When is Gibrat's Law a Law?*

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Abstract

The purpose of this paper is to investigate if the industry context matters for whether Gibrat's law is rejected or not using a dataset that consists of all limited firms in 5-digit NACE-industries in Sweden during 1998-2004. The results reject Gibrat's law on an aggregate level, since small firms grow faster than large firms. However, Gibrat's law is confirmed about as often as it is rejected when industry-specific regressions are estimated. It is also found that the industry context - e.g., minimum efficient scale, market concentration rate, and number of young firms in the industry - matters for whether Gibrat's law is rejected or not.

Keywords: Firm growth, firm size, job creation, small firms

JEL-codes: D22, L11, L25, L26

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1 Introduction

In 1931, Robert Gibrat, after observing that the size distribution of French manufacturing establishments closely resembled the lognormal distribution, suggested a law of proportionate effect. Gibrat's law predicts that firm growth is a purely random effect and therefore should be independent of firm size (Gibrat, 1931). According to Sutton (1997, p. 41), Gibrat eventually succeeded in convincing his readers "that this was a statistical regularity sufficiently sharp to provide a basis for serious mathematical modeling."

A large number of empirical studies have tested whether Gibrat's law holds (for overviews, see Geroski, 1995; Sutton, 1997; Caves, 1998; and Lotti et al., 2003). More recent results tend to reject the hypothesis that growth is independent of firm size. Instead, it seems that small firms grow faster than large firms (Hall, 1987; Evans, 1987a, 1987b; Dunne et al., 1989; Dunne and Hughes, 1994; Audretsch et al., 1999; and Calvo, 2006).

However, some researchers (Mowery, 1983; Hart and Oulton, 1996; Cefis and Orsenigo, 2001; Lotti et al., 2003; Geroski and Gugler, 2004; and Becchetti and Trovato, 2002) still argue that Gibrat's law holds for firms over a certain size, i.e, larger than the industry minimum efficient scale (MES) of production. Other studies that cannot reject at least a weak version of the law are Bottazzi et al. (2005), Droucoupoulos (1983), Hardwick and Adams (2002), and Audretsch et al. (2004).

As noted by Coad (2009, p. 25), most empirical studies into Gibrat's law have focused exclusively on the manufacturing sector. The growth process might nonetheless differ across industries. Teruel-Carrizosa (2008) claims that the MES[1] of service industries is generally smaller than that of manufacturing industries, so that small service firms thus tend to grow slower than same-size manufacturing firms. The relationship between size and growth of service firms has received increasing attention in recent years (for a survey, see Audretsch et al., 2004), but in most cases the results seem to be qualitatively similar to those obtained for manufacturing. The negative relationship between size and growth seems to hold in the service sector as well, as demonstrated for by Variyam and Kraybill (1992) and Johnson et al. (1999), and also in other investigated sectors, such as New York credit unions (Barron et al., 1994), Austrian farms (Weiss, 1998), Taiwanese electronic plants (Liu et al., 1999), and the pharmaceutical sector (Bottazzi and Secchi, 2005).

Audretsch and Elston (2010) present some contradictory evidence, finding a positive relationship between firm size and growth in Germany, in different time periods and across different industries. They argue that differences in the institutional framework (e.g., the system of finance) might explain this result and conclude (p. 4) that the relevant question to ask is: "Under what contexts is the empirical evidence compatible with Gibrat's law and under what contexts is it not?"

This paper addresses this question by explicitly examining why Gibrat's law is rejected or not for specific industries. In contrast to previous studies, which are undertaken at a high level of aggregation or focused only on variations in Gibrat's law across sectors, we use a data set consisting of all limited firms in 5-digit NACE-industries in Sweden during the period 1998-2004.

[1] In this case an abbreviation for "Medium Efficient Size", but the meaning is the same.

We find that Gibrat's law can be rejected at an aggregate level, because small firms tend to grow faster than large firms. Yet when industry-specific regressions are estimated, the law is confirmed about as often as it is rejected. We also find that Gibrat's law is more likely to be rejected for industries characterized by: a large number of firms; a high MES; and a high share of firms located in metropolitan areas. The likelihood that the law will hold is greater in mature industries with high market concentration and a large share of group ownership. The results thus suggest that the industry context matters for whether Gibrat's law holds or not.

The next section presents hypotheses for why Gibrat's law might hold in some circumstances, but not in others. Data and the empirical methods employed are then described in Section 3, while the results are presented and discussed in Section 4. Section 5 summarizes and draws conclusions.

2 Theoretical background

Gibrat's (1931) law states that firm growth is a purely random effect, independent of firm size. Many studies have investigated whether Gibrat's law holds, but the more interesting question of under what circumstances it holds has not been investigated as much (Audretsch and Elston 2010).

There are several theoretical explanations why Gibrat's law might hold in some industries but not in others. Mansfield (1962) argued that Gibrat's law holds only over a certain size, i.e., for firms above a certain industry Minimum Efficient Scale (MES) of production, because the growth of small firms is spurred by the size of the gap between the MES and the size of the firm. In industries with a larger MES, the scale disadvantage of a small firm is larger. Small entrants are thus forced to grow quickly or exit (Strotman, 2007, p.89). Thus Gibrat's Law would hold either in industries with a low MES, so that small firms are not forced to grow faster than large firms, or in industries with a high MES, where new (small) firms are deterred from entry.

Furthermore, industries that are relatively young may be characterized by a higher degree of firm dynamics, i.e., more entry and exit of firms, and thus more fast-growing firms, contradicting Gibrats's law. On the other hand, small firms in mature industries are likely to exhibit lower average growth due to a lower level of opportunity (Coad, 2007 p. 40). When following a cohort of new Italian startups, Lotti et al. (2003) provide some support for this argument, finding that while small firms grow faster at first, the independence of size and growth becomes clearer as time passes.

