Age and firm growth.
Evidence from three European countries

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Abstract

This paper provides new insights on the dependence of firm growth on age along the entire distribution of (positive and negative) growth rates, and conditional on survival. 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 with more than 10 employees 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 quantiles; (ii) young firms face the same probability of declining than their older counterparts; (iii) results are robust to the inclusion of other firms' characteristics such as labor productivity, capital intensity, and the financial structure; (iv) high growth is associated with younger CEOs and other attributes which capture the attitude of the firm toward growth and change. The effect of age on firm growth is rather similar across countries.

Keywords: firm growth, age, quantile regression

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1. Introduction

Both academic scholars (see Haltiwanger et al., 2010; López-García and Puente, 2012, 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 their 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 by Fizaine (1968) on French establishments, and by Evans (1987a, 1987b) and Dunne, Roberts and Samuelson (1988, 1989) on U.S. manufacturing.

However, at least two aspects of the relationship between age and growth have not been adequately explored yet. First, little attention has been devoted to exploring asymmetries in upsizing and downsizing processes. Many firms experience a reduction in size, which in the last two decades in Europe has been equally likely as upsizing[2]. In this paper we therefore investigate the relationship between age and firm growth along the entire growth spectrum (positive and negative), and we find that asymmetric patterns do 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 as their younger counterparts. Interestingly, we find that the negative effect of age is particularly large and significant among the fast-growing firms.

Second, the empirical literature has not fully explored yet the factors driving this relationship between age and growth. One recurrent explanation links age to a learning process, which may deter growth (Jovanovic, 1982), but growth 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, contributes to this literature. We find that age keeps a large and robust explanatory power, even after controlling for a number of covariates, including 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); and other factors in themselves conducive to growth (such as the financial structure of the firm).

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

[2] Recent evidence on downsizing has been provided by Bravo-Biosca (2011) for manufacturing firms both in Europe and the U.S., and by Braguinsky, Branstetter and Regateiro (2011) for Portuguese companies.

Our 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. Our data derive from the merge of Bureau Van Dijk's Amadeus with the EU-EFIGE[3]/Bruegel-Unicredit (EFIGE) survey, and combine 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 of other drivers of growth) along the entire growth rates distribution, we use quantile regressions, thus being able to investigate if different behavioral patterns characterize upsizing and downsizing firms.

The rest of the paper is structured as follows: Section 2 critically overviews the main theoretical and empirical contributions on the role of age in shaping firm size dynamics. 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 size dynamics: theory and evidence

2.1 Theory

Why should firm age have an effect on size dynamics?

If a learning-by-doing process is at work (Arrow, 1962) younger firms may be disadvantaged with respect to their 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 the role of age in shaping firms' growth into account. In particular, some of them consider a process of learning, which occurs over time. In the Jovanovic (1982) model of passive learning, firms do not know their efficiency level (their 'type') with certainty, but they know the distribution of such parameter. Thus, a firm sets its output (and employment) based on its guess about its efficiency. If at the end of the period profits are larger than expected, the firm infers that it is more efficient than it had 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 a distribution of efficiency levels with a higher variance) than their older counterparts, they are more likely to make mistakes and set their size at a lower (higher) level that their level of efficiency would require, so the update is stronger and hence growth rates are larger (see Jovanovic, 1982, p. 656)[4]. In the Ericson and Pakes (1995) active learning framework, firms

[3] 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.

[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.

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 a more favorable distribution of efficiency 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 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[5] and age is negatively correlated with growth, since it captures the role of learning. However, firms' subjective-motivational characteristics may also 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), as well as human capital and innovation (Arrighetti and Ninni, 2009), may certainly play a key role. According to Penrose (1959), lack of managerial skills may hinder firm growth, especially in small-sized firms, even if firms would like to grow. 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 have lower levels of equity capital. Relying mostly on internal cash-flow and commercial debt, young firms may face higher financial constraints which hinder growth.

The literature on firm growth has almost always focused on positive growth and its determinants: firms are usually seen along a virtuous pattern that leads to growth[6]. Nonetheless, since, as shown by Bravo-Biosca (2011, pp. 9-10) for Europe and the U.S., negative growth (downsizing) is as likely as positive growth (upsizing), one may want to understand if age may have different effects on the two phenomena. On 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.

2.2 Empirical evidence

The studies by Evans (1987a, 1987b) and Dunne, Roberts and Samuelson (1988, 1989) were among the first studies explicitly analyzing the role of age as a determinant of firm growth in the U.S. manufacturing industry in the seventies and the eighties. One of the main

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[5] From a theoretical point of view, this is also in line with evolutionary tradition of growth of the fitter (Nelson and Winter, 1982; Winter, 1984; Dosi et al., 1995).

[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).

results of these studies, which Sutton (1997; p. 46) indicates as the 'life cycle' regularity, is that for any given firm size, the proportional rate of growth decreases as the firm gets older. The interesting feature of these works is that even controlling for sample selection[7], young/small firms show higher growth rates than their older counterparts.

Lotti et al. (2009) 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 the 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, using the same database over a longer period of time (from 1990 to 2000), Calvo (2006) finds 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' regularity 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[8].

However, as discussed in the theoretical section, different effects of age on the processes 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 percentile of the growth rates distribution, firms' growth is negative (downsizing is a relatively frequent phenomenon), and when firms are downsizing (5th, 10th and 25th percentiles), age is not correlated with 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

[7] 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. We cross-refer the reader to Section 3 for a more in depth discussion of this issue in the context of the present paper.

[8] 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.

manufacturing, services and construction firms. Coad et al. (2013), 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 asymmetric 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, we extend to three large, yet (on many respects) rather different European countries (France, Italy and Spain) the analysis of the role of age both in the upsizing and downsizing process, 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 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 per employee, 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[9].

Given that we use the information on the number of employees as a measure for the size of the firm[10], we need to restrict our analysis to three countries, France, Spain and Italy, which have the largest number of non-missing employment figures. Our main variable of interest is the one-year growth rate in employment of firm *i* at time *t*, which is computed as,

$$gr_{i,t}^{1} = \ln(SIZE_{i,t}) - \ln(SIZE_{i,t-1}); \tag{1}$$

we also compute the average growth rate over the 2001-2008 period as

$$g_{i,t}^{7} = \frac{\ln(SIZE_{i,2008}) - \ln(SIZE_{i,2001})}{7} \tag{2}$$

but, as we will argue later, the one-year growth rate is our preferred measure.

[9] We cross-refer the reader to the Data Appendix (A1) contained in Barba Navaretti et al. (2012), for more information on representativeness of the Amadeus-EFIGE sample used in the analyses of the present paper.

[10] 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".

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 one-year growth rates distribution, while Figure 1(b) represents the distribution of average growth rates. The two plots show some interesting features. In all three countries: (i) both the one-year and the average growth rates support the idea that most of the firms persist around their initial size, showing growth rates equal to zero, which is the mode of both distributions; (ii) for many firms increasing the number of employees, many firms also shrink, suggesting that upsizing and downsizing firms coexist in the three European countries.

[Insert Figure 1(a) and Figure 1(b) here in the text]

Nonetheless, several peculiarities can be discovered looking at the shape of the growth rates' distribution in each country, which are even clearer analyzing the plot of average growth rates over the entire period of time: (i) Spanish firms have grown more than their French and Italian counterparts; (ii) conversely, Italian firms have shrunk more than their French and Spanish counterparts; (iii) finally, French firms have been the more persistent around their initial size[11]. The higher growth of Spanish firms in the 2001-2008 period is consistent with the expanding phase of the economic cycle which ended just before the 2008 crisis, and mainly based on a remarkable increase in employment (see, among others, López-García and Puente, 2012, p. 11; Bravo-Biosca, 2011, p. 16). The higher frequency of downsizing in Italy showed in Figure 1(b) may be related to the co-occurrence of two phenomena happening in the same period; on the one hand, in 2003 a new regulation on temporary workers was introduced in Italy[12], and firms, after the introduction of asymmetric labor market reforms may have increased their use of temporary workers to react to the cyclical fluctuations of demand (Boeri and Garibaldi, 2007). It may be that Amadeus data are not able to fully account for this more extensive use of temporary workers and pick up only the corresponding negative trend in permanent employment after 2004. On the other hand, it has been noted that after the 2001 crisis, Italian firms underwent a profound restructuring and transformation, which may explain the significantly higher propensity to downsize (ISAE, 2006, pp. 219-224). Finally, the higher persistence of French firms is consistent with the relatively more mature industrial structure in France, with a higher share of more established enterprises, which are less likely to exhibit significant size dynamics.

These figures are confirmed in Table 1, showing different percentiles of the growth rates distribution: the median growth rate is equal to 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, 90th and 95th 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 5th, 10th, 25th and 50th percentiles, showing that downsizing has affected them more than their French and Spanish counterparts from 2001 to 2008. French firms, thus, show the lower inter-quartile range, that suggests a higher "persistence" around their initial size.

[11] This fact can be also appreciated by observing the steeper shape of the 'tent' around the modal value equal to zero.

