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Does Gibrat's Law hold among young, small firms?*

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Abstract. According to Gibrat's Law of Proportionate Effect, the growth rate of a given firm is independent of its size at the beginning of the examined period. Aimed at extending this line of investigation, the present paper uses quantile regression techniques to test whether Gibrat's Law holds for new entrants in a given industry: that is for new small firms in the early stage of their life cycle. The main finding is that for some selected industries in Italian manufacturing Gibrat's Law fails to hold in the years immediately following start-up, when smaller firms have to rush in order to achieve a size large enough to enhance their likelihood of survival. Conversely, in subsequent years the patterns of growth of new smaller firms do not differ significantly from those of larger entrants, and the Law therefore cannot be rejected.

Key words: Industrial dynamics – Young firms – Small firms – Gibrat's Law – Quantile regression

JEL Classification: L11, L60

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1 Introduction

A commonly accepted interpretation of the Law of Proportionate Effect identified by Robert Gibrat (1931) is that the growth rate of a given firm is independent of its size at the beginning of the period examined. In other words, "the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry – regardless of their size at the beginning of the period" (Mansfield, 1962, p. 1031).

Gibrat's Law can be empirically tested in at least three different ways. Firstly, one can assume that it holds for all firms in a given industry, including those that have exited the industry during the period examined (setting the proportional growth rate of disappearing firms equal to minus one). Secondly, one can postulate that it holds only for firms that survive over the entire time period. If survival is not independent of firm's initial size – that is, if smaller firms are more likely to exit than their larger counterparts – the empirical test can be affected by a sample selection bias and estimates must take account of this possibility (this observation applies in particular to new and small firms, for which the hazard rate is generally high; see Sect. 3 below). Thirdly, one can state that Gibrat's Law only applies to firms large enough to have overcome the minimum efficient scale (MES) of a given industry [for instance, Simon and Bonini (1958) found that the Law was confirmed for the 500 largest U.S. industrial corporations].

This paper investigates whether Gibrat's Law holds for new entrants in the early stages of their life cycle. For each examined sector Gibrat's Law will be tested only *within* the subpopulation of new entrants, in order to assert whether: 1) the main result obtained by previous studies – i.e. that smaller firms grow faster than larger firms – still holds among *young*, small firms; 2) the alleged departure from Gibrat's Law over time is confirmed by the data or, conversely, a convergence towards a Gibrat-like pattern of growth occurs with the passage of time. The paper is organized as follows. Section 2 surveys the rich empirical literature on Gibrat's Law, with particular emphasis on the studies dealing with the post-entry performance of newborn firms; Section 3 presents the dataset and discusses some methodological issues related to estimation of Gibrat's Law; while Section 4 conducts a within-industry longitudinal investigation of the second version of Gibrat's Law. Finally, Section 5 summarizes the main results obtained in the present study.

2 Previous empirical tests of Gibrat's Law

While early studies tended to confirm Gibrat's Law (Hart and Prais, 1956; Simon and Bonini, 1958; Hymer and Pashigian, 1962), subsequent research began to question its overall validity. In this respect, the contribution by Edwin Mansfield (1962) is a point of departure for empirical analyses of industry dynamics[1].

Mansfield (1962) investigated three industries (steel, petroleum, tires) in different time periods between 1916 and 1957. The specification used by Mansfield relates

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[1] For theoretical speculations on the Law, see Cabral (1995), McCloughan (1995), Sutton (1997) and Geroski (1999).

the logarithm of final size (measured in terms of capacity in steel and petroleum and in terms of employment in tires) to the logarithm of initial size and investigates whether the coefficient is equal to one (in which case Gibrat's Law is confirmed, while an estimated coefficient less than one implies that smaller firms grow more than their larger counterparts. As far as the first version of the Law of Proportionate Effect is concerned, Mansfield found that it failed to hold in seven cases out of ten, while the second version was rejected in four of his ten samples. As correctly pointed out by Sutton (1997, p.44), Mansfield was aware that the rejection of the Law may be a consequence of the fact that smaller firms are more likely to die; if this is the case, both versions of the Law may be incorrectly specified. In particular, the second version of the Law has its main point of weakness in not having taken into account the distribution of growth rates that would result if all firms survive.

Table 1 summarizes a selection of previous empirical studies that have dealt specifically with Gibrat's Law and found that small firms grow faster than their larger counterparts.

As far as previous Italian studies are concerned, Brusco, Giovannetti and Malagoli (1979), tested Gibrat's Law over the 1966–1977 period for about 1,250 small firms operating in the province of Modena (in the Emilia-Romagna region of Italy) and belonging to three manufacturing industries: ceramic tiles, metal working & mechanical, textiles. Using quarterly data on firms' employees, they adopted the same method as Mansfield (1962) by regressing the logarithm of final size on that of initial size. They found the Law held in most cases when all firms were included, but they obtained the opposite results when only surviving firms were included (a coefficient less than one, revealing that smaller surviving firms tended to grow faster than their larger counterparts).

The results obtained by Brusco, Giovannetti and Malagoli (1979) prompt the following important qualification: if one assumes the reasonable hypothesis that small firms with lower growth rates are more likely to die, estimates based on surviving firms are affected by a sample censoring which tends to magnify the impact of rapidly growing small firms. Thus, the rejection of the Law, and the conclusion that smaller firms tend to have growth rates higher than their larger counterparts, may be partly due to a sample selection bias. Most of the recent literature has been devoted to finding an econometric specification able to deal with this kind of problem.

In parallel to the crucial problem of sample selection, two more traditional econometric issues arise when one tries to test Gibrat's Law. The first concerns the heteroskedasticity which may occur when the Law is not confirmed (if small firms grow faster than their larger counterparts, the variance of growth should tend to decrease with size). The second one was first discussed in a seminal paper by Chesher (1979) and concerns the fact that, when there is serial correlation in growth rates, ordinary least squares (OLS) estimators are inconsistent "even though estimation proceeds using cross-sectional data" (ibidem, p. 404). The studies now discussed have dealt jointly with one or more of these econometric problems.

