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The role of age in shaping firms' size dynamics: 'learning' effects or willingness to grow?

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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 firms in the period from 2001 to 2008. After controlling for several firms' characteristics, country and sector specificities we find that: (i) older firms are less likely to grow fast, but they experience the same probability of shrinking a lot than younger counterparts; (ii) several qualitative characteristics of the firm linked to its growth attitude, like the age of the CEO, the qualification of the labor-force and its degree of involvement in R&D activities, the innovation attitude of the firm are also significantly related to the process of growth, especially for those firms which grow the most (fast-growing firms). Overall, our results suggest that the process of firm growth is the result of a combination of 'learning' and willingness to grow.

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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 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.

At the origin of the interest on this topic there is the empirical evidence that young firms grow more than older counterparts: this empirical regularity has been found in a large amount 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 relates to the fact that, traditionally, firms have been always thought to be on a virtuous upsizing path, which they tread at a slower pace and with less variability as firm age increases. Nonetheless, many firms, in each year start or continue to experience a reduction in their size, i.e. a downsizing process, which in the last decade in Europe has been at least as likely as upsizing[1]. Thus, it is relevant to understand the relationship between age and growth along the entire growth possibilities (either positive or negative) that a firm may experiment: the attention on young and fast-growing firms has almost overshadowed the attention on downsizing firms, and the role that age plays for them. The second one is the attempt to take account of subjective drivers of growth which could be caught up by the age measure; a clear example is the existence of a growth attitude by some firms and not others: if younger firms have younger managers and workers who want to foothold in the market and are less risk-averse, this attitude may be captured by age if not properly taken into account. Thus, in order to deepen our understanding of the channels through which age plays a role in the process of (positive and negative) firm growth, firm characteristics which may be well correlated with age and willingness to grow should be included in the analysis.

This paper gives new insights for these neglected aspects providing new evidence in a sample of French, Italian and Spanish firms in the period from 2001 to 2008. The availability of a new database, obtained from the merge of Bureau Van Dijk's Amadeus with the EU-EFIGE[2]/Bruegel-Unicredit (EFIGE) survey, allows us to recover firm age starting from the year of establishment, and to study its effect on firm growth after controlling for many other economic and financial characteristics such as productivity, technology, profitability, access to credit, cash-availability. At the same time, we exploit the information contained in the EFIGE

[1] 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.

[2] 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.

survey including in the econometric analysis a set of firms' characteristics which may be indicators of the attitude to grow by the firm, like the age of the CEO and the qualification of the labor force.

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 which is suitable for this purpose.

After controlling for several firms' characteristics, country and sector specificities we find that: (i) firm age has a negative effect on growth if the firm has experienced an upsizing process over the considered period, while it does not exert any role if the firm has experienced a heavy reduction of its size, that is, older firms are less likely to grow fast, but they experience the same probability of shrinking a lot than younger counterparts; (ii) several qualitative characteristics of the firm linked to its growth attitude, like the age of the CEO, the qualification of the labor-force and its degree of involvement in R&D activities, the innovation attitude of the firm are also significantly related to the process of growth, especially for those firms which grow the most (fast-growing firms). Overall, a mixture of "learning" and willingness to grow (inferred through qualitative characteristics of the firm) characterizes the process of grow of firms in the sample.

The rest of the paper is structured as follows: section 2 critically overviews the main theoretical contributions which have been advanced regarding the link between age and firm growth, and section 3 provides a selection of empirical works which have investigated the relationship. Section 4 describe the data used in the analysis and provide some descriptive statistics; in section 5 the econometric framework and results are listed and commented and section 6 provide some conclusions. A Data Appendix concludes the paper.

2. Theory - the role of age in shaping firm dynamics

Why should firm's age have an effect on size dynamics? Even if several strands of the literature -such as Neoclassical models of perfect competition- do not assign any role to age in the process firms' growth, building on models of imperfect competition and economies of scale[3], some scholars have taken into account the role played by firms' age in shaping their growth process.

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 in to account the role of age in shaping firms' growth. In particular, some of them consider a process of learning, which takes some time to mature. In Jovanovic (1982) model of passive learning, younger and smaller firms grow more than larger counterparts: this is not just the result of the selection process, which would let us observe just those young firms which grow enough in order to survive, but also of the fact that in the earlier stages of their life, firms experiment more uncertainty about their type (time invariant unknown inefficiency parameter), so the update is stronger and hence growth rates are greater (see Jovanovic, 1982, p. 656) for younger firms[4]. 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)[5].

Most of the above theoretical contributions start from the hypothesis that firms aim to maximize profits and that this has implications for growth which hold in the entire life-time of a firm (Hart, 2000). But is this hypothesis reasonable? As for age, as time passes and a firm

[3] 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[3]. 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.

[4] 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.

[5] Cooley and Quadrini (2004) provide another dynamic model in which they try to account for the simultaneous dependence of firm dynamics on both size and age, introducing two channels of heterogeneity: (i) a persistent stochastic shock and (ii) financial frictions which are due to a cost/premium associated with increasing equity and a costly defaulting on the debt.

gets older and (most likely) larger, conflict of interests may be at work within the company between managers and owners/shareholders: the first may be attracted by maximizing sales and increasing the number of staff more than what a profit-maximization (supported by shareholders) conduct suggests. This conflict of interest may not be an issue for young small firms (where sales and profit maximization may be compatible targets) but, it may be definitely an issue for larger and older companies, as the "managerial" theory of the firm would predict (Mueller, 1969). In the short-run, managerial empire building might generate more jobs, while in the long-run, the resulting inefficiency and lack of competitiveness might destroy them. These conflicts may bring to a more stochastic pattern of growth for older than for younger firms: these last may, in fact, be more oriented toward upsizing their organizations.