Innovation is another determinant of firm growth that has received a lot of study (e.g., Mansfield, 1962; Scherer, 1965; Mowery, 1983; Geroski & Machin, 1992; Geroski & Toker, 1992; Roper, 1997; Freel, 2000; Bottazzi et al., 2001). Audretsch (1995) finds, for example, that while the likelihood of survival for new entrants is lower in innovative industries, those firms that do survive exhibit higher growth than in other industries. Thus, when analyzing continuing firms, small firms in innovative industries might have higher growth than large firms. On the other hand, production of knowledge is also characterized by economies of scale and scope (Mueller and Tilton, 1969), implying that small firms should experience lower growth rates, and that Gibrat's law therefore should be more likely to hold in industries characterized by a high degree of innovation.

The industry-specific degree of uncertainty may also influence the relationship between firm growth and firm size. The entrepreneurial process is characterized by uncertainty at every stage (Coad, 2007, p.31-32). Thus Knight (1921) defined the entrepreneur as a decision-maker under uncertainty (randomness with unknowable probabilities), as opposed to risk (randomness with knowable probabilities). Industries characterized by a high degree of uncertainty might prevent entry of new firms and investments, thereby making it more likely that Gibrat's law would hold for these industries.

Another variable with theoretical influence on average growth rates is whether the industry, on average, faces liquidity constraints. If this is the case, small firms should face barriers to entry and growth, again making it more likely that Gibrat´s law would hold for these industries. Fazzari et al. (1988) noted that liquidity constraints are more severe for smaller firms, which are thus less likely to obtain new capital at market interest rates.

Ownership structure is another relevant factor to consider with respect to growth rates. There is evidence of multiplant firms having higher growth rates than single-plant firms, in the case of U.S. small businesses (Variyam and Kraybill, 1992; Audretsch and Mahmood, 1994), large European corporations (Geroski and Gugler, 2004), and Italian manufacturing firms (Fagiolo and Luzzi, 2006). Multiplant firms can be expected to have greater financial backing than single-plant firms and should thus experience higher growth. Thus, Gibrat's law is expected to hold more frequently in industries that are dominated by enterprise groups.

While competition and concentration within industries might be a result of whether Gibrat's law holds or not (Coad, 2007, p.23), these phenomena in turn can also influence the relationship between firm size and firm growth. Small firms could experience significant barriers to entry and growth in industries characterized by a high degree of monopoly power. For example, incumbents in these industries, might engage in strategic behavior to prevent entry of new firms, making it less likely that small firms would experience faster growth than large firms in these industries.

Regional factors must also be taken into account when explaining the relationship between firm growth and firm size. For example, small firms located in metropolitan areas should have easier access to capital, and thereby might grow faster. But in the literature examining this hypothesis, the evidence is mixed. Gabe and Kraybill (2002) find neither county growth-rates nor metropolitan-area dummies to have any statistically significant effects on firm growth rates in Ohio. McPherson (1996), however, finds that small businesses grow faster in urban than in rural areas of southern Africa. Thus, Gibrat's law might be more likely to hold in peripheral regions than in metropolitan areas.

Finally, as emphasized by Audretsch and Elston (2002, 2010), whether Gibrat's law holds or not might depend on the time period under study. Small firms might be more vulnerable to recessions. We thus expect Gibrat's law to be more likely to hold during such periods.

To summarize, we hypothesize that Gibrat's law is more likely to hold in older industries characterized by high MES, liquidity constraints, greater spending on R&D, and a high degree of uncertainty. Firm growth is also less likely to be related to firm size during recessions and in industries dominated by enterprise groups. On the other hand, small firms are expected to grow faster than large ones in industries that have a high degree of competitiveness and a higher share of firms located in bigger cities.

3 Data and empirical method

All limited-liability firms in Sweden are legally required to submit an annual report to the Swedish patent and registration office (PRV). This study uses data collected from MM (Market Manager)-Partner, now merged with PAR, a Swedish consulting firm that gathers economic information from PRV. This information is primarily used by decision-makers and stakeholders in Swedish commercial life. Our analysis is based on data from all Swedish limited-liability companies active at some point between 1998 and 2004, in total 288,757 firms. The data include all variables that can be found in the annual reports, e.g., number of employees, salaries and wages, fixed costs, profits, and liquidity.

To test Gibrat's law of proportionate effect, only annual data on firm-size is needed. In the literature, many indicators have been used to measure firm-size (Delmar, 1997). Employment and revenue are the most commonly used, and are both used in this paper. In the data, firms are classified into industries according to the European Union's NACE-standard, a classification based on firm activity commonly employed by Statistics Sweden (Statistiska Centralbyrån). The comprehensive data set makes it possible to estimate whether Gibrat's law holds for firms active in the 632 five-digit

NACE industries in the data.

The following equation is estimated using ordinary least-squares

$$\ln S^i_{jt} = \alpha_{j0} + \alpha_{j1} \ln S^i_{jt-1} + \boldsymbol{\theta}'_{jk}\mathbf{T}_t + \varepsilon_{jt}, \tag{1}$$

where S^i_{jt} is the size of firm i measured as either number of employees or revenues in industry j ($j = 1, 2, ..., 632$) in period t ($t = 1998, 1999, ..., 2004$), and $\mathbf{T}_t$ is a vector of time-specific fixed effects that is included to capture time-variant heterogeneity in growth rates. Gibrat's law holds if $\widehat{\alpha}_{j1}$ is equal to one, whereas an estimated parameter that is smaller (larger) than one implies that smaller (larger) firms grow faster than large (small).

