t}^{w} \geq 0 \\ D_{gr} = 0 \, , otherwise \end{cases}$$

Results of the estimation of equation (4) are presented in two columns (one for downisizers and one for upsizers/persistent firms) for purpose of easiness of reading.

The negative relationship between age and growth detected in specification (2) is the result of a much stronger effect for those firms which grow and a smaller (in magnitude) and positive relationship for those firms which reduce their size: younger firms grow more and older firms shrink less, but comparing the magnitudes of the two coefficients, it seems that the net effect suggests a higher relevance of the role of age on the process of upsizing than in the process of downsizing. Thus, age has a non-symmetrical effect on growth, depending on the fact that the firm is either in a positive or a negative path.

The existence of an asymmetric relation between age and firm growth is confirmed in terms of long-run growth rate (specification B2). The effect of age now is negative and significant just for those firms which have experienced a positive or zero growth rate over the entire period of time, while it does not exert an effect over shrinking firms. In the long-run downsizing may indistinctly affect both young and old firms, consistently with the idea that exogenous factors rather that firm age may play a key role in explaining downsizing. We will get back to this point in the final part of our empirical exercise, when we will assess how various firm-characteristics affect growth.

Overall, one may want to assess to what extent the change in regime occurs at zero, that is downsizing and upsizing are governed by different processes, or whether the effect of age varies over the whole distribution of firm growth. In order to address this issue, we resort to a quantile regression approach.

Table 4: The relation between age and growth; linear model and model with interaction-dumies; 1-year and long-run growth specifications

	1-year growth rates (x=1)			Long-run growth rates (x=7)		
Variable	A1	A2		B1	B2	
		Downsizers	**Upsizers**		**Downsizers**	**Upsizers**
AGE (t-x)	-0.022***	0.020***	-0.049***	-0.104***	0.008	-0.097***
	(0.002)	(0.003)	(0.003)	(0.009)	(0.011)	(0.015)
SIZE (t-x)	-0.055***	0.006***	-0.064***	-0.195***	-0.050***	-0.097***
	(0.001)	(0.002)	(0.003)	(0.008)	(0.011)	(0.015)
Constant	0.305***	-0.223***	0.621***	1.076***	-0.126**	1.388***
	(0.009)	(0.012)	(0.012)	(0.042)	(0.052)	(0.057)
Sector dummies	Yes	Yes		Yes	Yes	
Country dummies	Yes	Yes		Yes	Yes	
Year dummies	Yes	Yes		Yes	Yes	
Log-likelihood	-5,850	-1,837		-3,970	-2,728	
Observations	38,243	38,423		4,542	4542	
Chow test – Null hypothesis: $\rho_1 = \rho_2 = 0$				Chow test – Null hypothesis: $\rho_1 = \rho_2 = 0$		
F(2, 38,399) = 506.23 Critical value (5%) = 1.84				F(2, 4,524) = 89.41 Critical value (5%) = 1.84		

The quantile regression model (see Koenker, 2005, for an introduction) allows estimating the coefficients of the regressor of interest at various quantiles of the conditional distribution of growth rates. In particular, considering again equation (3), the quantile regression model can be written as:

$$gr_{i,t}^{w} = \beta_{\theta}' X_{i,t-x} + \varepsilon_{\theta it} \quad (5),$$

where $gr_{i,t}^{w}$ is the growth rate defined as above, $X_{i,t-x}$ is the vector of regressors, β_{θ} is the vector of parameter to be estimated and $\varepsilon_{\theta it}$ is the error component.

The quantile regressor estimator is the vector of parameters β which solves the following operation:

$$\min_{\beta} \frac{1}{n}\left\{ \sum_{i,t:\, gr_{i,t}^{w} \geq \beta' X_{i,t-x}} \theta \left| gr_{i,t}^{w} - \beta' X_{i,t-x} \right| + \sum_{i,t:\, gr_{i,t}^{w} < \beta' X_{i,t-x}} (1-\theta) \left| gr_{i,t}^{w} - \beta' X_{i,t-x} \right| \right\} \quad (6)$$

Equation (6) is the objective function and is an asymmetric linear loss function, and θ is the quantile defined as $Q_{\theta}\left(gr_{i,t}^{w} \middle| X_{i,t-x}\right) \equiv inf\left\{ gr_{i,t}^{w}: F\left(gr_{i,t}^{w} | X_{i,t-x}\right) \geq \theta\right\}$, in which $0 < \theta < 1$ and $gr_{i,t}^{w}$ is a random sample from a random variable with a conditional distribution function $F\left(\cdot \,| X_{i,t-x}\right)$. For $\theta = 0.5$ the estimator is that of a median regressor (absolute loss function).

Making vary θ within its bounded interval, we can obtain quantile coefficients, which can be interpreted in much the same fashion as the OLS coefficients: they represent the marginal change in the dependent variable due to a marginal change in the exogenous variable, conditional on being the θ^{th} quantile of the distribution of growth rates. The quantile regression approach constitutes a suitable methodology to deal with the existence of unobserved heterogeneity (models) at different quantiles of the conditional distribution of growth rates, and it may be preferable to the usual average regression technique for a number of reasons (Coad and Rao, 2008; pp. 641-642): (i) the normally distributed errors assumption may be relaxed, which is relevant in our case because of the heavily-tailed growth rates distribution depicted in Figures 1(a), 1(b), 3(a) and 3(b)[20]; (ii) this approach is more robust to outliers then the average regression model; (iii) quantile regressions are able to describe the entire conditional distribution of the dependent variable; (iv) these type of regressions acknowledge firm heterogeneity and consider the possibility that estimated slope parameters vary at different quantiles of the conditional growth rate distribution (see also Lotti et al., 2003; p. 221).

We start by examining the role of age in seven points of the growth rate distribution, namely the 5th, 10th, 25th, 50th (median – absolute loss function), 75th, 90th and 95th quantiles. As in Table 4, we start by estimating a very simple model where firm size, together with country and sector dummies, are the only control variable; Table 5 shows the results both for 1-year growth rates and the long-run growth rates.

[20] A huge number of empirical studies have proved the non-normality of employment, sales and value added growth rates. Just to mention a few of them: Geroski and Gugler (2004), Bottazzi and Secchi (2003) and Bottazzi and Secchi (20072006).