[12] This regulation is known as the *Biagi Law*, after Professor Marco Biagi one of the consultants at the Ministry of Labor who helped drafting the law.

[Insert Table 1 here in the text]

We can now 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, between year *t* and the year of establishment of the firm.

[Insert Figure 2(a) and Figure 2(b) here in the text]

The age distributions of firms in the three countries in 2001[13] show some similarities (Figure 2(a)): (i) on semi-log axes they are rather well approximated by a straight line over most of their support, suggesting that the exponential distribution, which has been plotted with a thick dark grey line, is a good approximation of the empirical distribution of age in the sample (Coad and Tamvada, 2008; Coad 2010)[14]; (ii) in each country, young firms are relatively more frequent than older establishments. In line with Coad (2010), we find the exponential distribution to be a particularly good approximation for firms which are not very young, nor very old. Figure 2(b) highlights the first part of the distribution, which refers to those firms between 0 and 50 years old, discovering 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. Finally, France shows a higher frequency of very old firms (more than 50 years)[15]. Another useful way to describe the age structure is to classify firms into age groups. We use the taxonomy suggested by Coad et al. (2013), defining three classes of firms: those from 0 to 10 years old, those from 11 to 20 years old, and those active from 21 years or more. The percentage of observations by country in each age class (in 2001) is shown in Table 2: Spanish firms in the sample are more concentrated in the two first classes, suggesting that Spanish firms are significantly[16] younger than their French and Italian counterparts in the sample[17], while French firms are more concentrated in the category of the oldest firms. Thus, there are also some differences in the age structure from a cross-country perspective.

[Insert Table 2 here in the text]

Overall, modal ages in 2001 contrast with the modal age implied by an exponential distribution, which would correspond to the youngest age group (Coad, 2010, p.10), and it may suggest that young firms are under-represented in our database, especially in the case of

[13] 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 if we plotted the age distribution at the end of the period (year 2008).

[14] The theoretical exponential distribution refers to 500,000 draws generated with the pseudorandom number generator in Stata 12 environment.

[15] Firms which are more than 50 years old are 20% of the sample in France, and 7% both in Italy and Spain.

[16] Computing the Pearson's chi-squared (χ_4^2) 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 age classes across countries.

[17] We cross-refer the reader to the Data Appendix A2 (Table A2), where, the number of observations in each class and each year is reported. In Barba Navaretti et al. (2012), an alternative taxonomy for the age classes is provided, made up of five age classes as robustness check. The main evidence of youth of Spanish firms and the seniority of French ones is confirmed.

French firms. Moreover, the Amadeus-EFIGE sample refers to the population of firms with more than 10 employees. This constitutes a limit of our analysis and suggests caution in interpreting the results, since our sample may over-represent larger/more successful young firms with above-average performance.

The sample selection issue is well known in the literature relating firms' growth to their age and size, and it has been analyzed and addressed in recent empirical works (see, among others, Fariñas and Moreno, 2000; Calvo, 2006; Lotti et al. 2009). Since younger firms tend to have more volatile (positive and negative) growth rates than their older counterparts, and a higher probability of exiting the market (Dunne et al., 1989, pp. 678-680), we would likely observe only the faster upsizers within the group of young small firms. This may generate an upward bias in the estimation of the negative effect of firm age on growth (Hall, 1987, p. 593), which magnifies the role played by young small firms which grow the most. Unfortunately, the nature of the data does not allow us to control for sample selection, given that we neither observe the youngest/smallest firms nor firms' exit, thus we are forced to conduct an analysis of the relationship between age and growth, *conditional on survival* (see Lotti et al., 2003, p. 221). Even if the majority of previous works have shown that the relationship between age and growth is rather robust to sample selection (an exception is Fariñas and Moreno, 2000, which use non-parametric estimation techniques), some caution is needed when interpreting our results.

Combining the information on age and growth rates, we draw the growth rates distribution by age class in Figure 3(a) and Figure 3(b). In line with Coad et al. (2013), these plots suggest that younger firms have a higher probability of experiencing high growth rates, both for one-year growth rates (Figure 3(a)) and for average (2001-2008) growth rates (Figure 3(b)). Conversely, differences in age do not seem to be associated with different shrinking (downsizing) patterns, especially in the case of one-year growth rates (Figure 3(a)), while for average (2001-2008) growth rates (Figure 3(b)) younger firms have a slightly lower probability of downsizing[18].

[Insert Figure 3(a) and Figure 3(b) here in the text]

From this impressionistic evidence, age seems to play different roles on the process of upsizing and downsizing of the firm. In order to (i) analyze if upsizing and downsizing are processes governed by different factors and (ii) better clarify the role of age on the two processes, in the next section we will carry out a multivariate econometric analysis, controlling for firms' characteristics which may be well related to age and firm growth.

In Table 3, we summarize the main variables affecting firm growth which will be included in the econometric analysis[19]. The choice of these control variables is based on the existing literature.

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[18] The evidence provided in Figure 3(b), referring to average growth rates may be explained by the fact that it is easier for older and larger firms to have experienced a significant reduction in their size on average in the overall period of time, and to be still observable in the database.

[19] We cross-refer the reader to the Data Appendix (A1) for further information on how variables included in the analysis have been built.

First, we control for a measure of *initial firm size*, in the tradition of an extensive literature testing Gibrat's Law (Gibrat, 1931) of proportional effects (see, among others, Mansfield, 1962; Hall, 1987; Evans, 1987a; Dunne et al., 1989; Fariñas and Moreno, 2000; Calvo, 2006; Lotti et al., 2009).

Second, *labor productivity* is introduced as a proxy for firm efficiency, which both competitive learning models (Jovanovic, 1982; Ericson and Pakes, 1995) and the evolutionary theory of "growth of the fitter" (Nelson and Winter, 1982) point out as a key predictor for growth, while the *capital-labor ratio* aims to control for differences in factors' proportion across firms (Liu et al., 1999). We also include a measure of *firm profitability* (ratio of EBITDA to sales), in order to control for the possibility that firms grow by re-investing higher earnings (Coad, 2007; Bottazzi et al., 2008), and a measure of the *cost of labor per employee* which should partially capture the effect of the endowment of skilled workers employed by the firm (Robson and Bennett, 2000; López-García and Puente, 2012).

Third, in the light of the theory and evidence showing that financial constraints are related to firm growth opportunities (Cooley and Quadrini, 2004; Bottazzi et al., 2011) and that young and old firms are characterized by different financial structures (Coad et al., 2013), we include the ratio between *short-term obligations and total assets*, the ratio between *long-term obligations and total assets*, and the *ratio of cash to total assets*.

Fourth, as introduced in Section 2, we consider a vector of firm characteristics, such as the *age of the CEO,* which may capture the higher attitude towards risk; (ii) the *number of graduates in the work force*, which is a proxy for the quality of human capital; (iii) the *number of employees involved in R&D activities* and *the introduction of product and process innovations*, which may be correlated with the capacity of the firm to understand and manage the complexity of firm growth. All these variables should capture firms' willingness toward growth and change, and their 'love for risk' (Arrighetti and Ninni, 2009; Stenholm and Toivonen, 2009).

Table 3, which compares firms' characteristics across age classes and by country, reveals that young and old firms are clearly different in several dimensions.

[Insert Table 3 here in the text]

Firms which have been active for at most 10 years (young) are smaller, less productive, less capital-intensive, bear lower costs of labor per employee and are less likely to introduce product innovation than the median firm in the other two classes. At the same time, factors conducive to growth appear to be more concentrated in younger firms; for example, these are more likely to be managed by a young CEO: in 33.8% of young firms the CEO is less than 45 years-old, while the percentage is respectively equal to 23% and 21% in the case of firms which have been active from 11 to 20 years, and firms which have been active for more than 21 years. Furthermore, young firms employ a higher proportion of graduate workers in their work-force than their older counterparts (6.25% of the workforce) and are more indebted, both in a short-term and long-term perspective, which is a signal of the greater need of access to external finance for younger businesses.

Some country peculiarities (irrespectively of the age class) can be also detected. The median French firm is larger, more productive, bears a higher cost of labor per employee and it is less indebted than their Italian and Spanish counterparts. Conversely, the Spanish median firm shows higher values in terms of proxies for willingness-to-growth, and love for risk, as a higher percentage of young CEOs, a higher percentage of firms which have introduced product and process innovations, and higher percentages of graduates and workers employed in R&D activities. The median Italian firm performs rather well both in terms of productivity and size, it is also more indebted (at least in term of short-term obligations), and it shows low values in all the proxies for willingness-to-growth, and love for risk, showing the lowest percentage of young CEOs (18.43%). Overall, these figures are consistent with the descriptive evidence provided by Figures 1(a) and 1(b) of a more established and static structure of firms in France and a more dynamic group of firms in Spain. These country peculiarities are generally confirmed also within each age class.

Given that young and old firms are different in several dimensions, 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 other firm characteristics is taken into account. This will be the focus of the next section.