In the next step, for each period t and industry j, a dummy variable is created taking the value one if Gibrat's law is rejected, and zero otherwise. The following probit model is estimated.

$$\begin{aligned}\Pr(D_{jt} &= 1) = F(\beta_1 INDSIZE_{jt-2} + \beta_2 MES_{jt-2} + \beta_3 AGE_{jt} \\ &+\beta_4 R\&D_{jt-2} + \beta_5 LIQ_{jt-2} + \beta_6 GROUP_{jt-2} \\ &+\beta_7 UNCERT_{jt-2} + \beta_8 CONC_{jt-2} + \beta_9 CITY_{jt-2} + \nu_{jt}),\end{aligned} \tag{2}$$

where the dependent variable, D_{jt}, takes the value one if Gibrat's Law holds for industry j in period t (i.e., if $\widehat{\alpha}_{j1} = 1$), and zero otherwise; $INDSIZE_{jt-2}$ is the number of firms in industry j in period $t-2$; MES_{jt-2} is the minimum efficient scale (MES) of production in industry j in period $t-2$; AGE_{jt} is the average age of the firms in the industry; $R\&D_{jt-2}$ is the average R&D expenditure as a share of revenue in the industry; LIQ_{jt-2} is the industry average liquidity as a share of revenue; $GROUP_{jt-2}$ indicates the share of firms in the industry that belong to an enterprise group; $UNCERT_{jt-2}$ is the variation in returns on total assets within the industry; $CONC_{jt-2}$ measures the degree of competition within the industry; $CITY_{jt-2}$ measures the share of firms in the industry that are located in the metropolitans area of Stockholm, Gothenburg, or Malmö; and ν_{jt} is a random-error term.[2]

Industry size, $INDSIZE_{jt-2}$, is included in the model to control for any unintended confirmation of Gibrat's law due to a too-small sample-size leading to insignificant coefficients.

In the literature, MES has been measured in several ways. Audretsch (1995), for example, adopts the standard Comanor and Wilson (1967) proxy for measuring MES, i.e., the mean size of the largest plants in each industry accounting for one-half of the industry value of shipments. Other commonly used proxies for MES are the size of the industry's median plant and the ratio of that plant's output level to the industry total (Sutton, 1991). We use, the size of the median plant in industry j as the measure of MES_{jt-2} presented in the general text[3].

In the literature, besides investments in R&D and the number of patents are the most common ways of measuring innovativeness. However, one

[2] Gibrat's law is tested by using the lagged firm size has an independent variables, see Eq. (1). All independent variables except industry-age are included in the model as two period lags to alleviate a possible endogeneity problem, since the previous year's values are predetermined.

[3] Four other ways of measuring MES were used as well. The results of employing these versions of MES are reported in the Appendix.

should be wary of the drawbacks of each of these indicators (Coad, 2007, p.33).

Liquidity, LIQ_{jt-2}, was measured as the industry average liquidity per revenue. In accordance with the results presented by Fazarri et al (1988) and Blundell et al. (1992), the degree of financial constrains was also measured by the average cash-flow in the industry. Note, however, that there has been a considerable debate concerning the appropriateness of this measure (Kaplan and Zinagles, 1997; 2000). The results from employing this alternative measure will be reported in footnotes.

The degree of concentration in industry j is measured by a Herfindahl index consisting of the sum of squares of all firms' market shares in industry j. Market concentration is thus computed as the sum of squares of firm market-shares in the industry, i.e., $s_{1j}^2 + s_{2j}^2 + ... + s_{kj}^2$, where k is the number of firms in industry j. If all firms have equal revenues, the concentration rate would be $1/k$, whereas it would be one if the entire industry were supplied by one firm.

Means and standard deviations of all industry-specific variables included in the empirical analysis are presented in Table 1.

Table 1 about here

In accordance with the hypotheses presented in Section 2, we expect the likelihood of confirming Gibrat's law to be positively correlated with MES_{jt-2}, AGE_{jt}, $R\&D_{jt-2}$, $GROUP_{jt-2}$, $UNCERT_{jt-2}$, and $CONC_{jt-2}$; whereas it should be negatively correlated with LIQ_{jt-2} and $CITY_{jt-2}$.

4 Results

In this section, we first test whether Gibrat's law holds for some five-digit industries, but not for others. In the next step, we investigate under what circumstances Gibrat's law seems to hold.

4.1 Does Gibrat's law hold?

Equation (1) is first estimated for the full sample (Model I, Table 2), consisting of both surviving firms and firms that exited during the study period.[4] However, including all firms when estimating Equation (1) might obscure the relationship between size and growth, since smaller firms have higher exit rates than their larger counterparts (Lotti et al., 2003). A second version (Model II) that includes only firms that survived throughout the study period is therefore also estimated. A third version (Model III) includes only firms above the industry MES, defined as median plant-size in number of employees. These models correspond to Mansfield's (1962) three renditions of Gibrat's law. Both number of employees and revenue are used as measures of firm-size.[5]

Table 2 about here

[4] In Manfield's (1962) renditions, the regressions testing the law used growth rate, not the log-size of the firm, as the dependent variable. In Model I, a growth rate of -100% was attributed to firms that exited. Using Equation (1) a similar operation is not possible, as this would entail assigning the size 0 to firms that exited. As the log of 0 is impossible, we instead delete firms that exit.

[5] To investigate whether we have a problem with multicollinearity, we employ a correlation analysis that shows small positive or negative correlations between the independent variables. The highest correlation (0.38) was found between $GROUP_{jt-2}$ and AGE_{jt}.

Gibrat's law holds if $\widehat{\alpha}_1 = 1$. The results presented in Table 2 indicate that $\widehat{\alpha}_1 < 1$ irrespective of whether we use number of employees or revenues as our firm-size variable, and also irrespective of whether all firms, only continuing firms, or only firms above the industry specific minimum efficient scale are included. This implies that small firms grow faster than large firms and that firm-growth thus is dependent on firm-size. That Gibrat's law does not hold, both for all firms and for continuing firms is in accordance with most previous studies. That the law also does not hold when only firms above industry MES are included is less expected, as it contradicts many previous studies.

However, as discussed above, differences in the industry-context could mean that Gibrat's law is holds for some industries, but not for others. Hence, aggregating firms across different industries might obfuscate relationships that are present in a less aggregated analysis. Equation (1) is therefore also estimated separately for each five-digit NACE industry j $(j = 1, 2, ..., 632)$.[6]

Only 5-digit industries with at least 30 observations per regression are included in order to avoid statistical rejection of Gibrat's law due to too few observations. Figure 1 summarizes the results from the industry-specific regressions of Eq. (1) using all firms (Model I), while Figure 2 summarizes for continuing firms only (Model II), with firm size measured as either number of employees or revenue.