Table 5: Quantile regression - age and size

1-year growth rates	Quantiles						
Variables	q05	q10	q25	q50	q75	q90	q95
AGE (t-1)	0.0136***	0.000991	-0.00844***	-0.00728***	-0.0326***	-0.0565***	-0.0733***
	[0.00360]	[0.00195]	[0.000879]	[0.00151]	[0.00114]	[0.00228]	[0.00330]
SIZE (t-1)	-0.0276***	-0.0132***	-0.00951***	-0.00406***	-0.0210***	-0.0372***	-0.0538***
	[0.00497]	[0.00231]	[0.00101]	[0.000612]	[0.000741]	[0.00127]	[0.00230]
Constant	-0.197***	-0.0943***	0.0336***	0.0535***	0.289***	0.540***	0.754***
	[0.0221]	[0.0124]	[0.00526]	[0.0102]	[0.00554]	[0.0119]	[0.0169]
Observations	38,423	38,423	38,423	38,423	38,423	38,423	38,423
Long-run growth rates	Quantiles						
Variables	q05	q10	q25	q50	q75	q90	q95
AGE (t-7)	-0.0321**	-0.0334***	-0.0608***	-0.0961***	-0.142***	-0.173***	-0.211***
	[0.0152]	[0.00996]	[0.00984]	[0.00812]	[0.00946]	[0.0182]	[0.0328]
SIZE (t-7)	-0.254***	-0.194***	-0.129***	-0.107***	-0.116***	-0.157***	-0.192***
	[0.0248]	[0.0187]	[0.0127]	[0.00974]	[0.00827]	[0.0146]	[0.0216]
Constant	0.287***	0.310***	0.369***	0.699***	1.179***	1.773***	2.425***
	[0.0833]	[0.0724]	[0.0586]	[0.0454]	[0.0471]	[0.0795]	[0.176]
Observations	4,542	4,542	4,542	4,542	4,542	4,542	4,542

Interestingly, age has the expected negative sign starting from the 25% of the conditional growth rate distribution, while at the very bottom of it shows a positive effect. This non-linear effect may be explained by a set of concurring factors: as Jovanovic (1982) and Ericson and Pakes (1995) have suggested, younger firms may need to learn to know about their type (productivity), and this uncertainty may induce them to adjust their size more than their older counterparts. Following this interpretation, age is a proxy firm's learning. The non-significance at the 10 percentile suggests that the downsizing phenomenon may be basically driven by factors which may affect firms independently of their age (negative shock in the demand, increased level of competition, etc.). Finally, the positive relationship found at the very bottom of the growth distribution suggests a positive relationship between growth and age: older firms may be less prone to experience heavy negative variation in size with respect to younger counterparts: ageing is associated both to lower growth but also lower heavy shrinks, providing the firm with a more stable profile (Coad et al., 2012).

In the long-run the evidence that younger firms grow more is confirmed, but now the negative relationship between age and growth is significant at all the estimated quantiles, although the marginal effect at the 90th percentile in five times larger than it is at the 10th percentile. In other words, for the lower quantiles, results suggest that younger firms shrink less than older counterparts (see also Figure 3(b)). As we noted before, the short-run and long-run results may be reconciled thinking that in the long-run, we are observing only the best young firms, those which have remained in the market over the entire period: thus, long-run results may suffer more of selection-bias issues.

Note also that the non linearities in the effect of age are not just among upsizing and downsizing firms. Both in short and long run growth estimations, the coefficient of age becomes larger in absolute terms when we move towards the top quintiles in the distributions. This implies that being young is especially important for the fastest growing firms.

These results may of course suffer from omitted-variables bias: in Table 6 we include a set of economic and financial characteristics at the beginning of the period, as well as firm attributes which may affect growth (the vector **Z** in equation 3). In particular, the former set of variables includes labor productivity, capital intensity, profit margins, wage levels, short and long terms debt as a share of total assets, and liquidity ratio. Exploiting the information provided by the EFIGE survey, we introduce: (i) a dummy variable for those firms with a chief executive officer (CEO) younger than 45 years old*,* which may capture the higher attitude towards risk for those firms; (ii) the number of graduates in the work force which is a proxy for the quality of human capital and may be correlated with the capacity of the firm to understand and manage the complexity of firm growth; (iii) the number of employees involved in R&D activities and two dummies for those firms which have introduced product or process innovations aimed at capturing the attitude of firm towards change[21].

[21] Since the attributes from the EFIGE survey refer to the year 2008, they may introduce some endogeneity. As a robustness check we run equation 5 including only economic and financial controls at the beginning of the period. These variables, which are lagged one period, should therefore less subject to endogeneity problems. Results, presented in Table A7, do not differ much from those in Table 6.

The main result of table 5 is confirmed: as for 1-year growth rates, age has a negative effect on growth starting from the 25 percentile, while it does not have any significant effect on those firms which experience heavy reductions of their size in terms of employees. Age seems to play a stronger effect at the very top 95% of the growth rate distribution, confirming the non linearities observed in table 3. Conversely, among the firms which shrink the most there are both young and old firms. In the long-run the negative effect is confirmed along the entire conditional distribution of growth rates, although the effect at the 90th percentile is three times larger in magnitude than the effect at the 10th percentile. The OLS (horizontal line) and the quantile regression coefficients for age are plotted in the same graph in Figures 4(a) and 4(b): the above non-linearities can be clearly appreciated. All in all, including additional characteristics, aiming to control for a firm willingness to grow, as well as for its economic and financial conditions, does not change the main results, although the magnitude of the effect of age on firm growth is somewhat affected. In particular, by comparing Table 5 and Table 6 we can appreciate that the coefficient of age drops by one percentage point (from -0.0565 to -0.0465) at the 90th percentile and by 1.5 percentage points at the 95th percentile. This suggests that at least some of the effect of age has to do with other firm characteristics also affecting growth, but also correlated with age. The lower part of Table 6 provides some insights as to what these characteristics could be.

Results suggest that the age of the CEO affects positively growth, and mostly those which show the highest growth rates (top 95 percentile) but this effect is significant just for upsizing firms: downsizing firms may be both governed by young or old CEOs without any significant difference. The number of graduates in the work-force and the number of employees involved in R&D activities is positively correlated with the rate of growth, even if the latter characteristics is not significant up to the 10th percentile. Interestingly enough, process innovation seems to affect growth positively, but up to the median. This can interpreted as evidence that firms which are downsizing (since the median is zero) are involved in some restructuring, which involves process innovation.

Other control variables confirm previous evidence that economic and financial conditions affect firm growth. The coefficient on productivity indicates that more productive firms at the beginning of the period grow more, but that the benefit of being more productive is stronger in the top percentiles of the growth rate distribution: the effect at the 95th percentile is almost three times larger than at the median. In other words, in order to be a fast-growing firm, being very productive is crucial, but the same does not help explaining shrinking. The same is true for the capital-labor ratio and for the two variables referring to access to short-term and long-term debt: access to credit, which seems to barely affect the lowest part of the growth rate distribution (5th and 10th percentiles) have a stronger positive effect for those firms experiencing the highest growth rates. Note that these non-linearities go in the same direction as those highlighted for the age variable.