4. Econometric analysis

In order to identify the effect of age on firm growth, we start by specifying the following linear regression:

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

where $gr_{i,t}^{w}$ is the growth rate experienced by firm *i* in the period of time *t*. The index *w* can respectively be equal to 1 if the growth rate is calculated considering two consecutive years (x=1) and equal to 7 if it is calculated as the average over the entire period under analysis (x=7). $AGE_{i,t-x}$ refers to the age of the firm *i* 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 (in log); μ_j is a vector of sectoral fixed effects which are included in order to control for all time-invariant sector characteristics, 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 (only in the case of one-year growth rates). We estimate Equation (3) both on the whole sample and on individual countries. In the former case, we include a vector γ_c of country fixed effects in order to control for country-specific time invariant factors. We are mainly interested in the sign and statistical significance of β_1 which captures the effect of an increase in firms' age on growth.

Table 4 shows the results from the estimation of Equation (3) by means of OLS. One-year and average (2001-2008) growth rates are respectively used as dependent variables in the left-hand and right-hand panel of the table. For each dependent variable, we report results for the whole sample, and for the individual countries. The well-known negative relationship between age and growth can be appreciated, both in the overall sample and within each country: on average young firms grow more than older counterparts and this holds both for the one-year and the average growth specifications. The initial size has a negative relation with growth, suggesting that smaller firms grow faster (see Hall, 1987; Wagner, 1992 among others).

[Insert Table 4 here in the text]

Results do not differ much across countries, except for a larger effect of age on growth in Spain[20]. Instead, coefficients in the average growth specifications show a lower growth elasticity to age, than in the one-year growth specification. This is due to the fact that these regressions are restricted to a group of firms which entered the sample in 2001 and remained in it until 2008. In other words, firms which entered the database after 2001 (which are younger and grow more than the others), are not taken into account in the average growth specifications[21]. Thus, the sample used in the average growth regressions clearly suffers from a higher under-representation of younger firms, than the sample of firms included in the one-year specifications: one can expect the elasticity of firm growth to age to be smaller.

In order to avoid such a bias, in the remaining part of the paper we will report only results for one-year growth. Nevertheless, it is worth recalling that also these results, which include also firms entering the sample after 2001, are conditional on firm survival until 2008, and refer to a sample of firms with more than 10 employees. The nature of the data (i.e., exits

[20] This is consistent with the descriptive evidence provided in Section 3 regarding the younger age and the smaller size of Spanish firms with respect to their older French and Italian counterparts.

[21] We cross-refer the reader to Data Appendix (Tables A2 and A3), for further descriptive information regarding the age profile of firms either included in the one-year or in the average growth specifications.

are not observed and only firms with more than 10 employees are considered) may affect our results in two opposite directions. One the one hand, conditioning on survival, we may overestimate the effect of age on growth (see Section 3 for a discussion). On the other hand, by using data on relatively larger (and older) firms, we may underestimate the effect of age.

As we have underlined in the previous section, the high frequency of negative growth rates suggests that it is worth investigating if age has a different effect in the event that a firm is on a path of positive growth, or if 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 experience a growth rate greater or equal than 0. The new equation becomes:

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

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 Table 5 both for the overall sample and for each country. Coefficients are reported in two columns (one for downsizers and one for upsizers/persistent firms) to make them more readable.

The negative relationship between age and growth detected in specifications (A1) and (A2) 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, 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 an asymmetrical effect on growth, depending on the fact that the firm is either in a positive or a negative path. Results are very similar across countries.

[Insert Table 5 here in the text]

More generally, 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.

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 the dependent variable. In particular, considering again Equation (3), the quantile regression model can be written as:

$$gr_{i,t}^{1} = \beta_{\theta}' X_{i,t-1} + \varepsilon_{\theta it} \qquad (5),$$

where $gr_{i,t}^{1}$ refers to the one-year growth rates defined by Equation (1), $X_{i,t-1}$ is the vector of regressors at the beginning of the period, β_{θ} is the vector of parameter to be estimated and $\varepsilon_{\theta it}$ is the error component.

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

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

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

Making θ vary 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 regressor, 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 heterogeneity 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 heavy-tailed growth rates distribution depicted in Figures 1(a), 1(b), 3(a) and 3(b)[22]; (ii) this approach is more robust to outliers than 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). As customary with quantile regressions, standard errors are bootstrapped (1,000 replications).

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. In Table 6, we start by replicating the models estimated in Table 4, where firm size, country, sector and year dummies, are the only control variables.

[Insert Table 6 here in the text]

Interestingly, age shows the expected negative sign starting from the 25th percentile of the conditional growth rate distribution, while for lowest growth rates (q5 and q10) the effect of age is even positive. This is true especially for Italy and Spain, while in the case of France the effect at q5 and q10 is non-significantly different from zero. Such evidence is in line with some previous research (Serrasquiero et al., 2010; Reichstein et al., 2010) and may be explained by a set of concurring factors: as Jovanovic (1982) and Ericson and Pakes (1995) have suggested, younger firms may learn to know about their type (efficiency), and this uncertainty may induce them to adjust their size more than their older counterparts. Following this interpretation, age is a proxy for firm’s learning. The non-significance at the 10th percentile suggests that the downsizing phenomenon may be basically driven by factors which affect firms independently

[22] A 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 (2006).

of their age. Finally, the positive relationship found at the very bottom of the growth distribution suggests that older firms may be less prone to experience heavy negative variations in size with respect to their younger counterparts: ageing is associated both to lower growth and restrained decline, providing the firm with a more stable profile (Coad et al., 2013).

Note also that both the baseline OLS model of Equation (3) and the model specified in Equation (4) may be too restrictive. As a matter of fact, the quantile regression suggests that the effect of age is far from constant along the distribution of growth rates. As illustrated by Figure 4 the effect of age is smaller in magnitude (i.e. closer to zero) than the OLS coefficient (depicted by the thick horizontal line) up to the 75th percentile and is larger (i.e. more negative) in the top quartile. This entails that being young is especially important for the fastest growing firms. Furthermore, one should note that the effect of age turns significantly negative at the 25th percentile, which still corresponds to negative growth rates (-5.1% in the whole sample, as reported by Table 1). In other words, also the model specified in Equation (4) is too restrictive, since it imposes a changing regime at a growth rate equal to zero (downsizing vs upsizing).

[Insert Table 7 and 8 around here in the text]

These results may suffer from omitted-variables bias: as we showed in Table 3, younger firms are quite different from older ones, so firm age may actually pick up the effect of some other confounding factors. To control for this, in Table 7 we include a vector of economic and financial characteristics at the beginning of the period, and in Table 8, we also include a set of firm qualitative attributes which may affect growth (see Section 3, for the rationale regarding their choice as control variables)[23]. The former vector includes labor productivity, capital intensity, profit margins, labor cost per employee, short and long term debt as a share of total assets, and liquidity ratio. The latter set of qualitative attributes (provided by the EFIGE survey), includes: (i) a dummy variable for those firms with a chief executive officer (CEO) younger than 45 years old; (ii) the number of graduates in the work force; (iii) the number of employees involved in R&D activities and two dummies for those firms which have introduced either product or process innovations. It is worth mentioning that the attributes from the EFIGE survey refer to the year 2008, so we need to assume that these variables are rather constant over time, or allow for the possibility of reverse causality. As a matter of fact, some of these firm characteristics do evolve rather slowly over time (for example the age of the CEO or the propensity to innovate), but more importantly, we do not want to provide a strictly causal interpretation here, but rather to provide a more descriptive exercise and assess to what extent firm age may actually pick up the variability in firm growth explained by these firm characteristics.

The main result in Table 6 is also confirmed both in Table 7 and 8, after controlling for the other firm characteristics. Age shows a negative effect on growth starting from the 25th percentile, while it does not have any significant effect on firms experiencing heavy reductions of the number of their employees. Age seems to play a stronger effect at the very top of the growth rate distribution. Conversely, age is not significant among the firms that shrink. The magnitude of the effect of age on firm growth is somewhat affected. In particular, the

[23] To save space and given the similarity of results with respect to the estimations over the entire sample, country-specific results are not shown, but are available upon request.

coefficient of age at the 90th percentile goes from -0.056 in Table 6 to -0.050 in Table 7 and -0.046 in Table 8. An even larger drop in magnitude can be appreciated at the 95th percentile. This suggests that at least some of the effect of age has to do with other firm characteristics affecting growth, but also correlated with age. The lower part of Tables 7 and 8 provides some insights as to what these characteristics could be.

Table 7 confirms 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, both in line with learning models (Jovanovic, 1982; Ericson and Pakes, 1995) and evolutionary theories (Nelson and Winter, 1982), 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 four times larger than at the median. In other words, in order to be a fast-growing firm, being very productive is crucial. The same is true for the capital-labor ratio (Liu et al., 1999) and for the two variables referring to access to short-term and long-term financing. Access to credit, which seems to barely affect the lowest part of the growth rate distribution (5th and 10th percentiles) has a stronger positive effect for those firms experiencing the highest growth rates. This is consistent with previous studies, such as Lee (2011) and Segarra et al. (2013). For example Lee (2011), using information derived from two business surveys, reports that obtaining finance and short-term liquidity is perceived as a significant obstacle to business success for 32% of high-growth firms participating in the surveys.