[6] We have also estimated annual industry-specific regressions for the period 1998-2004. The results - available from the authors upon request - are qualitatively similar, although Gibrat's law holds for more industries.

Figure 1 about here

Figure 2 about here

When firm-size is measured as number of employees, Gibrat's law is rejected ($\widehat{\alpha}_{j1} \neq 1$) for 403 out of 632 industries when all firms are included and for 293 industries of 601 when only continuing firms are included. When firm-size is measured by revenue, Gibrat's law is rejected ($\widehat{\alpha}_{j1} \neq 1$) for 393 industries of 641 when all firms are included, and for 278 out of 600 industries when only continuing firms are included. Gibrat's law thus holds for about a third of industries when all firms are included, and for just over half when only continuing firms are included.[7]

This picture is quite different from that suggested by the aggregated numbers reported above, and in recent empirical investigations. This suggests that aggregate analysis can be misleading regarding the relationship between firm-growth and firm-size. Thus researchers should more carefully investigate under what circumstances Gibrat's law seems to hold. Incidentally, when Gibrat's law is rejected, the estimated coefficient $\widehat{\alpha}_{j1}$ is larger than one in only a few cases, suggesting in general that, when the law does not hold, small firms grow faster than large ones.

[7] As a robustness check, we also perform regressions testing whether Gibrat's law holds or not at the 4-digit industry level. The results are presented in Figures A1 and A2 in the Appendix. They are very similar to the results from the five-digit level, the only substantial difference being that, when size is measured as number of employees in Model 1, Gibrat's Law holds less often than at the five-digit level, but still more often than when size is measured by revenue.

4.2 Under what circumstances does Gibrat's law hold?

The results from estimating Equation (2) for Models I, II and III - i.e., under what circumstances Gibrat's law holds - are presented in Table 3.[8] All coefficients displayed are marginal-effects coefficients from the probit regressions.

Table 3 about here

The values for the dependent variable D_{jt} are taken from the industry-specific and year-specific estimations of Equation (1), taking a value of one if $\widehat{\alpha}_{j1} = 1$ for industry j in period t, and zero otherwise. The results are fairly consistent across models, regardless of the choice of dependent variable.

The size of the industry, ($INDSIZE_{jt-2}$), has a significant and negative coefficient across all regressions. Thus, the larger the industry, the smaller the probability that Gibrat's law holds. This can be interpreted as a statistical effect, as the number of firms is also the number of observations in Equation (1).[9]

Two other variables that seem to influence the circumstances under which Gibrat's law holds are the share of enterprise-ownership in the industry ($GROUP_{jt-2}$) and market-concentration ($CONC_{jt-2}$). Gibrat's law is more likely to hold in industries characterized by a higher degree of

[8] Table A6 in the Appendix shows results from the same regression undertaken at the four-digit industry level. In general, they are very similar to the results at the five-digit level. The main exception is the city variable, whose coefficients are never significant at the four-digit level.

[9] We also try to omit $INDSIZE_{jt-2}$ from the estimations. The Pseudo R2 statistics decreased from about 0.17 to 0.07, but the results were qualitatively similar. The main difference was that MES_{jt-2} was never significantly determined, whereas $UNCERT_{jt-2}$ was negative and significant in two regressions. The results are available from the authors upon request.

enterprise-ownership in both the full sample (Model I) and when only continuing firms are included (Model II), irrespective of the choice of growh measurement. This effect is weaker, however,when only firms with an above-industry MES are considered. Firm-growth also seems to be unrelated to firm-size in industries characterized by high market concentration, i.e., low competition, suggesting that small firm-growth in these industries are hampered by low industry dynamics because of the market power of large firms.

Gibrat's law is also more likely to hold in mature industries, suggesting that small firms exhibit lower average growth due to a lower level of opportunity in these industries. However, when the sample consists only of continuing firms (Model II), AGE_{jt} is not statistically significantly determined.

Uncertainty in the industry ($UNCERT_{jt-2}$) and average R&D share of revenue ($R\&D_{jt-2}$) do not appear to have any clear effects on whether Gibrat's law holds. [10] This is particularly interesting as these two measures were those that could be linked theoretically to the process of entrepreneurship. However, it is difficult to assess whether the effect of investment in R&D is really zero, since this variable theoretically could have either a positive or a negative effect. The likelihood of supporting Gibrat's law can thus be influenced by both hypotheses, thereby canceling out any significant effects of investments in R&D on the probability that Gibrat's law holds.

A greater industry minimum efficient scale (MES_{jt-2}) generally has a negative effect on the likelihood that the law holds, although the variable is

[10] This result also holds when in a separate set of regressions R&D spending was not weighted for revenue. These results are available from the authors upon request.

only significant in three out of six cases.[11] It thus appears that a high MES in an industry works as an incentive for new (small) firms to grow, rather than as a deterrent to entry.

$CITY_{jt-2}$ is always negative when significant, indicating that the probability that Gibrat's law holds is lower when a greater share of firms in an industry is located in a metropolitan area.

Industry liquidity, meanwhile, appears to have a negative effect on the probability that Gibrat's law holds for both Model I (all firms) and Model II (continuing firms), which is in line with our hypothesis.[12] The opposite, however, seems to hold for Modell III (firms larger than the industry MES).

Thus, many of the hypotheses that were presented in Section 2 are supported by our empirical analysis, suggesting that there are numerous variables that influence whether Gibrat's law holds or not for a particular industry.

5 Summary and conclusions

Gibrat's law of proportionate effect states that firm-growth is a purely random effect and therefore should be independent of firm-size. The law has received a huge interest in the literature, as attested by two authoritative surveys in the Journal of Economic Literature (Sutton, 1997; Caves, 1998). However, previous studies have focused their attention simply on investi-

[11] Four other ways to measure MES were tested, with results reported in Table A2 the Appendix. Although the significance of some of the other coefficients was affected, the signs of the estimated coeffecients remained the same.