Figure 4(a): The effect of age on growth at different percentiles of the conditional 1-year growth rates distribution

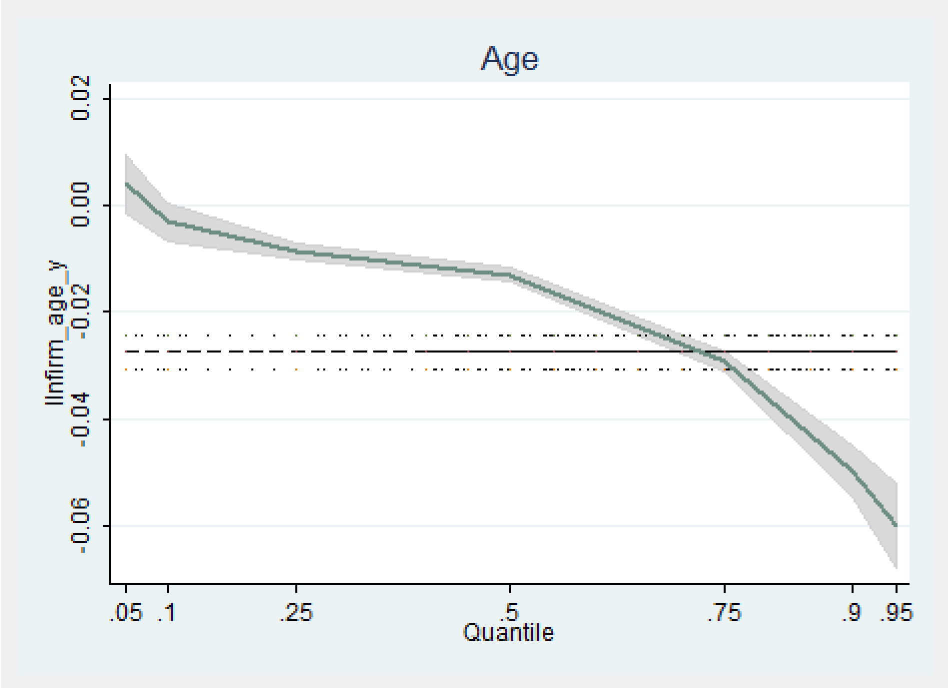
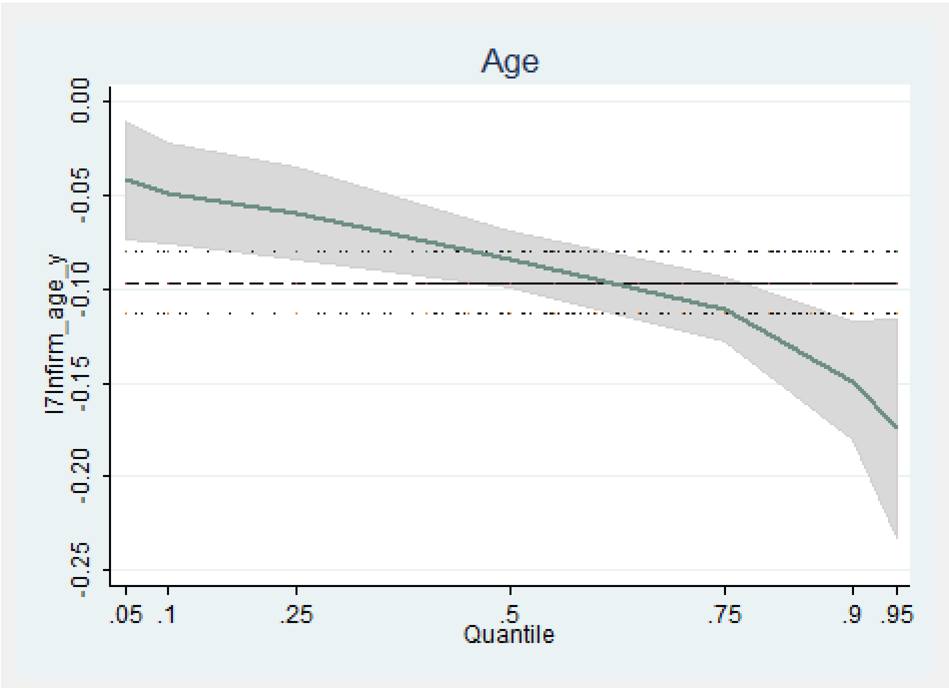


Figure 4(b): The effect of age on growth at different percentiles of the conditional long-run growth rates distribution



Size shows a negative relationship with firm growth over the entire growth rate distribution with the expected sign: smallest firms are those which, *ceteris paribus*, experience the highest growth. Finally, some variables show interesting asymmetric effects. Profitability has a significantly negative relationship with growth for firms experiencing upsizing, while a positive relationship for those experiencing downsizing. One possible interpretation may be that in order to grow firms bear high investments and costs which have lowered profits, while among those firms which shrink those which experience higher profitability shrink less. The U-shaped relationship between the average wage and growth may have different explanations for upsizing and downsizing firms: the positive relationship at the top of the distribution may be a sign for the quality of the labor-force of growing firms, while the positive sign at the lower percentiles may be a sign of the rational for downsizing of those firms bearing high labor costs.

Long-run estimates mainly confirm the results (see Table 7). To graphically appreciate these non-linearities we cross-refer the reader to the Data Appendix, where the full set of quantile regression coefficients is depicted in Figure A2.

Table 6: The effect of age and firm characteristics on firm growth, quantile regression, 1-year growth rates