Another channel through which age may play a role on firms' growth is linked to the financial sources available to the firm (Cooley and Quadrini, 2004). Access to finance may vary with firm age: young firms generally obtain less long-term bank debt and show lower levels of equity capital, while mostly hold on internal cash-flow and commercial debt. This may imply different patterns of growth for young and old firms. For this reason, it is relevant to take into account the financial structure of the firm in order to try to isolate a true "age-effect".

Finally, subjective-motivational characteristics seem to have an important impact on firms' growth (see Sargant Florence, 1934; Baum, Locke and Smith, 2001, among others). There are significant differences in growth aspirations among firms and these are positively related with actual growth (Stenholm and Toivonen, 2009): it may well be the case that growth orientation is linked to some characteristics of small and young firms like the age of the CEO or the qualification of the labor force, and that this orientation may be better able to foster growth in young than in older firms, generally characterized by a more complex organizational structure (Arrighetti, 2012). Thus, it is crucial to take these dimensions of the firm into account in order to have a better comprehension of the "age-effect" on growth.

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[6]. Nonetheless, given that positive (upsizing) and negative growth (downsizing) are both likely phenomena in any industry and country, it is worth to try to rationalize if age may have different effects on the two phenomena. One the one hand, higher growth rates for younger firms may be explained by a set of motivations such as "learning" processes (either passive or active), market selection, less conflict of interests, different financial structures and a more effective growth orientation. On the other hand, the process of downsizing may be a choice which is dictated by circumstances out of the firm control, which have less to do with the stage of life where the firm is, while being more related to external factors, as an increased level of competition (Couke et al.2007) or negative demand shocks.

There are no clear a priori on how young and old firms should be affected in different ways when facing a downsizing pattern: that is, while age definitely plays a role in the process of upsizing, the effect of it on downsizing is not a clear-cut.

[6] 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).

3. Previous empirical studies

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 (i.e. the fact that small and young firms with lower growth rates are more likely to die than larger and older counterparts), which could magnify the impact of rapidly growing small/young firms, younger firms show 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.

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 belonging to 14 European countries from 1994 to 1998, finding that the life-cycle effect significantly determine 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 their more 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[7].

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

[7] 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.

relationship between determinants 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 distrbution, 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 employment and sales growth rates 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 upsizing and downsizing 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 decline.

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 range of other firms' characteristics as controls; second, we take a step further and, exploiting the insightful information contained in the EFIGE survey, the role of subjective factors of growth is also explored together in their interactions with firm age.

4. 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, like measures of productivity, profitability, labor cost and the size of the firm. The EFIGE survey, which has originally been conducted on a sample of 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 degree of innovation of the firm[8].

Given that we use the information on the number of employees as measure for the size of the firm[9], we are constrained to limit our attention to those observations which have

[8] We cross-refer the reader to the paper by Barba Navaretti et al. (2010) for a description and for obtaining more information on the sample Amadeus-EFIGE used in the analyses of the present paper.

[9] 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 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.

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

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

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

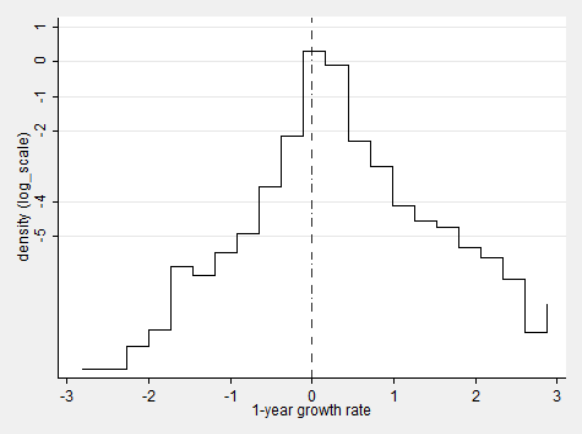
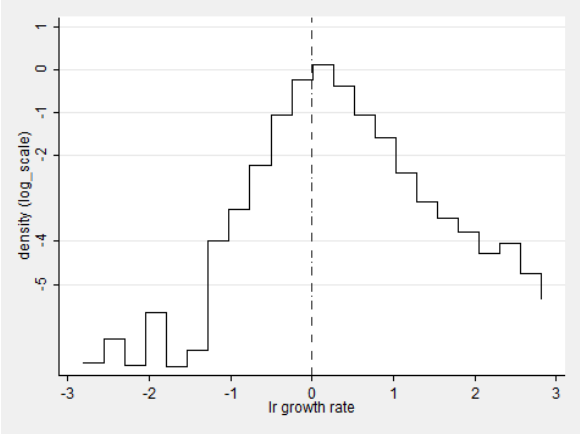


Figure 1(b): distribution for long-run (2001-2008) employment growth rates.