[12] We also used industry average cash-flow as a measure of industry liquidity. The estimated coefficient had the same sign, but was only significant when only continuing firms were studied and revenues were used as our growth-measure.

gating whether the law holds or not. Audretsch and Elston (2010, p. 4) argue that a more relevant question to ask is, "Under what contexts is the empirical evidence compatible with Gibrat's law, and under what contexts is it not?"

We attempt to answer this question empirically using a novel dataset that consists of all Swedish limited-liability firms during the period 1998-2004. The specific purpose has been to study whether Gibrat's law would hold for some five-digit industries but not for others, and whether the outcome depends on industry-specific characteristics. To our knowledge, no previous study has explicitly addressed these questions.

In the aggregated dataset, we found that small firms exhibited higher growth than large firms. Thus, in accordance with the existing literature, Gibrat's law was rejected. However, when data were disaggregated into five-digit NACE industries and when only continuing firms were studied, Gibrat's law could be confirmed in about half of the industries. Thus, aggregating data meant that results present in a less aggregated analysis were wiped out. On the other hand, when Gibrat's law was rejected, small firms were found to grow faster than their larger counterparts.

A number of variables influenced whether Gibrat's law held or not. For example, Gibrat's law was more likely to be rejected for industries characterized by a large number of firms, a high minimum efficient scale, and a high share of firms located in metropolitan areas. On the other hand, Gibrat's law was more likely to hold in mature industries, in industries with a high degree of group ownership, and in industries with a high market-concentration. Thus, the industry context seems to matter a great deal for the relationship between firm-size and growth, implying that future studies should investigate more carefully under which circumstances Gibrat's law holds or not.

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Table 1: Means and standard deviations for all variables included in the analysis, Models I-III.

	Model I		Model II		Model III	
Variable	Employment	Revenue	Employment	Revenue	Employment	Revenue
$S_{it}(emp)$	12,2		14,4		14,8	
	(139,4)		(160,7)		(151,8)	
$S_{it}(rev)$		27037,8		32204,4		32853,5
		(495551,5)		(555778,5)		(547487,3)
D_{jt}	0,65	0,61	0,75	0,71	0,34	0,48
	(0,48)	(0,49)	(0,43)	(0,45)	(0,47)	(0,50)
$INDSIZE_{jt}$	463,0	464,0	519,7	521,5	512,6	513,7
	(1021,6)	(1023,8)	(1080,3)	(1082,0)	(1071,4)	(1072,4)
MES_{jt}	3,10	3,10	3,04	3,04		
	(2,81)	(2,81)	(2,62)	(2,63)		
AGE_{jt}	12,54	12,54	12,56	12,57	12,40	12,40
	(2,82)	(2,82)	(2,75)	(2,75)	(2,70)	(2,70)
$R\&D_{jt}$	0,0041	0,0041	0,0040	0,0040	0,0041	0,0041
	(0,018)	(0,018)	(0,018)	(0,018)	(0,019)	(0,019)
LIQ_{jt}	38,50	38,48	38,02	38,03	39,64	39,63
	(27,96)	(28,00)	(27,66)	(27,67)	(28,53)	(28,54)
$GROUP_{jt}$	0,28	0,28	0,28	0,28	0,28	0,28
	(0,15)	(0,15)	(0,14)	(0,14)	(0,14)	(0,14)
$UNCERT_{jt}$	35,38	35,38	35,29	35,27	36,35	36,31
	(23,49)	(23,41)	(22,16)	(22,11)	(23,56)	(23,46)
$CONC_{jt}$	0,10	0,10	0,09	0,09	0,09	0,09
	(0,12)	(0,12)	(0,11)	(0,11)	(0,11)	(0,11)
$CITY_{jt}$	0,22	0,22	0,22	0,22	0,23	0,23
	(0,13)	(0,14)	(0,13)	(0,13)	(0,13)	(0,13)

Table 2: Estimation results (Eq. 1): Does Gibrat's law hold? (t-values in parantheses)

	Model I (all firms)		Model II (continuing firms)		Model III (firm size>MES)	
Variable (parameter)	Employment	Revenue	Employment	Revenue	Employment	Revenue
Constant (α_0)	0.05	0.34	0.03	0.25	0.08	0.35
	(102.73)	(115.21)	(61.68)	(75.49)	(139.22)	(104.11)
$\ln S^i_{t-1}(\alpha_1)$	0.97	0.96	0.98	0.97	0.97	0.96
	(-100.95)	(-106.77)	(-63.04)	(-70.77)	(-105.28)	(-92.90)
N of obs	1,029,437	1,010,639	641,837	641,837	722,846	710,487
R^2	0.93	0.88	0.94	0.90	0.93	0.89

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The t-value for α_1 is negative, as the hypothesis is wether it is statistically different from 1, not 0.

Figure 1. Model I: Results from industry-specific regressions testing Gibrat's law for all firms in 5-digit industries, 1998-2004, with firm size measured by employment and revenue

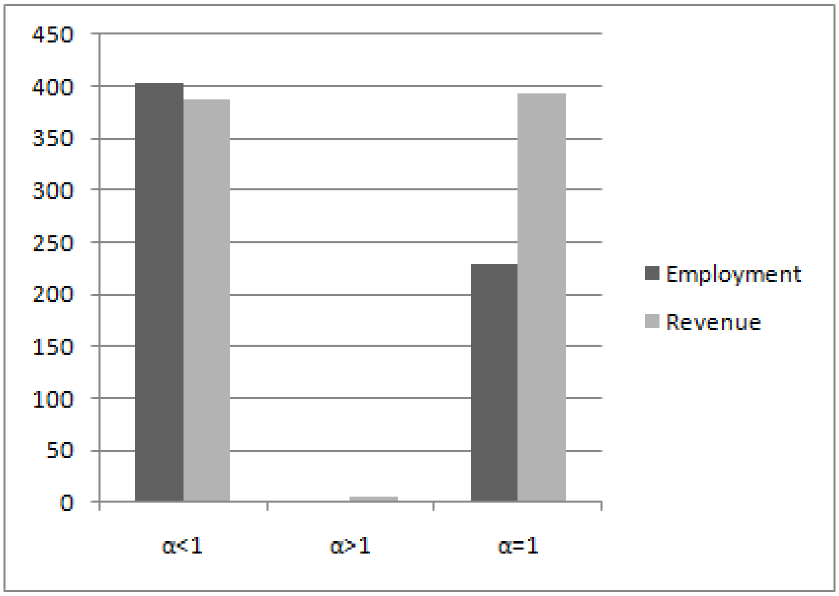

Figure 2. Model II: Results from industry-specific regressions testing Gibrat's Law for continuing firms in 5-digit industries, 1998-2004, with firm size measured by employment and revenue