1-year growth rates	Quantiles						
Variables	q05	q10	q25	q50	q75	q90	q95
AGE (t-1)	-0.00125	-0.00376	-0.00908***	-0.0131***	-0.0275***	-0.0465***	-0.0585***
	[0.00462]	[0.00256]	[0.00123]	[0.00101]	[0.00164]	[0.00267]	[0.00444]
SIZE (t-1)	-0.0260***	-0.0171***	-0.0164***	-0.0199***	-0.0431***	-0.0683***	-0.0976***
	[0.00595]	[0.00230]	[0.00130]	[0.00118]	[0.00146]	[0.00288]	[0.00544]
CEO < 45 years old (2008)	-0.00672	-0.00430	0.00104	0.00300*	0.00945***	0.0138***	0.0250**
	[0.00708]	[0.00414]	[0.00219]	[0.00166]	[0.00230]	[0.00510]	[0.0110]
# Graduates work-force (2008)	0.0116**	0.00771***	0.00743***	0.00913***	0.0163***	0.0235***	0.0361***
	[0.00499]	[0.00267]	[0.00126]	[0.000890]	[0.00138]	[0.00315]	[0.00558]
# Emp R&D activities (2008)	-0.00228	-0.00268	0.00244*	0.00407***	0.00788***	0.0149***	0.0220***
	[0.00510]	[0.00256]	[0.00132]	[0.000804]	[0.00127]	[0.00295]	[0.00445]
Product innovation (2008)	0.00605	0.00821**	0.00232	0.000924	0.000505	-0.00283	-0.00281
	[0.00790]	[0.00388]	[0.00214]	[0.00130]	[0.00192]	[0.00414]	[0.00739]
Process innovation (2008)	0.0160*	0.0136***	0.00706***	0.00403***	0.00290	0.00339	-0.00784
	[0.00815]	[0.00404]	[0.00231]	[0.00141]	[0.00227]	[0.00384]	[0.00539]
EBITDA_marg (t-1)	0.215***	0.166***	0.0739***	0.0400***	0.00133	-0.0974**	-0.223**
	[0.0512]	[0.0287]	[0.0162]	[0.0120]	[0.0222]	[0.0483]	[0.107]
LP (t-1)	0.0199	0.0200*	0.0293***	0.0271***	0.0362***	0.0546***	0.0765***
	[0.0142]	[0.0107]	[0.00436]	[0.00356]	[0.00575]	[0.0134]	[0.0226]
KL_ratio (t-1)	0.00859**	0.00744***	0.00218**	0.00236***	0.00955***	0.0157***	0.0276***
	[0.00375]	[0.00224]	[0.00105]	[0.000672]	[0.00102]	[0.00204]	[0.00369]
WAGE (t-1)	0.119***	0.0903***	0.0314***	0.00704	0.0122	0.0515***	0.114***
	[0.0220]	[0.0135]	[0.00640]	[0.00544]	[0.00859]	[0.0186]	[0.0328]
ST_DEBT_share (t-1)	-0.0425	-0.00486	0.00991**	0.0225***	0.0718***	0.103***	0.121***
	[0.0300]	[0.0139]	[0.00423]	[0.00501]	[0.00780]	[0.0121]	[0.0262]
LT_DEBT_share (t-1)	-0.0232	-0.0206	0.0216**	0.0296***	0.0670***	0.124***	0.157***
	[0.0327]	[0.0178]	[0.0110]	[0.00775]	[0.0118]	[0.0252]	[0.0406]
LIQUIDITY_ratio (t-1)	-0.00882	-0.00280	-0.00138	-0.000917	0.00196	0.00318*	0.00290
	[0.00744]	[0.00259]	[0.00156]	[0.000852]	[0.00165]	[0.00166]	[0.00252]
Constant	-0.650***	-0.491***	-0.196***	-0.0276**	0.0601**	0.0683	-0.0271
	[0.0674]	[0.0328]	[0.0168]	[0.0139]	[0.0240]	[0.0474]	[0.0797]
Observations	27,169	27,169	27,169	27,169	27,169	27,169	27,169

Summing up, as a few other papers have already shown (Delmar et al. 2003; Henrekson and Johansson, 2010), fast-growing firms are qualitative different from the rest of their peers. The very top of the growth rate distribution is populated by the youngest, but also the smallest, those with younger CEOs and more qualified workforce, the most productive and most capital-intensive and those for which have better access to short-term and long-term credit. Overall, age shows a negative relationship with growth, but the effect is mainly significant for positive growth, especially for fast-growing firms, while it is not significant for those firms experiencing heavy downsizing. Estimating the standard regression by means of least squares on the "average firm" would hide the important features of this asymmetric effect, which instead is fully appreciated using a quantile regression approach.

Table 7: The effect of age and firm characteristics on firm growth, quantile regression, long-run growth rates

Long-run growth rates	Quantiles						
Variables	q05	q10	q25	q50	q75	q90	q95
AGE (t-7)	-0.0588***	-0.0615***	-0.0590***	-0.0802***	-0.0994***	-0.115***	-0.138***
	[0.0179]	[0.0127]	[0.00923]	[0.00816]	[0.0115]	[0.0149]	[0.0201]
SIZE (t-7)	-0.321***	-0.274***	-0.224***	-0.213***	-0.239***	-0.283***	-0.296***
	[0.0398]	[0.0204]	[0.0147]	[0.0107]	[0.0148]	[0.0224]	[0.0282]
CEO < 45 years old (2008)	-0.0150	-0.0448	-0.00708	0.0270	0.0744***	0.0303	0.0224
	[0.0343]	[0.0297]	[0.0208]	[0.0201]	[0.0247]	[0.0373]	[0.0560]
# Graduates work-force (2008)	0.0844***	0.0824***	0.0993***	0.0953***	0.136***	0.176***	0.185***
	[0.0249]	[0.0213]	[0.0125]	[0.0112]	[0.0135]	[0.0211]	[0.0313]
# Emp R&D activities (2008)	0.0262	0.0105	0.0310**	0.0411***	0.0391***	0.0592***	0.117***
	[0.0221]	[0.0235]	[0.0127]	[0.0102]	[0.0131]	[0.0214]	[0.0361]
Product innovation (2008)	0.0200	0.0380	0.0155	0.00863	0.0133	0.0227	0.0230
	[0.0378]	[0.0261]	[0.0175]	[0.0147]	[0.0171]	[0.0294]	[0.0398]
Process innovation (2008)	0.0711**	0.0603***	0.0446**	0.0309**	0.0212	-0.0137	-0.0652
	[0.0339]	[0.0216]	[0.0177]	[0.0157]	[0.0201]	[0.0252]	[0.0397]
EBITDA_marg (t-7)	0.314	0.0791	-0.155	-0.473***	-0.613***	-0.716**	-1.233***
	[0.301]	[0.225]	[0.154]	[0.165]	[0.191]	[0.290]	[0.402]
LP (t-7)	0.0461	0.127*	0.183***	0.289***	0.323***	0.358***	0.456***
	[0.0677]	[0.0695]	[0.0392]	[0.0476]	[0.0609]	[0.106]	[0.132]
KL_ratio (t-7)	0.0330**	0.0281**	0.0317***	0.0407***	0.0489***	0.0677***	0.0834***
	[0.0148]	[0.0110]	[0.0101]	[0.00768]	[0.0103]	[0.0139]	[0.0222]
WAGE (t-7)	0.152*	0.0863	-0.00238	-0.0739	-0.103	-0.0489	-0.0528
	[0.0878]	[0.0755]	[0.0564]	[0.0635]	[0.0846]	[0.145]	[0.184]
ST_DEBT_share (t-7)	0.0286	0.0128	0.0327	0.138***	0.223***	0.414***	0.435**
	[0.129]	[0.103]	[0.0618]	[0.0496]	[0.0617]	[0.117]	[0.216]
LT_DEBT_share (t-7)	0.299**	0.195	0.139	0.225***	0.320***	0.562***	0.491**
	[0.146]	[0.120]	[0.0918]	[0.0744]	[0.0908]	[0.175]	[0.224]
LIQUIDITY_ratio (t-7)	0.00413	-0.00354	-0.0130	-0.0110	0.00333	0.00917	0.00507
	[0.0339]	[0.0170]	[0.00938]	[0.0107]	[0.0139]	[0.0233]	[0.0352]
Constant	-0.403*	-0.413*	-0.282*	-0.194	0.0329	-0.00640	-0.0762
	[0.245]	[0.223]	[0.155]	[0.139]	[0.171]	[0.367]	[0.520]
Observations	3,385	3,385	3,385	3,385	3,385	3,385	3,385

5. Conclusions

Young and fast-growing companies play a significant role for the growth of economies and their study is becoming a central topic in current economic research. However, at least two aspects of the relationship between age and growth have not been adequately explored yet. The first one relates to the fact that most of the literature has assumed a symmetric effect of the determinants of firm growth: the same model that explains positive growth applies for downsizing. Since this latter process is quantitatively as relevant as the former, it is worth understanding to what extent this assumption holds in the data. The second one is identifying empirically the causes of this relationship.