For instance, Kumar (1985) used data on 1,747 UK quoted firms in manufacturing and services over the period 1960–1976 to measure size in terms of net assets, physical assets, equity assets, employment and sales. Following Chesher

Table 1a Selected empirical studies on Gibrat's Law

Study	Methodology	Controls	Data	Results
Mansfield, 1962	Logarithmic specification	None	About 1,000 US firms in steel, petroleum and tires over 1916–1957.	Gibrat's law fails to hold in about 50% of cases: smaller firms grow faster.
Brusco, Giovannetti and Malagoli, 1979	Logarithmic specification	None	1,250 Italian firms in ceramics, mechanical and textiles over 1966–1977.	Gibrat's law fails to hold in most cases when only survived firms are included: smaller firms grow faster.
Kumar, 1985	Logarithmic specification	Persistence	1,747 UK quoted firms in manufact. and services over 1960–1976.	Smaller firms grow faster.
Hall, 1987	Growth rate regression	Sample selection, heteroskedasticity	1,778 US manufact. firms over 1972–1979 and 1976–1983 (only incumbents)	Smaller firms grow faster.
Evans, 1987a,b	Growth rate regression	Sample selection, heteroskedasticity	42,339 US manufacturing firms, subdivided in 100 sectors.	Smaller firms grow faster in 89 industries out of 100.
Contini and Revelli, 1989	Growth rate regression	Persistence	1,170 Italian firms over 1980–1986 (only incumbents).	Moderate evidence that smaller firms grow faster.
Dunne, Roberts and Samuelson, 1989	Growth rate regression with grouping procedure	None	219,754 US manufacturing plants over 1967–1982 (only entrants).	Smaller firms grow faster.
Wagner, 1992	Logarithmic specification	Persistence	About 7,000 West German manufact. plants over 1978–1989; (only incumbents).	Gibrat's law fails to hold, but no evidence that smaller firms grow faster.
Dunne and Hughes, 1994	Logarithmic specification	Sample selection, heteroskedasticity, persistence	2,149 UK companies over 1980–1985 (only incumbents).	Smaller firms grow faster.

Table 1b (continued)

Study	Methodology	Controls	Data	Results
Mata, 1994	Growth rate regression	Sample selection, heteroskedasticity	3,308 Portuguese manufacturing firms over 1983–1987 (only entrants).	Smaller firms grow faster.
Hart and Oulton, 1996	Logarithmic specification	Heteroskedasticity, persistence	87,109 UK companies over 1989–1993 (only incumbents).	Smaller firms grow faster.
Harhoff, Stahl and Woywode, 1998,	Growth rate regression	Sample selection, heteroskedasticity	10,902 West German firms over 1989–1994 (only incumbents).	Smaller firms grow faster.
Almus and Nerlinger, 2000	Logarithmic specification	Persistence	39,355 West German manufacturing firms over 1989–1996 (only entrants).	Smaller firms grow faster.
Heshmati, 2001	Growth rate regression	Sample selection, heteroskedasticity	5,913 Swedish firms with fewer than 10 employees over 1993–1998.	Results very sensitive with respect to the method of estimation.
Lotti, Santarelli and Vivarelli, 2001	Logarithmic specification	Sample selection, heteroskedasticity, persistence	129 micro-firms (<5 emp.) and 85 firms (>5) in the Italian Instruments industry over 1987–1993 (only entrants)	Initially, smaller firms grow faster. A few years after entry a Gibrat-like pattern of growth is detected.
Fotopoulos and Louri, 2001	Growth rate quantile regression	Sample selection, heteroskedasticity	2,640 Greek manufacturing firms operating in both 1992 and 1997.	Firm size is found to have a negative effect on firm growth, particularly in the case of fast growing firms.
Becchetti and Trovato, 2002	Growth rate multivariate regression	Sample selection, heteroskedasticity	1144 firms with $<$ 50 employees, 1427 firms with $<$ 100 employees, and 462 firms with $>$ 100 employees in Italy.	Gibrat's Law is not rejected for large firms; rejected for small and medium sized firms under financial constraints.

(1979), Kumar controlled for persistence in growth and found weak evidence of serial correlation; he then tested a logarithmic specification of Gibrat's Law and found coefficients significantly less than unity, regardless of the measure adopted.

Bronwyn Hall (1987) studied 1,778 US manufacturing firms which had already reached a certain minimum size (measured in terms of employment) and belonged to two samples spanning the periods 1972–1979 and 1976–1983. Unlike Mansfield (1962), Hall directly regressed growth rates on the logarithm of the initial size and found that the observed negative relationship between size and growth was robust to corrections for both sample attrition and heteroskedasticity. The control for sample bias was carried out by means of a maximum likelihood estimation of the sample selection model, using a probit selection equation which related survival and initial size.

Evans (1987a) analyzed 100 4-digit manufacturing industries using firm level data drawn from the US Small Business Data Base (42,339 firms). The novel feature of this study was its introduction of age as a possible factor – in addition to size measured in terms of employment – in explaining departure from Gibrat's Law. Accordingly, Evans carried out separate estimates for firms six years old or younger and for firms seven years or older and he included age as an additional regressor in the econometric specification (similar to the one used by Hall, 1987). A negative relationship between growth and size was found in 89 per cent of the industries examined, while a negative relationship between growth and age was verified in the 76 per cent of the industries. Like the previous study, the estimation procedure controlled for sample selection bias and heteroskedasticity (both in Hall, 1987 and in this study heteroskedasticity was dealt with using White (1980)'s correction). Similar results were obtained in the companion study by Evans (1987b).

Evans's two studies suggested that the proportional rate of growth of a firm conditional on survival is decreasing both in size and age. Interestingly for the purposes of the present study, his results were confirmed by Contini and Revelli (1989) using data from a panel of manufacturing firms located in the Northern Italian region of Piedmont (although the departures from Gibrat's Law were considered "modest" by Contini and Revelli).

The joint influence of size and age on firms' growth patterns suggests that small and young firms must "rush" in order to survive in the market, whereas more established and larger firms tend to converge towards a Gibrat-like pattern of growth. In economic terms, young firms entering the market at a sub-optimal scale may experience decreasing average costs and enjoy rapid growth, while well-established mature firms can relax along a flattening average cost curve (see Acs and Audretsch, 1990; Audretsch, 1995). Differently from Evans (1987a,b), our study focuses only on young firms (less than 6 years old) and age will not be an additional regressor but rather a longitudinal dimension (see Sect. 3).