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

Having computed those, we can 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 in Figure 1(b) 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 which grow, many firms also shrink, that is the upsizing and the downsizing phenomenon coexist as likely phenomenon in the overall pool of observations belonging to the three European countries[10]. These figures can be appreciated also in Table 1, where different percentiles of growth rates distribution have been calculated for the three countries.

Table 1: Growth rates at different percentiles, by country

	FRA	ITA	SPA	Total

[10] 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.

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

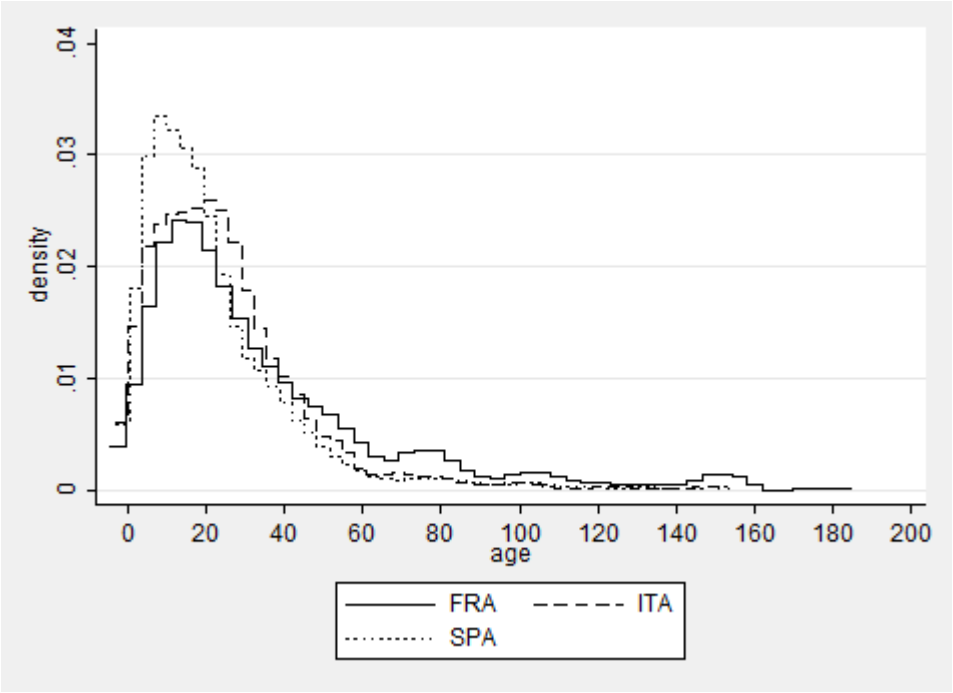
The general findings showed by the plots are confirmed: the median growth rate is equal to 0 (1-year rates), or at least around it (long-run rates), and upsizing firms coexist with shrinking ones. At the country level, some peculiarities can be added: Spanish firms show higher growth rates at the 50th, 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 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.

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. The age distributions[11] of firms in the three countries in 2001[12] 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.

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

[12] As Coad (2010) underlines, where 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).

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



A useful way to further get some hints on the age structure is to define age categories for the firms. 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 showing 21 or more years since the establishment. The number of observations in each class is showed in Table 2, splitting them by country and year: it is evident that in each year 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 frequencies in the first two categories, suggesting that Spanish firms are significantly[13] younger than French and Italian counterparts in the sample[14]. Conversely, France systematically shows higher frequencies in the last categories, those with the oldest firms. Thus, even if the three age distributions show some similarities, there are also some differences in the age structure of manufacturing firms in our sample from a cross-country perspective.

Table 2: Frequencies in each age class, by country and year

	2001			2002			2003			2004		
Age class	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA	FRA	ITA	SPA

[13] Computing the Pearson's χ^2 statistics (i.e. 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 classes across countries. Results are available from the authors upon request.

[14] We cross-refer the reader to the Data Appendix (Table A1), where, as robustness check we provide an alternative taxonomy which is made up of five age classes. The main evidence of youth of Spanish firms and the seniority of French ones is broadly confirmed.

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

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[15].

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

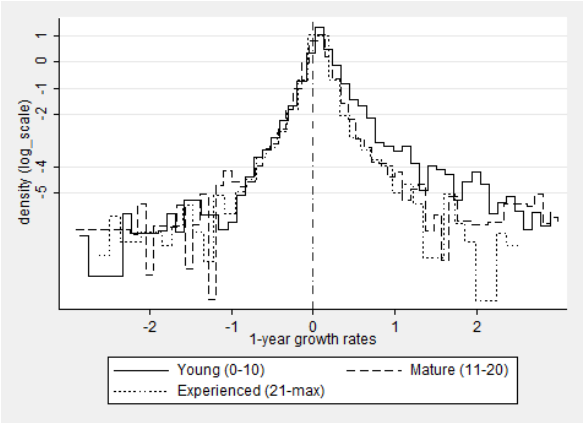
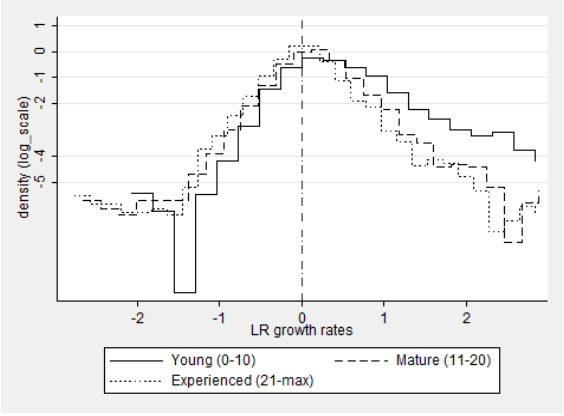


Figure 3(b): Distribution for long-run employment growth rates, by age classes.