This paper provides new insights for these aspects uncovering new evidence for a sample of French, Italian and Spanish firms in the period from 2001 to 2008 from the EFIGE Survey. In order to analyze the effect of age and that of other drivers of growth along the entire growth rates distribution, thus being able to see if different behavioral models exist for upsizing and downsizing firms, we adopt a quantile regression approach.

After controlling for several firms' characteristics, country and sector specificities we find that firm age has a negative effect on growth if the firm is on an upsizing path, while it does not exert any role if the firm has experienced a downsizing. In other words, older firms are less likely to grow fast, but they have the same probability of a significant shrinking than younger counterparts. Furthermore, we find that the age of the CEO, which can be associated with higher risk-taking attitude, and the qualification of the labor-force, as well as productivity, capital intensity and access to finance are also significantly related to the process of growth, especially for the fast-growing firms. However, even controlling for these firm characteristics, age still retains its explanatory power. These findings are consistent with a combination of different explanations. On the one hand, they suggest that firm growth may derive from inexperience and, as firm become older, learning about their 'type' may reduce firm growth. On the other hand, they indicated that the fast-growing firms have indeed peculiar attributes, both in terms of subjective characteristics (such as the age of the CEO) and economic performance (such as higher productivity).

A. Data Appendix

A1 - The database: representativeness

The database has been obtained from the merge of Bureau Van Dijk's Amadeus with the EFIGE survey. The survey contains both qualitative and quantitative data on manufacturing firms' characteristics: data regard the year 2008, with some questions asking for information regarding 2009 and others regarding the period from 2007 to 2009. Information regards the structure of the firm, workforce, investments, technological innovation and R&D, internationalization, finance, market and pricing. Data ware then matched with balance sheet information from Amadeus. The survey has been conducted over a sample of firms with more than 10 employees, by the market research organization GFK Eurisko within the EFIGE project –*European firms in a global economy: internal policies for external competitiveness*— supported by the Research Directorate of the European Commission through the FP7 programme. The research organization collected the data via CATI (Computer Assisted Telephone Interview) and CAWI (Computer Assisted Web Interview).

The original sample includes firms from 7 EU countries (Austria, France, Germany, Hungary, Italy, Spain, UK). For the purpose of this paper we choose to focus on France, Italy and Spain, since for the other countries the number of usable observations was too low, due to missing values in the employment variable. The sample includes around 3,000 firms for France, Italy and Spain. The sampling design followed stratifications by sector and firm size. We show the distribution by sectors and firm size for the original sample and the reference population in the following tables.

Table A1 - Distribution by sectors and firm size; France

France		**Firm size**							
		from 10 to 49		**from 50 to 249**		**more than 250**		**Total**	
NACE Rev 1.1		Sample	Pop	Sample	Pop	Sample	Pop	Sample	Pop
DA	Food products beverages and tobacco	6,60%	19,26%	7,40%	14,81%	12,62%	16,52%	7,20%	18,33%
DB	Textiles and textile products	6,23%	5,52%	6,09%	5,82%	2,80%	3,12%	5,95%	5,46%
DC	Leather and leather products	0,98%	0,81%	1,97%	1,43%	0,00%	0,55%	1,11%	0,91%
DD	Wood and wood products	3,58%	5,07%	2,14%	2,91%	2,80%	1,21%	3,23%	4,50%
DE	Pulp paper and paper products publishing and printing	8,41%	9,18%	6,91%	8,50%	4,67%	8,31%	7,84%	9,02%
DF+DG	Coke refined petroleum products and nuclear fuel + Chemicals chemical products and man-made fibers	2,23%	2,48%	6,25%	6,08%	9,81%	12,84%	3,60%	3,62%
DH	Rubber and plastic products	8,00%	4,85%	8,06%	8,38%	7,01%	7,10%	7,94%	5,59%
DI	Other nonmetallic mineral products	5,44%	3,56%	4,93%	3,69%	3,74%	4,33%	5,21%	3,62%
DJ	Basic metals and fabricated metal products	35,05%	23,38%	26,32%	19,29%	13,55%	11,93%	31,72%	22,10%
DK	Machine and equipment n.e.c.	8,97%	8,89%	10,69%	9,76%	10,75%	9,42%	9,45%	9,07%
DL	Electrical and optical equipment	10,04%	8,32%	12,66%	10,31%	17,76%	12,03%	11,13%	8,85%
DM	Transport equipment	2,51%	2,52%	3,45%	3,91%	12,15%	8,61%	3,40%	3,06%
DN	n.e.c.	1,95%	6,17%	3,13%	5,11%	2,34%	4,03%	2,22%	5,88%
Total		100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
Number of firms		2151	32019	608	7365	214	1986	2973	41370
Distribution by firm size		72,35%	77,40%	20,45%	17,80%	7,20%	4,80%	100,00%	100,00%

Overall, the sample represents rather well the reference population in terms of the inter-industry composition and size in each country; nonetheless, there are some exceptions. For example, in France the DA (food products) sector is slightly under-represented and the DJ (metal products) is slightly over-represented; as for the size distribution, small firms are a bit under-represented, while large firms weakly over-represented. In Italy, the distribution of firms across industries is definitely very close to actual population, while in terms of size large firms are over-represented and, conversely, small firms are under-represented.

Table A2 - Distribution by sectors and firm size; Italy

Italy		**Firm size**							
		from 10 to 49		**from 50 to 249**		**more than 250**		**Total**	
NACE Rev 1.1		Sample	Pop	Sample	Pop	Sample	Pop	Sample	Pop
DA	Food products beverages and tobacco	8,02%	8,66%	8,16%	7,68%	4,83%	8,66%	7,88%	8,55%
DB	Textiles and textile products	10,47%	11,68%	8,62%	9,48%	8,28%	9,02%	10,10%	11,39%
DC	Leather and leather products	3,93%	5,17%	3,96%	3,63%	1,38%	1,78%	3,81%	4,94%
DD	Wood and wood products	3,39%	4,32%	0,93%	2,11%	0,69%	1,07%	2,91%	4,02%
DE	Pulp paper and paper products publishing and printing	5,97%	5,52%	4,66%	5,24%	6,90%	5,18%	5,83%	5,48%
DF+DG	Coke refined petroleum products and nuclear fuel + Chemicals chemical products and man-made fibers	2,74%	2,14%	8,16%	5,33%	9,66%	10,65%	3,84%	2,64%
DH	Rubber and plastic products	5,44%	4,75%	5,59%	6,08%	8,28%	5,04%	5,60%	4,91%
DI	Other nonmetallic mineral products	5,77%	5,37%	4,90%	5,48%	3,45%	6,11%	5,53%	5,40%
DJ	Basic metals and fabricated metal products	23,35%	24,23%	22,14%	18,64%	13,79%	11,93%	22,72%	23,40%
DK	Machine and equipment n.e.c.	12,07%	10,65%	13,99%	15,89%	17,24%	17,19%	12,59%	11,35%
DL	Electrical and optical equipment	8,79%	7,53%	9,79%	9,37%	10,34%	9,73%	9,01%	7,78%
DM	Transport equipment	2,17%	2,30%	3,03%	4,32%	9,66%	9,73%	2,65%	2,65%
DN	n.e.c.	7,89%	7,66%	6,06%	6,75%	5,52%	3,91%	7,52%	7,50%
Total		100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
Number of firms		2455	77092	429	10062	145	1408	3019	88562
Distribution by firm size		80,99%	87,05%	14,21%	11,36%	4,80%	1,59%	100,00%	100,00%

As for Spain, the DB sector (textiles) is slightly under-represented while the DK (machine and equipment) is slightly over-represented. Regarding size, the sample weakly over-represents large firms and under-represents small ones.

Table A3 - Distribution by sectors and firm size; Spain

Spain		Firm size							
		from 10 to 49		**from 50 to 249**		**more than 250**		**Total**	
NACE Rev 1.1		Sample	Pop	Sample	Pop	Sample	Pop	Sample	Pop
DA	Food products beverages and tobacco	16,54%	13,87%	15,02%	15,88%	17,12%	19,70%	16,35%	14,28%
DB	Textiles and textile products	3,68%	7,92%	2,22%	5,75%	2,05%	3,37%	3,39%	7,52%
DC	Leather and leather products	1,84%	3,51%	1,23%	1,54%	0,00%	0,89%	1,66%	3,18%
DD	Wood and wood products	8,64%	5,46%	2,71%	2,77%	2,74%	1,58%	7,49%	5,01%
DE	Pulp paper and paper products publishing and printing	4,39%	7,73%	3,69%	8,51%	8,22%	6,53%	4,48%	7,81%
DF+DG	Coke refined petroleum products and nuclear fuel + Chemicals chemical products and man-made fibers	3,73%	2,95%	5,91%	5,78%	8,22%	11,88%	4,27%	3,54%
DH	Rubber and plastic products	5,00%	4,48%	7,39%	6,14%	2,74%	4,55%	5,23%	4,71%
DI	Other nonmetallic mineral products	5,00%	8,06%	10,84%	10,05%	3,42%	8,02%	5,76%	8,33%
DJ	Basic metals and fabricated metal products	23,55%	22,28%	21,18%	17,69%	17,12%	12,57%	22,88%	21,43%
DK	Machine and equipment n.e.c.	11,10%	7,42%	9,85%	8,16%	8,22%	6,93%	10,77%	7,51%
DL	Electrical and optical equipment	3,60%	4,32%	4,19%	5,74%	11,64%	9,11%	4,10%	4,62%
DM	Transport equipment	2,76%	2,85%	5,67%	5,78%	13,70%	11,39%	3,74%	3,44%
DN	n.e.c.	10,18%	9,15%	10,10%	6,22%	4,79%	3,47%	9,89%	8,62%
Total		100,00 %	100,00 %	100,00 %	100,00 %	100,00 %	100,00 %	100,00 %	100,00 %
Number of firms		2280	38116	406	6241	146	1010	2832	45367
Distribution by firm size		80,51%	84,02%	14,34%	13,76%	5,16%	2,23%	100,00 %	100,00 %

A2 – Definition of explanatory variables

Table A4 – Variables included in the analysis: definitions

Variable	Definition	Unit
Firm growth	ln (# employees $_t$)- ln (# employees $_{t-x}$)	% Variation
Firm age	Number of years since the firm establishment	Absolute value
CEO < 45 years old	Dummy variable which is 1 for firms which are managed by a CEO who is less than 45 years old in 2008	Dummy
Product innovation (t_T)	Dummy variable which is 1 for firms which introduced a new product between 2007 and 2009	Dummy
Process innovation (t_T)	Dummy variable which is 1 for firms which adopted a new process between 2007 and 2009	Dummy
Graduate workers	Percentage of university graduates over the total number of employees	Share
Employees in R&D activities	Percentage of employees involved in R&D activities over the total number of employees	Share
Labor productivity	Ratio of value added to the number of employees	Thousands euro /employees
Capital-labor ratio	Ratio of tangible fixed assets to the number of employees	Thousands euro /employees
EBITDA margin_op	Ratio of Ebitda to sales	Ratio
Average wage	Ratio of the total personnel cost to the number of employees	Thousands euro /employees
Short-term debt (intensity)	Short-term obligations, due within the present accounting year over total sales	Ratio
Long-term debt (intensity)	Long-term obligations (bonds payable and long-term lease obligations) not due within the present accounting year over total sales	Ratio
Liquidity ratio	Ratio of cash (or equivalents) to total assets	Ratio