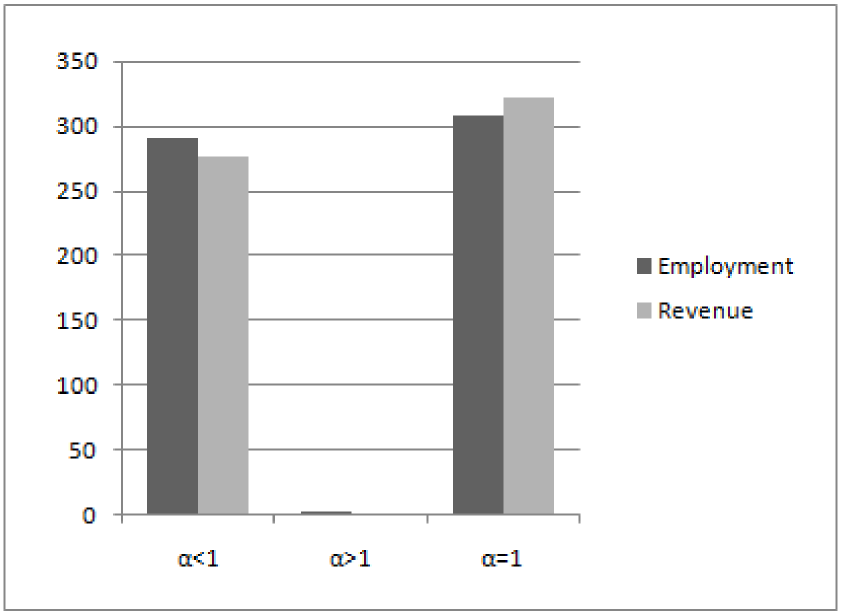

Table 3: Marginal effects coefficients for Model I, II and III (z-values in parantheses)

	Model I (all firms)		Model II (continuing firms)		Model III (firmsize >= MES)	
Variables	Employment	Revenue	Employment	Revenue	Employment	Revenue
$INDSIZE_{jt-2}$	-0.000610***	-0.000473***	-0.000233***	-0.000206***	-0.000487***	-0.000680***
	(-5.25)	(-9.84)	(-7.70)	(-6.16)	(-5.34)	(-10.94)
MES_{jt-2}	-0.0120**	-0.00330	-0.0177***	0.00229		
	(-1.97)	(-0.56)	(-2.92)	(0.32)		
AGE_{jt}	0.0205***	0.0220***	-0.000254	0.00620	0.00615*	0.0263***
	(3.93)	(4.16)	(-0.06)	(1.23)	(1.70)	(5.13)
$R\&D_{jt-2}$	1.778*	0.482	0.111	-0.176	-0.0194	-0.184
	(1.69)	(0.65)	(0.15)	(-0.24)	(-0.04)	(-0.27)
LIQ_{jt-2}	-0.000886	-0.000481	-0.00135***	-0.00100*	0.00221***	0.00137***
	(-1.54)	(-0.87)	(-2.71)	(-1.83)	(4.83)	(2.68)
$GROUP_{jt-2}$	0.296***	0.211*	0.532***	0.415***	0.148*	-0.123
	(2.66)	(1.82)	(5.21)	(3.74)	(1.92)	(-1.31)
$UNCERT_{jt-2}$	-0.000746	-0.000118	0.000552	-2.61e-05	3.98e-05	-0.000496
	(-1.29)	(-0.21)	(0.96)	(-0.04)	(0.10)	(-0.91)
$CONC_{jt-2}$	0.532***	0.331***	0.517***	0.173	0.395***	0.425***
	(4.08)	(2.89)	(3.60)	(1.45)	(2.62)	(3.69)
$CITY_{jt-2}$	-0.205*	-0.185*	-0.322***	0.0152	-0.0229	-0.0544
	(-1.87)	(-1.66)	(-3.18)	(0.14)	(-0.30)	(-0.53)
Observations	2,029	2,016	1,809	1,799	1,790	1,786
Pseudo R-squared	0.210	0.150	0.179	0.105	0.175	0.165

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Appendix

Table A1: Means, standard deviations and definitions of other MES-variables.

Variable	Mean (S.d.)	Definition
$MES2_{jt}$	954965.5	Minimum efficient scale, measured as the average size (revenue) of the largest firms
	(4661620)	contributing to 50% of output in industry j at time period t.
$MES3_{jt}$	.16	Minimum efficient scale, measured as the average size (revenue) of the largest firms
	(.15)	contributing to 50% of output, divided by the total output in industry j at time period t.
$MES4_{jt}$	.05	Minimum efficient scale, measured as the median number of employees divided by the
	(.17)	total number of employees in industry j at time period t.
$MES5_{jt}$	.05	Minimum efficient scale, measured as the median revenue divided by the total revenue
	(.18)	in industry j at time period t.