Dunne, Roberts and Samuelson (1989) confirmed the empirical patterns found in the studies discussed above: within each age category, growth rates decline along employment size classes, while within each size class, growth rates decline with increases in plant age. Dunne, Roberts and Samuelson obtained these results from data on 219,754 individual plants – rather than firms as in the previous studies – collected in five US censuses of manufactures (1963-67-72-77-82). Unlike Evans

(1987a,b) and Hall (1987), the authors did not use a standard sample selection model but preferred a grouping procedure which enabled them to represent 15 combinations of age and size classes by means of 15 dummy variables.

In contrast to the previous American studies, Wagner (1992) did not control for sample selection and heteroskedasticity but for autocorrelation in growth rates. Using data on around 7,000 manufacturing establishments in Lower Saxony over the period 1978–1989, he found that the validity of Gibrat's Law was rejected in most cases, but he did not come up with systematic evidence that small firms grow faster than larger ones. In contrast with Kumar (1985) and Dunne and Hughes (1994, see below), Wagner found a "persistence of change" (ibidem, p.129) whereby growth appeared to be an autocorrelated process (the presence of contrasting results on the possible persistence in firms' growth has been pointed out by Caves, 1998, pp. 1949–1950).

Another important contribution to investigation of Gibrat's Law has been made by Dunne and Hughes (1994), who used the original Mansfield-Chesher specification (see Sect. 3) and tested the Law of Proportionate Effect over the periods 1975–1980 and 1980–1985 using 2,149 quoted and unquoted UK companies belonging to 19 different manufacturing industries. After controlling for sample attrition and heteroskedasticity by means of standard procedures similar to those used by Hall (1987) and Evans (1987a,b), Dunne and Hughes found further confirmation that smaller companies tend to grow faster than larger ones; they also found that younger companies, for a given size, tended to grow faster than old ones. These results proved robust after controlling for autocorrelation in growth rates (very weak in this particular sample; see Dunne and Hughes, 1994, pp. 129–130).

José Mata (1994) studied the relationship between size – measured in terms of employment – and growth for 3,308 entrants into Portuguese manufacturing in 1983. Mata did not use the Mansfield-Chesher specification, but instead made direct estimates of growth depending on size. After controlling for sample attrition and heteroskedasticity in the usual ways (sample selection model and White's correction), he found an overall negative relationship between initial size and post-entry rate of growth. This result concerning newborn firms was consistent with previous studies on incumbent firms. Interestingly enough, over the post-entry period 1984–1987, the negative relationship between size and growth proved to be rather stable, with no indication of convergence towards a Gibrat-like pattern of growth.

More recently, Hart and Oulton (1996, 1999) have used data on 87,109 UK incumbent companies over the period 1989–1993 and tested the Chesher-Mansfield specification measuring size in terms of employment, sales and net assets. In all cases, they found both an overall estimated coefficient of less than one: on average, small firms grow more quickly than larger ones. Unlike most previous studies, Hart and Oulton (1996) did not control for sample selection.

An important recent contribution has been the paper by Harhoff, Stahl and Woywode (1998). Although the purpose of this study is not direct verification of Gibrat's Law, but rather examination of the relationship between firm's legal form and survival and growth, it introduces initial size (in terms of employment) and age in the growth equation as controlling variables. The estimates are based on data concerning 10,902 West German firms over the period 1989–1994. After controlling for sample attrition (Heckman's model) and heteroskedasticity (White's correction), the authors confirm previous results on the negative correlation between employment growth and firm's size and age.

Almus and Nerlinger (2000) focused their attention on firms younger than six years, using West German manufacturing data on start-ups in the period 1989-1996 (subdivided into five periods with the following number of observations: 1990–1992: 784 firms; 1991–1993: 1,420; 1992–1994: 2,831; 1993–1995: 3,495; 1994–1996: 4,278). The chosen logarithmic specification of Gibrat's Law is taken from Chesher (1979) and hence controls for autocorrelation, but not for heteroskedasticity and sample selection. Almus and Nerlinger find that the Law is rejected in all cases with the estimated parameters smaller than one, and except for two cases always significantly different from one; in addition, the deviation from Gibrat's Law decreased with increasing firm size.

Fotopoulos and Louri (2001) perform a non-parametric Kernel Density estimation, an Ordinary Least Squares estimation and a Quantile Regression in dealing with a sample of 2,640 Greek manufacturing firms that were active both in 1992 and 1997, in this way escaping the problem of firms exiting before the end of the period. Firm size and firm age are found to exert a definitely negative effect on growth, in particular in the case of fastest growing firms.

Controlling for various factors characterizing the sample firms, their capital structure, performance, human capital, and local labor market conditions, Heshmati (2001) shows that the relationship between the growth, size and age of firms is very sensitive with respect to the method of estimation, functional form and definition of growth and size. In a preliminary study on the post-entry performance of newborn firms in the instruments industry, Lotti, Santarelli and Vivarelli (2001) carry out separate estimates for micro-firms (having fewer than 5 employees) and larger firms, controlling for sample attrition (Heckman's two-step procedure), heteroskedasticity and autocorrelation. While in general Gibrat's Law is not confirmed, once attention is focused on firms' post-entry evolution a non-monotonic convergence toward a Gibrat-like pattern of growth is identified. Finally, Becchetti and Trovato (2002), investigating a sample of Italian firms in various industries, find that the hypothesis of independence of firm growth from the initial size is not rejected for larger firms with more than 100 employees, whereas Gibrat's Law does not hold in the case of smaller firms with less than 100 employees.

3 Data and methodology

3.1 Data

The main hindrance to empirical analysis of the post-entry performance of newborn firms has been the lack of longitudinal data sets tracking the evolution of firms subsequent to their birth. In this paper we use a unique data set from the Italian National Institute for Social Security (INPS). This data set identifies new manufacturing firms (with at least one paid employee) born in January 1987 and tracks their post-entry employment performance at monthly intervals until January 1993. No information on firms with zero paid employees is obtainable from the INPS file; however, these firms usually identify "solo self-employment" (as defined by Bögenhold, Fachinger and Leicht, 2001) which only occasionally becomes true entry with positive employment growth rates in the follow-up period. Thus, focusing on such firms is not particularly important for the purposes of this study.