A3 - The aggregate age distribution

Figure A1: Aggregate age distribution; French, Italian and Spanish firms; 2001

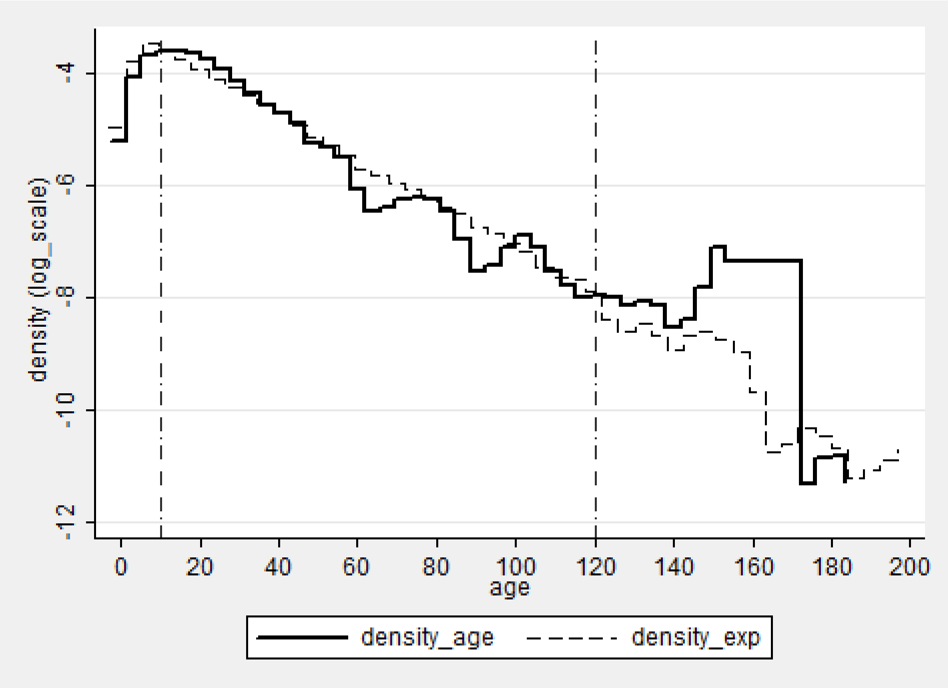


Figure A1, depicts the age distribution for the sample under analysis in 2001 for purpose of description and comparison with previous evidence. Young firms are the most numerous, and as age increases the number of firms heavily decreases.

Drawing on the results provided by Coad and Tamvada (2008) for the Indian data, and Coad (2010) for Spanish and Italian firms, we plot the age distribution on semi-log axes, finding that it is quite well approximated by a straight line of negative slope, over most of the support. This fact means that the empirical distribution of age in the sample under analysis is well approximated by an exponential distribution, which has been also plotted with a dashed line in the same Figure.

In line with Coad (2010), we find that the exponential distribution seems to be a good approximation for firms which are not very young, nor very old. Graphically we show this fact, by highlighting the central part of the distribution between two dash-dot lines. It is evident that over the support from around 10 to 120 years, the exponential distribution appears to be a reasonable approximation, but that is not the case for the youngest and the oldest firms.

The modal age for the aggregate age distribution is around 10 years, which implies that our sample is underrepresenting young firms. We may, in fact, end up with data on young firms which over-represent those with above-average performance. Country-specific information on the age distribution by country is provided in section 4.

A4 – Alternative taxonomies of age classes

Table A5: Frequencies in each age class (3 classes), by country and year

	2001			2002			2003			2004		
Age class	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA
Young (0-10)	618	728	899	597	721	890	569	690	840	540	656	804
Mature (11-20)	667	675	765	678	656	769	691	682	785	698	700	806
Experienced (21-max)	1,464	1,377	948	1,516	1,447	1,000	1,571	1,497	1,083	1,633	1,549	1,139
Total	2,749	2,780	2,612	2,791	2,824	2,659	2,831	2,869	2,708	2,871	2,905	2,749
	2005			2006			2007			2008		
Age class	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA
Young (0-10)	518	641	747	475	607	676	450	550	588	410	500	516
Mature (11-20)	702	692	837	697	688	843	669	681	855	648	676	862
Experienced (21-max)	1,689	1,616	1,202	1,759	1,686	1,295	1,843	1,765	1,383	1,915	1,829	1,454
Total	2,909	2,949	2,786	2,931	2,981	2,814	2,962	2,996	2,826	2,973	3,005	2,832

Table A6: Frequencies in each age class (5 classes), by country and year

	2001			2002			2003			2004		
Age class	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA
Infant (0-2 years)	142	213	190	138	185	167	128	163	150	122	125	137
Adolescent (3-4 years)	95	121	184	90	134	176	96	139	136	96	141	120
Middle age (5-25)	1,296	1,464	1,536	1,300	1,469	1,581	1,310	1,470	1,653	1,308	1,464	1,675
Old (26-50)	667	765	530	710	808	556	732	855	581	765	926	621
Very old (51-max)	549	217	172	553	228	179	565	242	188	580	249	196
Total	2,749	2,78	2,612	2,791	2,824	2,659	2,831	2,869	2,708	2,871	2,905	2,749
	2005			2006			2007			2008		
Age class	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA
Infant (0-2 years)	118	125	127	100	112	106	91	91	77	64	56	46
Adolescent (3-4 years)	88	118	101	82	89	96	80	81	90	78	80	78
Middle age (5-25)	1,313	1,453	1,679	1,285	1,403	1,664	1,275	1,377	1,659	1,260	1,372	1,625
Old (26-50)	798	991	675	851	1,101	732	884	1,152	767	913	1,189	836
Very old (51-max)	592	262	204	613	276	216	632	295	233	658	308	247
Total	2,909	2,949	2,786	2,931	2,981	2,814	2,962	2,996	2,826	2,973	3,005	2,832

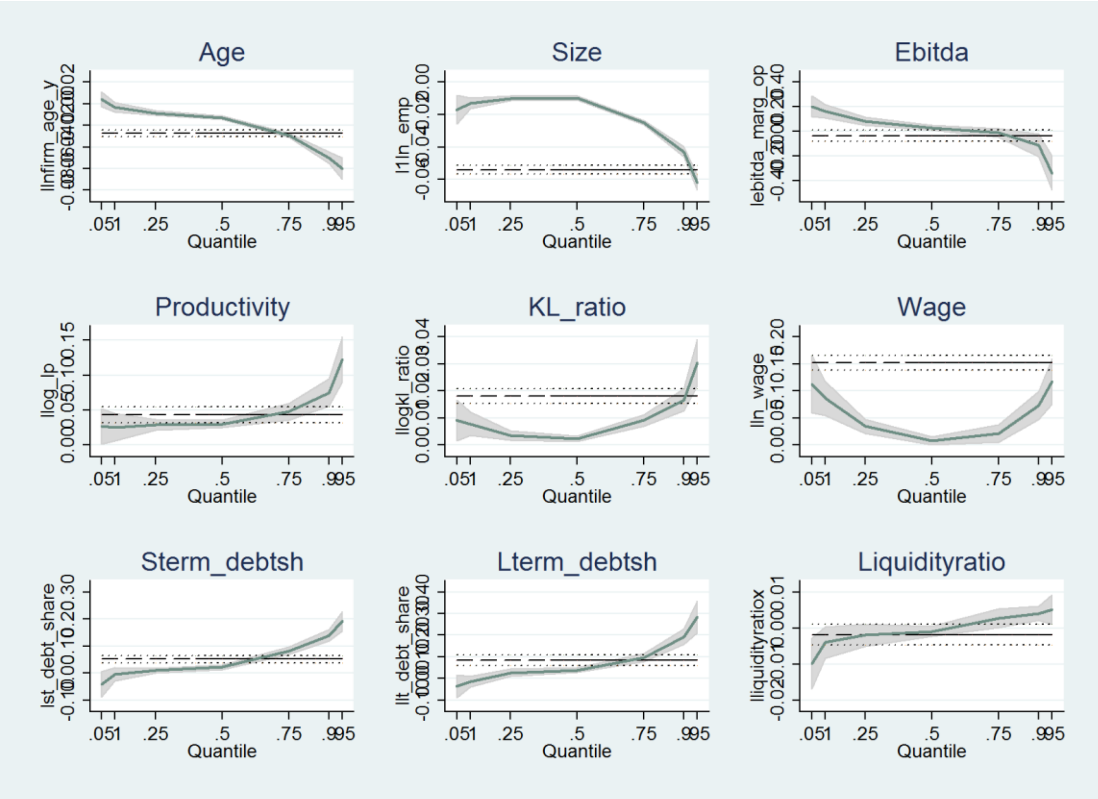
Alternative taxonomies of age classes confirm the evidence provided in section 4: Spanish firms are more concentrated on the young classes, while France shows higher frequency on the class of very old firms. Again, Italy maintains an intermediate profile, showing high frequency among young firms, but also among the classes of old firms.