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

Given this suggestive 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'

[15] 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.

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. In this Table, we summarize the main variables affecting the growth process of firms, which have lately been included in the econometric analysis. Young and old firms are clearly different in several dimensions.

Table 3: Descriptive statistics on the whole sample, by age class; median values, standard error in parentheses

	Young	Mature	Experienced	Total
Growth employees	0.04	0.00	0.00	0.00
	(0.38)	(0.28)	(0.27)	(0.30)
Labor productivity	37.29	40.45	43.60	41.60
	(135.20)	(6,346.41)	(676.33)	(3,244.16)
Capita-labor ratio	16.06	16.37	18.19	17.26
	(251.73)	(2,365.87)	(1,906.72)	(1,838.19)
EBITDA_marg_op	0.07	0.08	0.07	0.07
	(1.29)	(0.47)	(0.39)	(0.71)
(average) Wage	26.42	28.40	31.76	29.65
	(91.34)	(4,158.20)	(199.34)	(2,107.01)
ST_debt_share	0.59	0.52	0.49	0.51
	(0.49)	(0.22)	(0.38)	(0.38)
LT_debt_share	0.02	0.01	0.00	0.01
	(0.17)	(0.13)	(0.11)	(0.13)
Liquidity_ratio	0.86	1.00	1.03	0.98
	(1.56)	(1.56)	(1.39)	(1.48)
CEO < 45 years old (2008)	33.87%	23.39%	21.52%	24.75%
	(0.47)	(0.42)	(0.41)	(0.43)
Product innovation (2008)	44.91%	43.49%	48.69%	46.52%
	(0.50)	(0.50)	(0.50)	(0.50)
Process innovation (2008)	45.39%	43.32%	44.78%	44.55%
	(0.50)	(0.50)	(0.50)	(0.50)
Graduate workers (2008)	6.25%	5.88%	5.56%	5.88%
	(16.01)	(13.01)	(11.30)	(12.89)
Employees in R&D activities (2008)	3.03%	3.23%	3,03%	3.13%
	15.33	12.72	10.47	12.23

For median values, younger firms are less productive, use less capital-intensive technologies, pay lower wages and introduce less product innovation. Nonetheless, they grow more and show higher levels of debt (both short and long term type) with respect to assets. Furthermore, they usually hire younger CEO and a higher proportion of graduate workers over their labor-force. In order to assess the role of age in shaping firm size dynamics, it is necessary to conduct a multivariate econometric analysis which takes into account those variables which may be well related both to age and growth.

5. 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:

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

where $gr_{i,t}^{w}$ is the growth rate experienced by the i^{th} firm in the period of time which goes from *t* to *t-x*, and the super-index *w* can respectively be equal to $1, LR$, if the growth rate is calculated considering two consecutive year (x=1) or 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 and $\mathbf{Z}$ is a vector of firm-specific characteristics also inserted at the beginning of the period; finally, 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.

Table 4 shows the results from the estimation of variants of equation (3) by means of OLS. When we include the AGE variable only, together with sector, country and year dummies (specification A1), the well-known negative relationship between age and growth can be appreciated: on average young firms grow more than older counterparts in the sample under analysis and the period from 2001 to 2008. Of course, the magnitude of the effect is likely to be biased, given that several other factors which we have presented in the previous section are going to affect the growth path of the firm and be correlated with the age of the firm. When the vector of controls (specification A2) is introduced, the magnitude of the age effect gets reduced but the sign of the relationship is confirmed. The sign of the other variables is also worthy of comment: the coefficient of SIZE is negative, indicating that smaller firms grow more than larger counterparts; the EBITDA_marg coefficient is not significant, thus confirming an already found result in the literature of a not significant relationship between profitability and successive growth. Most productive firms grow more than less productive counterparts as the coefficient of LP shows, and the adopted technology seems to affect the rate of growth in several respects: more capital-intensive firms and those which pay higher wages grow more than their counterparts. Finally, the availability of both short-term and long-term debt (with respect to total assets) is positively associated with higher growth rates.

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 (and the other firms' characteristics) 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 interact each regressor with a dummy which is equal to 1 if the firms experiences a growth rate which is greater or equal than 0 during the period of time (specification A3). The new equation becomes:

$$gr_{i,t}^{w} = \beta_0 + \rho_0 D_{gr} + \beta_1 \ln(AGE_{i,t-x}) + \rho_1 D_{gr} \cdot \ln(AGE_{i,t-x}) + \boldsymbol{\delta}'\mathbf{Z} + \boldsymbol{\varphi}' D_{gr} \cdot \mathbf{Z} + \mu_j + \gamma_c + \tau_t + \varepsilon_{it}, \quad (4)$$

where

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

The 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.