All private Italian firms are obliged to pay social security contributions for their employees to INPS. Consequently, the registration of a new firm as "active" signals an entry into the market, while the cancellation of a firm denotes an exit from it (this happens when a firm finally stops paying national security contributions). For administrative reasons – delays in payment of the social security contributions, for instance, or uncertainty about the actual status of the firm – cancellation may sometimes be preceded by a period during which the firm is "suspended". The present paper considers these suspended firms as exiting from the market at the moment (month) of their transition from the status of "active" to that of "suspended", while firms which have halted operations only temporarily (for one or a few months) during the follow-up period, and which were "active" in January 1993, have been treated as survivors.

In addition to the procedure described above, the original INPS file was subjected to a further control, in order to identify entry and failure times correctly and to detect inconsistencies in individual tracks due to administrative factors, problems related to file truncation in January 1993, cancellations due to firm transfers, mergers and take-overs. This cleaning procedure reduced the total number of firms in the database from 1,889 to 1,570.

3.2 Econometric methodology

The central relationship tested in this study is the original logarithmic specification of Gibrat's Law:

$$\log S_{i,t} = \beta_0 + \beta_1 \log S_{i,t-1} + \varepsilon_{i,t} \; . \tag{1}$$

Following Chesher (1979, p.404), if both sides of equation (1) are exponentiated, it becomes clear that if β_1 is equal to unity, then growth rate and initial size are independently distributed[2] and Gibrat's Law is in operation. By contrast, if $\beta_1 < 1$ smaller firms grow at a systematically higher rate than do their larger counterparts, while the opposite is the case if $\beta_1 > 1$.

If – as in the majority of previous studies – growth and exit are not treated as homogeneous phenomena (that is assuming the disputable hypothesis that exit is equal to a minus one rate of growth), empirical estimates need to deal only with surviving firms, obtaining results conditional on survival (i.e. we have to deal with *conditional objects*). By using such a methodology, Audretsch et al. (1999) found that, for Italian manufacturing, the post-entry growth rates of *surviving firms* are negatively correlated with their start-up size.

In this paper we use the quantile regression as a suitable methodology to deal with *conditional objects* by hypothesizing the existence of an *unobserved* behavioral model. Normally, this leads to a deviation of the distribution of the error

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[2] Following a random walk (with drift) stochastic process.

terms from the canonical hypotheses of normality and homoskedasticity. In such a framework, the quantile regression (QR) represents a robust alternative to the least squares estimation: it consists in a Least Absolute Deviation estimator (LAD) that fits the median to a linear function of the covariates. In this way, the estimates are robust for all the deviations from the normality of the error terms and especially for the presence of outliers. This methodology defines the conditional quantiles as a minimization problem of a non differentiable function in β that can be easily solved by linear programming (Buchinsky, 1995). The point of departure is the definition of the sample quantiles, which is extended then to a linear model (Koenker and Bassett, 1978).

The θ^{th} sample quantile, with $0 < \theta < 1$, is defined as the:

$$\min_{b \in R} \left[\sum_{i \in \{i: y_i \geq b\}} \theta \left| y_i - b \right| + \sum_{i \in \{i: y_i < b\}} (1 - \theta) \left| y_i - b \right| \right] . \tag{2}$$

Dealing with the simple linear model $y_i = \beta' x_i + \varepsilon_i$, the θ^{th} regression quantile is defined as the solution to an analogous minimization problem as the one reported in equation (2).

$$\min_{b \in R^k} \left[\sum_{i \in \{i: y_i \geq x_i b\}} \theta \left| y_i - x_i b \right| + \sum_{i \in \{i: y_i < x_i b\}} (1 - \theta) \left| y_i - x_i b \right| \right] . \tag{3}$$

Solving for b we have a robust estimate of β. To avoid any further restrictions about the distribution of the error terms, we use a *bootstrapping* technique to estimate the covariance matrix (Efron, 1979).

Finally, since the possible occurrence of persistence in firms' patterns of growth represents in turn a violation of the Law of Proportionate Effect, we tested for this possibility by using annual growth rates (as in Kumar, 1985 and Dunne and Hughes, 1994): in the vast majority of cases no significant AR(1) process emerged, so that specification (1) was not extended (see Table A2 in the Appendix).

The application of the econometric methodology described in the present section to the dataset described in Section 3.1 above in the empirical test of equation (1) should shed some light on the following two questions:

$a)$ Is the overall inverse relationship between size and growth – found by most of the studies discussed in the previous section – confirmed during the infancy of newborn firms (that is within the subpopulation of new entrants)?

$b)$ Is there a convergence towards a Gibrat-like pattern of growth with the passage of time?

Whereas positive answer to the first question would provide support to the results obtained by Audretsch et al. (1999) in relation to surviving firms only, positive answer to the second one would shed new light on the selection and adjustment mechanisms that characterize the early stages of the firm life cycle. In fact, if both hypotheses are supported by the data, one may argue that Gibrat's Law exhibits a behavior strictly dependent on firm's life cycle: it fails to hold during the first years after start-up and becomes acceptable once a certain threshold in terms of size and age is reached.

Given the characteristics of the data base, which includes all firms born in January 1987 with at least one paid employee, and the specific features of the Italian industrial system (dominated by small firms), most firms in our sample showed a small start-up size, with micro-firms having less than 5 employees representing more than 50 per cent of the initial sample. Taking into account the cleaning procedures described in the first part of this section, and owing to problems of small sample size over time (until January 1993) for some industries, only six industries were examined (for a total of 855 firms born in January 1987, out of 1,570).