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 lower ex-ante profits. Conversely, among shrinking firms, the relatively more profitable firms tend to shrink less. This is consistent with previous evidence showing an unclear relationship between profitability and growth (e.g. Coad, 2007, pp. 35-38). 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 reason for downsizing of those firms bearing high labor costs.

Results from Table 8 suggest that firms with a ‘young’ CEO (45 years-old or less) grow faster, but this positive effect of the age of the CEO is significant just for upsizing firms and it is stronger in the top quantiles[24]. Conversely, 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 are not significant up to the 10th percentile. This result is in line with those obtained by López-García and Puente (2012) and Lee (2011), who have underlined the relevance of workers’ skills and human capital as factors explaining the performance of fast-growing businesses. Interestingly enough, process innovation seems to

[24] The age of the CEO and the age of firm are significantly and positively correlated (0.131 in terms of Pearson’s coefficient; 0.122 in terms of Spearman’s rho coefficient), but the age of the CEO keeps a significant and positive coefficient in Table 8, thus excluding a problem of multicollinearity.

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.

Summing up, fast-growing firms are qualitatively different from the rest of their peers. The very top of the growth rate distribution is populated by the youngest (and smallest) firms, 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 negatively affects growth, but the effect is mainly significant for positive growth, especially for fast-growing firms, while, as also shown in Serrasquiero et al. (2010), Reichstein et al. (2010) and Segarra et al. (2013), it is not significant for those firms experiencing heavy downsizing. Estimating an OLS regression imposing equal growth elasticities over the whole distribution of conditional growth rates would hide the important features of these asymmetric effects, which instead are fully appreciated using a quantile regression approach.

5. Conclusions

Young and fast-growing companies play a significant role for the growth of economies and their study is becoming a central topic both in the popular press[25] and in current economic research (see Haltiwanger et al., 2010; López-García and Puente, 2012, among others). 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 firm age on firm growth: the same model that explains positive growth applies for downsizing. Since this latter process has been shown to be quantitatively as relevant as the former in the last fifteen years both in Europe and the U.S. (Bravo-Biosca, 2011), it is worth understanding to what extent this assumption holds in the data. The second one is the attempt to identify empirically the causes of this relationship: what is behind the role of firm age in firm growth?

This paper provides new insights for these aspects, uncovering new evidence for a sample of French, Italian and Spanish manufacturing firms with more than 10 employees in the period from 2001 to 2008 and taken from an original cross-country database, which is the result of the merge of Bureau Van Dijk's Amadeus with the EFIGE survey. Adopting a quantile regression approach, we analyze the effect of age on firm growth along the entire growth rates distribution, investigating if upsizing and downsizing firms follow different behavioral models.

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. These results generalize to three of the largest EU countries, results previously obtained on individual countries (Serrasquiero et al., 2010, in a sample of Portuguese firms; Reichstein et al., 2010, for Danish manufacturing firms; Segarra et al., 2013 in a panel of Spanish manufacturing

[25] For example, in 2012 *The Economist* published several articles on the role played by young and fast-growing firms for growth and job-creation in modern economies.

firms). In other words, older firms are less likely to grow fast, but they have the same probability of a significant shrinking than their younger counterparts;

- economic and financial factors, such as labor productivity, capital intensity and access to finance, together with other firm characteristics, such as the age of the CEO, and the qualification of the labor force are important factors explaining firm growth. In particular, the correlation between these firm characteristics is higher in the highest quintiles (i.e. among the fast-growing firms);
- controlling for such firm characteristics, lowers the effect of firm age, which nonetheless retains significant explanatory power;
- the sign and magnitude of the effect of age on firm growth is stable across the three EU countries considered in the analysis, despite non-negligible cross-country differences in the age structure of firms, as well in a number of other firm characteristics.

Different explanations may be consistent with these results. First, the negative relationship between firm age and *positive* firm growth suggests that growth may in part derive from a 'learning' process (Jovanovic, 1982). As time passes, young and inexperienced firms, learn about their 'type' and this reduces the variance in growth rates. Second, the reduction in the coefficient of age upon controlling for other firm characteristics suggests that part of the explanatory power traditionally attributed to age, actually, is due to some peculiar attributes of young- (and fast-) growing firms, such as the higher exposure towards lenders and the age of the CEO, both of which may reveal an attitude towards growth.

Finally, it is worth mentioning that the nature of the data calls for a few words of caution when interpreting our results. First, our analysis of the relationship between age and firm growth is *conditional on firm survival*. This induces some sample selection bias, which may inflate our estimates. Second, our sample includes only firms with more than 10 employees. By focusing on the relatively larger (and probably older) firms we may miss part of the story among the small and fast-growing firms. Third, some of our explanatory variables, such as the age of the CEO, refer to the last year in the database (i.e. 2008) and, consequently, their coefficients cannot be interpreted as causal relationships with (previous) firm growth. However, we believe it is instructive to illuminate on how these characteristics are systematically associated to firms' growth or shrinking patterns.

Bearing in mind those limitations, our results suggest that: (a.) young firms are key to achieve the job creation that comes from firm growth; (b.) fast-growing firms are confirmed to be more productive and have better access to credit; (c.) fast-growing firms are also managed by younger CEOs. Thus, one may lay out some implications for economic policy. In particular, policies should be directed towards (i) increasing firm productivity, also through the elimination of barriers to entrepreneurship, and anti-competitive product market regulation, (ii) ensuring the effectiveness of markets for venture capital and finance for firm growth, (iii) fostering a generational change in firm management.

Table 1: Growth rates at different percentiles, by country

	France	Italy	Spain	Total
Percentile	**1 year growth rates**			
p5	-0.182	-0.302	-0.248	-0.243
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
p95	0.223	0.325	0.405	0.336
Observations	10,750	12,293	15,763	38,806
Percentile	**Average growth rates (2001-2008)**			
p5	-0.084	-0.099	-0.079	-0.088
p10	-0.064	-0.076	-0.055	-0.064
p25	-0.029	-0.044	-0.020	-0.030
p50 (median)	0.000	-0.007	0.012	0.000
p75	0.029	0.039	0.060	0.043
p90	0.081	0.099	0.121	0.101
p95	0.126	0.147	0.181	0.150
Observations	1,416	1,534	1,678	4,628

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

Age class	**France**	**Italy**	**Spain**
Age: $0-10$	22.48	26.19	34.42
Age: $11-20$	24.26	24.28	29.29
Age: $21-max$	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

Table **3**: Descriptive statistics by age class and country; values either refer to the percentage of firms in the sample or to the median value

		Age: 0-10				**Age: 11-20**				**Age: 21-max**				**All age classes**			
Variable	Measure	France	Italy	Spain	**Total**	France	Italy	Spain	**Total**	France	Italy	Spain	**Total**	*France*	*Italy*	*Spain*	**Total**
Size (#employees)	Median value	20.00	18.00	18.00	**18.00**	23.00	22.00	22.00	**22.00**	33.00	29.00	26.00	**29.00**	28.00	25.00	23.00	**24.00**
Labor productivity	Median value	43.56	42.07	30.21	**37.29**	44.70	44.97	34.13	**40.45**	45.31	47.39	36.72	**43.60**	44.91	45.90	34.25	**41.60**
Capital-labor ratio	Median value	9.11	20.38	18.91	**16.06**	9.70	24.33	18.58	**16.37**	10.56	31.22	19.28	**18.19**	10.11	27.61	19.00	**17.26**
EBITDA margin	Median value	0.07	0.08	0.07	**0.07**	0.07	0.08	0.08	**0.08**	0.06	0.08	0.07	**0.07**	0.07	0.08	0.07	**0.07**
Labor cost x employee	Median value	34.80	26.86	22.08	**26.42**	35.15	27.63	24.04	**28.40**	36.33	30.39	26.89	**31.76**	35.80	28.46	24.73	**29.65**
ST debt over assets	Median value	0.59	0.66	0.54	**0.59**	0.51	0.59	0.47	**0.52**	0.49	0.53	0.43	**0.49**	0.51	0.57	0.47	**0.51**
LT debt over assets	Median value	0.00	0.00	0.15	**0.02**	0.00	0.00	0.10	**0.01**	0.00	0.00	0.07	**0.00**	0.00	0.00	0.10	**0.01**
Liquidity ratio	Median value	1.01	0.84	0.78	**0.86**	1.16	0.92	0.93	**1.00**	1.13	0.94	1.00	**1.03**	1.12	0.91	0.91	**0.98**
CEO < 45 years old (2008)	Share of firms	32,34%	29,08%	39,04%	**33,87%**	25,11%	17,71%	26,69%	**23,39%**	23,31%	14,50%	28,42%	**21,52%**	25,37%	18,43%	30,79%	**24,75%**
Product innovation (2008)	Share of firms	43,12%	45,29%	45,84%	**44,91%**	40,64%	47,91%	42,16%	**43,49%**	46,36%	51,57%	48,10%	**48,69%**	44,42%	49,35%	45,72%	**46,52%**
Process innovation (2008)	Share of firms	37,63%	45,62%	50,62%	**45,39%**	35,25%	44,57%	49,03%	**43,32%**	38,66%	44,44%	53,86%	**44,78%**	37,67%	44,73%	51,55%	**44,54%**
Graduate workers (2008)	Median value	5,26%	3,33%	8,42%	**6,25%**	5,66%	4,35%	7,14%	**5,88%**	5,00%	4,35%	8,00%	**5,56%**	5,13%	4,17%	7,86%	**5,88%**
Employees in R&D activities (2008)	Median value	2,16%	0,00%	5,00%	**3,03%**	2,89%	2,22%	3,85%	**3,23%**	3,03%	2,50%	3,57%	**3,03%**	2,86%	2,04%	4,00%	**3,13%**

Table 4: The relation between age and growth in the overall sample and by country; linear model; one-year and average growth rates specification

Dependent variable	*One-year growth rates (x=1)*				*Average growth rates (x=7)*			
	A1				A2			
	Sample	FRA	ITA	SPA	Sample	FRA	ITA	SPA
Age_{t-x} (log)	-0.022***	-0.018***	-0.014***	-0.030***	-0.015***	-0.007***	-0.017***	-0.019***
	(0.002)	(0.002)	(0.004)	(0.003)	(0.001)	(0.002)	(0.003)	(0.002)
$Size_{t-x}$ (log)	-0.055***	-0.025***	-0.067***	-0.072***	-0.028***	-0.020***	-0.029***	-0.035***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)	(0.002)
Constant	0.305***	0.202***	0.315***	0.381***	0.154***	0.121***	0.156***	0.196***
	(0.009)	(0.011)	(0.018)	(0.013)	(0.006)	(0.011)	(0.011)	(0.009)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	-	-	-	-
Country FE	Yes	-	-	-	Yes	-	-	-
Observations	38,423	10,668	12,184	15,571	4,542	1,391	1,506	1,645
R^2 (adjusted)	0.053	0.040	0.054	0.074	0.188	0.119	0.171	0.241

Significance at ***1%, **5%, *10%.

Table 5: The relation between age and growth in the overall sample and by country; model with interaction-dummies; one-year growth rates specification

Dependent variable	*One-year growth rates (x=1)*							
	B							
	Sample		France		Italy		Spain	
	Down	Up	Down	Up	Down	Up	Down	Up
Age_{t-x} (log)	0.020***	-0.049***	0.008***	-0.030***	0.022***	-0.037***	0.021***	-0.059***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.006)	(0.007)	(0.005)	(0.005)
$Size_{t-x}$ (log)	0.006***	-0.064***	0.016***	-0.042***	-0.024***	-0.038***	0.011***	-0.090***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.005)	(0.006)	(0.004)	(0.005)
Constant	-0.223***	0.621***	-0.166***	0.432***	-0.160***	0.531***	-0.258***	0.747***
	(0.012)	(0.012)	(0.014)	(0.015)	(0.025)	(0.026)	(0.019)	(0.021)
Sector FE	Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes	
Country FE	Yes		-		-		-	
Observations	38,423		10,668		12,184		15,571	
R^2 (adjusted)	0.232		0.262		0.213		0.261	
Chow-test – H_0: $\rho_1 = \rho_2 = 0$ (interaction dummies not significant)								
F- statistics	506.23		165.88		47.26		284.44	
Critical value (5%)	2.99		2.99		2.99		2.99	

Significance at ***1%, **5%, *10%.

Table 6: Quantile regressions: the effect of age and size; overall sample and by country

Dependent variable				*One-year growth rates (x=1)*			
				Sample			
	q05	**q10**	**q25**	**q50**	**q75**	**q90**	**q95**
Age_{t-x} (log)	0.014***	0.001	-0.008***	-0.007***	-0.033***	-0.056***	-0.073***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)
$Size_{t-x}$ (log)	-0.028***	-0.013***	-0.009***	-0.004***	-0.021***	-0.037***	-0.054***
	(0.005)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Constant	-0.197***	-0.094***	0.037***	0.053***	0.290***	0.540***	0.754***
	(0.020)	(0.012)	(0.004)	(0.009)	(0.006)	(0.011)	(0.017)
Observations				38,423			
Pseudo R^2	0.033	0.018	0.009	0.001	0.043	0.076	0.094
				France			
	q05	**q10**	**q25**	**q50**	**q75**	**q90**	**q95**
Age_{t-x} (log)	0.006	-0.001	-0.008***	-0.001*	-0.022***	-0.046***	-0.060***
	(0.005)	(0.003)	(0.001)	(0.001)	(0.002)	(0.003)	(0.006)
$Size_{t-x}$ (log)	0.005	0.002	-0.005***	-0.002**	-0.017***	-0.027***	-0.034***
	(0.004)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.004)
Constant	-0.191***	-0.094***	0.019*	0.011**	0.217***	0.447***	0.609***
	(0.030)	(0.015)	(0.009)	(0.005)	(0.011)	(0.019)	(0.031)
Observations				10,668			
Pseudo R^2	0.010	0.006	0.007	0.001	0.042	0.079	0.095
				Italy			
	q05	**q10**	**q25**	**q50**	**q75**	**q90**	**q95**
Age_{t-x} (log)	0.021***	0.007*	-0.007***	-0.014***	-0.031***	-0.048***	-0.059***
	(0.007)	(0.004)	(0.002)	(0.002)	(0.003)	(0.005)	(0.008)
$Size_{t-x}$ (log)	-0.039***	-0.013***	-0.005*	-0.005***	-0.020***	-0.036***	-0.056***
	(0.009)	(0.005)	(0.003)	(0.001)	(0.001)	(0.003)	(0.005)
Constant	-0.174***	-0.095***	0.027**	0.113***	0.300***	0.515***	0.709***
	(0.045)	(0.026)	(0.011)	(0.013)	(0.011)	(0.019)	(0.039)
Observations				12,184			
Pseudo R^2	0.097	0.087	0.044	0.013	0.039	0.061	0.070
				Spain			
	q05	**q10**	**q25**	**q50**	**q75**	**q90**	**q95**
Age_{t-x} (log)	0.020***	0.004	-0.009***	-0.017***	-0.042***	-0.076***	-0.097***
	(0.007)	(0.005)	(0.001)	(0.002)	(0.002)	(0.004)	(0.009)
$Size_{t-x}$ (log)	-0.041***	-0.021***	-0.014***	-0.008***	-0.028***	-0.051***	-0.077***
	(0.009)	(0.005)	(0.001)	(0.001)	(0.002)	(0.003)	(0.006)
Constant	-0.165***	-0.077***	0.051***	0.091***	0.338***	0.651***	0.949***
	(0.029)	(0.019)	(0.004)	(0.012)	(0.012)	(0.020)	(0.043)
Observations				15,571			
Pseudo R^2	0.019	0.013	0.017	0.003	0.048	0.083	0.105
Sector FE				Yes			
Year FE				Yes			
Country FE				Yes (only in the estimation over the entire sample)			

Bootstrapped standard errors (1,000 reps) are shown in parentheses.
Significance at ***1%, **5%, *10%.

Table 7: Quantile regressions: the effect of age and other firm characteristics at the beginning of the period; one-year growth rates

Dependent variable	*One-year growth rates (x=1)*						
	Sample						
	q05	q10	q25	q50	q75	q90	q95
Age $_{t-x}$ (log)	0.004	-0.003	-0.008***	-0.013***	-0.029***	-0.050***	-0.060***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)	(0.005)
Size $_{t-x}$ (log)	-0.017***	-0.013***	-0.010***	-0.010***	-0.025***	-0.043***	-0.062***
	(0.005)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)
Labor productivity $_{t-x}$ (log)	0.027**	0.026***	0.029***	0.031***	0.048***	0.075***	0.122***
	(0.014)	(0.009)	(0.004)	(0.003)	(0.005)	(0.009)	(0.014)
Capital-labor ratio $_{t-x}$ (log)	0.009***	0.008***	0.003***	0.002***	0.009***	0.017***	0.030***
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)
EBITDA marg $_{t-x}$	0.202***	0.163***	0.081***	0.028***	-0.012	-0.114**	-0.339***
	(0.045)	(0.027)	(0.014)	(0.010)	(0.020)	(0.049)	(0.074)
Labor cost x employee $_{t-x}$ (log)	0.113***	0.086***	0.034***	0.007*	0.021***	0.073***	0.118***
	(0.022)	(0.012)	(0.006)	(0.004)	(0.007)	(0.013)	(0.020)
ST debt over assets $_{t-x}$	-0.042**	-0.005	0.009**	0.022***	0.082***	0.139***	0.192***
	(0.020)	(0.010)	(0.004)	(0.004)	(0.007)	(0.012)	(0.024)
LT debt over assets $_{t-x}$	-0.037	-0.014	0.026***	0.038***	0.096***	0.193***	0.284***
	(0.028)	(0.015)	(0.009)	(0.006)	(0.011)	(0.023)	(0.034)
Liquidity ratio $_{t-x}$	-0.010**	-0.004**	-0.002*	-0.001	0.003*	0.004***	0.005*
	(0.005)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
Constant	-0.681***	-0.503***	-0.219***	-0.062***	-0.046***	-0.135***	-0.331***
	(0.052)	(0.024)	(0.014)	(0.008)	(0.013)	(0.034)	(0.063)
Sector FE				Yes			
Country FE				Yes			
Year FE				Yes			
Observations				34,996			
Pseudo R^2	0.065	0.047	0.027	0.011	0.064	0.113	0.156

Bootstrapped standard errors (1000 reps) are shown in parentheses.

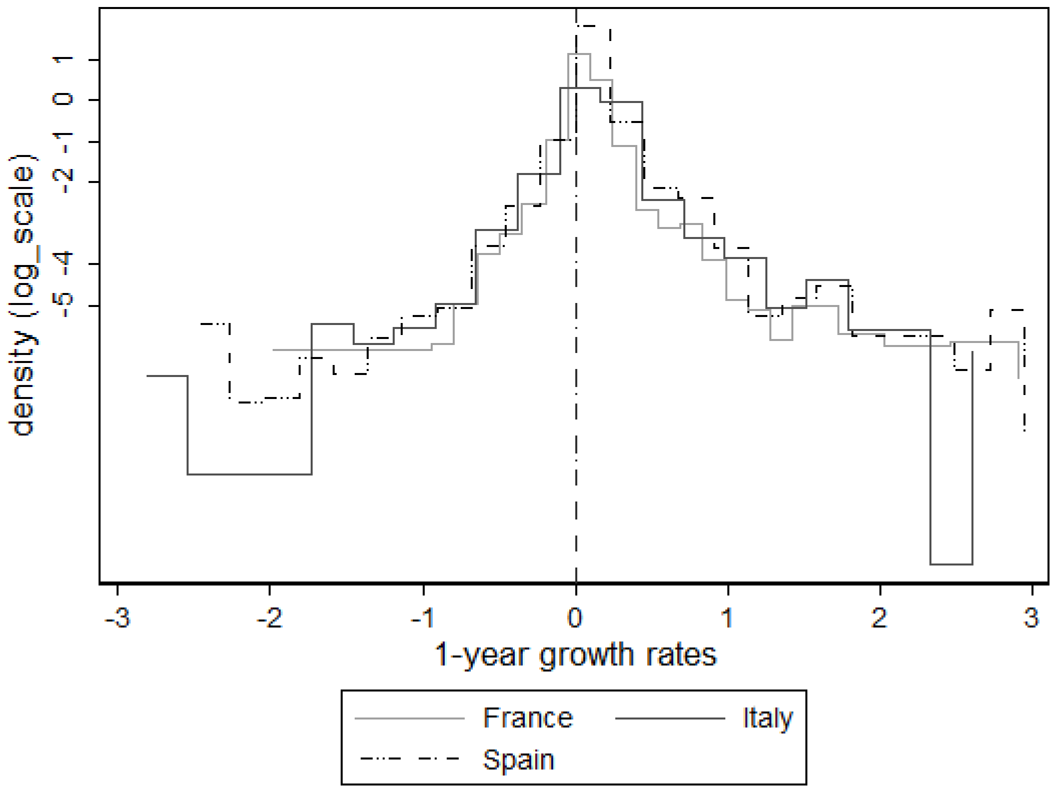
Significance at ***1%, **5%, *10%.

Table8: Quantile regressions: the effect of age and other firm characteristics (full vector of control variables); one-year growth rates

Dependent variable	*One-year growth rates (x=1)*						
	Sample						
	q05	q10	q25	q50	q75	q90	q95
Age $_{t\text{-}x}$ (log)	-0.001	-0.004	-0.009***	-0.013***	-0.028***	-0.046***	-0.059***
	(0.005)	(0.003)	(0.001)	(0.001)	(0.002)	(0.003)	(0.004)
Size $_{t\text{-}x}$ (log)	-0.026***	-0.017***	-0.017***	-0.020***	-0.043***	-0.069***	-0.098***
	(0.006)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)	(0.005)
Labor productivity $_{t\text{-}x}$ (log)	0.020	0.020*	0.030***	0.027***	0.036***	0.055***	0.076***
	(0.014)	(0.011)	(0.004)	(0.004)	(0.006)	(0.013)	(0.023)
Capital-labor ratio $_{t\text{-}x}$ (log)	0.009**	0.007***	0.002**	0.002***	0.010***	0.016***	0.028***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)
EBITDA marg $_{t\text{-}x}$	0.215***	0.166***	0.074***	0.040***	0.001	-0.097**	-0.223**
	(0.051)	(0.029)	(0.016)	(0.012)	(0.022)	(0.048)	(0.107)
Labor cost x employee $_{t\text{-}x}$ (log)	0.119***	0.090***	0.031***	0.007	0.012	0.051***	0.114***
	(0.022)	(0.014)	(0.006)	(0.005)	(0.009)	(0.019)	(0.033)
ST debt over assets $_{t\text{-}x}$	-0.042	-0.005	0.010**	0.022***	0.072***	0.103***	0.121***
	(0.030)	(0.014)	(0.004)	(0.005)	(0.008)	(0.012)	(0.026)
LT debt over assets $_{t\text{-}x}$	-0.023	-0.021	0.022**	0.030***	0.067***	0.124***	0.157***
	(0.033)	(0.018)	(0.011)	(0.008)	(0.012)	(0.025)	(0.041)
Liquidity ratio $_{t\text{-}x}$	-0.009	-0.003	-0.002	-0.001	0.002	0.003*	0.003
	(0.008)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)
CEO < 45 years old	-0.007	-0.004	0.001	0.003*	0.010***	0.014***	0.025**
	(0.007)	(0.004)	(0.002)	(0.002)	(0.002)	(0.005)	(0.011)
Graduate workers	0.012**	0.008***	0.007***	0.009***	0.016***	0.023***	0.036***
	(0.005)	(0.003)	(0.001)	(0.001)	(0.001)	(0.003)	(0.006)
Employees in R&D activities	-0.002	-0.003	0.002*	0.004***	0.008***	0.015***	0.022***
	(0.005)	(0.003)	(0.001)	(0.001)	(0.001)	(0.003)	(0.004)
Product innovation	0.006	0.008**	0.002	0.001	0.001	-0.003	-0.003
	(0.008)	(0.004)	(0.002)	(0.001)	(0.002)	(0.004)	(0.008)
Process innovation	0.016*	0.014***	0.007***	0.004***	0.003	0.003	-0.008
	(0.008)	(0.004)	(0.002)	(0.001)	(0.002)	(0.004)	(0.006)
Constant	-0.650***	-0.491***	-0.196***	-0.028**	0.060**	0.068	-0.027
	(0.067)	(0.033)	(0.017)	(0.014)	(0.024)	(0.047)	(0.080)
Sector FE				Yes			
Country FE				Yes			
Year FE				Yes			
Observations				27,169			
Pseudo R^2	0.071	0.053	0.031	0.015	0.073	0.121	0.162

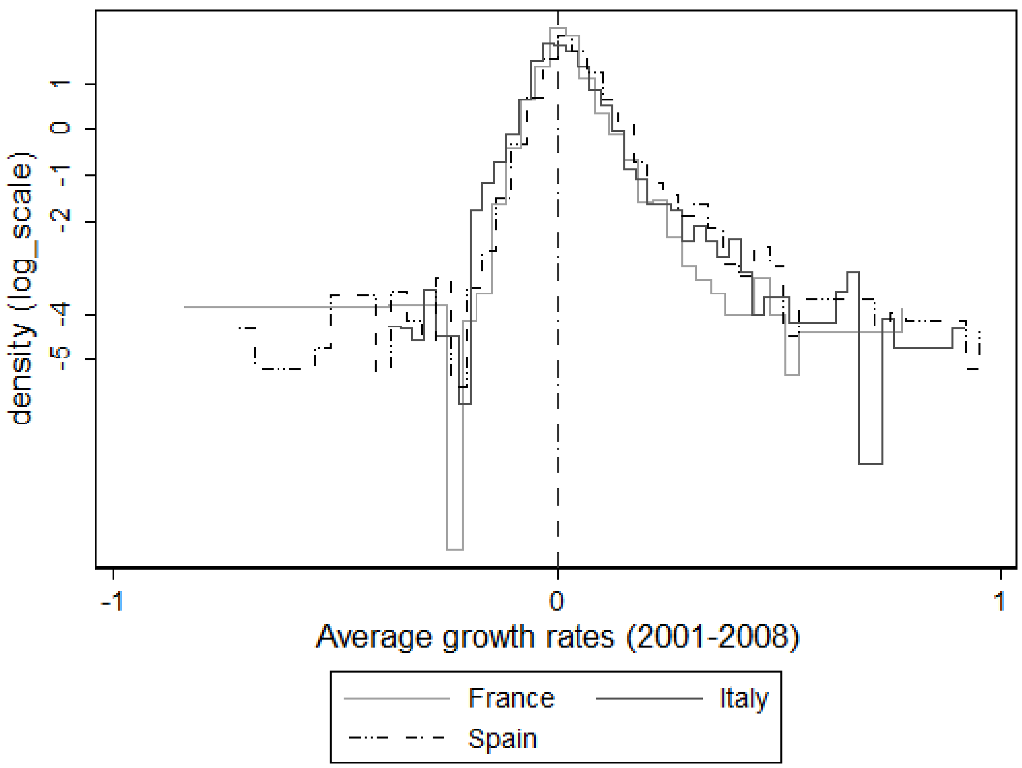
Bootstrapped standard errors (1000 reps) are shown in parentheses.
Significance at ***1%, **5%, *10%.

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



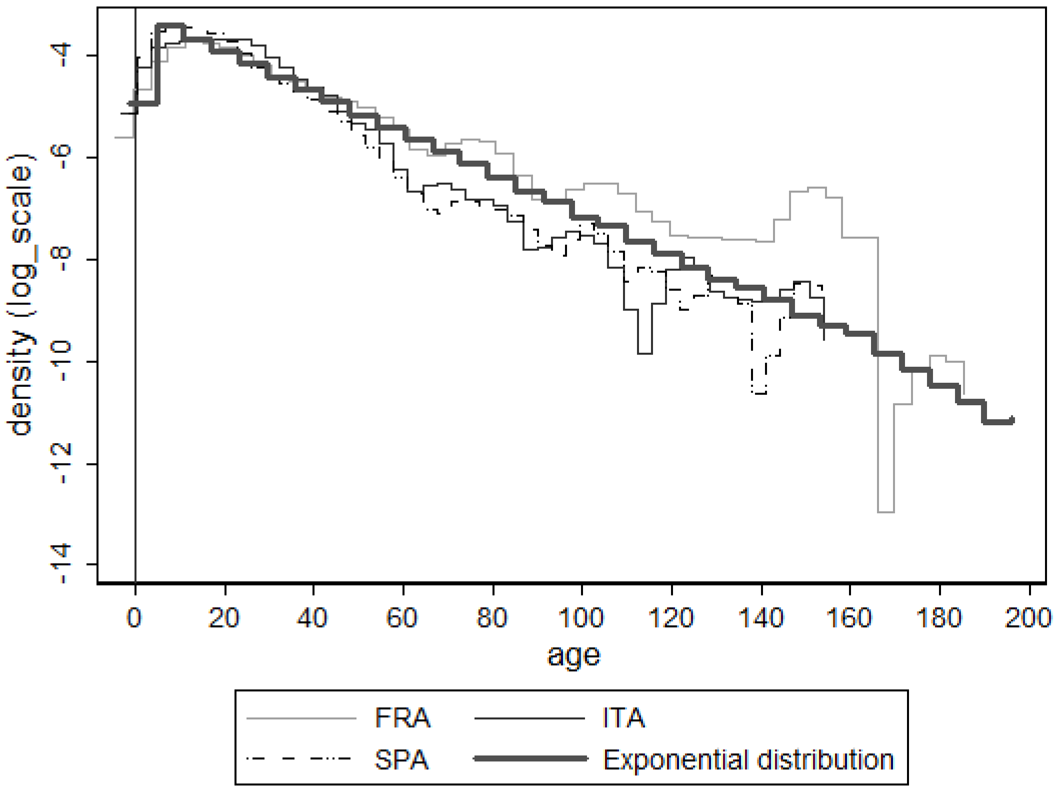
Note: The y-axis is on log-scale, and the Kernel density has been fitted using an Epanechnikov kernel

Figure 1(b): distribution of average (2001-2008) employment growth rates



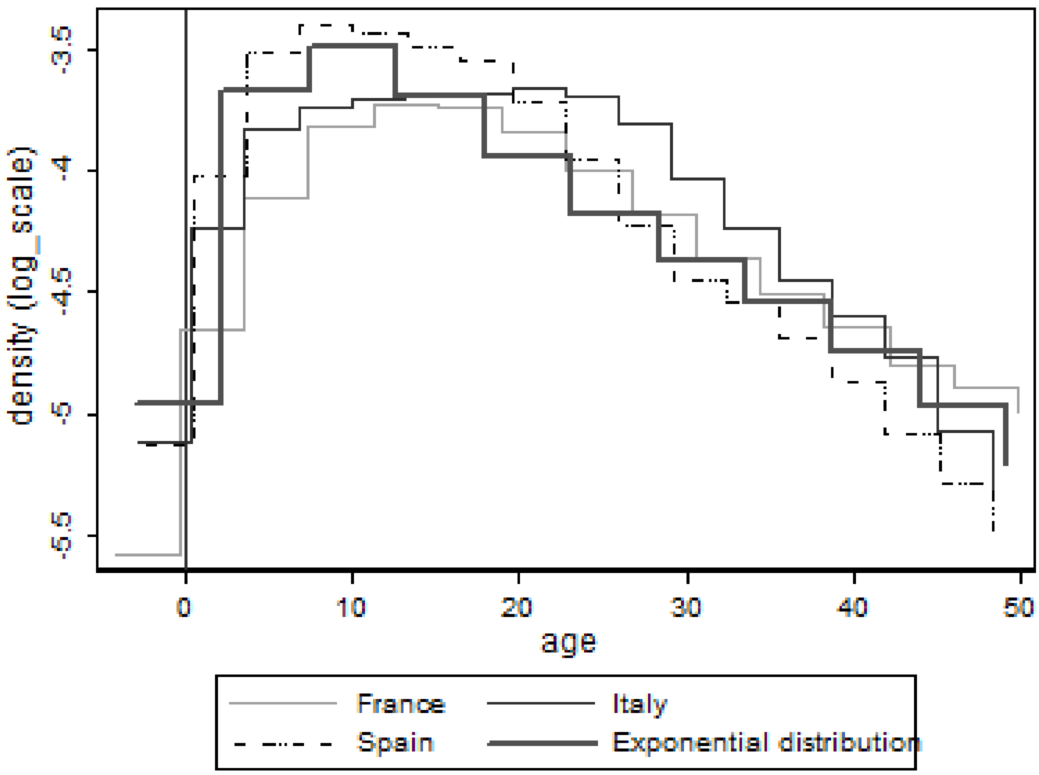
Note: The y-axis is on log-scale, and the Kernel density has been fitted using an Epanechnikov kernel

Figure 2(a): The age distribution in 2001, by country



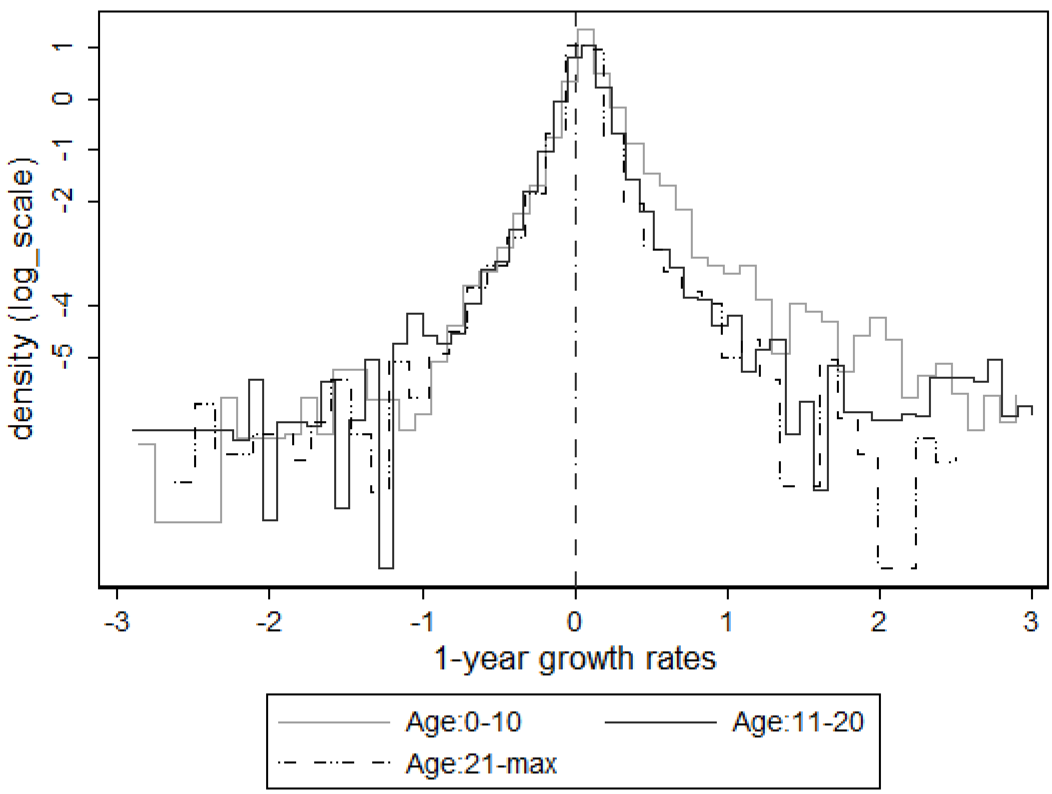
Note: The y-axis is on log-scale, and the Kernel density has been fitted using an Epanechnikov kernel; the theoretical exponential distribution refers to 500,000 draws generated with the pseudorandom number generator in Stata 12 environment

Figure 2(b): The age distribution in 2001, by country; range: 0-50 years



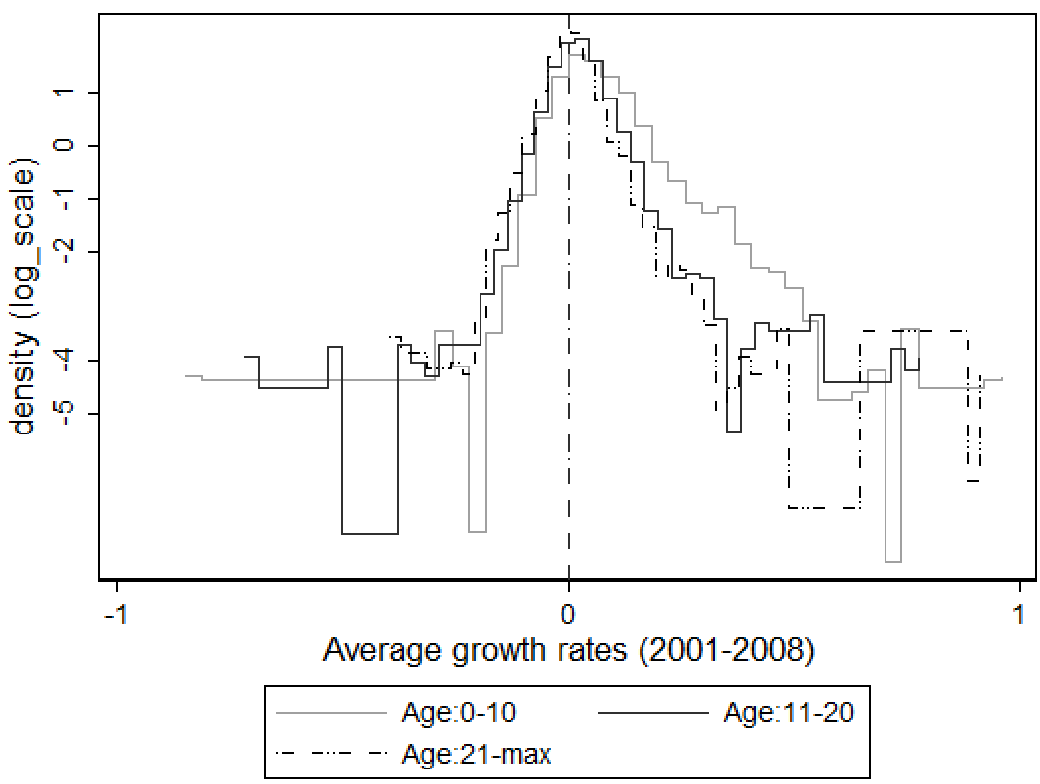
Note: The y-axis is on log-scale, and the Kernel density has been fitted using an Epanechnikov kernel; the theoretical exponential distribution refers to 500,000 draws generated with the pseudorandom number generator in Stata 12 environment

Figure 3(a): distribution of one-year employment growth rates, by age classes



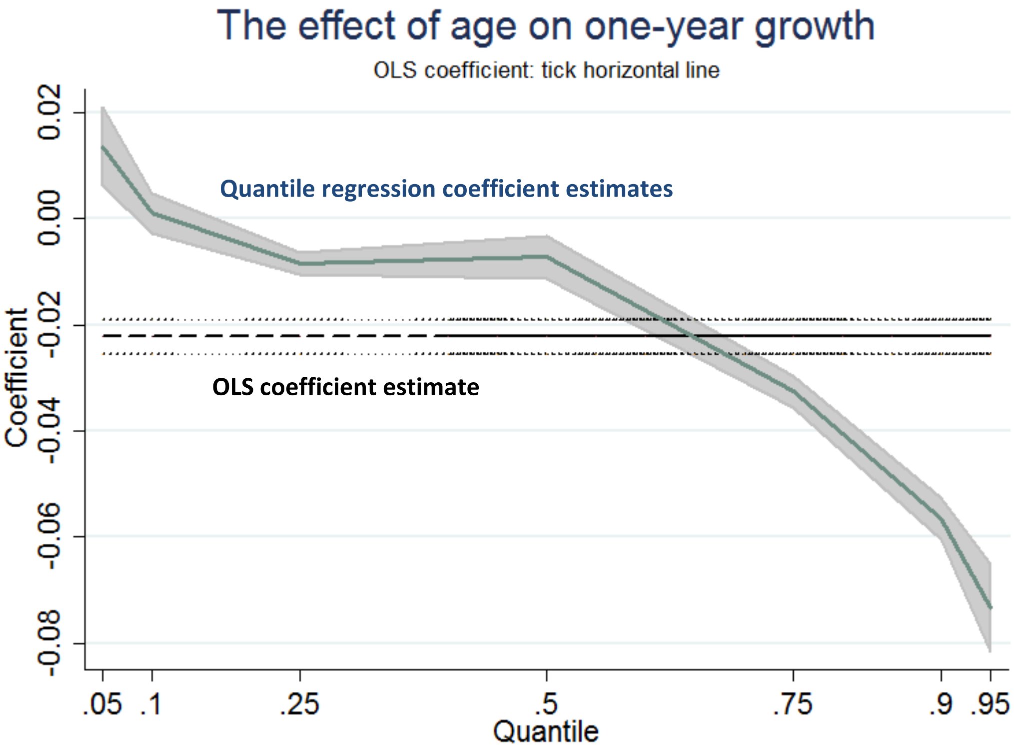
Note: The y-axis is on log-scale, and the Kernel density has been fitted using an Epanechnikov kernel

Figure 3(b): distribution of average (2001-2008) 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

Figure 4: The effect of age on one-year growth rates at different percentiles of the conditional growth distribution



A. Data Appendix

A1 – Definition of explanatory variables

Table A1 – Variables included in the analysis: definitions

Variable	Definition	Unit
Firm age	Number of years since the firm establishment	Absolute value
Firm size	# employees $_t$	Absolute value
Firm growth	[ln (# employees $_t$)- ln (# employees $_{t-x}$)]/(t-t-x)	Variation
Labor productivity	Ratio of value added to the number of employees	Thousands of Euros /employees
Capital-labor ratio	Ratio of tangible fixed assets to the number of employees	Thousands of Euros /employees
EBITDA margin	Ratio of Ebitda to sales	Ratio
Labor cost x employee	Ratio of the total personnel cost to the number of employees	Thousands of Euros /employees
ST debt over assets	Short-term obligations, due within the present accounting year over total assets	Ratio
LT debt over assets	Long-term obligations (bonds payable and long-term lease obligations) not due within the present accounting year over total assets	Ratio
Liquidity ratio	Ratio of cash (or equivalents) to total assets	Ratio
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	Dummy variable which is 1 for firms which introduced a new product between 2007 and 2009	Dummy
Process innovation	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 in 2008	Share
Employees in R&D activities	Percentage of employees involved in R&D activities over the total number of employees in 2008	Share

A2 – Firms in the sample

Table A2: Frequencies in each age class, by country and year

	2001			2002			2003			2004		
Age class	France	Italy	Spain	France	Italy	Spain	France	Italy	Spain	France	Italy	Spain
Age: 0-10	618	728	899	597	721	890	569	690	840	540	656	804
Age:11-20	667	675	765	678	656	769	691	682	785	698	700	806
Age: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	France	Italy	Spain	France	Italy	Spain	France	Italy	Spain	France	Italy	Spain
Age: 0-10	518	641	747	475	607	676	450	550	588	410	500	516
Age:11-20	702	692	837	697	688	843	669	681	855	648	676	862
Age: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

From Table A2 is it possible to appreciate that, as time passes, a higher number of firms enter the sample under analysis, in each country. Table A3 shows that the sample of firms which are observable both in 2001 and in 2008 are significantly older than those considered in the 1-year growth specifications (unbalanced panel): in other words, firms which have entered the sample in the years following 2001 are younger than those staying in the database for the entire period of time. This may explain the strongest negative relationship between age and growth that is found in the one-year specification, captured by a set of largest coefficients in the left panel of Table 4.

Table A3: Selected percentiles of the distribution of age, size and growth rates in the sample of firms used to estimate the one-year (top panel) and average growth (bottom panel) regressions

Firms included in the one-year sample	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**N**
Age	5	7	13	23	37	57	79	38,423
Size (# employees)	10	12	16	25	46	117	272	38,423
One-year growth rates	-0.241	-0.147	-0.052	0	0.080	0.197	0.318	38,423

Firms included in the average growth sample	**p5**	**p10**	**p25**	**p50**	**p75**	**p90**	**p95**	**N**
Age	10	12	18	27	41	61	84	4,542
Size (# employees)	10	12	16	25	47	123	278	4,542
Average growth rates	-0.087	-0.064	-0.030	0	0.041	0.100	0.142	4,542

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