A5 – Coefficients and graphs for the quantile regression coefficients

Table A7 - The effect of age and firm characteristics (at the beginning of the period) on firm growth, quantile regression

1-year growth rates				Quantiles			
Variables	q05	q10	q25	q50	q75	q90	q95
AGE (t-1)	0.00408	-0.00297	-0.00851***	-0.0129***	-0.0292***	-0.0500***	-0.0601***
	[0.00362]	[0.00188]	[0.000897]	[0.000869]	[0.00121]	[0.00226]	[0.00414]
SIZE (t-1)	-0.0171***	-0.0129***	-0.00996***	-0.00967***	-0.0250***	-0.0429***	-0.0621***
	[0.00535]	[0.00241]	[0.000900]	[0.000821]	[0.000950]	[0.00188]	[0.00333]
EBITDA_marg (t-1)	0.202***	0.163***	0.0814***	0.0282**	-0.0118	-0.114**	-0.339***
	[0.0438]	[0.0268]	[0.0137]	[0.0112]	[0.0196]	[0.0457]	[0.0676]
LP (t-1)	0.0267**	0.0255***	0.0288***	0.0305***	0.0478***	0.0751***	0.122***
	[0.0131]	[0.00911]	[0.00424]	[0.00298]	[0.00549]	[0.00948]	[0.0151]
KL_ratio (t-1)	0.00915***	0.00788***	0.00349***	0.00240***	0.00916***	0.0168***	0.0305***
	[0.00312]	[0.00181]	[0.000905]	[0.000516]	[0.00108]	[0.00190]	[0.00416]
WAGE (t-1)	0.113***	0.0865***	0.0345***	0.00731*	0.0213***	0.0732***	0.118***
	[0.0255]	[0.0125]	[0.00645]	[0.00439]	[0.00770]	[0.0143]	[0.0236]
ST_DEBT_share (t-1)	-0.0419**	-0.00528	0.00939***	0.0221***	0.0820***	0.139***	0.192***
	[0.0211]	[0.0112]	[0.00333]	[0.00380]	[0.00615]	[0.0127]	[0.0219]
LT_DEBT_share (t-1)	-0.0366	-0.0141	0.0265***	0.0382***	0.0958***	0.193***	0.284***
	[0.0309]	[0.0155]	[0.00904]	[0.00638]	[0.0103]	[0.0217]	[0.0342]
LIQUIDITY_ratio (t-1)	-0.00991**	-0.00405*	-0.00200	-0.000934*	0.00266*	0.00400***	0.00506**
	[0.00481]	[0.00236]	[0.00123]	[0.000543]	[0.00139]	[0.00121]	[0.00238]
Constant	-0.681***	-0.503***	-0.219***	-0.0620***	-0.0459***	-0.135***	-0.331***
	[0.0618]	[0.0277]	[0.0134]	[0.00839]	[0.0145]	[0.0380]	[0.0614]
Observations	34,996	34,996	34,996	34,996	34,996	34,996	34,996
Long-run growth rates				Quantiles			
Variables	q05	q10	q25	q50	q75	q90	q95
AGE (t-7)	-0.0421***	-0.0490***	-0.0595***	-0.0842***	-0.111***	-0.149***	-0.174***
	[0.0157]	[0.0116]	[0.0106]	[0.00689]	[0.00980]	[0.0175]	[0.0242]
SIZE (t-7)	-0.236***	-0.173***	-0.134***	-0.122***	-0.137***	-0.147***	-0.170***
	[0.0257]	[0.0192]	[0.0106]	[0.00824]	[0.00948]	[0.0149]	[0.0224]
EBITDA_marg (t-7)	0.322	-0.0377	-0.324**	-0.381***	-0.667***	-1.258***	-1.389***
	[0.285]	[0.231]	[0.160]	[0.145]	[0.207]	[0.277]	[0.401]
LP (t-7)	0.154***	0.188***	0.252***	0.295***	0.343***	0.574***	0.543***
	[0.0596]	[0.0546]	[0.0375]	[0.0430]	[0.0510]	[0.0821]	[0.131]
KL_ratio (t-7)	0.0432***	0.0384***	0.0425***	0.0509***	0.0642***	0.0750***	0.0987***
	[0.0123]	[0.0115]	[0.00839]	[0.00772]	[0.0112]	[0.0164]	[0.0207]
WAGE (t-7)	0.00242	0.0137	-0.0159	0.00360	0.0509	0.0102	0.0653
	[0.101]	[0.0933]	[0.0521]	[0.0458]	[0.0682]	[0.108]	[0.181]
ST_DEBT_share (t-7)	0.174	0.00828	0.0683	0.221***	0.331***	0.362***	0.425***
	[0.118]	[0.0772]	[0.0591]	[0.0455]	[0.0722]	[0.110]	[0.149]
LT_DEBT_share (t-7)	0.335**	0.237**	0.279***	0.309***	0.456***	0.711***	0.789***
	[0.136]	[0.0978]	[0.0734]	[0.0650]	[0.116]	[0.147]	[0.207]
LIQUIDITY_ratio (t-7)	0.00401	-0.00208	-0.00803	-0.00958	-0.00341	-0.0364***	-0.0448**
	[0.0211]	[0.0149]	[0.00820]	[0.00789]	[0.00992]	[0.0135]	[0.0175]
Constant	-0.647**	-0.655***	-0.688***	-0.700***	-0.710***	-0.983***	-0.778**
	[0.319]	[0.250]	[0.128]	[0.125]	[0.192]	[0.275]	[0.379]
Observations	4,309	4,309	4,309	4,309	4,309	4,309	4,309

Figure A2: Graphical representation of the coefficients showed in Table A7



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