With respect to the other variables, it is interesting to note that some of them, like size and the capital-labor ratio are significant just for explaining those firms which experience a positive growth: thus, they seem to be relevant factors just for explaining one direction of growth. Conversely, others show coefficient which are in line with the existence of an effect along the entire growth values, with a changing sign and different magnitudes, thus suggesting non-linearities in factors explaining the upsizing and downsizing processes. Productivity shows a positive coefficient in the case of growth and a negative in the case of downsizing, indicating that more productive firms show higher positive growth rates, while the less productive firms have a higher propensity to exhibit negative growth. The same is true for the short-term and long-term availabilities and the liquidity ratio. The proxy for the level of profitability at the beginning of the period (EBITDA_marg) shows a negative relationship with positive growth rates and a positive one with negative growth rates: on the one hand, growing firms t may have experienced low profits for investing in technology and new products development, while higher level of profits may lessen the negative path of shrinking firms. At the same time, firms which pay higher wages show lower growth rates, but the average positive effect found in specification (2) is almost entirely captured by the positive relationship which appears for downsizers. The inadequacy of pooling together upsizing and downsizing growth processes is confirmed by the F-test on the joint significance of the interaction terms, which is reported below Table 3: the null hypothesis is soundly rejected.

The existence of non-linearities is confirmed and in several cases reinforced by the estimation of equation (3) in terms of long-run growth rates. 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 affects both young and old firms, because it may be more linked to exogenous factors, not controlled by the firm. Most of the other regressors confirm their effects for upsizing firms but become not significant for explaining the downsizing process[16].

Overall, given that age seems to play different roles on growth rates depending on how much the firm grows or shrink, and that some variables have an effect just over one direction of the growth path (the positive one), we want to better understand the likely non-linearity through which age exerts an effect over growth along different values of its distribution. The proper tool to deal with that is a quantile regression approach.

[16] An exception is constituted by the effect of size: larger firms, in the long-run, grow less and shrink more than smaller counterparts.

Table 4: Linear model; 1-year and long-run growth rates; different specifications

	1-year growth rates (x=1)				Long-run growth rates (x=7)			
Variable	A1	A2	A3		B1	B2	B3	
			Downsizers	**Upsizers**			**Downsizers**	**Upsizers**
AGE (t-x)	-0.037***	-0.027***	0.012***	-0.044***	-0.169***	-0.097***	0.001	-0.091***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.009)	(0.009)	(0.011)	(0.014)
SIZE (t-x)		-0.054***	-0.003	-0.048***		-0.175***	-0.053***	-0.093***
		(0.001)	(0.002)	(0.003)		(0.007)	(0.010)	(0.012)
EBITDA_marg (t-x)		-0.035	0.165***	-0.362***		-0.496***	0.199	-0.938***
		(0.023)	(0.038)	(0.045)		(0.128)	(0.163)	(0.208)
LP (t-x)		0.043***	-0.041***	0.090***		0.329***	0.028	0.239***
		(0.006)	(0.009)	(0.011)		(0.032)	(0.044)	(0.054)
KL_ratio (t-x)		0.018***	0.000	0.022***		0.065***	0.006	0.063***
		(0.001)	(0.002)	(0.002)		(0.008)	(0.009)	(0.012)
WAGE (t-x)		0.152***	0.174***	-0.051***		0.005	0.115**	-0.070
		(0.007)	(0.011)	(0.012)		(0.037)	(0.051)	(0.059)
ST_DEBT_share (t-x)		0.051***	-0.044***	0.113***		0.235***	-0.049	0.289***
		(0.007)	(0.012)	(0.014)		(0.051)	(0.058)	(0.081)
LT_DEBT_share (t-x)		0.083***	-0.067***	0.179***		0.397***	0.064	0.242**
		(0.012)	(0.019)	(0.023)		(0.073)	(0.094)	(0.115)
LIQUIDITY_ratio (t-x)		-0.002	-0.009***	0.008**		-0.011	-0.005	-0.018
		(0.001)	(0.003)	(0.003)		(0.010)	(0.011)	(0.017)
DUMMY_gr				0.257***				0.306**
				(0.027)				(0.136)
Constant	0.170***	-0.442***	-0.564***		0.643***	-0.652***	-0.641***	
	(0.008)	(0.016)	(0.024)		(0.041)	(0.092)	(0.107)	
Sector dummies	Yes	Yes	Yes		Yes	Yes	Yes	
Country dummies	Yes	Yes	Yes		Yes	Yes	Yes	
Year dummies	Yes	Yes	Yes		Yes	Yes	Yes	
Log-likelihood	-6,552	-1,950	1,714		-3,970	-2,961	-2,000	
Observations	38,423	34,996	34,996		4,542	4,309	4,309	
Chow test – Null hypothesis: $\rho_0 = \rho_1 = \boldsymbol{\varphi}' = 0$					Chow test – Null hypothesis: $\rho_0 = \rho_1 = \boldsymbol{\varphi}' = 0$			
F(10, 34,958) = 814.21 Critical value (5%) = 1.84					F(10, 4,277) = 240.41 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:

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

where $gr_{i,t}^{w}$ is the growth rate defined as above, $X_{i,t-x} = (AGE_{i,t-x}; SIZE_{i,t-x}; EBITDmargin_{i,t-x}; LP_{i,t-x}; KLratio_{i,t-x}; STDEBTshare_{i,t-x}; LTDEBTshare_{i,t-x}; LIQUIDITYratio_{i,t-x}; D_j; D_c; D_t)$ 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 minimizes:

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

Equation (6) is the objective function and is an asymmetric linear loss function, and θ is the quantile defined as $Q_{\theta}\left(gr_{i,t}^{w} \mid X_{i,t-x}\right) \equiv inf\left(gr_{i,t}^{w} : F\left(gr_{i,t}^{w} \mid X_{i,t-x}\right) \geq \theta\right)$, in which $0 < \theta < 1$ and $gr_{i,t}^{w}$ is a random sample from a random variable with a conditional distribution function $F(\cdot \mid X_{i,t-x})$. 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)[17]; (ii) this approach is more robust to outliers with respect to the average regression model; (iii) quantile regressions are able to describe the entire conditional distribution of the dependent variabile; (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. Following the literature, a measure of size is included in order to isolate the effect of age: Table 5 shows the results both for 1-year growth rates and the long-run growth rates:

[17] 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 (2007).

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 is found to show 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 fact may make them heavier adjust in terms of growth rates with respect to older counterparts. 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; for the low quantiles, results suggest that younger firms shrink less than older counterparts (see also Figure 3(b)). 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 not shrink much over the entire period: thus, long-run results may suffer more of selection-bias issues.

However, these results may suffer from omitted-variables bias: in Table 6 we include the set of economic and financial characteristics at the beginning of the period, which may well be correlated with the growth process (the vector **Z** in equation 1). The main result 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, which indicates that the youngest firms are those which*, ceteris paribus*, show higher growth rates. 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. 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.

Some variables show the same effect in each of estimated quantiles of the conditional growth rate distribution, but with different magnitudes: 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 experimented more at the top 95% of the growth rate distribution, by the fast-growing firms. 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 (5^{th} and 10^{th} percentiles) seems to have a stronger positive effect for those firms experiencing the highest growth rates.

Table 6: Age and economic and financial characteristics

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

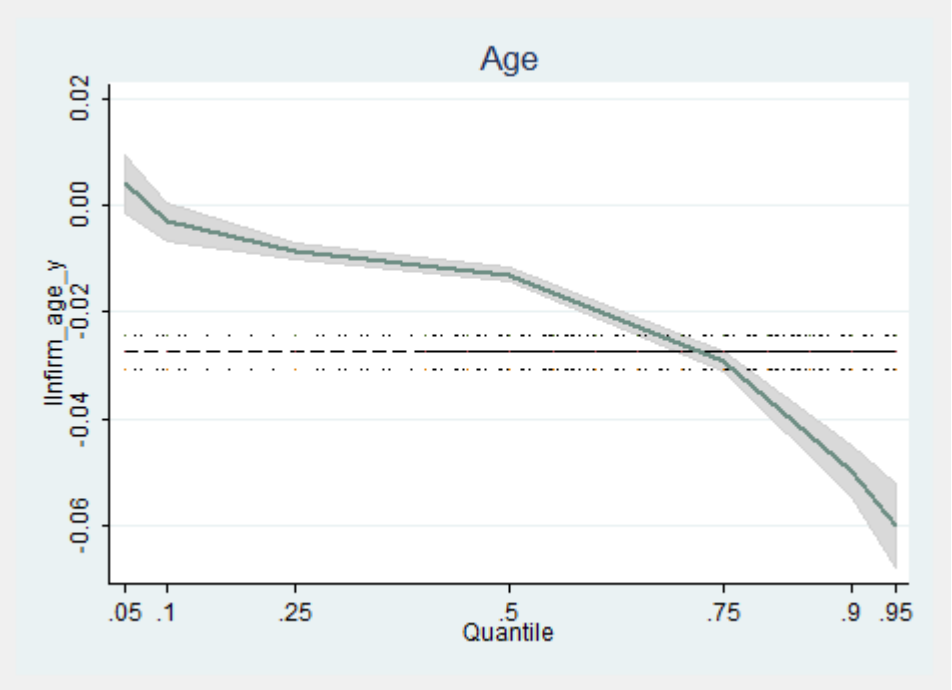
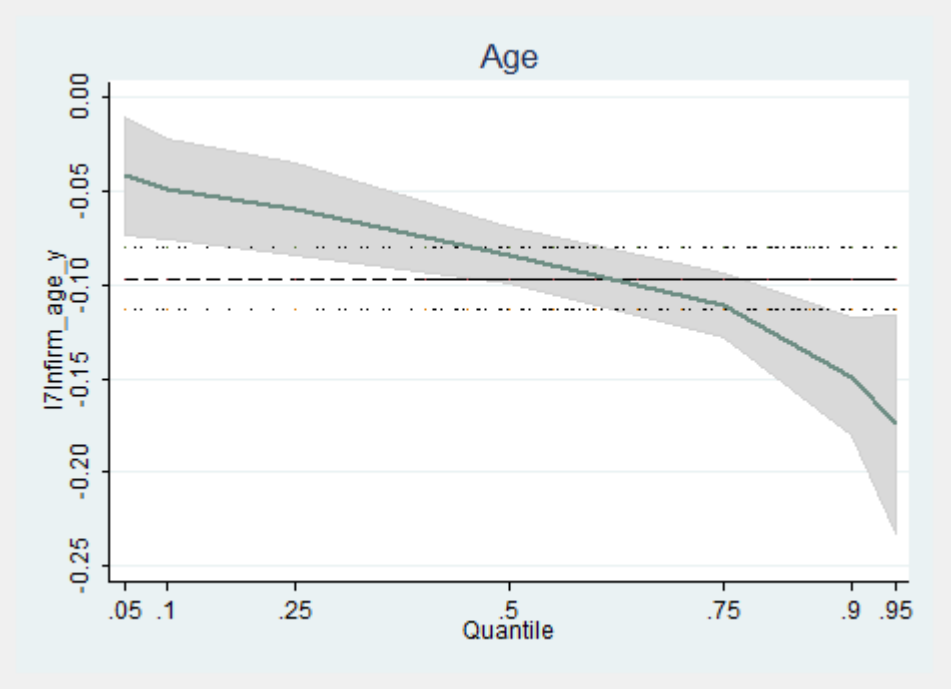


Figure 4(b): The effect of age on growth at different percentiles of the conditional long-run growth rates distribution



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 non-linearities. The measure of profitability shows a significant 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 have borne 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 stronger positive relationship at the top of the distribution may be a sign for the quality of the labor-force of growing firms, while the stronger at the bottom may be a sign of the rational for downsizing of those firms bearing high labor costs. Long-run estimates mainly confirm the results. 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. Summing up, the very top of the growth rate distribution is characterized by qualitatively "different" firms: those experiencing the higher growth rates are the youngest, the smallest, the most productive, the most capital-intensive and those for which having access to short-term and long-term credit is more important. As several papers in the literature have already shown, fast-growing firms are qualitative different from the rest of their peers.

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 the effect, while making use of a quantile regression approach we have pointed out this non-linearity. Going a step further, some qualitative characteristics of the firm, which may be indicated as subjective drivers of growth, may be hidden behind this age-effect. In other word, it is worth asking if the age-effect captures entirely and only a "learning" effect, or that is not the case and young firms grow more also because of being characterized by some factors related to a higher willingness to grow.

Thus, 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 be a signal of attitude toward risk and desire for success in the market; (ii) the number of graduates in the work force which may be correlated with the capacity of the firm to understand the complexity of modern markets; (iii) the number of employees involved in R&D activities, which may be a proxy for the attitude to invest; (iv) two dummies for those firms which have introduced product or process innovations, which depending on the technological regimes, may be more associated to young or old firms. Results are provided in Tables 7. 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 positively affect growth, even if the second characteristics is significant at the 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th} only.

Table 7: Age, economy and financial characteristics and subjective drivers of growth

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]
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]
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]
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

Interestingly, innovation seems to affect growth positively, but not for the top quantiles of the conditional growth rate distribution. Results in terms of long-run growth rates are in line with those referring to 1-year growth rates (see Table 8).

However, the coefficient of age does not change much with respect to that in Table 5. Our interpretation is that a mixture of learning and willingness to grow (inferred through qualitative characteristics of the firm) characterizes the process of firms growth. On the one hand, these results provide empirical support for the dynamic competitive models which consider a process of learning which takes some time to be exploited (Jovanovic, 1982; Ericson and Pakes, 1995); on the other hand, they also provide support for those theoretical contribution claiming for the relevant role of subjective drivers of growth which definitely affects the behavior of younger firms, being proxies for the attitude toward risk and

investments, the desire for success in the market and the fitness with modern complexity of markets.

Table 8: Age, economy and financial characteristics and subjective drivers of growth

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]
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]
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]
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

6. 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 the attempt to try and disentangle to what extent the role of firm age in hindering firm growth is due to learning, as posited by some popular competitive equilibrium models of firm dynamics or it is rather due to firm characteristics which correlate with firm age. In other words, "Do young firms grow faster because they are inexperienced or because they have inherently different characteristics?

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 heavy reduction in its size. In other words, older firms are less likely to grow fast, but they have the same probability of a significant downsizing than younger counterparts. Furthermore, in an attempt to understand whether age measures firm's experience and learning about their 'type' or it is rather a figment of peculiar characteristics that go along with age, we find that the age of the CEO, the qualification of the labor-force and its degree of involvement in R&D activities, the innovation attitude of the firm are also significantly related to the process of growth, especially for those fast-growing firms. However, even controlling for these firm characteristics, age still retain its explanatory power. Overall, our results lead us to conclude that the process of firm growth is the result of a combination of 'learning' and willingness to grow.

A. Data Appendix

A1 - The aggregate age distribution

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

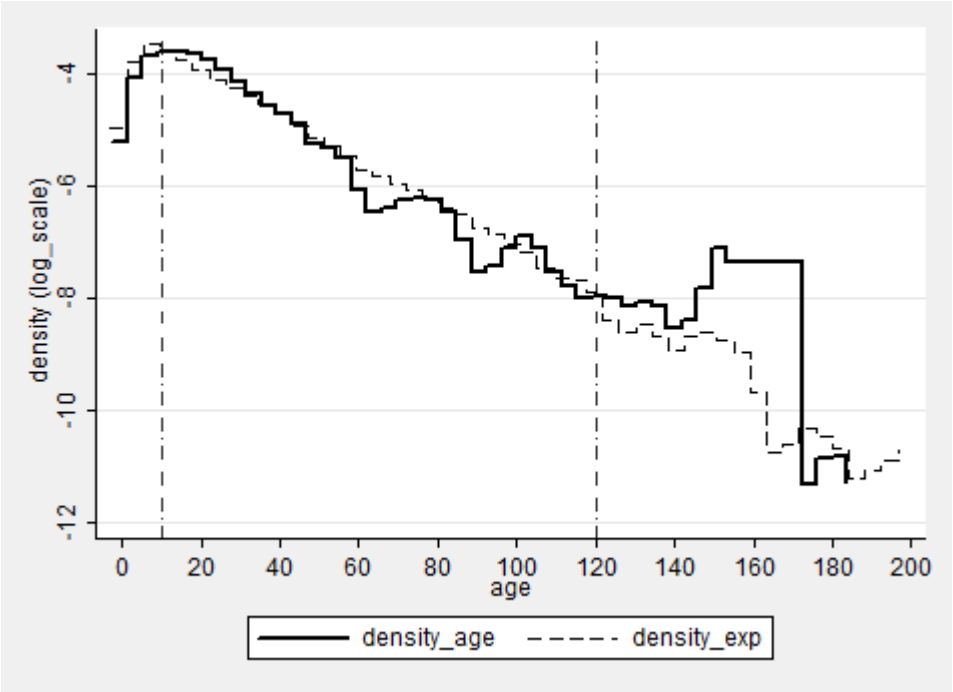


Figure A1, depicts the age distribution for the sample under analysis in 2001 for purpose of description and comparison with previous evidence. Young firms are the most numerous, and as age increases the number of firms heavily decreases.

Drawing on the results provided by Coad and Tamvada (2010) 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.

A2 – An alternative taxonomy of age classes

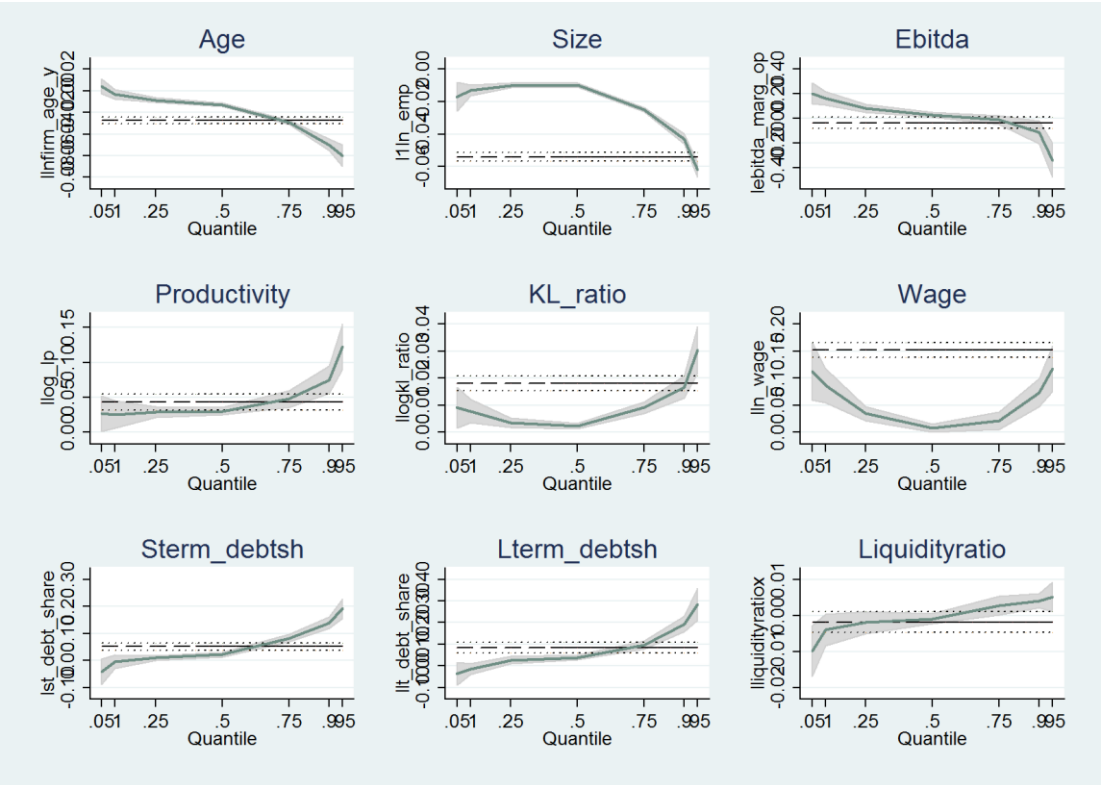
Table A1: Frequencies in each age class, by country and year

	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	1,3	1,469	1,581	1,31	1,47	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	1,26	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

This alternative taxonomy of age classes basically confirms the evidence provided in section 4: Spanish firms are more concentrated on the young classes, especially “Adolescent” and “Middle age”, while France shows higher frequency on the class of very old firms, i.e. “Very old” class. Again, Italy maintains an intermediate profile, showing high frequency amoung young firms, but also among the “Old”class.

A3 – Graphs for quantile regression coefficients

Figure A2: Quantile regression coefficients



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