The descriptive statistics in Table 2 provide an overview of new firms' patterns of growth across the six industrial sectors selected.[3] Firstly, both the variation in the mean value and in the standard deviation of start-up size across industries are sufficiently large, with the average entry size ranging from 7 employees (rubber & plastics) to 14 (footwear & clothing). Secondly, at the end of the period (six years after start-up) the average size increases fourfold in the food industry, and doubles or nearly doubles in electrical & electronic engineering, footwear & clothing, and rubber & plastics, whereas it grows less markedly in the remaining industries: 57 per cent in instruments, 43 per cent in wood & furniture. As regards growth rates, one notes that, in all sectors, they are very high in the first year, but lower immediately after. Moreover, we observe a strong departure from normality of the logs of firms size (see the Kolmogorov – Smirnov normality test reported in Table 2) especially in the first years after start-up. These results suggest the presence of a discontinuity in new firms' patterns of growth along the early stages of their life cycle.

4 Results

We studied, for the overall period and year by year, the effects of firm size on growth at different quantiles ($\theta[0.10]$, $\theta[0.25]$, $\theta[0.50]$, $\theta[0.75]$, $\theta[0.90]$).[4] In Tables 3a and 3b we report the complete QR results from the estimation of equation (1) in relation to the median ($\theta[0.50]$) quantile only, whereas the sole values of β_1 found from the estimates on various quantiles are reported in Table A1 in the Appendix.[5] In particular, the first column of each panel of Tables 3a and 3b sets out the results from the estimations carried out for the entire six-year period (1987–1993), along with the usual statistical diagnostics, including a specific Wald test for the validity of Gibrat's Law ($\beta_1 = 1$; question (a) posed in the previous section) and sample sizes with and without exits.[6] In the following columns the same estimations are repeated for each year, in order to test the possible convergence path with the passage of time (question (b) posed in Sect. 3 above). Thus, 7 estimates are presented for the entire sample (all industries) and for each industry.

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[3] Of course, the observed patterns of both average sizes and growth rates depend on the combination between employment growth in surviving firms and the exit of the slow growing ones.

[4] We performed also OLS and sample selection estimates. Since the results are consistent with the reported QR ones, they have not been inserted in the paper but are available from the authors upon request.

[5] The regression diagnostics from these estimates are available from the authors upon request.

[6] Besides the Wald test, also unit root-like tests were carried out, with similar findings. Results from application of this procedure are available from the authors upon request.

Table 2a Average size, growth rate and corresponding standard deviations (S.D.): firms still alive at the end of each period

Industry		1987	1988	1989	1990	1991	1992	1993
Electrical & electronic engineering	Average size	12.40	15.41	19.84	20.89	22.23	23.64	23.42
	S.D. of average size	38.92	46.27	59.31	63.46	68.8	68.85	65.05
	Average growth rate	–	87.63	8.35	7.58	−7.27	−4.27	−7.29
	S.D. of growth rate	–	190.89	70.4	41.27	57.83	40.92	32.47
	Number of active firms	129	123	105	101	94	87	83
	Number of exiting firms	0	6	18	4	7	7	4
	Kolm.-Sm. normality test	0.198***	0.150***	0.118*	0.122**	0.116*	0.146**	0.156**
Instruments	Average size	12.17	12.96	15.84	18.86	19.6	21.01	19.17
	S.D. of average size	30.18	27.16	34.95	43.25	42.75	51.33	40.46
	Average growth rate	–	69.34	14.75	3.02	−14.57	−6.25	−5.99
	S.D. of growth rate	–	175.29	64.65	50.33	102.97	51.09	43.48
	Number of active firms	214	200	183	169	156	141	131
	Number of exiting firms	0	14	17	14	13	15	10
	Kolm.-Sm. normality test	0.249***	0.134***	0.130***	0.186***	0.180***	0.195***	0.162***

Table 2b (continued)

Industry		1987	1988	1989	1990	1991	1992	1993
Food	Average size	11.16	30.72	33.59	34.46	39.11	40.58	42.49
	S.D. of average size	21.16	182.61	181.55	163.19	173.1	172.54	160.91
	Average growth rate	–	47.28	35.19	2.04	−6.3	−4.98	−4.43
	S.D. of growth rate	–	211.17	217.96	54.32	51.12	51.05	49.25
	Number of active firms	81	64	58	54	47	43	39
	Number of exiting firms	0	17	6	4	7	4	4
	Kolm.-Sm. normality test	0.305***	0.273***	0.227***	0.285***	0.316***	0.341***	0.385***
Footwear & clothing	Average size	14.61	19.67	22.53	22.75	24.62	26.32	27.08
	S.D. of average size	34.62	38.43	41.87	45.24	49.19	50.75	52.18
	Average growth rate	–	109.26	8.26	−5.03	−40.5	−9.98	−8.58
	S.D. of growth rate	–	559.67	113.3	53.67	351.03	66.27	38.12
	Number of active firms	231	205	180	159	144	124	113
	Number of exiting firms	0	26	25	21	15	20	11
	Kolm.-Sm. normality test	0.228***	0.161***	0.160***	0.158***	0.177***	0.206***	0.213***

Table 2c (continued)

Industry		1987	1988	1989	1990	1991	1992	1993
Wood & furniture	Average size	11.51	15.71	16.55	17.15	15.04	15.42	16.46
	S.D. of average size	24.58	26.35	28.36	29.39	17.79	18.15	19.37
	Average growth rate	–	72.43	−1.68	0.08	−7.33	5.75	2.96
	S.D. of growth rate	–	189.9	43.75	55.97	52.89	74.83	30.75
	Number of active firms	115	100	91	81	78	72	70
	Number of exiting firms	0	15	9	10	3	6	2
	Kolm.-Sm. normality test	0.214***	0.115*	0.107	0.118	0.044	0.025	0.019
Rubber & plastics	Average size	7.23	10.38	12.46	13.72	14.57	14.54	15.17
	S.D. of Average size	9.58	12.38	12.35	14.21	16.19	16.94	18.01
	Average growth rate	–	104.76	43.88	4.07	−3.19	−2.12	2.36
	S.D. of growth rate	–	230.58	172.33	35.5	35.74	38.27	35.14
	Number of active firms	85	79	74	71	69	67	65
	Number of exiting firms	0	6	5	3	2	2	2
	Kolm.-Sm. normality test	0.162**	0.057	0.053	0.069	0.088	0.107	0.128

Let us first consider the results for the six-year period (1987–1993). In five out of six industries (with the exception of food) and in the aggregate estimate, the QR estimates of β_1, although significantly different from zero,[7] are significantly less than one.[8] This confirms that, in general, smaller firms grow faster than their larger counterparts over the entire period.