Table A2: Estimation results, marginal effects (z-values in parantheses)

	Model I (all firms)		Model II (continuing firms)	
Variables	Employment	Revenue	Employment	Revenue
$INDSIZE_{jt-2}$	-0.000566***	-0.000474***	-0.000218***	-0.000211***
	(-5.21)	(-9.54)	(-7.40)	(-6.11)
$MES2_{jt-2}$	-0.173	-0.208	-0.258	0.365
	(-0.39)	(-0.52)	(-0.59)	(0.90)
AGE_{jt}	0.0227***	0.0227***	0.00100	0.00578
	(4.23)	(4.16)	(0.21)	(1.12)
$R\&D_{jt-2}$	2.137*	0.738	0.331	-0.659
	(1.85)	(0.95)	(0.40)	(-0.75)
LIQ_{jt-2}	-0.000212	-0.000523	-0.000850*	-0.00103*
	(-0.38)	(-0.93)	(-1.73)	(-1.87)
$GROUP_{jt-2}$	0.0729	0.127	0.287**	0.425***
	(0.66)	(1.18)	(2.49)	(3.77)
$UNCERT_{jt-2}$	-0.000760	-0.000144	0.000446	0.000150
	(-1.26)	(-0.24)	(0.74)	(0.23)
$COMP_{jt-2}$	1.530*	0.816	1.485*	-0.505
	(1.92)	(1.12)	(1.88)	(-0.68)
$CITY_{jt-2}$	-0.145	-0.146	-0.202*	-0.0335
	(-1.31)	(-1.32)	(-1.94)	(-0.30)
Observations	1,886	1,875	1,708	1,700
Pseudo R-squared	0.210	0.151	0.174	0.106

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A3: Estimation results, marginal effects (z-values in parantheses)

	Model I (all firms)		Model II (continuing firms)	
Variables	Employment	Revenue	Employment	Revenue
$INDSIZE_{jt-2}$	-0.000568***	-0.000469***	-0.000218***	-0.000211***
	(-5.19)	(-9.48)	(-7.29)	(-6.00)
$MES3_{jt-2}$	2.19e-09	-2.59e-09	1.05e-10	9.13e-10
	(0.64)	(-1.03)	(0.03)	(0.19)
AGE_{jt}	0.0228***	0.0224***	0.000988	0.00583
	(4.25)	(4.10)	(0.21)	(1.12)
$R\&D_{jt-2}$	2.144*	0.730	0.321	-0.645
	(1.85)	(0.94)	(0.39)	(-0.73)
LIQ_{jt-2}	-0.000212	-0.000565	-0.000855*	-0.00101*
	(-0.38)	(-1.00)	(-1.73)	(-1.85)
$GROUP_{jt-2}$	0.0631	0.139	0.285**	0.421***
	(0.56)	(1.29)	(2.44)	(3.68)
$UNCERT_{jt-2}$	-0.000754	-0.000166	0.000447	0.000147
	(-1.25)	(-0.27)	(0.74)	(0.23)
$COMP_{jt-2}$	1.183***	0.522**	1.037***	0.119
	(4.31)	(2.24)	(4.07)	(0.47)
$CITY_{jt-2}$	-0.148	-0.148	-0.205**	-0.0312
	(-1.34)	(-1.33)	(-1.96)	(-0.28)
Observations	1,886	1,875	1,708	1,700
Pseudo R-squared	0.210	0.152	0.174	0.105

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A4: Estimation results, marginal effects (z-values in parantheses)

	Model I (all firms)		Model II (continuing firms)	
Variables	Employment	Revenue	Employment	Revenue
$INDSIZE_{jt-2}$	-0.000506***	-0.000467***	-0.000202***	-0.000193***
	(-4.31)	(-8.53)	(-6.77)	(-5.67)
$MES4_{jt-2}$	17.92***	0.653	10.90**	6.832
	(2.92)	(0.15)	(2.37)	(1.43)
AGE_{jt}	0.0206***	0.0220***	0.000435	0.00555
	(3.90)	(4.18)	(0.09)	(1.09)
$R\&D_{jt-2}$	1.812*	0.471	0.0899	-0.122
	(1.70)	(0.64)	(0.12)	(-0.17)
LIQ_{jt-2}	-0.000369	-0.000371	-0.000669	-0.00103**
	(-0.69)	(-0.72)	(-1.46)	(-2.03)
$GROUP_{jt-2}$	0.296**	0.188*	0.409***	0.475***
	(2.37)	(1.76)	(3.39)	(4.23)
$UNCERT_{jt-2}$	-0.000666	-0.000108	0.000720	9.71e-06
	(-1.15)	(-0.19)	(1.22)	(0.02)
$COMP_{jt-2}$	0.615***	0.337***	0.560***	0.194
	(4.56)	(2.89)	(3.89)	(1.62)
$CITY_{jt-2}$	-0.0950	-0.167	-0.210**	0.0210
	(-0.87)	(-1.55)	(-2.10)	(0.19)
Observations	2,029	2,016	1,809	1,799
Pseudo R-squared	0.214	0.150	0.178	0.106

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A5: Estimation results, marginal effects (z-values in parantheses)

	Model I (all firms)		Model II (continuing firms)	
Variables	Employment	Revenue	Employment	Revenue
$INDSIZE_{jt-2}$	-0.000543***	-0.000478***	-0.000211***	-0.000195***
	(-4.43)	(-8.72)	(-6.89)	(-5.76)
$MES5_{jt-2}$	13.03*	-1.382	8.081	7.114
	(1.92)	(-0.29)	(1.62)	(1.35)
AGE_{jt}	0.0212***	0.0221***	0.000985	0.00597
	(4.04)	(4.20)	(0.21)	(1.17)
$R\&D_{jt-2}$	1.779*	0.456	0.0709	-0.130
	(1.68)	(0.62)	(0.09)	(-0.18)
LIQ_{jt-2}	-0.000403	-0.000384	-0.000695	-0.00103**
	(-0.75)	(-0.74)	(-1.51)	(-2.03)
$GROUP_{jt-2}$	0.250**	0.174	0.390***	0.470***
	(2.04)	(1.64)	(3.34)	(4.27)
$UNCERT_{jt-2}$	-0.000669	-0.000115	0.000679	-3.63e-06
	(-1.15)	(-0.20)	(1.16)	(-0.01)
$COMP_{jt-2}$	0.604***	0.326***	0.560***	0.202*
	(4.37)	(2.78)	(3.83)	(1.67)
$CITY_{jt-2}$	-0.103	-0.173	-0.211**	0.0264
	(-0.94)	(-1.60)	(-2.11)	(0.24)
Observations	2,029	2,016	1,809	1,799
Pseudo R-squared	0.211	0.150	0.176	0.105