Even more interesting results are yielded by the separate estimations carried out for each year and each industry. In five industries out of six, Gibrat's Law fails to hold in the year immediately following start-up, whereas it holds, or fails less severely, when firms approach maturity. In all sectors (apart from food) only in the first year following start-up do the QR estimates yield a β_1 significantly less than one, while an almost monotonic convergence of β_1 towards one occurs in the subsequent years, with the Wald test never rejecting Gibrat's Law.[9]

As reported in Table A1 in the Appendix, equation (1) has been estimated also for the (θ[0.10], θ[0.25], θ[0.75], θ[0.90]) quantiles. Consistently with the results obtained from estimations on the median quantile, the β_1 coefficients show a convergence towards 1 with the passage of time (although they also show, not surprisingly, a wider dispersion from the convergence value – 1.000 – that is instead a focal point for the median quantile regression).

Thus, in the five industries for which Gibrat's Law is initially not confirmed, one finds that smaller entrants rush to achieve an acceptable size immediately after their start-ups, while once they reach (in subsequent years) a size large enough to enhance their likelihood of survival their pattern of behavior matches that of larger entrants.

The most significant exception is the food industry, where for the entire period and for each of the six years following start-up Gibrat's Law is never significantly rejected. This finding suggests that some industry-specific determinants of firm growth are in operation. The regularity over time in the patterns of post-entry growth by small and larger entrants in the food industry indicates that, more than strategic interdependence within submarkets, in this case it is independence across submarkets that may be involved (see Sutton, 1997, 1998).[10]

5 Conclusions

With the focus specifically on new entries, the main finding of this paper is that, in some selected industries in Italian manufacturing, Gibrat's Law of Proportionate Effect exhibits a behavior which depends on the life cycle of the firm. In effect,

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[7] Cf. the stars on the estimated coefficients β_1 reported in Tables 3a and 3b.

[8] Cf. the stars on the values of the Wald test for $\beta_1 = 1$.

[9] Moreover, we tested the stability of the estimated β_1 over time through a pooled regression with time dummies interacted with the log S_{t-1} variable. Results confirm that in the first period the estimated β_1 significantly differ from the remaining time intervals.

[10] In fact, seventeen out of eighty-one entrants (21%) are bakeries, which by definition operate in very small markets (neighbourhoods rather than municipal areas) which in most cases are characterized by the presence of a single firm. Thus, even new entrants with a very small start-up size are likely to operate at the MES level of output of their submarkets and do not need to rush for enhancing their likelihood of survival.

Table 3a Quantile regression (θ[0.50]) estimates: all industries with industry dummies, electrical & electronic engineering, instruments, food

		1987–1993	1987–1988	1988–1989	1989–1990	1990–1991	1991–1992	1992–1993
All industries	β_1	0.637***	0.810***	1.000***	1.000***	1.000***	1.000***	1.000***
		(0.034)	(0.021)	(0.015)	(0.004)	(0.001)	(0.001)	(0.001)
	β_0	1.246***	0.617***	0.000	0.000	0.000	0.000	0.000
		(0.108)	(0.077)	(0.040)	(0.027)	(0.010)	(0.009)	(0.019)
	Wald test $\beta_1 = 1$	110.78***	64.98**	0.00	0.00	0.00	0.00	0.00
	pseudo R^2	0.286	0.496	0.709	0.738	0.723	0.760	0.802
	N. obs.	855	855	771	691	635	588	534
	Censored	354	84	80	56	47	54	33
	Uncensored	501	771	691	635	588	534	501
Electrical & electronic engineering	β_1	0.602***	0.791***	0.925***	1.000***	1.016***	1.008***	0.999***
		(0.134)	(0.059)	(0.048)	(0.027)	(0.021)	(0.029)	(0.004)
	β_0	1.386***	0.693***	0.287***	0.000	−0.001	−0.013	0.001
		(0.223)	(0.145)	(0.109)	(0.091)	(0.061)	(0.063)	(0.015)
	Wald test $\beta_1 = 1$	8.78***	12.36***	2.37	0.00	0.57	0.08	0.03
	pseudo R^2	0.200	0.427	0.667	0.700	0.653	0.737	0.798
	N. obs.	129	129	123	105	101	94	87
	Censored	46	6	18	4	7	7	4
	Uncensored	83	123	105	101	94	87	83

*** = significant at 99% level of confidence; ** = significant at 95% level of confidence; * = significant at 90% level of confidence.

Table 3b (continued)

		1987–1993	1987–1988	1988–1989	1989–1990	1990–1991	1991–1992	1992–1993
Instruments	β_1	0.639***	0.769***	1.029***	1.014***	1.000***	1.000***	0.987***
		(0.062)	(0.056)	(0.033)	(0.08)	(0.003)	(0.002)	(0.015)
	β_0	1.098***	0.693***	0.001	−0.001	0.000	−0.001	0.014
		(0.151)	(0.131)	(0.102)	(0.005)	(0.002)	(0.002)	(0.020)
	Wald test $\beta_1 = 1$	34.03***	16.81***	0.77	2.67	0.00	0.00	0.75
	pseudo R^2	0.334	0.509	0.694	0.732	0.742	0.776	0.773
	N. obs.	214	214	200	183	169	156	141
	Censored	83	14	17	14	13	15	10
	Uncensored	131	200	183	169	156	141	131
Food	β_1	0.821***	1.000***	0.990***	1.000***	1.000***	1.000***	1.000***
		(0.197)	(0.095)	(0.667)	(0.017)	(0.027)	(0.011)	(0.008)
	β_0	0.693*	0.000	0.017	−0.001	−0.001	−0.0001	−0.001
		(0.373)	(0.245)	(0.201)	(0.020)	(0.048)	(0.022)	(0.006)
	Wald test $\beta_1 = 1$	0.82	0.00	0.02	0.00	0.00	0.00	0.00
	pseudo R^2	0.302	0.575	0.651	0.755	0.744	0.821	0.857
	N. obs.	81	81	64	58	54	47	43
	Censored	42	17	6	4	7	4	4
	Uncensored	39	64	58	54	47	43	39
Footwear & clothing	β_1	0.655***	0.811***	1.009***	1.000***	1.000***	1.000***	0.998***
		(0.071)	(0.030)	(0.028)	(0.001)	(0.019)	(0.006)	(0.006)
	β_0	1.226***	0.693***	0.001	−0.001	−0.001	−0.001	0.002
		(0.136)	(0.100)	(0.095)	(0.002)	(0.063)	(0.008)	(0.007)
	Wald test $\beta_1 = 1$	23.55***	38.57***	0.10	0.00	0.00	0.00	0.08
	pseudo R^2	0.308	0.498	0.762	0.733	0.727	0.760	0.838
	N. obs.	231	231	205	180	159	144	124
	Censored	118	26	25	21	15	20	11
	Uncensored	113	205	180	159	144	124	113

*** = significant at 99% level of confidence; ** = significant at 95% level of confidence; * = significant at 90% level of confidence.

Table 3c (continued)

		1987–1993	1987–1988	1988–1989	1989–1990	1990–1991	1991–1992	1992–1993
Wood & furniture	β_1	0.606***	0.807***	1.000***	1.000***	1.000***	0.990***	1.000***
		(0.103)	(0.045)	(0.007)	(0.031)	(0.013)	(0.048)	(0.004)
	β_0	1.239***	0.632***	−0.001	0.000	0.000	0.021	−0.001
		(0.248)	(0.102)	(0.012)	(0.114)	(0.033)	(0.154)	(0.014)
	Wald test $\beta_1 = 1$	14.77***	18.03***	0.00	0.00	0.00	0.04	0.00
	pseudo R^2	0.326	0.508	0.777	0.735	0.681	0.677	0.776
	N. obs.	115	115	100	91	81	78	72
	Censored	45	15	9	10	3	6	2
	Uncensored	70	100	91	81	78	72	70
Rubber & plastics	β_1	0.574***	0.737***	0.925***	1.017***	1.000***	1.000***	1.005***
		(0.093)	(0.045)	(0.075)	(0.013)	(0.006)	(0.008)	(0.021)
	β_0	1.371***	0.693***	0.289	−0.012	0.000	−0.001	−0.002
		(0.183)	(0.079)	(0.200)	(0.018)	(0.008)	(0.006)	(0.064)
	Wald test $\beta_1 = 1$	20.75***	32.85***	1.01	1.72	0.00	0.00	0.06
	pseudo R^2	0.169	0.353	0.587	0.778	0.760	0.743	0.760
	N. obs.	85	85	79	74	71	69	67
	Censored	20	6	5	3	2	2	2
	Uncensored	65	79	74	71	69	67	65

*** = significant at 99% level of confidence; ** = significant at 95% level of confidence; * = significant at 90% level of confidence.

for five out of six industries taken into account, we found that the Law fails to hold during the first year following start-up – when smaller entrants grow faster than their larger counterparts – whereas it becomes acceptable once a minimum threshold in terms of size and age has been reached.

In sum, the statistical regularities that emerged from the estimates carried out in Section 4 are such that both questions raised in Section 3 can be answered in the affirmative: not only is the overall inverse relationship between size and growth confirmed during the infancy of newborn firms in some industries, but these firms display a convergence towards a Gibrat-like pattern of growth with the passage of time. This means that – *within* the subpopulation of new entrants – smaller firms, which entered the market at a sub-optimal scale, have initially to rush in order to reach a size comparable to that of larger entrants, while subsequently they converge towards random growth rates (Gibrat-like). Of course, this evidence is not in contrast with a possible rejection of Gibrat's Law once incumbents are taken into account together with new entrants: in this case, the test is heavily influenced by the comparison *between* the patterns of growth of (smaller) new entrants and (larger) incumbents. An extension of the present analysis to the consideration of the comparison between the two subpopulations might be matter of further research.

From a theoretical viewpoint, these empirical findings appear to be consistent with the model put forward by Cabral (1995): entering the market implies capacity and technology costs which can involve some degree of sunkness. Newborn firms build only a fraction of their long-run capacity and technology in the first period after entry. In a Bayesian framework (Jovanovic, 1982; Pakes and Ericson, 1998), small new firms invest a lower fraction because they may have a lower efficiency and a higher expected probability of exit than their larger counterparts. In other words, small less efficient entrants are more likely to exit than are large entrants and so – since entry costs are sunk – it is optimal for them to invest more gradually and thus experience higher growth rates immediately after start-up.

Finally, our results also implicitly corroborate John Sutton's (1997, 1998) assumption that any industry, as conventionally defined in official statistics, usually contains several clusters of products, some of which compete closely whereas others do not compete at all. The combination of the interdependence and the independence effects determines the patterns of post-entry growth observed in each industry.

Appendix

Table A1 Quantile regression estimates ($\theta[0.10]$, $\theta[0.25]$, $\theta[0.50]$, $\theta[0.75]$, $\theta[0.90]$): β_1 values [a]

		1987–1993					1987–1988					1988–1989					1989–1990				
		$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$	$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$	$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$	$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$
All industries	β_1	0.792	0.738	0.637	0.570	0.564	0.896	0.977	0.810	0.683	0.646	1.041	0.988	*1.000*	0.879	0.885	1.123	0. *998*	*1.000*	0.940	0.898
Elec. & electron. eng.	β_1	0.774	0.699	0.602	0.556	0.657	0.884	*1.000*	0.791	0.746	0.734	*1.037*	*1.000*	*0.925*	0.847	0.859	*1.052*	*0.994*	*1.000*	0.940	0.872
Instruments	β_1	*0.827*	0.686	0.639	0.635	0.549	0.792	*0.982*	0.769	0.736	0.653	*1.064*	*1.000*	*1.029*	0.881	0.875	1.187	*1.044*	*1.014*	*0.936*	0.946
Food	β_1	*0.921*	*1.000*	*0.821*	*0.905*	*0.841*	*0.927*	*0.972*	*1.000*	*0.683*	*1.000*	*1.057*	*0.947*	*0.990*	0.802	*0.854*	*1.084*	*0.998*	*1.000*	*0.937*	*0.884*
Footwear & clothing	β_1	*0.837*	0.765	0.655	0.536	0.583	0.918	*0.977*	0.811	0.656	0.592	*1.035*	*0.987*	*1.009*	0.926	0.891	*1.015*	*0.967*	*1.000*	*0.942*	0.868
Wood & furniture	β_1	0.720	0.656	0.606	0.444	0.383	*0.954*	1.000	0.807	0.665	0.596	*0.890*	*0.966*	*1.000*	*0.991*	*0.939*	*1.131*	*0.998*	*1.000*	0.920	0.881
Rubber & plastics	β_1	0.600	0.671	0.574	0.522	0.480	*0.817*	*0.929*	0.737	0.602	0.562	*1.055*	*1.000*	*0.925*	0.840	0.672	1.196	*1.000*	*1.017*	*1.081*	*0.954*
		1990–1991					1991–1992					1992–1993									
		$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$	$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$	$\theta[0.10]$	$\theta[0.25]$	$\theta[0.50]$	$\theta[0.75]$	$\theta[0.90]$					
All industries	β_1	1.033	*0.970*	*1.000*	0.950	0.901	1.057	*1.011*	*1.000*	*0.975*	0.922	1.064	0.972	*1.000*	*0.999*	0.916					
Elec. & electron. eng.	β_1	*1.008*	*1.046*	*1.016*	*0.957*	0.921	*1.121*	*1.037*	*1.008*	*0.975*	*0.936*	*1.111*	*1.038*	*0.999*	*1.000*	*0.951*					
Instruments	β_1	*1.084*	*0.960*	*1.000*	*0.959*	0.900	*1.054*	*0.967*	*1.000*	*1.030*	*0.922*	*0.990*	0.942	*0.987*	*0.954*	0.895					
Food	β_1	*1.107*	*1.020*	*1.000*	*0.950*	*0.917*	*1.101*	*1.009*	*1.000*	*1.015*	*0.915*	*1.090*	*0.983*	*1.000*	*1.042*	*1.000*					
Footwear & clothing	β_1	*0.961*	*0.960*	*1.000*	*0.930*	0.895	*1.030*	*1.000*	*1.000*	*0.979*	*0.956*	*1.047*	*0.970*	*0.998*	*0.985*	*0.940*					
Wood & furniture	β_1	*1.033*	*0.972*	*1.000*	*0.907*	*0.839*	*0.961*	*1.011*	*0.990*	*0.871*	*0.783*	1.111	*1.023*	*1.000*	*0.945*	*0.933*					
Rubber & plastics	β_1	*1.023*	*1.071*	*1.000*	*1.009*	*0.853*	*1.160*	*1.035*	*1.000*	*1.019*	*0.945*	*1.064*	*0.988*	*1.005*	*0.937*	0.873					

[a] All estimates are significantly different from zero at a 0.001 confidence level. Figures are reported in italics when not significantly different from unity (Wald test).

Table A2 Persistence in firms' patterns of growth

$$G_{i,t} = \alpha_0 \alpha_1 G_{i,t-1} + \eta_t \sim AR(1)$$

where G_t is the growth rate of firm i at time t

Electrical & electronic engineering

	1987–1993	1989	1990	1991	1992	1993
α_0	−0.02	0.31***	0.13***	0.08*	0.05	−0.02
α_1	0.00	−0.03	−0.04	0.02	−0.15	−0.07
F	0.00	1.04	0.56	0.03	2.08	0.56
R^2 adj.	−0.01	0.00	−0.01	−0.01	0.01	−0.01
White[a]	0.30	1.59	0.06	1.72	1.45	1.84

Instruments

	1987–1993	1989	1990	1991	1992	1993
α_0	0.01	0.24***	0.14***	0.16*	0.04	0.00
α_1	0.00	0.02	−0.08	−0.48*	−0.04	0.00
F	0.00	0.69	1.51	11.99***	0.73	0.00
R^2 adj.	−0.01	0.00	0.00	0.07	0.00	−0.01
White[a]	1.36	3.44**	0.90	5.70***	1.59	0.52

Food

	1987–1993	1989	1990	1991	1992	1993
α_0	−0.04	0.47	0.07	0.30	0.03	0.01
α_1	0.03**	0.04	0.05*	-0.52	0.01	-0.13
F	5.68**	0.08	3.07*	2.59	0.03	1.71
R^2 adj.	0.11	−0.02	0.04	0.03	−0.03	0.02
White[a]	0.90	1.06	0.31	2.61*	3.15**	1.16

Footwear & clothing

	1987–1993	1989	1990	1991	1992	1993
α_0	0.01	0.24***	0.07*	0.09**	0.03	0.00
α_1	0.00	−0.01	0.01	−0.08	0.12	−0.02
F	0.59	0.14	0.18	0.74	1.15	0.14
R^2 adj.	0.00	0.00	−0.01	0.00	0.00	−0.01
White[a]	0.73	0.27	0.15	0.45	0.69	1.61

Wood & furniture

	1987–1993	1989	1990	1991	1992	1993
α_0	0.04	0.04	0.12**	0.20	0.18*	0.07**
α_1	0.02	0.04	0.10	−0.28	−0.17	−0.05
F	1.76	6.47**	0.44	1.38	4.03**	1.38
R^2 adj.	0.01	0.06	−0.01	0.00	0.04	0.01
White[a]	2.55*	5.27***	0.07	3.33**	3.77**	3.61**

Rubber & plastics

	1987–1993	1989	1990	1991	1992	1993
α_0	0.06	0.59**	0.08**	0.09	0.03	0.06
α_1	−0.01	−0.04	0.00	−0.04	−0.20**	−0.04
F	0.14	0.20	0.01	0.03	5.04**	0.11
R^2 adj.	−0.01	−0.01	−0.01	−0.01	0.06	−0.01
White[a]	0.88	0.19	0.15	0.04	2.93*	0.04

*** = significant at 99% level of confidence; ** = significant at 95% level of confidence; * = significant at 90% level of confidence.

[a], F- statistic; null hypothesis: homoskedasticity; in case of heteroskedasticity (at least at 90% level of confidence) a consistent covariance matrix was used (White's correction).

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