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Figure A1. Model I: Results from industry-specific regressions testing Gibrat's law for all firms in 4-digit industries, 1998-2004, with firm size measured by employment and revenue

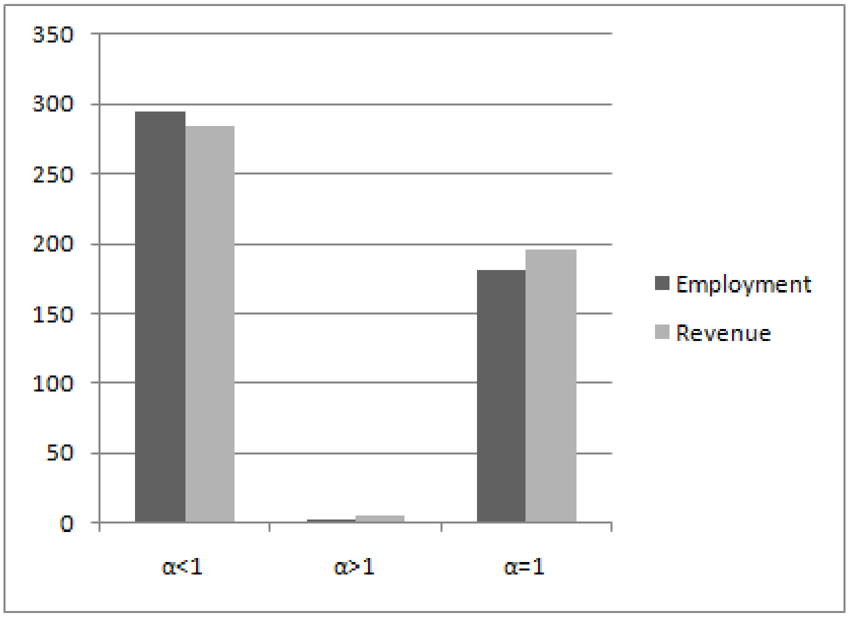

Figure A2. Model II: Results from industry-specific regressions testing Gibrat's law for continuing firms in 4-digit industries, 1998-2004, with firm size measured by employment and revenue

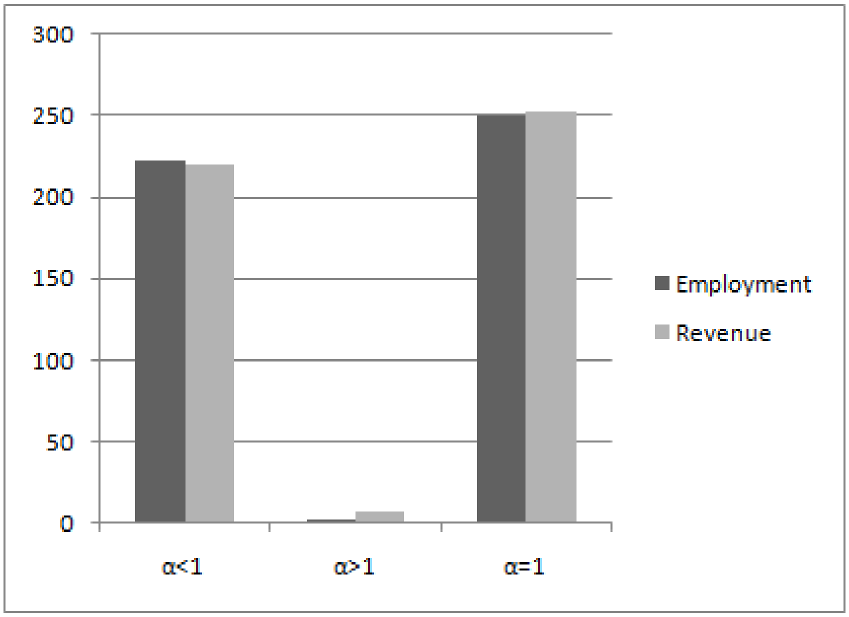

Table A6. Estimation results on 4-digit level, marginal effects (z-values in parantheses)

	Model I (all firms)		Model II (continuing firms)	
VARIABLES	Employment	Revenue	Employment	Revenue
$INDSIZE_{jt-2}$	-0.000550***	-0.000406***	-0.000285***	-0.000210***
	(-6.93)	(-11.30)	(-9.03)	(-7.12)
MES_{jt-2}	0.00116	-0.00225**	-0.000392	-0.00220***
	(0.40)	(-2.54)	(-0.46)	(-2.71)
AGE_{jt}	0.0239***	0.0276***	0.00674	0.0126**
	(4.07)	(4.64)	(1.12)	(2.11)
$R\&D_{jt-2}$	2.404	1.091	1.457	-0.160
	(1.42)	(1.03)	(0.91)	(-0.16)
LIQ_{jt-2}	0.000618	-0.00129**	-0.000379	-0.00146***
	(1.07)	(-2.26)	(-0.70)	(-2.62)
$GROUP_{jt-2}$	0.199*	0.0977	0.364***	0.433***
	(1.71)	(0.90)	(2.89)	(4.10)
$UNCERT_{jt-2}$	-0.000260	0.000330	0.000348	0.000487
	(-0.41)	(0.55)	(0.54)	(0.71)
$CONC_{jt-2}$	0.298***	0.234***	0.224**	0.430***
	(2.92)	(2.66)	(2.42)	(4.46)
$CITY_{jt-2}$	0.0203	-0.0580	-0.0586	0.00703
	(0.18)	(-0.51)	(-0.50)	(0.06)
Observations	2,049	2,040	1,806	1,808
Pseudo R-squared	0.280	0.189	0.228	0.156

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively