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ANNEX I

EQUIVALENCE OF SECTORS

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FIRM GROWTH, PERSISTENCE AND MULTIPLICITY OF EQUILIBRIA: AN ANALYSIS OF SPANISH MANUFACTURING AND SERVICE INDUSTRIES.
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MANUFACTURES		
AGRUPATION OF ACTIVITIES		**EQUIVALENCE IN CNAE MANUFACTURES**
Food products and beverages	15	Food products and beverages
Textile, leather clothes, tanning and dressing leather manufactures	17	Textiles
	18	Leather clothes
	19	Tanning and dressing of leather
Wood and cork	20	Manufacture of wood and products of wood and cork, except furniture
Paper products, publishing, printing and reproduction of recorded media	21	Pulp, paper and paper products
	22	Publishing, printing and reproduction of recorded media
Chemical manufactures	24	Chemicals and chemical products
Rubber and plastic products	25	Rubber and plastic
Other non-metallic mineral products	26	Other non-metallic mineral products
Basic metals and fabricated metal products	27	Basic metals
	28	Fabricated metal products, except machinery and equipment
Machinery and equipment n.e.c	29	Machinery and equipment n.e.c
Electrical, electronic and optic apparatus	30	Office machinery and computers
	31	Electrical machinery and apparatus n.e.c
	32	Radio, television and communication equipment and apparatus
	33	Medical, precision and optical instruments, watches and clocks
Transport equipment	34	Motor vehicles, trailers and semi-trailers
	35	Other transport equipment
Furniture	36	Furniture

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SERVICES		
AGRUPATION OF ACTIVITIES	**EQUIVALENCE IN CNAE SECTORS**	
Motor vehicles	50	Sale, maintenance and repair of motor vehicles and motorcycles
Wholesale trade	51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
Hotels and restaurants	55	Hotels and restaurants
Transport	60	Land transport
	61	Water transport
	62	Air transport
	63	Supporting and auxiliary transport activities
Telecommunications	64	Post and telecommunications
Finances	65	Financial intermediation, except insurance and pension funding
	66	Insurance and pension funding, except compulsory social security
	67	Activities auxiliary to financial intermediation
Renting	71	Renting of machinery and equipment without operator
Computer activities	72	Computer and related activities
R&D	73	Research and development

Source: National Institute of Statistics.
Note: CNAE = Clasificación Nacional de Actividades Económicas (National Classification of Economic Activities)

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ANNEX II

WE KNOW ABOUT SPANISH MANUFACTURING ENTRIES, BUT WHAT ABOUT SERVICES?

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ANNEX II

WE KNOW ABOUT SPANISH MANUFACTURING ENTRIES, BUT WHAT ABOUT SERVICES?

1. INTRODUCTION

New entries and exits are the engine for the market selection process. Whereas new entries represent increased competition, exits represent the unsuccessful trial of a learning process. New firms begin a learning process of heir level of efficiency in the market (Jovanovic, 1982) but their survival is obstructed by barriers to entry. Evidence shows that while these barriers do not prevent entry they condition it. This means that firms enter the market in a continuous process of trial-and-error (Geroski, 1995). However, one should expect the barriers to entry to be highly heterogeneous and, in the manufacturing and service sectors, to be diverse (Audretsch et al., 2004).

Our aim, therefore, is to analyse the process of entry by comparing Spanish firms in the manufacturing and service sectors from the *Sistema de Análisis de Balances Ibéricos* (SABI) between 1994 and 2002. There is ample evidence for manufacturing firms but there are few studies, if any,

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of firms in the service sector. This underlines the relevance of our analysis.

Geroski's (1995) stylised facts illustrate the broad empirical evidence on firm entry and its relationship with industrial dynamics. One important aspect is the contradiction between the theoretical approach of industrial organization and the empirical evidence. As the evidence does not match the theory, some of the theoretical hypotheses must be failing.

The analysis of Spanish firm entry is a relatively new research field that has developed only over the last ten years. The reason for this late development compared to international research is a lack of data. Recent studies have attempted to fill this gap. Segarra et al. (2002), for example, showed that high entry and exit rates are more common between small firms than between large firms, i.e. small firms have a high turnover and large firms have a low turnover. As we have seen, however, most studies of Spanish firm demography have focused on the manufacturing sector and little is known about the service sector.

Our results can be summarised as follows. Firstly, the service sector differs significantly from the manufacturing sector. This difference is also clear if we analyse size during creation: new firms in the service industries have less heterogeneous size than those firms in the manufacturing industries. Also, the penetration rate, measured in terms of the percentage of sales new firms seize from incumbents, is small. Finally, the way new businesses start up is not homogenous between the manufacturing and service industries. When a new firm is created through the diversification of an existing firm, it will be considerably larger in a manufacturing industry than in a service industry.

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This study is structured as follows. In section 2 we summarise the literature on Geroski's (1995) stylised facts. In section 3 we review the Spanish literature on firm entry. In section 4 we present the data description of the Spanish data base SABI (*Sistema de Análisis de Balances Ibéricos*). In section 5 we present the empirical evidence of the manufacturing and service entrants. Finally, in section 6 we summarise our main findings and present our conclusions.

2. "WHAT DO WE KNOW ABOUT ENTRY?"

Firm dynamics have been the focus of industrial organization. Geroski (1995), Sutton (1997) and Caves (1998) inferred stylized facts and stylized relationships about the basic elements of firm dynamics and industrial evolution. Firm entries and exits, in addition to the selection and learning process, can explain the evolution of an industry. Johnson and Parker (1994) solved the puzzle about the post-entry effect of firms on firm dynamics. New entrants can have a multiplier effect, but they can also have a competitive effect. The former implies that new entries encourage the entrance of other firms and the latter implies that new entrants will discourage the entrance of new firms because of increased competition in the market.

Whatever the relationship between entries, exits and future industrial dynamics, one characteristic is constant: entries and exits are highly correlated. This correlation has been extensively analysed by empirical studies. Geroski's (1995) stylised facts are the main findings in the literature.

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When Geroski (1995) analysed the stylised facts and the stylised results about firm entry, he linked the empirical evidence to the theory. While theory helps economists to simplify reality, it can also hide features that are crucial to characterising industrial dynamics. Geroski (1995) points out that the reality can have striking results that are not explained by rational arguments. His main contribution is the interconnection of different stylised fact obtained from empirical evidence.

Sutton (1997) discussed the empirical and theoretical literature on Gibrat's Law and argued that most entries and exits have relatively little effect on the largest firms in the industry (which are likely to have achieved the optimal scale).

Caves (1998) summarised previous evidence on firm entry, exit and mobility. He established that entrants suffer from high rates of infant mortality, though small firms suffer more intensively. The main consequence of this is that net entry rates are small.

In the next section we present and comment Geroski's (1995) stylised facts in more detail.

Table 1. Stylised facts and results about firm entry

Stylised Fact 1	High entry, but low penetration rate
Stylised Fact 2	Larger "within" than "between" industry variation
Stylised Fact 3	Low net entries and penetration rates
Stylised Fact 4	Low survival rate and low average size
Stylised Fact 5	Entry by diversification less common but more successful
Stylised Fact 6	Different waves of entrants affect markets
Stylised Fact 7	Large-scale and very rapid post-entry penetration implies high cost of adjustment

Source: author's own from Geroski (1995).

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Table 1 summarises Geroski's (1995) Stylised Facts. While Geroski also described Stylised Results, these referred to econometric relationships between different variables. The Stylised Facts, on the other hand, refer to observed evidence of firm entry. Here we focus on the stylised facts.

2.1. Stylised facts about entry

Stylised fact 1. **Entry is common. Large numbers of firms enter most markets in most years, but entry rates are far higher than market penetration rates.**

Geroski's (1995) stylised fact 1 confirms the existence of a high entry rate but low penetration rate. This means that it is easy to start a new business but it is not easy to achieve enough share of the market. Consequently, new firms will not erode the market power of incumbents.

What is the explanation for this? Firstly, we could argue that new firms are blocked by incumbents. However, Geroski also states that incumbents react selectively to the new entrants (stylised result 6). Secondly, new firms are not efficient enough. This affects their ability to compete against the active firms. For example, incumbents may have better information about competitiveness, so they know which firms are real threats in the market.

Why do firms enter a market without having achieved a high level of efficiency? There are four explanations for this. Firstly, and as Geroski (1995) states, the size of most new firms is lower than the market average. Entrepreneurs may have enough ability, their techniques may be correct and there may be demand in the market but, if the firm does not take advantage of scale economies, they may struggle to achieve a

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high proportion of market share and even to survive. Secondly, this divergence between entry rates and penetration rates may be due to overestimated expectations (Audretsch, 1995b). In other words, entrepreneurs may overestimate their ability to achieve enough market share to be viable. Evidence suggests that people tend to overestimate their abilities relative to others[1]. Entrepreneurs may estimate profits in the industry on the basis of past profits or their future value. However, few firms are able to acquire a share of the market[2]. Thirdly, an entrepreneur's lack of ambition or unwillingness to take risk may cause a firm to be born undersized. A lack of ambition would damage the firm's viability in the long run[3]. Finally, some firms may be temporary alleviations to the problem of unemployment[4] without having a viable long-term project.

What, then, about services? Since the average size of service firms is smaller, they may remain active more easily. Also, thanks to lower fixed costs, they can enter and leave the market more easily, though this is obviously conditioned by the particular sectorial characteristics.

[1] These over-optimistic estimates of ability can have profound consequences in many areas. For example, entrepreneurs may overestimate their own ability to pick stocks, take inappropriate risks in product development, overestimate their chances of winning in court and be too willing to take cases to trial, or take excessive risks in founding a firm (Odean, 1999; Simon and Houghton, 2003).

[2] In fact, Ilmakunnas and Topi (1999) showed that only rapid growth in demand creates opportunities for firms to enter irrespective of the size of the entry barriers.

[3] Storey (1994a) stated that that an entrepreneur's ambition is an explicative factor of firm growth. Schutjens and Wever (2000) stated that an entrepreneur's ambition is a key factor to success.

[4] Audretsch et al. (2001) identified a double relationship between unemployment and entrepreneurship: "Schumpeter" and "refugee" effects. The "Schumpeter" effect reduces unemployment and a "refugee" effect stimulates entrepreneurship. Also, Storey (1991) reported the presence of a "pull" and a "push" hypothesis. The "pull" effect implies that a high growth in GDP improves anticipated profitability and increases the number of entrants. The "push" effect implies that, in times of crisis, the number of workers in the economy will increase and the potential entrant's opportunity cost of starting a new business will decrease.

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Stylised fact 2. **Although there is a very large cross-section variation in entry, differences in entry between industries do not persist for very long. In fact most of the total variation in entry across industries and over time is "within" industry variation rather than "between" industry variation.**

Industries are made up of potential firms that are willing to enter the market and achieve a high level of efficiency. However, the desire to enter varies across time. During some periods, waves of firms burst into the market to achieve market share but, during others, entry rates diminish considerably.

This fluctuating behaviour of entry rates within an industry cannot be explained by different levels of structural variables since barriers to entry, profits and market concentration are stable over time (Geroski, 1995).

Why, then, does entry vary "within" an industry? An explanation can be found in the external reasons to enter the industry. Economic cycles can influence the evolution of firm entry in the long run. Following Audretsch et al. (2001), in a "Schumpeter" model, firms enter the market to take opportunity of positive expectations on the economy. In a "refugee" model, however, the number of entrants increases if there is a decline in the economy. Whatever the model in an industry, the economic situation can affect the number of firm entries.

However, a variety of structural and technological changes can determine different waves of firms. The product life cycle theory recognises that when a product appears in the market there are different periods (Abernathy and Utterback, 1975; Utterback and Abernathy,

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1975; Utterback, 1979). Firms can enter more or less intensely depending on the expectations in the market. Moreover, firms entering in the market can respond to technological changes: firms entering at the beginning focus on the technology process and firms entering at the end introduce product innovations.

We should expect economic expectations and life product cycles to be different between industries, especially if we compare manufacturing and services. Is the product life cycle longer in the manufacturing than in the service sector? Can this difference affect entry performance?

Stylised fact 3. **Entry and exit rates are highly positively correlated, and net entry rates and penetration are modest fractions of gross entry rates and penetration.**

High levels of turnover imply high levels of market turbulence. This empirical evidence would be reflected by two observations. First, the low capacity of new entrants to remain active in the market may be the result of their difficulty in achieving a high level of competitiveness and a bigger size. Second, the number of active firms in the market is stable in the long run. This means that if in one sector the number of new firms entering is approximately the same as the number of firms exiting, the number of incumbents will remain equal.

The next question is whether the exiting firms are those that entered recently or whether they are obsolete firms that have been expelled from the market. The answer to this question is stylised fact 4.

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***Stylised fact 4*. The survival rate of most entrants is low, and even successful entrants may take more than a decade to achieve a size comparable to the average incumbent.**

This stylised fact states that firms recently entering the market are the first to exit it. Firm survival likelihood is therefore higher for older firms than for new entrants. The fact that most new firms entering the market are smaller than the average implies that firms will take a long time to achieve an efficient scale of production. Success may be rapid, but efficiency may take longer.

This stylised fact is metaphorically similar to Audretsch's (1995b) conical revolving door, which represents market turbulence. Because of the conical shape of the door, the speed in the lower part of the door is higher than at the top. This speed reflects the speed at which firms exit the market. Consequently, a large number of firms would enter the market, but their low likelihood of survival implies that few of them would remain in the market for a long period of time[5].

The crucial point is the low market erosion. The high number of entrants would not be able to erode the incumbents' market share. Moreover, the surviving firms would not achieve the average size needed to compete with the active firms in the market in the short run and this would increase the obstacles to competing in the market.

***Stylised fact 5. De novo* entry is more common but less successful than entry by diversification.**

[5] In fact, each metaphor corresponds to a different entrepreneurial model. In a model where young firms substitute

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There are two main reasons for the greater success of new entrants by diversification. Firstly, new firms not supported by a parent company encounter greater difficulties than those that enjoy the financial help and benefit from the know-how of the original company. Market knowledge and previous experience transmitted to a subsidiary can enhance its chances of survival. Secondly, a company that diversifies its portfolio can neutralize losses caused by risky investments.

A spin-off or new plant of a large company is therefore less likely to fail. Services, however, may have a greater capacity to adapt to the market, so being a *de novo* entry may not be significant.

Stylised fact 6. **Entry rates vary over time, coming in waves which often peak early in the life of many markets. Different waves tend to contain different types of entrant.**

The number of entrants and their characteristics are highly correlated with the product life cycle. The product life cycle considers that, in each phase, the kind of technology used in the production is different. Because of different technological shakeouts, active firms may not be able to adapt their traditional techniques. In every technological shakeout, a burst of new firms will enter the market with new technologies that are very different from previous ones (Abernathy and Utterback, 1975; Utterback and Abernathy, 1975; Utterback, 1979). Consequently, firms entering at the first few stages of the product life cycle will be very different from those entering at the final stages[6].

[6] These technological waves are a reference to the technological entrepreneurship regime and routine regime (Audretsch, 1991). In the early stages, there is a highly innovative entrepreneur regime and in the later stages there is a routine regime.

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With the appearance of a new market, and after a period of exploration by the first new entrants, there will be a huge increase in the number of entrants. In the first few stages, massive producers appear in the market and fill the gap with standardised products. Later, more specialised firms appear, diversifying the product and attempting to satisfy small niches and enhance the quality of the product with new models.

Stylised fact 7. **Costs of adjustment seem to penalize large-scale initial entry and very rapid post-entry penetration rates.**

Entry is difficult, but it is more difficult if you are large. Large firms may have the size needed to compete but they do not know their level of efficiency (Jovanovic, 198) until they enter the market. Consequently, a company that is born large has to invest larger amounts of money than one that is born small. If this company overestimates its level of efficiency, the cost of adjustment will also be larger. Conversely, small firms can be more flexible and can adapt to changes both in demand and in production.

Finally, a rapid penetration rate with a price strategy will diminish a company's future viability. A price strategy such as the reduction of price will, for example, reduce a company's price-cost margin as well as its profits, which are needed for re-investment, increase the size of its plant and change its production process.

2.2. Preliminary conclusions

As Geroski (1995) pointed out, the results from the empirical literature and industrial theories are conflicting. Theories can provide reasonable arguments to explain reality, but reality surpasses theory since this

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theory cannot reflect perfectly the empirical evidence (Audretsch et al., 2004). Consequently, there is an unexplained gap between theory and empirical evidence.

However, there are gaps not only in the theory but also in the empirical evidence. For example, what is the effect of regional and urban differences on the process of firm entry? A large number of studies have analysed the effect of territorial variables on firm entry but there is no compilation of empirical evidence to unify all the results.

Finally, and more specifically for our purpose, services have been completely ignored. In a knowledge-based economy, where service industries are becoming increasingly important in the economic structure, services cannot be ignored. Our aim is to fill this gap.

3. SPANISH EMPIRICAL EVIDENCE

Having analysed Geroski's (1995) stylised facts, in the next section we present recent Spanish empirical literature on firm entry. Spanish researchers have only recently begun to analyse Firm Demography. This is mainly due to the lack of longitudinal industrial data.

The first studies to analyse the aggregate behaviour of industries were conducted by Fariñas et al. (1992), who analysed the turbulence of Spanish firms and their job creation between 1980 and 1998[7]. The main conclusion of their study is that small firms have a high job generation capacity[8].

[7] Those authors analysed the *Encuesta Industrial* database.
[8] Which is highly important since it is a period characterised by the industrial modernization.

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Clearly, new entrants are attracted to an industry because they hope to reap profits from a higher than expected level of efficiency. This firm entry pressure causes entering firms to modify industrial efficiency. Callejón and Segarra (1999) analysed the effect of firm entry and its impact on efficiency by considering the existence of creative destruction, i.e. whether a high market turnover has a positive effect on incumbents by encouraging them to increase their capacity to grow. Their study contributed to the literature through their regional approach to the analysis of efficiency levels.

Aranguren (1999) analysed firm entry in the Autonomous Community of the Basque Country (CAPV) between 1985 and 1993. The results of this study revealed several characteristics specific to the industrial structure of that region: small firms are created in technologically intensive sectors with a low minimum efficient scale.

More recently, Segarra et al. (2002) analysed the entry, exit and survival process of Spanish manufacturing firms between 1994 and 2000. Their contribution is a wide analysis that introduced locational determinants, product and process innovation, interaction between entries and exits and an analysis of firm survival[9].

Finally, Arauzo and Manjón (2004) and Costa et al. (2004) analysed the firm entry process in terms of locational factors. The first of these studies analysed the firm entry process for the Autonomous Community of Catalonia between 1987 and 1996 and showed that firms choose their location by taking into account the area around a municipality. The second of these studies analysed the process for Spanish manufacturers

[9] Segarra and Callejón (2002) analysed the survival of Spanish manufactures between 1994 and 1998.

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between 1980 and 1994 and showed that firms choose a location in accordance with the technological level and life cycle of the industries.

To sum up, the last few decades have seen a proliferation of Spanish studies on firm demography. Those studies have focused on the manufacturing industries, while the service sector has largely been ignored. Our aim is to fill this gap in the literature.

4. DATA DESCRIPTION

In this section we present the data for our analyses. The SABI database provides information from Spanish and Portuguese firms that present their accounts to the business register. It contains information about more than 550,000 Spanish firms and 50,000 Portuguese firms since 1994. It covers more than 95% of Spanish firms that present their accounts to the business register.

Our sample contains 139,922 Spanish firms, of which 68,281 firms are in the manufacturing sector and 71,641 firms are in the service sector, covering the period 1994 and 2002. All firms have a common feature, which is that they survived until 2002. However, some firms entered the market before the first period of observation (1994), while others have entered the market since then.

To overcome problems in estimation caused by missing data, we include firms in our sample up to the date at which information is missing on any variables used in the analysis. In this way we have constructed an

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unbalanced data panel without missing data[10]. Also, to take full advantage of the panel nature of the data (and to allow us to define firm growth), we include only firms with observations in at least two consecutive years.

5. What do we know about Spanish entrants?

This section shows empirical evidence to test the stylised facts analysed by Geroski (1995) in the Spanish case. Are new firms born smaller than active ones? And, more importantly, are there any differences between firms in the manufacturing sector and those in the service sector?

Most of the stylised facts and literature related to firm demography has analysed manufacturing and services remain on the dark side of the economy. Our aim is to highlight differences between these two sectors[11].

Having discussed the empirical evidence compiled in the literature, we will now compare the behaviours of the manufacturing and service sectors. Table 2 shows the means and standard deviations for these sectors.

Table 2. Mean and standard deviation of the number of workers

	Mean	Standard deviation
Manufacturing	29.86	219.36
Services	24.42	377.66

Source: author's own from SABI database.

[10] We have omitted firms after the first instance of missing data because we find evidence that missing data is randomly distributed across firms. Applying the alternative of (potentially incorrect) imputations could result in serious measurement errors.

[11] Database restrictions mean that we will not be able to test all of Geroski's (1995) stylised facts.

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First, we can see that the mean size in the service sector is different from the mean size in the manufacturing sector. This means that firms in the service sector will remain smaller than those in the manufacturing sector.

Secondly, the standard deviation is larger in the service sector than in the manufacturing sector. This indicates a higher heterogeneity in the service sector i.e. large firms coexist with small firms[12].

Having analysed several properties of the data base, we decided to estimate a test mean. Table 3 shows the difference in means between manufacturing and services.

Table 3. Test mean of sizes between manufacturing and services.

	Ha: difference < 0	Ha: difference =0	Ha: difference > 0
Probability	1.000	0.0000	0.0000

H0 = mean(manufactures) – mean(services)
Source: author's own.

As we can see, the test mean shows that the difference between firms' size in the manufacturing sector is smaller than in the service sector. This reinforces the argument about the heterogeneity of service firms: in the service sector, large and small firms coexist.

However, will this difference also be true between incumbents and new firms, or new entrants behave differently? As Geroski (1995) stated, new firms sustain high entry rates but their penetration rate is low.

[12] Obviously, within each service and manufacturing industry, there are different economic activities that are heterogeneous. However, we will focus not on the internal differences but on the main differences.

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Table 4 shows the ratio between new entrants and incumbents with respect to two variables: firm size, measured in terms of the number of employees, and sales for different percentiles in the data base. Specifically, we specify the following ratios:

$$Size = \frac{New \quad entrants \quad measured \quad in \quad employees}{Active \quad firms \quad measured \quad in \quad employees}$$

$$Penetration \quad rate = \frac{New \quad entrants \quad measured \quad in \quad sales}{Active \quad firms \quad measured \quad in \quad sales}$$

Size is the ratio of the size of new firms to the size of active firms, measured in terms of employees. The *Penetration* rate, on the other hand, shows the capacity of new entrants to affect demand.

We will compare the size ratio and penetration rate of manufacturing and service industries in 1994 and 2002. These are the initial and final years of our data base and will enable us to compare their evolution.

Table 4. Ratio of firm sizes and penetration rates for manufacturing and services (1994-2002).

Percentile	*Manufacturing*				*Services*			
	1994		2002		1994		2002	
	Size	Penetr. rate	Size	Penetr. rate	Size	Penetr. rate	Size	Penetr. rate
25	0.33	0.22	0.75	0.69	0.50	0.20	0.67	0.71
50	0.33	0.22	0.67	0.63	0.33	0.18	0.67	0.65
75	0.30	0.19	0.60	0.52	0.27	0.19	0.69	0.56
80	0.31	0.19	0.60	0.49	0.26	0.19	0.69	0.53
85	0.29	0.17	0.56	0.46	0.26	0.17	0.62	0.51
90	0.28	0.18	0.57	0.46	0.23	0.18	0.62	0.48
95	0.22	0.14	0.50	0.39	0.22	0.22	0.62	0.45
96	0.20	0.14	0.47	0.46	0.23	0.21	0.65	0.45
97	0.18	0.12	0.47	0.39	0.21	0.19	0.66	0.47
98	0.12	0.12	0.49	0.44	0.23	0.24	0.61	0.50
99	0.16	0.11	0.52	0.55	0.53	0.16	0.60	0.52
100	0.01	0.01	1.00	1.00	0.01	0.00	1.00	0.21

Source: author's own.

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Table 4 shows that firm size is larger than the penetration rate for all percentiles for both years and both types of industry. For firms in the manufacturing sector, the size of the first quartile is 0.33, which means that the size of new entrants is 33% of the size of active firms. The penetration rate for these firms is 22%. If we compare these measurements for both types of industry and both years, we can conclude that in general the first of Geroski's (1995) stylised facts is satisfied.

Also, firm size and penetration rate increased between 1994 and 2002,, which means that surviving firms in our database increased in size. Finally, if we compare the manufacturing and service sectors, we can see that in 1994 the size of new entrants in the service sector was rather similar to that of active firms (at least for the first quartile and the last percentile).

Table 5. Mean and "between" and "within" standard deviation for manufacturing and services.

		Mean	Standard Deviation
Overall		27.26	305.42
	Between		255.88
	Within		118.55
Manufacturing		29.86	219.36
	Between		167.31
	Within		121.46
Services		24.42	377.66
	Between		317.46
	Within		115.28

Source: author's own.

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To sum up, new entrants are smaller than active firms and their penetration rate is lower. However, this difference is larger for firms in the manufacturing sector than for firms in the service sector.

Table 5 shows the mean size measured in terms of employees and the standard deviation (both "between" and "within" industries). Earlier, Table 2 showed the differences between the mean and standard deviation of firm size measured in terms of number of employees.

Table 6. New firms entering the market without diversifying. Observations, mean and standard Deviation

	Year of observation								
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
1994	911 8.39 (28.14)	2492 12.01 (59.89)	4126 11.99 (51.98)	4019 14.27 (66.55)	4649 14.15 (63.09)	5325 14.36 (67.68)	6842 13.56 (67.68)	7249 13.45 (66.55)	8577 12.64 (62.00)
1995	-	1413 13.59 (246.92)	3588 10.84 (153.65)	3916 12.19 (147.45)	4780 12.38 (132.12)	5642 12.93 (125.09)	7119 11.95 (100.54)	7575 11.50 (100.54)	8632 10.81 (93.78)
1996	-	-	1699 7.59 (29.36)	3050 10.63 (39.38)	4305 11.27 (34.02)	5132 11.46 (35.87)	6478 11.53 (42.71)	6821 11.42 (35.26)	7475 11.10 (33.70)
1997	-	-	-	1767 9.02 (42.58)	4032 10.51 (35.76)	5350 11.12 (33.14)	6782 11.40 (32.96)	7242 11.86 (38.33)	7460 11.64 (34.40)
1998	-	-	-	-	2306 30.76 (1064.46)	5056 22.46 (723.44)	7183 19.71 (550.59)	8040 17.63 (460.60)	7607 17.13 (469.98)
1999	-	-	-	-	-	2771 8.82 (39.45)	6329 12.40 (67.34)	7895 12.57 (61.82)	6910 13.51 (60.52)
2000	-	-	-	-	-	-	3101 9.96 (72.71)	6559 10.70 (56.59)	5838 12.55 (64.18)
2001	-	-	-	-	-	-	-	2723 8.71 (60.25)	2723 10.93 (61.92)

Source: author's own.

With regard to standard deviation, the differences "within" the manufacturing sector and the differences "within" the service sector are quite similar, though the latter are slightly smaller.

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However, when we compare the "between" standard deviation there is a considerable difference. The "between" standard deviation is lower for the manufacturing sector than for the service sector, which confirms the idea that there is greater heterogeneity between firms in the service sector than between firms in the manufacturing sector.

We can conclude, therefore, that the differences between industries are higher than differences within industries and that Geroski's (1995) stylised fact 2 is true. However, this characteristic is much more intense for the service sector.

Table 7. New firms entering the market by diversification. Observations, mean and standard deviation

	Year of observation							
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
1994	-	2 3887.5 (5046.62)	1 12460 (-)	2 7715.5 (7028.55)	5 3476.4 (7028.55)	6 2982.8 (6420.3)	9 2061.4 (5250.3)	10 1901.2 (4987.6)
1995	1 101 (-)	1 112 (-)	2 218 (154.15)	2 272 (111.72)	3 321.33 (73.76)	2 192.5 (267.99)	4 203 (250.70)	4 316.25 (252.10)
1996	-	1 1060 (-)	1 1043 (-)	5 404.4 (359.02)	5 406.80 (355.31)	11 281.27 (257.13)	12 552.25 (542.72)	8 619.38 (639.80)
1997	-	-	2 1362 (1499.07)	5 1305.2 (869.64)	9 1125.11 (1002.45)	10 1799 (1974.04)	12 1831.5 (2472.66)	11 2073.27 (2718.24)
1998	-	-	-	5 1129 (1614.52)	8 1759.75 (1834.24)	14 1351.93 (1608.57)	14 1345.43 (1932.85)	12 1320.08 (1944.91)
1999	-	-	-	-	4 1220 (1672.48)	11 1398.91 (1161.15)	16 1442.5 (1518.51)	12 1274.75 (1882.47)
2000	-	-	-	-	-	5 3377.4 (3498.93)	12 3023.58 (4941.18)	11 3273.18 (5753.32)
2001	-	-	-	-	-	-	3 154.33 (151.00)	3 176.33 (115.14)

Source: author's own.

Finally, we compared entry by diversification and entry by firms that do not depend on any other firm. For entry by diversification we considered firms belonging to a parent company. Table 6 shows the mean firm size and classifies firms entering in a specific year from 1994 tp 2001 and their post-entry evolution from 1995 to 2002.

In general, the number of observations increases with time. Obviously, this is because they satisfy the requirements for belonging to the database over time. More importantly, we observe that entries by diversification (Table 7) are larger than other entries[13] but are less common.

Our database shows that entry by diversification is less common. However, we cannot extrapolate whether this type of entry is more successful because we have no information about their survival.

Table 8. Percentage of service firms and their relative size.

	Percentage of service firms over all entrants		Service size/Manufacturing size	
	Novo entry	Diversification	Novo entry	Diversification
1994	47.32	49.78	87.73	4.81
1995	44.02	38.89	64.02	87.82
1996	50.72	64.58	65.58	51.18
1997	51.09	55.92	72.10	132.64
1998	52.86	58.12	237.58	66.84
1999	43.73	58.62	80.57	59.02
2000	54.61	75.91	62.21	1511.07
2001	51.93	33.33	55.86	41.72

Source: author's own.

Table 8 summarises the above information in terms of ratios: (i) the percentage of service entrants with respect to all entrants between 1994 and 2002, and (ii) the ratio of firm size in the service sector to firm size in the manufacturing sector[14].

[13] In addition to standard deviation, which is also larger.
[14] These ratios are therefore as follows:

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Table 8 highlights two important points. Firstly, the percentage of entrants in the service sector is higher than in the manufacturing sector, both for *novo* entries and for entries by diversification. The only exceptions are 1994 and 1995, and 1999 for *novo* entries and 1994, 1995 and 2001 for entries by diversification. Secondly, with regard to firm size, we can see that firms in the service sector are larger than those in the manufacturing sector, though the values for firms entering by diversification are more volatile.

6. SUMMARY AND CONCLUSIONS

The aim of this analysis is to compare the entry behaviour of firms in the manufacturing sector with that of firms in the service sector. Geroski (1995) established several stylised facts but these refer mainly to manufacturing. Our contribution is to analyse Spanish service industries and compare them with manufacturing industries between 1994 and 2002. Spanish literature has traditionally focused on the manufacturing sector but, in a more knowledge-intensive society based on service industries, studies must widen their perspective.

Our results show that firms in the service industries are generally smaller than firms in the manufacturing industries but their size is more variable. As Audretsch et al. (2004) stated, services are not simply a

---

$$Percentage \quad of \quad service \quad firms \quad in \quad "t" = \frac{Firms \quad belonging \quad to \quad services \quad in \quad "t"}{Firms \quad entering \quad the \quad market \quad in \quad "t"} \times 100$$

$$Service \quad size / manufactures \quad size = \frac{Firm \quad size \quad of \quad manufactures}{Firm \quad size \quad of \quad services}$$

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mirror of manufactures. This greater variability can also be seen in the way they enter the market: service firms are smaller than manufacturing firms but they can be much larger if we focus on entry by diversification. This means that firms entering the market by diversification can become much bigger than *novo* entrants.

Firm entry generates employment and economic activity, introduces innovation and puts pressure on inefficient firms. Firm entry studies are important because they can enable policy makers to influence the creation of firms and increase the competitiveness of an industry. To design effective policies, policy makers need information. This study should provide information about the characteristics of firms and how they behave in each type of industry.

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ANNEX III

REVIEW OF THE EMPIRICAL LITERATURE

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Review of the empirical evidence

Author (year)	Sector	Sample	Country	Period of time	Dependent variable	Independent variable	Static or dynamic	Econometric methodology	Results
Hart and Prais (1956)	Distilleries, commercial and industrial, and iron, coal and steel.	Quoted firms	United Kingdom	1885-1950	Firm growth (final size divided by the initial) measured in employees.	Classification between small, medium and large firms.	Static-3	They compare the evolution in periods of 16 years.	Gibrat's Law is accepted. Firm growth distributions are similar.
					Analysis of firm size distribution. Observation of entries, exits and size changes.		Dynamic-2	Firm mobility is analysed in period of 5 years.	Gibrat's Law is accepted from 1885 to 1939, but 1939-50 small firms grow faster. Small firms have a higher probability to failure.
Simon and Bonini (1958)	Manufacturing sector.	The largest 500 firms. They use Hart and Prais's (1956) data base.	United States	1954-1956	Logarithm of the firm size in employees for the end of the time interval	Logarithm of the firm size in employees for the beginning of the time interval	Static-3	Graph of the logarithms of the firm size in the beginning and the end of the period.	Gibrat's Law is accepted since graphs are highly skewed.
Hymer and Pashigian (1962)	Manufacturing sector.	769 firms from the largest firms.	United States	1946-1955	Growth of assets in the end of the period.	Growth of assets in the beginning of the period.	Static-3	OLS regression. Industries were ordered by quartiles and their arithmetic average and standard deviation of growth rates were calculated.	Gibrat's Law is refused. The average size is not related with firm size. There is a negative relation between size and deviation.

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Mansfield (1962)	Steel, petroleum and tire industries.	All firms from *the Directory of the American Iron and Steel Institute, the Petroleum Refiner , the Rubber Red Book, Moody's Industrials* .	United States	Steel (1916-54), petroleum (1921-57) and tire (1937-52)	Growth of gross tons of ingot capacity (steel), daily crude capacity (petroleum) or employment (tire).	The same but for the beginning of the period.	Static-1	Chi-2 test to determine whether the frequency distributions are the same in each class.	Gibrat's Law is refused in seven of ten cases.
							Static-2	Chi-2 test to determine whether the frequency distributions are the same in each class.	Gibrat's Law is refused. The smallest surviving firms have higher and more variable growth rates than larger firms.
							Static-3	Chi-2 test to determine whether the frequency distributions are the same in each class.	Gibrat's Law is accepted, but in half of the cases, the firm growth variation is smaller in the largest firms.
Singh and Whittington (1975)	Manufactures, construction, distribution and services.	1955 surviving quoted firms	United Kingdom	1948-54 and 1954-60.	Logarithm of the firm size measured in assets in the final period.	Logarithm of the firm size measured in assets in the initial period.	Static-3	Regression to all the industries and separately to 21 industries.	Gibrat's Law is refused. Firm growth deviation has a negative relation with size. Positive relationship of firm growth and size in 19 industries, but not significant.
					Annual firm growth ratio in the end of the period.	Annual firm growth ratio in the beginning of the period. Size at the beginning of the period.	Dynamic-2	Regression by least squares.	Gibrat's Law is not accepted. Firms growing faster (slower) than average, they also have a faster (slower) growth than the average growth.

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Suárez (1977)	Electricity, chemistry, construction, textiles and mines industries from Agendas *Financieras del Banco de Bilbao*.	46 firms	Spain	1962-72	Annual firm growth measured in net assets.	Initial firm size measured in net assets.	Static-3	Regression by least squares.	Gibrat's Law is accepted. However He suggests that small firms should behave equally.
						Annual firm growth measured in net assets from the previous period.	Dynamic-3	Regression by least squares.	Past firm growth rates do not have any influence in the future growth rates.
Chesher (1979)	Services and manufactures.	183 quoted companies that survived the period.	United Kingdom	1960-1969	Deviation of the logarithm of the firm size respect the average logarithm firm size	The same deviation but from the previous year.	Dynamic-2	Regression with an autoregressive process of first order of the disturbances.	Gibrat's Law is refused when applied during different years
Droucopoulos (1983)	Manufactures and services.	The largest firms 152, 420, 551 and 396 for each period.	The whole world	1957-77, 1967-72, 1972-77 and 1967-77	Firm growth measured in employees.	Size, dummies controlling the industry and country.	Static-3	Results of second and third order for the size variable are obtained.	Gibrat's Law is refused. Weak negative relation between growth and size for all firms, but for period 1972-77.
Pisón (1983)	Large firms.	18 firms	Galicia (Spain)	1975-80	%of growth in the period measured in net assets and profitability	Initial firm size in the period.	Static-3	OLS estimation.	Gibrat's Law is accepted. But the sample was very small.
Buckley, Dunning and Pearce (1984)	19 manufacturing industries.	The largest firms: 636 and 866 firms respectivel	The whole world	1972 and 1977	Firm growth measured in employees and profits.	Size, multinationality and quadratic size. Dummies of multinationality, industry and	Static-3		Gibrat's Law is accepted, but firm growth rates differ significatively between countries and industries. No

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		y to 1972 and 1977.				nationality.			significative relation between growth and size.
Kumar (1985)	Manufacturing industries and a limited range of services from the *Company Accounts Data-bank in Cambridge*.	2000 quoted surviving companies	United Kingdom	1960-76	Logarithm of the annual firm growth. Size is measured in net assets, employees and sales.	Logarithm of the annual firm growth but one period before. Logarithm of size at the beginning of the period.	Dynamic-2	OLS regression. Distinction between internal growth and growth by acquisition	Gibrat's Law is not accepted. Existence of persistence but weaker than Singh and Whittington (1975). Weak negative relationship between firm growth and size.
Evans (1987a)	Manufacturing industries from the *Small Business Data Base*.	20000 firms, but there are not the smallest ones.	United States	1976-1982	Logarithm of the annual firm growth. Size is measured in employees.	Logarithm of the following variables: size, age, quadratic size, quadratic age and the cross product between size and age.	Static-2	OLS and Maximum Likelihood controlled for the sample selection bias and the heteroscecasticity.	Firm growth decreases with size, including young firms (confirming Jovanovic's (1982) theory.
Evans (1987b)	Manufacturing industries from the *Small Business Data Base*.	Random sample of 42,339 firms, 13,735 of which are young.	United States	1976-1980	Two estimations: Firstly, the difference of the logarithm of size measured in employees. Secondly, the variability of firm growth.	Logarithm of the following variables: size, age, quadratic size, quadratic age and the cross product between size and age.	Static-2	Maximum Likelihood controlled for the sample selection bias and the heteroscecasticity.	Gibrat's Law is not accepted. Firm growth decreases with size, especially between young firms.
Hall (1987)	Manufactures.	1194 firms that represents the 90% of employme	United States	1973-79 and 1976-83.	Logarithm of firm growth measured in employees.	Logarithm of firm size at the beginning of the period.	Static-3	OLS regression corrected for sample attrition, heteroscedasticity and non-linearity.	Gibrat's Law is refused. Negative relationship between size and growth and its standard deviation.

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		nt but 1% of firms.							No difference between small and large firms.
Dunne, Roberts and Samuelson (1988)	Manufactures from the *Census of Manufactures* with at least 5 workers one year.	265000 firms active in the first 3 years and 295000 during the last 2 years.	United States	1963, 1967, 1972, 1977 and 1982.	Stock market actions, relative average size from survival firms and the accumulated failure rates to each cohort of firms.	Results are presented in three groups: 1) new firms, new plants, 2) diversified firms, new plants, 3) diversified firms, mix of products.	Dynamic-3		Stock market decreases with age. Average firm size increases with age. Failure rates increases slowly each period. Diversified firms have a higher firm size and lower failure rates.
Contini and Revelli (1989)	Manufactures	1000 firms.	Italy	1980-1986, a recession (1980-83) and an expansion (1983-86);	Logarithm of firm growth measured in employees.	Logarithm of firm size, age, and the previous firm growth.	Static-2	OLS regression. The introduction of the squared terms of size and age.	Firm growth has a negative relation with size. During the recession there is not relation between growth and age, and during the expansion it is negative.
							Dynamic-2	OLS regression. Estimation for the largest firms (more than 10 employees). Problems of heteroscedasticity and sample selection bias are mentioned.	Small firms usually have expansions and recessions in periods of 3-4 years. This is the reason why there is a negative relationship between growth and the lagged growth. Largest firms show a positive relation and greater than zero.
Dunne, Roberts and	Manufactures from the	Plants that	United States	1967-72-77	Growth measured	Dummies of size class.	Dynamic-2	Regression.	Gibrat's Law is refused always. For

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Samuelson (1989)	*Census of Manufactures* with at least 5 workers one year.	entered in 1967, 1972 or 1977. There are 219,754 plants.			with employees and variance of growth rate.				the surviving firms, firm growth and its variance decline when the age increases.
Philips and Kirchhoff (1989)	Manufactures and services from the *United States Establishment Longitudinal*	New firms with a single plant and less of 500 employees.	United States	1976-86	They distinguish the firm growth and the survival.	Age	Static -2	Classification of manufactures in four groups depending on the number of employees.	Positive relationship between firm growth and age. Most firms do not grow during first four years.
Acs and Audretsch (1990)	Manufacturin g industries from the *Small Business Data Base.*	xxxx	United States	1976-1980	Average of firm growth measured in employees.	xxx	Static-1	Classification of manufactures in four groups depending on the number of employees.	Gibrat's Law is accepted. There are not significant differences in the firm growth between different sizes.
Bourlakis (1990)	Manufactures.	633 firms. 305 survived the period of observatio n	Greece	1966-1986	Firm growth in employees.	Size, age and other explicative variables.	Static-3	Results controlled by the sample selection bias and the heteroscedasticity. Classification between durable and non-durable consume goods and capital goods.	Gibrat's Law is refused. Growth decreases with age and size.
FirtzRoy and Kraft (1991)	Metallurgic industry.	51 firms	West German y	1977-79	Firm growth measures as the difference between the sales in 1979 and 1977 divided by the initial	Size, age (with dummies) and other explicative variables.	Static-2	Correction of heteroscedasticity.	Gibrat's Law is refused. Smaller firms and younger firms grow faster. More innovative firms, more profitable firms and firms with better-qualified workers, grow faster.

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					sales.				
Variyam and Kraybill (1992)	Manufacturing, sales and service firms from a survey conducted by *Small business Development Center*.	422 firms with less than 500 employees	25 counties in Georgia (United States)	5 years	Difference of logarithms of final and initial sizes and divided by the years. Measure in employees.	Initial size and age, their squares and cross product, dummies of independent establishment, manufacturing and sales, and different cross products.	Static-2	Regression with OLS.	Initial size does not substantially affect survival
Wagner (1992)	Manufacturing industry.	7000 firms with at least 20 workers.	Low Saxony (Germany)	1978-89	Logarithm of the difference between the firm size and the average of all the firms, measured in employees.	The lagged dependent variable (for 1 or 2 periods).	Dynamic-3	Regression with OLS. It is assumed an autoregressive first order process. He distinguishes between firms that produce basic products and consume goods.	Gibrat's Law is refused. There is positive autocorrelation between the firm growths. Small firms do not grow faster than the largest ones.
Amirkhalkhali and Mukhopadhyay (1993)	Industrial firms published in the *Fortune* list.	The largest surviving 231 firms. They are classified as R&D intensive sector or not.	United States	1965-87	Logarithm of the firm growth	Logarithm of firm growth from one and two previous years, The initial size. Dummies identifying R&D intensive firms.	Dynamic-2	Regression with OLS.	Gibrat's Law is not accepted. Positive autocorrelation between firm growth rates. Weak negative relationship between firm growth and its size.
Audretsch and Mahmood (1994a)	Manufacturing firms from the *Small Business Data Base*.	11.300 new firms that were born in 1976. Classified	United States	1976-86	Firm growth measured in employees.	Size, innovative activity, scale economies, intensity of capital, industrial growth and	Static-2 Static-3 (analysing by industries)	Regression with OLS.	Firm growth has a negative relationship with size and capital intensity, positive with the innovation, scale economies,

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		by single or multiplant ,				dummies for multiplant firms.			industrial growth and multiplant.
Dunne and Hughes (1994)	Manufacturing industries from *EXSTAT database* where small firms are not represented correctly.	1709 quoted and unquoted firms.	United Kingdom	1975-80 and 1980-85	Logarithm of firm size at the end of the period. Measured in net assets.	Logarithm of firm size at the beginning of the period.	Static-2	Regressions are estimated by OLS.	Gibrat's Law is refused since smallest firms grow faster. Age has an inverse relation with growth.
					Logarithm of firm growth. Measured in net assets.	Logarithm of previous firm growth. Measured in net assets.	Dynamic-2	Regressions are estimated by OLS.	Weak evidence of persistence in growth.
Mata (1994)	Manufacturing industries from a survey from the Ministry of Employment.	3308 firms with more than 5 employees.	Portugal	1983-88	Growth rates measured in employees.	Firm size from the previous year.	Static-2	Estimation with OLS. Mata mentions some sample selection problems and heteroscedasticity.	Gibrat's Law is refused. Surviving firms and the smallest firms grow faster.
Wagner (1994)	Manufacturing industry from the Statistical Office.	10743 entries from 4 different cohorts.	Low Saxony (Germany)	1987-90	Growth rates measured in employees.	-	Static-2	Distribution of the firms depending on the growth rate.	There are no clear-cut nexus between firm size and firm growth.
Audretsch (1995a)	Manufacturing firms from the *Small Business Data Base.*	11154 new firms that were born in 1976. Classified by single or multiplant .	United States	1976-86	Firm growth measured in employees.	Innovation rate, small-firm innovation rate, mean largest plant size, firm size, industry growth, organisation structure	Static-2	Estimation with OLS.	Gibrat's Law is refused: smaller firms grow faster. Neither the innovative environment nor scale economies have impact on growth.
Das (1995)	Computer hardware	51 firms that were	India	1983-88	Logarithm of firm growth	Previous size, age, cross	Static-1	Unbalanced panel data with fixed	Gibrat's Law is refused since smaller

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	industry from the computer magazine *Dataquest*.	active at least one year during the period.			measured in sales.	product, quadratic size and quadratic age. Size of two previous years		effects.	plants grow faster. The estimation with fixed effects is the most suitable. Evidence of non-observed heterogeneity.
Doms, Dunne and Roberts (1995)	Manufactures from *Census of Manufactures, Survey of Manufacturing Technology* and *Standard Statistical Establishment List.*	6090 plants	United States	1959-88	Firm growth measured in employees.	Employment size class, labour productivity, technologies, capital per worker, cohort of entry.	Static-1	Estimation with OLS controlled by Heckman's (1978) correction.	Gibrat's Law is refused since younger plants, higher productivity plants and smaller plants have higher rates of growth.
Reid (1995)	73 micro-firms from E*nterprise Trusts in the Lothian, Fife* and *Strathclyde regions* (EVENT, GET, LET, ASSET *etc)*	73 firms with less than 3 yers and less than 10 employees.	Scotland (United Kingdom)	1985-88	Logarithm of assets	Previous logarithm of assets	Static-1	Model with simultaneous equations to estimate growth and profits.	Gibrat's Law is refused (smaller firms grow faster). Presence of a trade-off between growth and benefits.
Stanley, Buldyrev, Havlin, Mantegna, Salinger and Stanley (1995)	Manufacturing industries from *Compustat*.	4071 firms	United States	1993	Logarithm of sales	Initial firm size	Static-1	Analysis of firm distribution using a technique common in physics: Zipf plot.	The log-normal distribution fits the data well except for the upper tail.
Amaral,	Manufacrures	Xxx	United	1974-93	Logarithm of	Initial size,	Dynamic-2	Panel tests. Use of	Gibrat's Law is

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Buldyrev, Havlin, Leschtorn, Maass, Salinger, Stanley and Stanley (1997)	from *Compustat.*		States		firm growth	temporal dummies, and dummies controlling simultaneously sector and period (to control specific sectorial shocks).		methodologies of Monte Carlo to analyse the distributions and the power of the test.	refused. Limitation of test cross-section (there is a lost of power and it has difficulties to refuse Gibrat's Law). Firm size converges to a mean size (specially during recessions).
Santarelli (1997)	Hospitality sector.	11660 start-ups	Italy	1989-94	Logarithm of firm growth measured in employees.	Logarithm of firm growth measured in employees for the previous year.	Static-2	20 equations are estimated at a regional level.	Gibrat's Law can not bet refused in 14 of the 20 Italian regions. The reason is that homogenous firm distribution of Italian firms.
González and Correa (1998)	Manufactures and service industries	1715 firms	Sta. Cruz de Tenerife (Spain)	1990-1993	Logarithm of firm growth measured in employees, added value or income.	Logarithm of firm size measured in employees, added value or income.	Static-2	OLS	Gibrat's Law is refused in favour to small firms.
						Logarithm of firm growth measured in employees, added value or income.	Dynamic-2	OLS	There is no presence of dependence among past and future growth.
Harhoff, Stahl and Woywode (1998)	Manufacturing, construction, trade and services sector from *Creditreform.*	8068 firms	Germany	1989-1994	Logarithm of average annual growth rate measured in employees.	Logarithm of initial size, age, the quadratic size and age, cross product between age and size. Dummies identifying firm characteristics.	Static-2	They analyse the problems of sample selection (Heckman's (1979) method), heterosdedasticity with an OLS estimation.	Gibrat's Law is refused. There is a negative relationship between firm growth and size.
Almus and Nerlinger (1999)	Manufacturing industries from	32045 firms	West Germany	1989-98	Logarithm of average annual	Firm specific variables (size, quadratic size,	Static-2	Multivariate regressions. They also calculate the	Gibrat's Law is refused. There is a negative relationship

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	CREDITREFORM from the ZEW-Foundation Panel.				growth rate measured in employees.	age...), founder-specific and firm external characteristics.		elasticity of firm growth in relation to firm size.	between firm growth and size. Young and small innovative firms have greater growth rates.
Audretsch, Santarelli and Vivarelli (1999)	Manufactures from *National Intitute for Social Security* (INPS).	1570 firms created in 1987.	Italy	1987-93	Logarithm of the firm size in the end of the period.	Logarithm of the firm size at the beginning of the period.	Static-1 Static-3	Within industry cross-sections.	Gibrat's Law is refused and more significantly among surviving firms.
Hart and Oulton (1999)	Manufacturing and non-manufacturing sectors from the *OneSource database*.	29000 firms divided in 12 groups.	United Kingdom	1989-93.	Logarithm of the size measured in employees.	Logarithm of the size from the previous year.	Static-1	OLS introducing dummy variables on the intercepts and size classes.	Gibrat's Law is refused. Smaller firms grow faster.
Lotti, Santarelli and Vivarelli (1999)	Manufacturing industries from the *Italian National Institute for Social Security*.	1570 firms with at least one employee	Italy	1987-93	Logarithm of firm size measured in employees.	Logarithm of firm size from the previous year measured in employees.	Static-2	Heckman's (1979) procedure to control sample selection. They apply tests for heteroskedasticity using the OLS and White's correction.	Initially, smaller firms grow faster over the entire period. But there is a convergence towards a Gibrat-like pattern.
Almus and Nerlinger (2000)	Manufacturing industries in three size classes (less than 5 workers, 6 to 19, more than 19) from the ZEW-foundation panel.	784 firms from 1990-2, 1420 from 1991-3, 2831 from 1992-4,: 3495 from 1993-5, 4278 from 1994-6.	West Germany	1989-96	Logarithm of firm growth measured in employees.	Logarithm of firm growth measured in employees for the previous year.	Dynamic-2	They use the Chesher's (1979) methodology to explore Gibrat's Law.	Gibrat's Law is refused for young firms but there are not differences between technologically intensive and non-intensive sectors.
Fariñas and	Manufactures.	1971	Spain	1990-95	Logarithm of	Dummies of size	Static-1	They show how the	Wald statistics show

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Moreno (2000)	*Encuesta de Estrategias Empresariales (ESEE)* from the Spanish Ministry of Manufacturing.	firms, with all the firms with more than 200 workers, and a random sample of firms between 10 and 200 workers.			firm growth rate measured in employees.	categories and sector.		average growth and the failure probability change with size and age. They correct sample selection bias and heteroscedasticity. Following Dunne *et al.* (1988), they distinguish potential and observed growth rates.	size is not uniform and that firm growth differences are not significant between sizes. The negative relationship between failure rates and size compensates the negative relation between surviving firm growth rates and sizes. The net effect of age on firm growth is similar to the firm size effect.
							Dynamic-1		The average firm growth decreases with firm age although this relationship is not so outstanding between firms with more than 500 employees.
Klette and Griliches (2000)	Firms in high-tech industries from the Norwegian R&D-performing line of:	586 firms with at least 20 employes.	Norway	1985-1995	Logarithm of the number of employees	Previous logarithm of the number of employees	Static-2	OLS regression	Gibrat's Law is accepted.
Lazarova, Urga and Walters (2000)	Manufactures	147 large quoted firms	United Kingdom	1955-85	Logarithm firm growth measured in total net		Dynamic-2	They analyse the long run convergence. Use of Augmented Dickey-	Firm that survived more than 30 years show a random growth. Firm size does

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Lensink, van Steen and Sterken (2000)	Annual survey.	Panel of 811 firms	Netherla nds	1995-99	Firm growth	Initial firm size.	Static-2	They analyse the differences between small and large firms.	Gibrat's Law is accepted.
Machado and Mata (2000)	Manufactures from the survey from the Ministry of Employment and covers all firm sizes.	Active firms between 1983 (18552 firms) and 1991 (26515 firms).	Portugal	1983-91	Firm size.		Static-1	Box-Cox Quantile regression to analyse the firm size distribution (FSD). Regression estimated with Generalized Least Squares (GLS) and they apply a normality test of estimated standardized error terms.	Gibrat's Law is not hold: lognormality prediction for the FSD is not confirmed. Firm characteristics affect to firm size, but this effect is larger for the superior quantiles. FSD shifts towards the smallest firms.
Pfaffermayr and Bellak (2000)	Manufactures.	700 national and foreign largest corporations.	Austria	1996-99.	Logaritm of firm growth	Logaritm of initial firm size.	Dynamic-2		Gibrat's Law is accepted.
Scherer, Harhoff and Kukies (2000)	High technollogical firms.	110 firms	United States.	1986-1995	Logarithm of final firm investment	Logarithm of initial firm investment	Static-2	A Monte Carlo experiments with monthly investments.	After ten years of random growth would appear skewness in the market.
Acs and Armington (2001)	LEEM registry	6 millions of establishm ents.	United States.	1994-95	Logarithm of firm growth measured in employees.	Previous logarithmic size and age.	Dynamic-2		Gibrat's Law is accepted only for multiplant establishments. There is a negative relationship between size and growth.
Blonigen	Manufacturin	688 plants	Japanes	1987-1990	3-year	Logarithm of	Static-2	OLS regression	Gibrat's Law is

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and Tomlin (2001)	g industries from *Japan's Expanding US Manufacturing Presence* by the Japan Economic Institute.		e plants in the United States.		percentage change in plant-level employees from 1987 to 1990.	initial size in employees, logarithm of plant age, dummy for joint venture and industry dummies.		controlling by heterogeneity	refused since smaller plants grow faster than the larger ones. There are learning effects.
Bottazzi, Dosi, Lippi, Pammolli and Riccaboni (2001)	Pharmaceutical industry from the *Pharmaceutical Industry Databe*.	Top 150 firms	USA, United Kingdom, France, Germany, Spain, Italy and Canada	1987-97	Firm growth measured in sales and market shares (normalized by the average over all firm sizes in a given year).		Static-2	Ordering firms by its firm grow rates and plotting the distribution function of firm sizes.	Gibrat's Law is refused since the distribution presents a fatter upper tail than a Gaussian.
							Dynamic-2	Plot of the probability density of growth obtained, the time autocorrelation of firm growth and the autocorrelation coefficients. There are also growth transition matrices at the aggregate level.	Presence of persistent forms of heterogeneity across firms. Autocorrelation in firm growth increases with the scale of observation.
Geroski and Gugler (2001)	Manufactures and agriculture from *Amadeus* database.	Around 25,000 firms	EU-15 with but Ireland, Luxembourg plus	1994-98	Difference of the firm size measured in employees between two periods.	Previous firm size in logarithm, age and others.	Static-2	Pooled and fixed effects estimations.	Evidence of "convergence clubs" since small and young firms grow more, while mature and large firms are best

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			Switzerl and						described by Gibrat's Law. Moreover, Convergence is more likely to occur within industries across countries than within countries across industries.
Heshmati (2001)	Manufactures from the *Market Manager*'s database and supplemented with additional information from the regional Labour Market Office.	7884 firms with a tasable turnover exceeding SEK 10000	Sweden	1993-98	Firm growth measured in employees, total net assets and total net sales. All in logarithmic form.	Several variables representing the firm, its behaviour, the human capital and the conditions from the local labour market.	Static-1	Regressions with OLS, GLS and adjustment models. A within and between estimation are also estimated and compared their results.	Gibrat's Law is refused. Negative relation between firm size and growth for the model with employees. This relation is positive for the model with sales, so there are scale effects. The size effect is not statistically significant for the model with assets.
Lotti, Santarelli and Vivarelli (2001)	Instruments industry from the Italian National Institute for Social Security.	214 firms created in 1987 with at least one employee.	Italy	1987-1993	Deviation of the logarithm of the firm size respect the average logarithm firm size, all measured in employees.	The dependent variable for the first and second previous years.	Static -1	Regressions with OLS and Sample Selection Model. They apply Chesher's (1979) method. Estimations for firms between 1 to 5 employees and firms with more than 5.	Gibrat's Law is refused is refused during first years (small firms grow faster), but Gibrat's Law is confirmed to firms with a size larger than a minimum size and age.
Del Monte and Papagni (2001)	Manufactures.	659 firms	Italy	1989-97	Firm growth measured in sales (deflacted by the deflactor		Dynamic-1	Panel data estimations applied to firms classified by sectors and sizes.	Gibrat's Law is accepted.

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					of the added value) and employment.			Test of unit root based on the estimations calculated in the temporal series from each firm.	
Vennet (2001)	Bank sector from the OCDE Bank Profitability database.	230 observations.	23 OECD countries	1985-94	Deviation of the logarithm of the firm size respect the average logarithm firm size, all measured in the total asset volume and the adjusted total assets.	The lagged dependent variable for the first and second previous years.	Dynamic-1	Data panel estimation applying Chesher's (1979) methodology.	Convergence of bank sizes during 1985-89, but their sizes stabilise during 1990-94. Factors such as the expansion of the market, the macroeconomic growth and bank efficiency determine the bank size evolution.
Shanmugam and Bhaduri (2002)	Manufactures from the Centre for Monitoring Indian Economy Prowness database.	392 firms	India	1989-1990 and 1992-1993	Rate of growth measured in employees.	Logarithmic size of the beginning period, logarithmic age, their quadratic value and their cross product.	Static 2	OLS and Fixed Effects model.	Gibrat's Law is not accomplished and age exerts a positive impact on the firm growth.
Becchetti and Trovato (2002)	Manufacturing industry from the Mediocredito database.	1832 firms	Italy	1995-97	Growth in number of employees	Industry dummies, macrosector dummies, size, year of establishment, total amount of shareholders, dummy	Static-1 Static-2	Cross-sectional estimation	Gibrat's Law is not refused for large firms, but it does not hold for small and medium sized firms.

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						indicating subsidies, exports.			
Botazzi, Cefis and Dosi (2002)	Pharmaceuticals, primary metals, machine tools and textiles from the *MICRO.1* data base.	Firms with more than 20 employees.	Italy	1989-96	Normalised logarithm of employees, sales and value added		Dynamic-2	Probability distributions for growth rates.	Gibrat's Law is refused. There is systematic heterogeneity across firms, striking persistent differences and profits tends to be asymmetrically distributed.
Davidsson, Kirchhoff, Hatemi-J and Gustavsson (2002)	Manufactures and services from Statistics Sweden.	11748 firms with more than 20 employees.	Sweden	1987-96.	Growth index calculated as 1996 employment minus initial employment divided by the average of 1996 and initial employment.	Age, size, overall enterprise size, industry sector, change in industry sector, legal form, change in legal form and governance, change in governance, international activities, location, change in location.	Static-2	OLS equation controlling heteroscedasticity with a White's (1980) correction.	There is a negative relationship between firm size and its growth.
Goddard, Wilson and Blandon (2002)	Manufactures from the *Nikkei Kaisha Jouhou* publications.	443 firms quoted	Japan	1980-96	Logarithm of firm growth measured in assets	Logarithm of firm initial size	Dynamic-2	Use of Monte Carlo methods, a panel test and a cross sectional test.	Gibrat's Law is rejected. Log firm sizes are mean reverting towards heterogeneous equilibrium values.
Hardwick and Adams (2002)	2 samples of insurance companies	210 surviving firms from	United Kingdom	1987-91 and 1992-96	Logarithm of firm growth measured in	Logarithm of the size from the first and second	Dynamic-1	They use the Chesher's (1979) methodology to	La Gibrat's Law is refused during 1987-91(smaller firms grow

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	from *Synthesis Life Database*.	1987-91. And 210 surviving firms from 1992-96			assets.	previous years.		explore Gibrat's Law.	faster). But there are not significant differences during 1992-96. There is not evidence that firm growth is negative related with profits.
Piergiovanni, Santarelli, Klomp and Thurik (2002)	Service industries from the *Italian National Institute for Social Security*.	9051 firms with at least an employee.	Italy	1989-94	Firm growth rates measured in employees	Initial firm size	Static-1 Static-2	Those authors apply the Chi-square test.	Gibrat's Law holds only for cafes and camping sites. In the Static-2 version only camping site rejects Gibrat's Law.
					Logarithm of firm growth in employees	Previous firm growth	Dynamic-1	Those authors apply the Chi-square test.	Gibrat's Law is accepted for camping sites.
Santarelli and Vivarelli (2002)	Firms in electrical and electronic engineering from the *Italian National Institute for Social Security*.	129firms with at least an employee created in 1987. 83 firms survived.	Italy	1987-1993	Logarithm of firm measured in employees.	Previous size measured in logarithm of firm measured in employees.	Static - 1	OLS and Sample Selection Model with a Heckman equation.	Small firms grow faster.
Cabral and Mata (2003)	Database from a private firm, that collects balance sheets and the second database is a survey from the	515 firms	Portugal	1984-1991	Logarithm of size measured in number of employees	Logarithm of size measured in number of employees	Static - 2	Analysis of the cohort of firms	Those authors observe that firm size distribution is significantly right-skewed, evolving over time toward a lognormal distribution.

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	Portuguese Ministry of Employment.								
Correa, Acosta, González and Medina (2003)	Firms belonging to non-financial sectors from *Commercial Performance Information Bureau of the University of La Laguna* database (CPIBLL).	1,092 surviving firms. Firms with extreme sizes in any of the years were excluded.	Sta. Cruz de Tenerife (Spain)	1990-96	Logarithm of size measured with five variables (total net assets, equity, operating income, added value and multicriteria variable, DIM)	Initial size, age and sectorial variable.	Static	OLS	Gibrat's Law is rejected: small firms grow faster. The age reveals contradictory results and the service sector does not imply a significant impact on the behaviour of firm growth.
Delmar, Davidsson and Gartner (2003)	Manufactures and services from Statistics Sweden.	11748 firms with more than 20 employees.	Sweden	1987-96.	Firm growth rates measure in employees and sales.		Static-2	A 4 step cluster to analyse the firm growth: 1) Selection of 19 variables. 2) Classification of sample between a tryout sample and a holdout one (the last one to check the results from the first one). 3) Solution more stable. 4) Optimum solution obtained and it ensures the internal validation.	Different patterns: "Super absolute growers": Manufacturing SMEs with high growths in sales and employees, which are intensive in knowledge. "Steady sales growers": Large traditional manufacturing firms with high growth in sales, but with less employees. "Super relative growers": Service knowledge intensity SMEs with random development in sales and employees.

									"Erratic one-shot growers": Service non-knowledge intensity SMEs with negative firm growth, but one period they present a very high growth.
Faggio and Konings (2003)	*Amadeus* database, *Polish InfoCredit, Estonian Kdrediidiinfo AS, Intercredit Ljubljana, Creditreform Bulgaria and the Chamber of Industry and Commerce.*	834 Polish firms, 233 Estonian firms, 511 Slovakian firms, 1548 Bulgarian firms from 1993-97, and 3776 Rumanian firms from 1994-97.	Poland, Estonia, Slovakia, Bulgaria and Rumania	1993-97	Logarithm of firm gorwth measured in employees.	Logarithm of initial size. Dummies about commercial orientation, ownership, interaction of lagged firm sizes and dummies of ownership, regional and temporal dummies.	Static-3	5 nested estimations (1 to each country). They follow Hamilton's (1998) meted to obtain a robust regressions.	Gibrat's Law is refused. Smaller firms grow faster. Hypotheses that there is a restructuration of large firms, since transition requires the reduction of large inefficient and public firms.
Lotti, Santarelli and Vivarelli (2003)	Telecommunication and Radio and TV equipment industries from the *Italian National Institute for Social Security.*	3285 firms with at least one employee.	Italy	1987-94	Logarithm of firm growth in employees	Previous size in logarithms, age.	Static-1	Introduction of a selection Probit model.	Gibrat's Law is refused. Smaller firms grow faster. A convergence to a Gibrat-like behaviour emerges since β approaches to 1 over time.
Del Monte and Papagni (2003)	Manufacturing industries from *Mediocredito*	496 firms classified depending on workers	Italy	1992-97	Rate of growth of sales at constant	Logarithm of the expenditure in R&D and previous firm	Dynamic-2	Generalised Method of Moments.	Positive effect of past sales on current sales. Effect of research on firm growth is greater

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	survey.	did research or not.			prices	growth of sales.			in the traditional sectors.
Oliveria and Fortunato (2003a)	Manufacturing industries from the annual accounts at the *Central Balance Sheet Office.*	8814 surviving firms.	Portugal	1990-99	Logarithm of firm growth measured in employees.	Firm size, age, foreign participation and capital structure.	Static-2	Test for a unit root in micro panel to assess whether the first differenced GMM estimator is identifies.	Gibrat's Law is refused. Smaller firms have larger potential growth.
Oliveria and Fortunato (2003b)	Manufacturing industries from the annual accounts at the *Central Balance Sheet Office.*	9319 surviving firms.	Portugal	1990-99	Logarithm of firm growth measured in employees.	Firm size, age, foreign participation and capital structure.	Static-2	GMM estimation	Gibrat's Law is refused. Large and mature firms have smaller growth rates.
Voulgaris, Asteriou and Agiomirgianakes (2003)	Manufacturing industries	143 firm	Greece	1988-96	Growth of sales	Firm size (ratio between assets and employees),age, exports.	Static-2	Panel data using the Fixed Effects methodology	Negative relationship between firm growth and size.
Fotopoulos and Louri (2004)	Manufactures.	2640 firms	Greece	1992 and 1997	Logarithm of the deviation of firm size in 1997 respect to the average. Measured in employees.	Initial firm size and age.	Dynamic-1	Estimation of a kernel non-parametric density function. Estimation of quantile regressions.	Gibrat's Law is not accepted. Firm size and age have a negative impact on firm growth.
Hoogstra and Dijk (2004)	Manufactures and services from the *Establishment Registers*	34918 surviving establishments, 3061 from	Provinces of Groningen, Fryslan	1994-99	Firm growth measured in employees.	Firm characteristics (size, age, sector and relocation) acting as control	Static-2	Estimation with OLS	There is a positive effect between employment growth and population level. Negative effect of the

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		manufacturing, 7839 from retail and 7291 from business services.	and Drenthe in the North of the Netherlands			variables. Locational characteristics (population levels and growth, regional employment growth, large number of firms, employment share of new firms, accessibility, enterprise zones)			employment growth in new firms
Mata and Portugal (2004)	Manufactures from the survey from the Ministry of Employment	613 firms with at least a 10% of foreign participation, and 5938 domestic firms.		1983-89	Firm growth measured in employees.	Age and type of foreign participation	Static-2	Distribution of firm growth rates depending on the type of foreign participation and age group.	Entry by acquisition is made acquiring an ongoing firm and "join the club" of incumbents. While the entry by greenfield, a firm enters relatively small and grows and upgrades its position afterwards.
Oliveria and Fortunato (2004a) and Oliveria and Fortunato (2004b)	Manufacturing and service industries from the annual accounts at the *Central Balance Sheet Office.*	8072 (419 of them from services) surviving firms in an unbalanced panel.	Portugal	1990-2001	Firm growth	Age, size in the initial period, measure of the extent of the foreign ownership for industry, ratio of book values of total liabilities to total assets and the liquidity.	Static-2	GMM-SYS estimator which uses additional moment conditions that require stronger assumptions on the initial conditions.	Gibrat's Law is refused since small firms grow faster than larger ones. Not only for manufactures but it also for services.
Peña (2004)	Survey obtained with the	114 start-up firms.	Basque Country (Spain)	1997-98	Firm growth measured in employees,	Firm size (approximated by investment), age,	Static-2	OLS regression.	Young firms have more capacity to grow. The estimation with

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	collaboration of nine incubators				sales and profits.	firm strategy related variables and variables related with the entrepreneur.			profits was ignored because the low explanatory power.
Reichstein and Dahl (2004)	Manufctures and service industries from NewBiz database.	8739 observatio ns	Denmar k	1994-1996	Logarithm of the firm growth	Logarithmic previous size, logarithmic age, growth of regional specialisation and market concentration.	Static	OLS estimation correcting the heroscedasticity multiplying the firm size with the industry dummy.	Gibrat's Law is rejected
Audretsch and Lehman (2005)	IPO database and publicly available information.	281 IPO firms	German y	-	Logarithm of growth of employees	Previous size, age, quadratic size and age, and the university spillovers and the university productivity	Static	OLS estimation and a 2SLS.	Gribat's Law is rejected: smaller firms grow faster and the university spillovers have a positive impact.
Niefert (2005)	Manufacturin g, construction, trade, transport & communicatio n and service sectors.	Sample of 1,387. Firms with 0 or more than 500 employees were eliminated .	German y	1990-99	Logarithmic employment growth.	Size, age, size×age, limited liability company, patents, innovation variables.	Static 2	Fixed effects equation and first-differencing dynamic panel data to control for time-constant, unobserved heterogeneity.	Gibrat's Law is rejected: smaller firms grow faster than larger ones. She argues that it is a reasonable result because the sample consists of start-up firms.
Nkurunziza (2005)	Survey of firms belonging to textile, food or metal sectors.	224 firms which started in 1992 and 70 firms created in 1999	Kenya	1992-99	Logarithm of firm growth measured in number of full time workers.	Initial size, age, age squared, ethnicity, sector,	Static-2	OLS regression, instrumental variables, fixed effects, GMM and a Heckman selection model of firm growth.	Many models reject Gibrat's Law since initial size is negative and significant supporting the convergence. Age is weakly related to growth.

Oliveira and Fortunato (2005)	Database constructed by the Portuguese Central Bank belonging to manufactures and services.	Unbalanced panel data of 1248 surviving firms with 5709 observations.	Portugal	1990- 2001	Logarithm of firm growth measured in number of employees	Previous size, previous growth, R&D intensity respect sales, investment respect capital, R&D respect knowledge capital.	Dynamic - 2	Generalized Method of Moments (GMM) system estimator and GMM-SYS estimator.	There is a positive relationship between firm size and firm growth: smaller firm grow faster. Moreover, R&D and other investments expel a positive influence.
Botazzi, Secchi and Tamagni (2006)	Data from the *Centrale dei Bilanci* of firms from manufactures and services.	Firms with more than one worker classified by a financial risk rate.	Italy	1998-2002	Value of total sales, value added and tangible assets in the current period.	Value of total sales, value added and tangible assets in the previous period.	Dynamic - 1	Autoregressive model.	They find that at the aggregate level, manufacting and service industries, and irrespectively of the size proxy, a negative exponential relation between average firm size average growth rate.

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ANNEX IV

ECONOMETRIC METHODOLOGY

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ANNEX IV

ECONOMETRIC METHODOLOGY

1. INTRODUCTION

1.1. The Model

For each cross section (individual) *i=1,2,...N* and each time period (time) t=1,2,...T,

$$Y_{it} = X_{it}\beta_{it} + \varepsilon_{it}$$

Let $\beta_{it} = \beta$ and assume $\varepsilon_{it} = u_i + v_t + e_{it}$ where u_i represents the individual or cross section difference in intercept and v_t is the time difference in intercept. Two-ways analysis includes both time and individual effects. For simplicity, we further assume $v_t = 0$. That is, there is no time effect. In other words, only the *one-way* individual effects will be analyzed in the following.

The component e_{it} is a classical error term, with zero mean, homogeneous variance, and there is no serial correlation and no contemporary correlation. Also, e_{it} is uncorrelated with the regressors X_{it}. That is,

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$$\begin{cases} E(e_{it}) = 0 \\ E(e_{it}^2) = \sigma_e^2 \\ E(e_{it} e_{i\tau}) = 0, \quad for \quad t \neq \tau \\ E(e_{it} e_{jt}) = 0, \quad for \quad i \neq j \\ E(X_{it} e_{it}) = 0 \end{cases}$$

1.2. Fixed Effects Model

Assume that the error component u_i, the individual difference, is *fixed* or *nonstochastic* (but it varies across individuals). Thus, the model error is simply $\varepsilon_{it} = e_{it}$. The model is expressed as:

$$Y_{it} = (X_{it}\beta + u_i) + e_{it}$$

where u_i is interpreted as the *change* in the intercept. Therefore the *individual effect* is defined as u_i plus the intercept.

1.3. Random Effects Model

Assume that the error component u_i, the individual difference, is *random* and satisfies the following assumptions:

$$\begin{cases} E(u_i) = 0 \\ E(u_i) = \sigma_u^2 \quad (\text{homoscedasticity}) \\ E(u_i u_j) = 0 \quad for \quad i \neq j \quad (no \quad cross-section \quad correlation) \\ E(u_i e_{it}) = E(u_i e_{jt}) = 0 \quad (independent \quad from \quad each \quad e_{it} \quad or \quad e_{jt}) \end{cases}$$

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Then, the model error is $\varepsilon_{it} = u_i + e_{it}$ with the following structure:

$$\begin{cases} E(\varepsilon_{it}) = E(u_i + e_{it}) = 0 \\ E(\varepsilon_{it}^2) = E\left[(u_i + e_{it})^2\right] = \sigma_u^2 + \sigma_e^2 \\ E(\varepsilon_{it}\varepsilon_{i\tau}) = E\left[(u_i + e_{it})(u_i + e_{i\tau})\right] = \sigma_u^2, \quad for \quad t \neq \tau \\ E(\varepsilon_{it}\varepsilon_{jt}) = E\left[(u_i + e_{it})(u_j + e_{jt})\right] = 0, \quad for \quad i \neq j \end{cases}$$

In other words, for each cross section "*i*", the variance covariance matrix of the model error $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{iT}]'$ is the following TxT matrix:

$$\sum = \begin{bmatrix} \sigma_e^2 + \sigma_u^2 & \sigma_u^2 & \cdots & \sigma_u^2 \\ \sigma_u^2 & \sigma_e^2 + \sigma_u^2 & \cdots & \sigma_u^2 \\ : & : & & : \\ : & : & & : \\ \sigma_u^2 & \sigma_u^2 & \cdots & \sigma_e^2 + \sigma_u^2 \end{bmatrix} = \sigma_e^2 I + \sigma_u^2$$

Let $\boldsymbol{\varepsilon}$ be a NT-element vector of the stacked errors $\varepsilon_1, \varepsilon_2, ..., \varepsilon_N$, $\boldsymbol{\varepsilon} = [\varepsilon_1, \varepsilon_2, ..., \varepsilon_N]'$, then $E(\boldsymbol{\varepsilon}) = 0$ and $E(\boldsymbol{\varepsilon\varepsilon}') = \Sigma \otimes I$, where I is an NxN identity matrix and Σ is the TxT variance-covariance matrix defined above.

2. MODEL ESTIMATION

2.1. Fixed Effects Model

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Consider the model as follows:

$$Y_{it} = \left(X_{it}\beta + u_i\right) + \varepsilon_{it} \quad \left(i = 1,2,...,N; t = 1,2,...,T\right)$$

Let $Y_i = [Y_{i1}, Y_{i2}, ..., Y_{iT}]'$, $X_i = [X_{i1}, X_{i2}, ..., X_{iT}]'$, and $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{iT}]'$, then the pooled (stacked) model is

$$\begin{bmatrix} Y_1 \\ Y_2 \\ : \\ Y_N \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ : \\ X_N \end{bmatrix} \beta + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ : \\ \varepsilon_N \end{bmatrix}$$

or, $Y = X\beta + \varepsilon$

- **Dummy Variables Approach**

For each "*i*", define NT×1 vector D_i with the element:

$$D_{ij} = \begin{cases} 1 \quad if \quad (i-1)\times T + 1 \le J \le i \times T \\ 0 \quad otherwise \end{cases}$$

Then **D** = $[D_1, D_2, ..., D_{N-1}]$ is NT×(N-1) matrix of N-1 dummy variables. Ordinary least squares can be used to estimate the model with dummy variables as follows:

$$Y = X\beta + D\delta + \varepsilon$$

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Since **X** includes a constant term, one less dummy variables are included for estimation and the estimated δ measures the individual *change* from the intercept.

- **Deviation Approach**

Let $Y_i^m = \frac{\left(\sum_{t=1,2,\ldots,T} Y_{it}\right)}{T}$, $X_i^m = \frac{\left(\sum_{t=1,2,\ldots,T} X_{it}\right)}{T}$, and $e_i^m = \frac{\left(\sum_{t=1,2,\ldots,T} e_{it}\right)}{T}$.

Then the *within* estimates of the model can be obtained by estimating the mean deviation model:

$$\left(Y_{it} - Y_i^m\right) = \left(X_{it} - X_i^m\right)\beta + \left(e_{it} - e_i^m\right)$$

Or, equivalently

$$Y_{it} = X_{it}\beta + \left(Y_i^m - X_i^m \beta\right) + \left(e_{it} - e_i^m\right)$$

Note that the constant term drops out due to mean deviation transformation. Therefore, the estimated *individual effects* of the model is $u_i = Y_i^m - X_i^m \beta$. The variance-covariance matrix of individual effects is estimated as follows:

$$Var(u_i) = \frac{v}{T} + X_i^m \left[Var(\beta)\right] X_i^{m'}$$

where v is the estimated variance of the mean deviation regression corrected for the degree of freedom NT-N-K (instead of NT-K). That is,

$$v = \frac{\Sigma_{i=1,2,\ldots,N} \Sigma_{t=1,2,\ldots,T} \left(e_{it} - e_i^m\right)^2}{\left(NT - N - K\right)}$$

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Note that K is the number of explanatory variables not counting the constant term.

It may be of interest to estimate the *between* parameters of the model by estimating

$$Y_i^m = X_i^m \beta + u_i + e_i^m$$

which is related to the estimated *individual effects* from the *within* estimates.

- **Testing for Fixed Effects**

Based on the dummy variable approach, this is a Wald F-test for the joint significance of the parameters associated with dummy variables representing the individual effects. If the null hypothesis δ = 0 can not be rejected, then there is no fixed effects in the model.

Based on the deviation approach, the equivalent test statistic is computed from the restricted (pooled model) and unrestricted (mean deviation model) sum of squared residuals. That is,

$$\frac{\dfrac{RSS_R - RSS_U}{N-1}}{\dfrac{RSS_U}{NT-N-K}} \approx F\left(N-1, NT-N-K\right)$$

2.2. Random Effects Model

Recall the pooled model for estimation

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$$Y = X\beta + \varepsilon$$

where $\boldsymbol{\varepsilon} = [\varepsilon_1, \varepsilon_2,\ldots, \varepsilon_N]'$, $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2},\ldots, \varepsilon_{iT}]'$, and the random error components $\varepsilon_{it} = u_i + e_{it}$. By assumptions, $E(\boldsymbol{\varepsilon}) = 0$, and $E(\boldsymbol{\varepsilon\varepsilon}') = \Sigma \otimes I$. The Generalized Least Squares estimates of β is

$$\beta = \left[X'\left(\Sigma^{-1} \otimes I\right)X\right]^{-1} X'\left(\Sigma^{-1} \otimes I\right)Y$$

Since Σ^{-1} can be derived from the estimated variance components σ^2_e and σ^2_u, in practice the model is estimated using the following *partial deviation approach*.

- **Partial Deviation Approach**
  1. From the dummy variable approach for estimating the fixed effect model, the estimated variance σ^2_e is obtained.
  2. Assuming the randomness of u_i, estimate the *between* parameters of the model:

     $$Y_i^m = X_i^m \beta + \left(u_i + e_i^m\right)$$

     where the error structure of $u_i + e^m_i$ satisfies:

     $$\begin{cases} E(u_i + e_i^m) = 0 \\ E\left(\left(u_i + e_i^m\right)^2\right) = \sigma_u^2 + \dfrac{\sigma_e^2}{T} \\ E\left(\left(u_i + e_i^m\right)\left(u_j + e_j^m\right)\right) = 0, \quad for \quad i \neq j \end{cases}$$

     Let $v = \sigma_e^2$ and $v_1 = T\sigma_u^2 + \sigma_e^2$. Define $w = 1 - \left(\dfrac{v}{v_1}\right)^{1/2}$.

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3. Using w to transform (partial deviations) all the data series as follows:

$$Y_{it}^{*} = Y_{it} - wY_{i}^{m}$$

$$X_{it}^{*} = X_{it} - wX_{i}^{m}$$

Then the model for estimation is:

$$Y_{it}^{*} = X_{it}^{*}\beta + \varepsilon_{it}^{*}$$

where $\varepsilon_{it}^{*} = (1-w)u_{i} + e_{it} - we_{i}^{m}$

Or, equivalently

$$Y_{it} = X_{it}\beta + w\left(Y_{i}^{m} - X_{i}^{m}\beta\right) + \varepsilon_{it}^{*}$$

It is easy to validate that

$$\begin{cases} E(\varepsilon_{it}^{*}) = 0 \\ E(\varepsilon_{it}^{*2}) = \sigma_{e}^{2} \\ E(\varepsilon_{it}^{*}\varepsilon_{i\tau}^{*}) = 0 \quad for \quad t \neq \tau \\ E(\varepsilon_{it}^{*}\varepsilon_{jt}^{*}) = 0 \quad for \quad i \neq j \end{cases}$$

The least squares estimate of $[w(Y_{i}^{m} - X_{i}^{m}\beta)]$ is interpreted as the *change* of individual effects.

- **Testing for Random Effects**

To test for *no* correlation relationship of the error terms $u_i + e_{it}$ and $u_i + e_{i\tau}$, the following Breusch-Pagan LM test statistic based on the

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estimated residuals of the restricted (pooled) model, ε_{it} (i=1,2,...N, t=1,2,...,T), is distributed as Chi-square with *one* degree of freedom:

$$LM = \frac{NT}{2(T-1)}\left(\frac{\sum_{i=1,2,...N}\left(\sum_{t=1,2,...T}\varepsilon_{it}\right)^2}{\sum_{i=1,2,...N}\sum_{t=1,2,...T}\varepsilon_{it}^2}-1\right)^2$$
$$= \frac{NT}{2(T-1)}\left(\frac{\sum_{i=1,2,...N}\left(T\varepsilon_i^m\right)^2}{\sum_{i=1,2,...N}\sum_{t=1,2,...T}\varepsilon_{it}^2}-1\right)^2$$

Note that $\varepsilon_i^m = \frac{\sum_{t=1,2,...,T}\varepsilon_{it}}{T}$.

2.3. Hausman's Test for Fixed or Random Effects

Let b_{fixed} be the estimated slope parameters of the fixed effects model (using dummy variable approach), and b_{random} be the estimated slope parameters of the random effects model. Moreover, Var(b_{fixed}) and Var(b_{random}) are the corresponding estimated variance-covariance matrix, respectively. Hausman's test for *no* difference of these two sets of parameters is a Chi-square test in which the degree of freedom corresponds to the number of slope parameters. The test statistic is defined as follows:

$$H = (b_{random}-b_{fixed})'[Var(b_{random})-Var(b_{fixed})]^{-1}(b_{random}-b_{fixed})$$

3. EXTENSIONS

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3.1. Unbalanced Panel Data

Panels in which the group sizes (time periods) differ across groups (individuals) are not unusual in empirical panel data analysis. These panels are called *unbalanced panels*. Estimation for fixed effects and random effects models discussed above must be modified to reflect the structure of unbalanced panels. Modify the dummy variable or deviation approach for estimating the fixed effects with unbalanced panel data is straightforward. However, for the random effects model, by allowing unequal group sizes, there presents the problem of groupwise heteroscedasticity.

3.2. Random Coefficients Model

For each cross section "*i*"=*1,2,...,N*, the model is written as:

$$Y_i = X_i \beta_i + e_i$$
$$\beta_i = \beta + \upsilon_i$$

where $Y_i = [Y_{i1}, Y_{i2}, \ldots, Y_{iT}]'$, $X_i = [X_{i1}, X_{i2}, \ldots, X_{iT}]'$, and $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2}, \ldots, \varepsilon_{iT}]'$. We note that not only the intercept but also the slope parameters are random across individuals. The assumptions of the model are:

$$\begin{cases} E(\varepsilon_i) = 0_{N\times 1} \\ Var(\varepsilon_i) = E(\varepsilon_i \varepsilon_i') = \sigma_i^2 I_{N\times N} \\ Cov(\varepsilon_i, \varepsilon_j) = 0_{N\times N}, \quad i \neq j \end{cases}$$

and

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$$\begin{cases} E(\upsilon_i) = 0_{K\times 1} \\ Var(\upsilon_i) = E(u_i u_i') = \Gamma_{K\times K} \\ Cov(\upsilon_i, \upsilon_j) = 0_{K\times K}, \quad i \neq j \\ Cov(\upsilon_i, \varepsilon_i) = 0_{K\times 1} \end{cases}$$

The model for estimation is

$$Y_i = X_i\beta + (X_i\upsilon_i + \varepsilon_i), \quad or$$

$$Y_i = X_i\beta + \omega_i \quad where \quad \omega_i = (X_i\upsilon_i + \varepsilon_i), \quad and$$

$$\begin{cases} E(\omega_i) = 0_{N\times 1} \\ Var(\omega_i) = E(\omega_i\omega_i') = E\left(X_i\upsilon\upsilon' X_i' + X_i\upsilon_i\varepsilon + \varepsilon_i\upsilon_i' X_i + \varepsilon_i\varepsilon_i'\right) = \sigma_i^2 I_{N\times N} + X_i\Gamma X_i' = \Omega_i \end{cases}$$

The stacked (pooled) model is

$$Y = X\beta + \omega$$

where $\boldsymbol{\omega} = [\omega_1,\ldots,\omega_N]'$, and

$$E(\boldsymbol{\omega}) = 0_{NTx1}$$

$$Var(\omega) = E(ww') = V = \begin{bmatrix} \Omega_1 & 0 & .. & 0 \\ 0 & \Omega_2 & .. & 0 \\ : & : & : & \\ 0 & 0 & .. & \Omega_N \end{bmatrix}$$

GLS is used to estimate the model. That is,

$$b^* = (X'V^{-1}X)^{-1}X'V^{-1}Y$$

$$Var(b^*) = (X'V^{-1}X)^{-1}$$

The computation is based on the following steps (Swamy, 1971):

1. For each regression equation *i*, $Y_i = X_i\beta_i + \varepsilon_i$, obtain the OLS estimator of β_i:

$$b_i = (X_i' X_i)^{-1} X_i' Y_i$$
$$Var(b_i) = (X_i' X_i)^{-1}(X_i'\Omega_i X_i)(X_i' X_i)^{-1} = \sigma_i^2 (X_i' X_i)^{-1} + \Gamma = V_i + \Gamma$$

(Taking account of heteroscedasticity, where $V_i = \sigma_i^2 (X_i' X_i)^{-1}$)

Note that σ_i^2 is estimated by $s^2_i = e_i'e_i/(N-K)$, where $e_i = Y_i - X_ib_i$.

Then, $V_i = s_i^2(X_i'X_i)^{-1}$.

2. For the random coeffcients equation, $\beta_i = \beta + \upsilon_i$, the variance of b_i (estimator of β_i) is estimated by

$$\frac{\sum_{i=1,\dots,G}(b_i - b^m)(b_i - b^m)'}{(G-1)} = \frac{\sum_{i=1,\dots,G}(b_i b_i' - Gb^m b'^m)}{(G-1)},$$

where $b^m = \frac{\sum_{i=1,\dots,G} b_i}{G}$.

Therefore, $\Gamma = \frac{\Sigma_{i=1,\dots,G}\left(b_i b_i' - Gb_m b_m'\right)}{(G-1)} - \frac{\Sigma_{i=1,\dots,G} V_i}{G}$.

Concerning the possibility that Γ may be nonpositive definite, we use

$$\Gamma = \frac{\Sigma_{i=1,\dots,G}\left(b_i b_i' - Gb_m b_m'\right)}{(G-1)}.$$

3. Write the GLS estimator of b as:

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$$
\begin{aligned}
b^* &= \left(X'V^{-1}X\right)^{-1} X'V^{-1}Y \\
&= \left[\Sigma_{i=1,2,\dots,G} X_i'\Omega_i X_i\right]^{-1}\left[\Sigma_{i=1,2,\dots,G} X_i'\Omega_i Y_i\right] \\
&= \left[\Sigma_{i=1,2,\dots,G} X_i'\Omega_i X_i\right]^{-1}\left[\Sigma_{i=1,2,\dots,G} X_i'\Omega_i X_i b_i\right] \\
&= \left[\Sigma_{i=1,2,\dots,G} (\Gamma+V_i)^{-1}\right]^{-1}\left[(\Gamma+V_i)^{-1} b_i\right] \\
&= \Sigma_{i=1,2,\dots,G} W_i b_i \quad \text{where} \quad W_i = \left[\Sigma_{i=1,2,\dots,G} (\Gamma+V_i)^{-1}\right]^{-1}\left[(\Gamma+V_i)^{-1}\right]
\end{aligned}
$$

Similarly,

$$Var(b^*) = \left(X'V^{-1}X\right)^{-1} = \left[\Sigma_{i=1,2,\dots,G} (\Gamma+V_i)^{-1}\right]^{-1}$$

The individual parameter vectors may be predicted as follows:

$$b_i^* = \left(\Gamma+V_i\right)^{-1}\left[\Gamma^{-1}b^* + V_i^{-1}b_i\right] = A_i b^* + (I-A_i)b_i$$

where $A_i = (\Gamma+V_i)^{-1}\Gamma^{-1}$.

$$Var(b_i^*) = \begin{bmatrix} A_i & I-A_i \end{bmatrix} \begin{bmatrix} \sum_{i=1,\dots,G} W_i(\Gamma+V_i)W_i' & W_i(\Gamma+V_i) \\ (\Gamma+V_i)W_i' & (\Gamma+V_i) \end{bmatrix}^{-1} \begin{bmatrix} A_i \\ I-A_i \end{bmatrix}$$

3.3. Seemingly Unrelated System Model

Consider a more general specification of the model:

$$Y_{it} = X_{it}\beta_i + \varepsilon_{it} \quad (i = 1,2,\dots,N;\ t = 1,2,\dots,T)$$

Let $Y_i = [Y_{i1},Y_{i2},\dots,Y_{iT}]'$, $X_i = [X_{i1},X_{i2},\dots,X_{iT}]'$, and $\varepsilon_i = [\varepsilon_{i1},\varepsilon_{i2},\dots,\varepsilon_{iT}]'$, the stacked N equations (T observations each) system is $\boldsymbol{Y = X\beta + \varepsilon}$, or

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$$\begin{bmatrix} Y_1 \\ Y_2 \\ : \\ Y_N \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \cdot\cdot & 0 \\ 0 & X_2 & \cdot\cdot & 0 \\ : & : & & : \\ 0 & 0 & \cdot\cdot & X_N \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ : \\ \beta_N \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ : \\ \varepsilon_N \end{bmatrix}$$

Notice that not only the intercept but also the slope terms of the estimated parameters are different across individuals. The error structure of the model is summarized as follows:

$$\begin{cases} E(\varepsilon) = 0 \\ E(X'\varepsilon) = 0 \\ E(\varepsilon\varepsilon') = \Sigma \otimes I \end{cases}$$

where $\Sigma = [\sigma_{ij}, i,j=1,2,...N]$ is the NxN variance-covariance matrix and I is a TxT identity matrix. Notice that contemporary correlation across individuals is assumed although there is no time serial correlation. The error structure of this model is different than that of random effects model described above.

The model is estimated using techniques for systems of regression equations.

The system estimation techniques such as 3SLS and FIML should be used for parameter estimation. It is called the Seemingly Unrelated Regression Estimation (SURE) in the current context. Denote $\boldsymbol{b}$ and S as the estimated $\boldsymbol{\beta}$ and S, respectively. Then,

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$$b = \left[X'\left(S^{-1} \otimes I\right)X\right]^{-1} X'\left(S^{-1} \otimes I\right)Y$$

$$Var(b) = \left[X'\left(S^{-1} \otimes I\right)X\right]^{-1}, \ and$$

$$S = \frac{ee'}{T}, \quad where \quad e = Y - Xb \quad is \quad the \quad estimated \quad error \quad \varepsilon.$$

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CHAPTER 1

INTRODUCTION

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CHAPTER 1

INTRODUCTION

> "*We know a great deal about the direction of movement of one variable with the movement of another, a little about the magnitudes of such movements, and almost nothing about the functional forms of the underlying relations*".
>
> Ijiri and Simon (1977)

1.1. PRESENTATION

Economic dynamics is largely determined by the performance of firms. Standards of living, macroeconomic variables and unemployment, to mention just a few examples, are highly correlated with the economic performance of firms. To explain the performance of the economy in general, we have to analyse the behaviour of active and potential microeconomic agents.

The main aim of this thesis is to analyse the growth of Spanish firms in the manufacturing and service industries between 1994 and 2002. The Spanish case is interesting because of the scarcity of the literature in this field, which is mainly due to the lack of databases. See, however, the recent work of Fariñas and Moreno (2000), Correa et al. (2003), Peña (2004) and Calvo (2006). However, these studies only partially analyse

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economic activity since they do not distinguish between industries, focus only on the firm growth process or concentrate on one Spanish region.

In this thesis, our interest in differentiating between manufacturing and service industries stems from the fact that today we are part of a globalised economy in which consumers spend more on the service and leisure sectors and in which more firms need the services of other firms. Nevertheless, services are still ignored by researchers (Audretsch et al., 2004).

To analyse firm growth we adopt Gibrat's Law. Gibrat (1931) postulates that the growth of a firm does not depend on its initial size. The main consequence of this hypothesis is the right-skewed distribution of firms in the market. In fact, Ijiri and Simon (1977) determine that "*there are two reasons why this [Gibrat's Law] is a plausible assumption on economic grounds. First, it agrees with the empirical findings. Secondly, if, as we have postulated, there exists approximately constant returns to scale (above a critical minimum size of firm) it is natural to expect the firms in each size-class to have the same chance on the average of increasing or decreasing in size in proportion to their present size*".

Recent empirical evidence, however, rejects this Law and supports the idea that small firms have a greater potential to grow. Obviously, there are different ways to measure both a firm's capacity to grow and the limits of its growth. However, Gibrat's Law has been one of the major focuses for Firm Demography and several authors, including Jovanovic (1982), Ericson and Pakes (1995) and Pakes and Ericson (1998), have incorporated Gibrat's Law into their models.

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As Ijiri and Simon (1977) pointed out, "*stochastic explanations for the size distribution of firms have considerable interest for economic theory and policy*". They interpret these distributions in terms of the dynamics of the growth process rather than in terms of static cost curves. Several reasons support the importance of analysing firm growth.

First, from the point of view of industrial policy, by analysing firm growth we can determine the external and internal characteristics that determine the evolution of firms. One of the main concerns of policy makers is economic growth. To enhance territorial evolution, firms receive subsidies to create positive externalities in the local economy. However, subsidies must be efficient, which means that, in order to make efficient investments, policy makers should know which characteristics positively affect firm growth (Santarelli and Vivarelli, 2002).

Second, research into firm growth will have a positive effect on an important Spanish issue: employment. After a long period of high unemployment, unemployment is still one of the population's main concerns. Firm growth is therefore crucial to determining which firms are more likely to increase in size and create stable jobs (Wagner, 1992).

Third, firm growth may be crucial to firm survival. It is a stylised fact that firms are created undersized (Geroski, 1995), i.e. they are created with fewer employees than the minimum efficient scale. Firm survival is one condition for increasing firm size but, also, a firm needs to grow in order to survive. If a firm is to survive it must therefore increase its size constantly over time (Segarra and Callejón, 2002). Obviously, firm growth should be solid over a medium period of time in order to increase the firm's likelihood of survival.

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Fourth, firm growth is a way to introduce innovations and increase competitiveness in the market. When a firm increases in size, its production increases. To sell all of its production in the market, they need to be competitive. One way to be competitive is to innovate. This increase in market competitiveness should enhance the allocative efficiency of resources among firms, increase the variety of products available and steer prices towards marginal cost.

Finally, firm growth will influence the evolution of market concentration i.e. if small firms grow more quickly than large firms, market concentration will tend to diminish. On the other hand, if large firms grow more quickly than small firms, market concentration will tend to increase. The analysis of firm growth is therefore crucial to determining the evolution of market concentration.

Firm growth is therefore an interesting field to analyse since such an analysis will benefit economic growth, employment and the future survival of firms.

1.2. MOTIVATIONS AND CONTRIBUTIONS

In this section I will explain what motivated me to write this PhD thesis, describe how the thesis is organised and advance some of its main contributions.

My membership of the GRIT (Group of Research of Industry and Territory) research group has been crucial to my research development. This group has mainly focused on industry and territorial dynamics from several approaches. GRIT is one of the first Spanish research groups to

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analyse Firm Demography, which is widely studied in international economics but ignored until last decade in Spain largely because of lack of data (Segarra et al., 2002).

Within the field of Firm Demography, there are several research areas, such as firm entry, exit and growth. Entries and exits have been widely studied but firm growth has been less so. A plausible reason for this is the complexity of the process, which is driven by multiple forces.

I gained a strong interest in firm growth during my doctoral dissertation at the University Rovira i Virgili when I analysed the empirical and theoretical literature, again during my MSc dissertation at the University of Essex when I analysed Spanish firm growth, and finally during this PhD thesis.

The chapters of this thesis are organised as follows. In Chapter 2 I review the theoretical and empirical literature. I first present several ways to analyse the firm growth process and describe the theoretical approaches in the economic literature. I then focus on the stochastic firm growth approach, emphasizing its main hypothesis and presenting the wide range of empirical evidence.

In Chapter 3 I analyse Gibrat's Law and the different determinants related to Jovanovic's (1982) model. The main aim is not only to determine whether Gibrat's Law is accomplished between manufacturing and service industries, but also to determine both the relationship between firm growth and age and the differences between industries. I therefore investigated the presence of Jovanovic's (1982) passive learning models and Ericson and Pakes's (1995) active learning models.

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Gibrat's Law estimates firm growth depending on previous size. However, one branch of the literature analyses the possible correlation between past and future firm growth process. This possible relationship between temporal growth rates is known as the persistence of firm growth. Gibrat's Law is called the static method for analysing firm growth (Piergiovanni, 2002; Audretsch et al., 2004), while the analysis of persistence is known as the dynamic method.

In Chapter 4 I analyse the persistence of firm growth. First I present the theoretical and empirical evidence. Then I estimate dependence for Spanish firms and discuss the relationship between the persistence and the learning process. We are also interested in the previous path evolution. This means that the effect of past evolution on the future may depend on previous firm trajectory. In other words, a firm that has grown in the previous two periods will have a different pattern from a firm that has decreased in size in the same period.

In chapter 5 I stress the fact that initial characteristics are crucial for future firm growth equilibrium. I characterise the final equilibrium of firm growth according to several crucial variables, including external activity, the characteristics of the firm and location pattern. I also stress the influence of the firm size of aggregate industries, manufactures and service industries, on the firm growth.

In chapter 6 I analyse the determinants of firm growth in manufacturing and service industries. I pay special attention to regional and sectorial factors related to external economies and barriers to grow. Then I classify firms depending on the technological and innovative intensity of sectors where they operate and I estimate the relationship between firm growth and determinants.

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In Chapter 7 I summarise the main conclusions and implications for industrial policy. Finally, I include several statistical and methodological annexes enlarging or clarifying the information from the previous chapters.

This thesis reviews several outstanding, mainly empirical, contributions that are closely related to the analysis of firm growth. Firm growth has been widely studied by authors such as Audretsch (1995a), Lotti et al. (2001) and Mata and Portugal (2004) and can be viewed from several perspectives. Most of the literature has focused on manufacturing industries, while service industries have remained in the shadow. Audretsch et al. (2004), Piergiovanni et al. (2002), Santarelli (1997) and Oliveira and Fortunato (2004a, 2004b) are some of the few contributions that have analysed the service industries. In Spain, however, there have been very few studies in this field. In the last ten years, Correa (1999), Fariñas and Moreno (2000), Correa et al. (2003), Peña (2004) and Calvo (2006) are the most important of these. The aim of this thesis is to further our knowledge of Spanish firm growth from several perspectives: an analysis of Gibrat's Law (or the Law of Proportionate Effects), the persistence of firm growth and the different equilibria between manufacturing and service industries.

The analysis of Gibrat's Law relates firm growth to firm size. Gibrat's Law suggests that firm growth is random, which means that large and small firms are just as likely to grow.

Gibrat's Law adopts a static perspective. Firm growth is related to a static variable: firm size in a particular period of time. We can take a step further and achieve a dynamic perspective. By analysing the

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persistence of firm growth, we can relate the current performance of a firm with its past evolution. The consequence is that firms with past positive firm growth may have more probabilities to grow than those with past negative firm growth. However, we can also analyse the different long run firm growth equilibria between manufacturing and service industries. The interaction of external and internal variables may be behind the diverse patterns of firm growth.

To analyse all these aspects we have used the SABI database (Sistema de Análisis de Balances Ibéricos), which provides individual data at the firm level from Spain and Portugal. The years available are from 1992 to 2004 but, since there are many lags, we have shortened the information for the last two years. The SABI database compiles data from balance sheets, financial rates, administrative information, etc. about 95% of the active firms in an industry.

1.3. MAIN CONCLUSIONS

In general, our results agree with previous ones. Gibrat's Law is not accepted and, like in most of the recent literature, we found that small firms tend to grow more quickly than large firms. Moreover, age seems to be a key variable in determining differences in firm growth, although its effects are considerably inferior to the size impact.

The main consequence of this is that market structure does not tend to concentrate. Although small and large firms coexist simultaneously in the market, large firms do not increase in size more intensively than small firms.

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With regard to firm growth persistence, our results show that there is a positive relationship between past growth and future growth. However, this time dependence diminishes over time, which means that firms that grew in the past will grow more in the future.

Finally, our data show that the differences between manufacturing and service industries are significant, especially when we include territorial variables. Territorial variables make the differences between manufacturing and service industries significant when both groups are analysed separately.

More specifically for each chapter, our main results are:

- In Chapter 2 I highlight the various theoretical approaches for analysing firm growth. The existence of different theories is due to the the complexity of this phenomenon. Despite this variety, Gibrat's Law is one of the hypotheses that have most been used to analyse firm performance. Although there is much empirical evidence, there are still some gaps in the literature. First, the literature has mainly analysed manufacturing industries while service industries have been largely ignored. Second, few studies have incorporated locational variables although in other research fields of the Firm Demography the locational variables have been widely studied.
- In Chapter 3 I analyse firm growth, Jovanovic's (1982) passive learning model and Ericson and Pakes's (1995) active learning model. Specifically, our results reject Gibrat's Law in favour of small firms i.e. small firms grow more quickly than large firms. Experience in the market seems to be a significant factor behind firm growth, though its impact is relatively small.

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- In Chapter 4 I present the determinants of the persistence of firm growth and differences that are conditional on past behaviour. Our results show a positive relationship between past growth and current growth i.e. firms that grew in the past will also grow in the future. However, there seem to be significant differences between individual sectors. Analysis of the persistence of firm growth conditioned to past performance shows a positive relationship between a firm's growth and its future evolution. In other words, firms that grew in the past will also grow in the future. Therefore, policy-makers should take into account the evolution of firms when applying supporting policies to favour firm growth.
- In Chapter 5, comparison of firm growth in the manufacturing and service industries shows that these types of industry behave heterogeneously. Obviously, growth in different industries is not homogeneous. However, when locational variables are introduced, the differences between the two types of industries are not significantly different. The only exception is the analysis of individual series. Our main conclusion is that manufacturing industries should be analysed separately from service industries when the spatial dimension is introduced. Main conclusion is that initial condition matter for future firm growth.
- In Chapter 6, regional and sectorial variables are crucial factors to firm growth. Our main conclusion is that regional and sectorial factors affect heterogeneously between manufacturing and service industries. Moreover, MAR and Jacobs externalities affect differently depending on the technological and knowledge intensity of sectors where firms operate. In particular, technologically non-intensive manufactures located in a diversified environment will grow more than technologically non-intensive manufactures located in other areas. In reference to the Jacobs

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externalities – i.e. the specialised externalities–, specialised environments present positive externalities for manufacturing firms but they present negative externalities on service firms regardless of the technological intensity. Therefore, regional and sectorial variables affect firm growth evolution.

The different patterns of firm growth can have important consequences for the labour market, the social market, subsidy policies and tax policies, etc. Although many contributions have sought answers to some of the previous questions, there are still gaps in the empirical literature. Today we are part of a globalised economy in which technologies and services are crucial to economic growth. Moreover, few studies have focused on the service sectors, but differentiating between manufacturing and service industries is important. We have found that the locational pattern is crucial to analysing the manufacturing and service industries separately.

Our study has scope for several future lines of research. One line of research would be to investigate which territorial factors drive the patterns of firms located in different spatial regions. There have been few studies of firm growth in relation to territorial variables. Clearly, the environment in which a firm develops its activity is crucial to its post-entry performance.

Service industries are significantly different from manufacturing industries because of the differences in the minimum efficient scale needed to remain active in the market. A second line of research would therefore involve the industrial forces that drive the different patterns between industries.

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CHAPTER 2

A REVIEW OF THE LITERATURE OF FIRM GROWTH

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CHAPTER 2

A REVIEW OF THE LITERATURE OF FIRM GROWTH

"*The growth and survival prospects of new firms will depend on their ability to learn about their environment, and to link changes in their strategy choices to the changing configuration of that environment*".

Geroski (1995)

2.1. INTRODUCTION

Firm Demography concerns the different stages in a firm's life cycle. Firms appear in the market, survive, grow and eventually die, transferring their knowledge and information to surviving firms. In this sense, firm size reflects how the firm evolves and adapts to its environment. Changes in size are therefore extremely important events in Firm Demography (Wissen, 2002).

Firm growth has been one of most widely studied topics in economic literature. Several arguments highlight the crucial importance of this field. First, firm growth is related very closely to firm survival. Specifically, firm growth is positively correlated with the likelihood of

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survival. Hence firms that experience continuous growth will have a higher probability of surviving in the market[1].

Second, firm growth has consequences for employment[2]. A positive rate of growth implies a net creation of new jobs, while a negative rate implies the net destruction of jobs. Job creation and job destruction are closely related to the ability of incumbents and new entrants to grow. And, obviously, the evolution of employment therefore has obvious impacts on government budgets.

The third factor behind the importance of firm growth is its effect on economic growth. Backward and forward linkages will be higher or lower depending on the evolution of active firms. If we look at the general effect on an economy, an increase in firm growth may increase its demand towards other sectors, thus producing an increase in the economic activity of a region. This dynamism in the economy can lead to major growth. On the other hand, a decrease in the number of employees in a firm may indicate or cause a crisis[3].

Fourth, firm growth is a way to introduce innovation and is a leitmotiv of technological change (Pagano and Schivardi, 2003). For example, if a firm wants to grow and survive in a competitive industry, it needs to

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[1] It is a well known fact that firms are born undersized (Geroski, 1995). Firms, which adapt to the market process, will grow in size to take advantage of scale economies.
[2] When we speak about firm growth we refer to worker flows or the number of jobs created or destroyed over a period of time. However, we do not consider the number of people who changed of jobs over a period of time.
[3] The causal relationship depends on the firm's expectations. Firms may foresee a crisis but they may also cause it if their expectations are incorrect about the economic evolution. For example, Penrose (1959: 40) pointed out the role of expectations in the productive opportunity of the firm.

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incorporate new technologies in order to be more efficient. In this sense, growth is a challenge a firm must meet by introducing innovation[4].

Fifth, the evolution of the size of incumbents and new entrants determines market concentration. If small firms grow at a high rate, market competitiveness will increase. Conversely, increases in the size of large firms will affect market concentration. The regulation of market concentration to avoid the creation of monopolies and oligopolies (Shepherd, 1979) has been one of the main interests of governments. The analysis of firm growth may therefore help to clarify the concentration of firms in a market.

Moreover, a study of firm growth can shed light on the importance of the selection process after a firm has entered the market (Audretsch and Mata, 1995). Once a firm enters a market a selection process takes place (Jovanovic, 1982) whereby less efficient firms decrease in size and disappear and more efficient ones survive and grow. The analysis of firm growth will therefore show how firms behave once they enter the market, their market opportunities, turbulence and level of efficiency.

Another important characteristic of this topic is that firm growth has practical consequences for policy-makers' decisions (Wagner, 1992). Firm growth can increase employment and economic activity and policy-makers can control these macroeconomic variables using firm growth policies. However, as the growth is heterogeneous between firms, it is crucial to know the internal and external characteristics of firms that affect their performance in the market. An ample knowledge of these

[4] Audretsch and Lehman (2005) found that there is a positive impact on firm growth when a firm invests in R&D. Also, Thornhill (2005) confirmed that innovations are positively correlated with firm performance, as measured by revenue growth.

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features will enhance the effectiveness of public policies as well as their impact.

Because of these important reasons, much of the literature has focused on the firm growth process. However, there has been no convergence of the theories. As Correa et al. (2003) pointed out, these varied approaches may be due to the complexity involved in defining the firm. Contributions from classic economic theory, the behaviourist, the stochastic growth theory and the learning models have helped to perceive the causes and effects of firm growth.

Our interest is to highlight contributions to the literature of stochastic firm growth. Since Gibrat's study (1931), several articles have sought to explain the relationship between firm growth and firm size. This approach characterises firm growth as a constant probability for a firm to grow independently of its initial size. As Simon and Bonini (1958) pointed out, the main consequence is that firm distribution has a skewed tail. Hence, the vast majority of firms in the market will be small and medium sized while a few firms will have the majority of the employees in the industry.

Gibrat's Law, or the Law of Proportionate Effect, is an alternative theory to classical economic theory which postulates that there is an optimal firm size. Classic economists found it difficult to explain the presence of firms with heterogeneous sizes. In this sense, Gibrat's Law explains the empirical evidence better. However, the classical and the stochastic theories offer different explanations for a firm's size and its performance in the market.

In the last few decades, the post-entry performance of firms has focused researchers' attention. Post-entry performance includes analysis of a

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firm's growth and the likelihood of its survival. This chapter has two aims: first, to present several economic theories that have been used to analyse the firm growth process, and second, to analyse Gibrat's Law more carefully from the theoretical and empirical perspectives. We also consider the learning models (Jovanovic, 1982; Ericson and Pakes, 1995; Pakes and Ericson, 1998), which are closely related to Gibrat's Law. As in the literature there are many empirical contributions, we will analyse the most outstanding ones. For Spain, however, studies are scarce but these few contributions will also be reviewed.

In advance we can say that in the literature there is heterogeneity in the analysis of firm growth—in the measure used to analyse growth and in the results. Gibrat's Law is generally rejected in favour of the growth of small firms. Moreover, service industries have been largely ignored. Also, there are few analyses of the locational effects on firm growth.

This chapter is structured as follows. In section 2.2 I briefly summarise the approaches to the analysis of firm growth in the economic literature and describe the main differences between them. In section 2.3, I describe Gibrat's Law (1931) and describe, from a theoretical and empirical perspective, the evolution of the literature. Finally, in section 2.4 I summarise the main conclusions of this chapter.

2.2. FIRM GROWTH THEORY AND FIRM SIZE

Firm growth is one of the most analysed fields in economics. Its impact on employment, industry concentration, firm survival and economic activity are reasons enough for it to be considered an issue of crucial

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interest[5]. However, there is no single theory to analyse the impact, causes or evolution of firm growth. As Correa (1999) pointed out, this may be because the definition of the firm is multiple and complex.

This complexity has led to the emergence of scholars with different perspectives and, more importantly, with different predictions of the evolution of growth. This is clearly seen from the variables used in the literature to measure firm growth and its determinants. Some theories focus on average size, some focus on internal characteristics and others focus on random variables.

In any case, we will see that firm size has been the link between the various theoretical approaches. The questions we focus on this section are as follows: which measures have been applied to the firm growth process? How has the economic literature approached the firm growth pattern? What is Gibrat's Law and what are its main empirical consequences?

2.2.1. Definition of the firm

As we intend to analyse the behaviour of firms, I shall describe what the literature understands by a firm, a definition that has evolved over the years. From the black box where a set of inputs enters production and transforms them into a set of outputs, the definition of the firm has widened its perspective and adopted a more ecological perspective in which firms interact with the other agents in society and have their own internal function. Here, we present the most relevant contributions and determine what our perspective will be.

[5] Undoubtedly firm growth is an objective a firm needs to survive and be competitive and is the result of individual and collective effort. However, authors such as Suárez (1999) pointed out that in a more globalised economy, it is more important for firms to concentrate on the production of added value products than on oversizing.

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First, a firm can be considered as the internal process superseded by the external price mechanism. In this sense, the firm is defined by the boundary from where the output leaves the production system and enters the market; at this point the firm does not have control of the output. Coase's (1937) seminal contribution considers that firms are created because of friction in the price mechanism. Firms are limited by a marginal rule and internalize activities up to the point where internal management costs equal the costs of transacting in the markets.

Second is the perspective that firms are a group of capabilities. Here we must mention Penrose (1959) and Richardson (1972). Penrose (1959) differentiated between resources and the services they render. Resources can provide a variety of productive services. In turn, the provision of these services can modify the attributes of the resources and enable the provision of new services. In this sense, the firm is considered as a collection of productive resources the disposal of which between different uses and over time is determined by administrative decisions (Penrose, 1959). The fact that there is heterogeneity rather than homogeneity of both human and material productive services implies that firms are unique. Finally, the limits are defined by the nature of the firm's managerial and administrative responsibilities.

Richardson (1972) replaced the Penrosian notion of productive services with capabilities and activities and widens the definition to the coordination of capabilities in industrial systems. He considered the firm as a network: the boundaries of the firm depend on the type of activities it carries out and how these activities fit with others. This means that the corporate ownership of a firm may control several autonomous firms

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that depend to some extent on the main corporation. The main examples are the franchises that depend on the main corporation[6].

Third, Hart (1995) defined a firm as the ownership of or the property rights to a firm. Therefore, the limit of the firm is when one person has all the risk of the economic activity. With this approach, the firm is conceived as a set of assets under common ownership and control. One problem with this definition is that, as employees are not a possession of the firm, they would not be considered as part of the firm.

Highly complementary assets should be owned in common and the owner of these assets should be the best person to provide investment incentives for the best use of these complementary assets (Hart, 1990). This view provides an answer to where the limits of the firm should lie since they coincide with decisions about physical asset ownership.

Finally, the firm can be defined in terms of its sphere of influence. Williamson (1985) extended the boundaries of the firm to other agents that are in direct contact with the firm, such as distributors, alliance partners and suppliers. From this perspective, the emergence of the firm is a response to problems causing delay (*hold-up* problems), given the intrinsic opportunistic nature of human actors and the specialized nature of assets required for efficient production.

As we can see, the firm is difficult to define because its influence is multiple. For the purpose of this thesis, we define the firm as the

[6] For Richardson (1972), the degree of interdependence defines whether activities are complementary or closely complementary. Complementarity implies that activities must be matched in either level or specification and require some form of sequential coordination. Close complementarities arise when activities are to some extent specialized and require more careful coordination in the way they are combined.

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ownership of assets i.e. the third definition above. However, we will consider employees as belonging to the firm. This means that we will not consider employees to be autonomous individuals with their own incentives. This definition, closely related to Hart's definition (1995), is often used in research (Kumar et al., 1999).

2.2.2. Measure of Firm Size

One of the main challenges in every discipline is to homogenise the criteria for classifying its units of observation. The analysis of firm growth is no different because there are different ways of measuring the growth of a firm. This diversification is sometimes due to the purposes of each author but, more usually, it is due to lag of data (Correa, 1999).

The main problem is therefore the difficulty in making comparisons with other studies. In fact, the empirical literature uses a wide range of measures whose use depends on the purpose and subject of the data.

Ardishvili et al. (1998) and Delmar (1997) found similar growth indicators used in the empirical literature. Some of these indicators) are[7]:

- The financial or stock market value
- The number of employees
- The sales and revenue[8]
- The productive capacity
- The value of production
- The added value of production

[7] See Annex III for a review of the variables used in the stochastic empirical literature. Also see Audretsch et al.'s (2004) review of the literature.
[8] Both variables, sales and revenues, are directly related since revenues are equivalent to sales less the costs of production.

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Although all of these parameters are highly correlated (in other words, when a firm increases the added value of its production it also increases its stock market value), not all of them react so quickly to external or internal changes. For example, it is obvious that sales are more volatile than productive capacity because firms can generally modify their sales more often than they can modify their assets.

For example, Kirchhoff and Norton (1992) compared three measures (employment, assets and sales) and showed that they are interchangeable because they produce the same results when tested over a seven-year period.

However, each variable can paint a different picture of the firm. These may be interesting depending on the purpose of the research[9]. We can therefore select the most suitable variable for our interests. So, as our objective is to measure the firm's economic activity, we will see whether the above variables explain this internal process:

- The revenues of the firm do not provide any information about its internal process but show the prices and the quantities sold in the market.

- Sales are easily available and relatively insensitive to capital intensity. However, they are an unsatisfactory indicator because they can be influenced by a firm's arbitrary decisions (marketing strategies, financial decisions, etc.). Moreover, they can also be influenced by the decision to vertically integrate certain

[9] Delmar et al. (2003) analysed different measures and conclude that firm growth can be expressed by different measures depending on the aim of the investigation.

production processes and are sensitive to inflation and currency exchange rates (Delmar et al., 2003).

- Added value may be a better variable since it explains the capacity of the process to increase the value of the output. It is therefore quite a good indicator of internal activity. Unfortunately, however, added value is sometimes not publicly available for individual firms.

- Assets can also define the size and growth of a firm. However, as we stated earlier, they are more rigid to changes in the internal process of the firm and may not be a good explanatory variable[10].

- As Kimberley (1976) stated, the number of employees is the most widely used measure of size. The number of employees reflects how the internal process is organised and adapts to changes in activity. Moreover, employment is not sensitive to inflation or currency exchange rates. Scholars agree that this variable is a direct indicator of organizational complexity and is suitable for analysing the managerial implications of growth (Penrose, 1959).

The best variables for measuring firm size are therefore added value and the number of employees. As we have mentioned, the problem with added value is that there is usually a lack of information. The only problem with using the number of employees is that it does not consider the growth in labour productivity. Depending on the problem at hand, other variables may also be possible. For example, economic activities directly related to tourism may have alternative measures, such as the

[10] It is true that assets can be a correct measure when manufacturing industries are taken into account. However, it can lose explanatory capacity when used with service industries.

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capacity of supply (the number of beds, etc.). However, authors such as Delmar et al. (2003) pointed out that different growth "*measures and calculations affect model building and theory development differently*".

Obviously, using a measure such as the number of employees has several disadvantages. Delmar et al. (2003) mentioned that the number of employees does not reflect "*labour productivity increases, machine-for-man substitution, degree of integration, and other make-or-buy decisions*".

Firm growth as measured by a difference in the number of employees has led to analyses of aspects such as labour policies, labour market evolution and job creation. In this sense, Hart (2000) argued that the limitation of using only the number of employees is not important since all measures of size are highly correlated.

2.2.3. Factors of firm growth

In this section we analyse some of the factors in the literature on firm growth. We present several important theories of the determinants of firm growth. Although it is true that we could be more accurate in our presentation of these theories, the aim of this section is simply to sketch several of the factors behind firm post-entry performance.

The first studies on firm growth concentrated mainly on the impact of size and age. However, the characteristics that can influence post-entry firm behaviour are wider and authors such as Storey (1994) determined several factors affecting firm growth.

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Following Storey's (1994a)[11] classification, a distinction is often made between three groups of growth determinants: (i) those related to the *entrepreneur* (also defined as founder-specific); (ii) those related to the *firm* (also defined as owner/manager specific); and (iii) those related to *strategy*.

Factors influencing growth in small firms		
The entrepreneur's resources	*The firm*	*Strategy*
1 Motivation	1 Age	1 Workforce training
2 Unemployment	2 Sector	2 Management training
3 Education	3 Legal form	3 External equity
4 Management experience	4 Location	4 Technological sophistication
5 Number of founders	5 Size	4 Market positioning
6 Prior self-employment	6 Ownership	6 Market adjustments
7 Family history		7 Planning
8 Social marginality		8 New products
9 Functional skills		9 Management recruitment
10 Training		10 State support
11 Age		11 Customer concentration
12 Prior business failure		12 Competition
13 Prior sector experience		13 Information and advice
14 Prior firm size experience		14 Exporting
15 Gender		
Source: Storey (1994a)		

With regard to (i) above, Storey defined the entrepreneur's inherited and learnt abilities e.g. motivation, experience and age[12]. With regard to (ii), features of the firm are e.g. age (the experience of the firm in the

[11] Following Storey (1994a)'s classification, firms can be divided into three groups: "failures", "trundlers" and "flyers". "Failures" are those firms that disappear after entering the market. "Trundlers" are firms that survive to the observed period but do not significantly change size. "Flyers" are firms that really contribute to job creation and increase in size.
[12] Casson (1998) emphasised the key role of entrepreneurial ability as an explanatory variable of firm growth.

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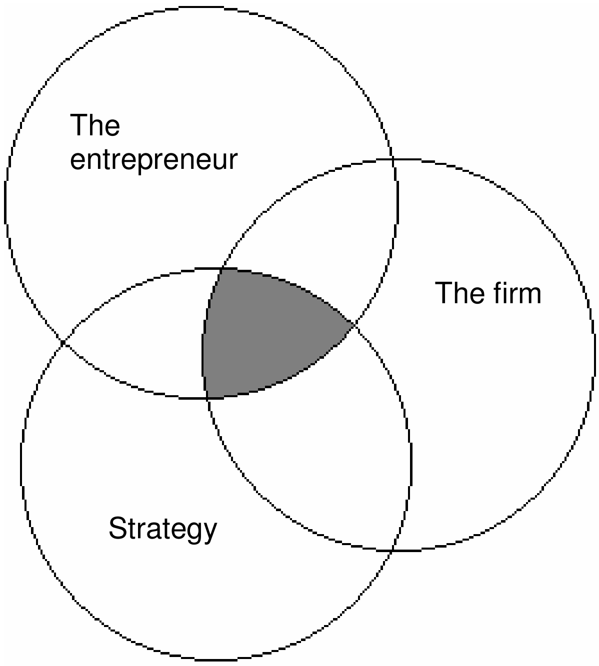
market), sector and size. With regard to (iii), firms may adopt strategies involving technology or exportation[13]. However, a lack of data in their analysis meant that they did not incorporate all of these dimensions[14].

However, all of these elements should be combined in an appropriate way so that the firm grows rapidly. Graph 2.1 represents each of these factors (the entrepreneur, the firm and strategy) by a circle. The intersection of all of the circles (the shaded area) is where the fast-growing firms are located (Storey, 1994a). For example, a firm with a good strategy for tackling market competition may obtain low results if the manager does not have enough skills to cope with the new market situation or the ability to motivate his or her workers.

Graph 2.1 Interaction of factors on firm growth.



Source: Storey (1994a)

[13] Barringer et al. (2005) recently analysed all these factors but grouped them into four explanatory vectors: founder characteristics, firm attributes, business practices and human resource management practices.
[14] For example, Peña (2004) used the entrepreneur's characteristics to analyse growth in an incubation centre; other authors, such as Fariñas and Moreno (2000) and Correa et al. (2003), introduced variables related to the firm.

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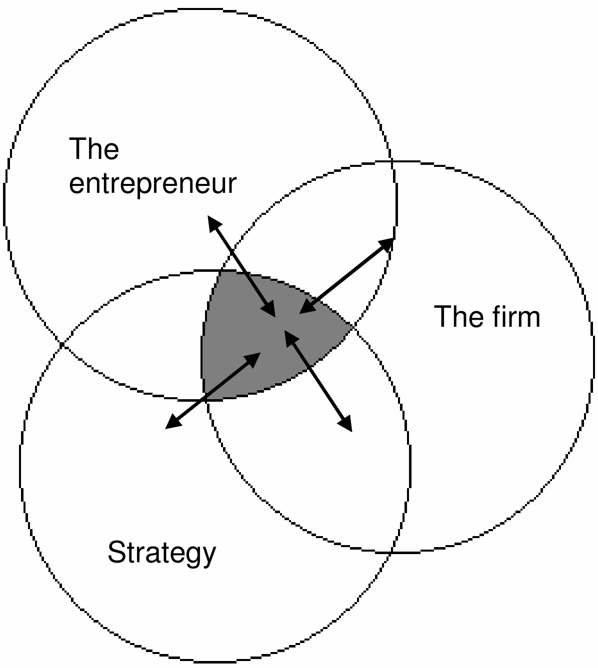
The interactions between these factors lead to a high heterogeneity in firm grow rates over time. Some researchers are therefore attempting to identify the relationships between all of these characteristics and firm growth.

A fourth factor also stands out: randomness. Some unexpected factors may affect the interaction of these factors. Geroski's (1999) theoretical study presents randomness as an event with an unknown form or a known fact whose date of occurrence is undetermined.

Graph 2.2 shows how this stochastic error term, represented by arrows, can affect this central core. The shaded area can increase or decrease depending on the effect of the error term.

Graph 2.2 Interaction of factors on firm growth and the error term.



Source: author's illustration based on Storey (1994a)

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Therefore, some factors can be controlled by the firm, but other, unexpected, events that are internal or external to the firm can also affect firm growth. Not only are there factors that increase the growth of firms. Storey (1994a) pointed out the existence also of growth barriers. These barriers can be due to human failures but they may also be beyond the control of managers and owners.

Geroski (1995) mentioned that one of the most interesting subjects in firm dynamics is the ability to learn and respond to their changeable environment. "*The implication is that the growth and survival prospects of new firms will depend on their ability to learn about their environment, and to link changes in their strategy choices to the changing configuration of that environment*". This ability to learn and adapt is crucial to firm growth and is highly correlated with the firm's age or experience. As Geroski (1995) said, this is not the only factor but it is one of the most important.

Barriers to growth
Availability and cost of finance for expansion
Availability and cost of overdraft facilities
Overall growth of market demand
Increasing competition
Marketing and sales skills
Management skills
Skilled labour
Acquisition of new technology
Difficulties in implementing new technology
Availability of appropriate premises or site
Access to overseas markets
Source: Storey (1994a)

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According to Scherer (1970), there are more factors that influence the size and growth of firms. These are:

Economies and diseconomies of scale

Classical economists explained that firm size and any changes in firm size depended on economies of scale. These economies of scale are due to diminishing costs when the firm increases. Therefore, the higher the economies of scale, the larger the optimum firm size[15]. Scherer (1970) claimed that diminishing unitary cost is not infinite. This is because:

- it implies the existence of a minimum optimal scale, but in the real economy there is a wide range of firm sizes in the same industry,
- when economies of scale exist, firm growth may reduce the unitary cost until other diseconomies appear: diseconomies of management due to a lack of harmony between different branches or the higher wages of executives, for example, should not exceed the benefits of economies of scale,
- transport costs are involved. This is because the larger the size of the firm, the larger its production and the higher its sales must be. To increase sales, the firm must sell at longer distances. Consequently, both unit shipping costs rise and prices rise. The limit is the price of the product in the market.

Mergers and acquisitions

Firms can grow internally or externally. They can grow organically, through acquisition, or by a combination of the two. Penrose (1959)

[15] The concept of economies of scales was introduced by Adam Smith in the *Wealth of the Nations*, which reported that the specialisation of workers increased their productivity.

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suggested smaller, younger firms in emerging industries mainly grow organically, whereas older, larger firms in mature industries mainly grow through acquisition.

When a firm acquires another firm, the concentration in the market and the market power of the firm increase. From Scherer's (1970) perspective, this situation responds to the "empire-building" desire of firms.

Ijiri and Simon (1977: 193) drew attention to two types of growth:

> *"The overall growth of firms consists of internal growth (due to mergers and acquisitions) and external growth (due to growth from sources outside the population). That overall growth satisfies Gibrat's law does not necessarily mean that internal growth and external growth each satisfy Gibrat's law individually, since deviations from the law may cancel with each other to produce an overall Gibrat's Effect."*

The impact of government policies

Sometimes consciously and sometimes unconsciously, government policies can increase or decrease market concentration. Tax policies, for example, may make it difficult for Small and Medium-Sized Enterprises (SMEs) to attract capital if there is corporate income tax exemption. Also, when a government gives subsidies to firms with certain characteristics, this decision can influence the market structure through the disappearance of efficient firms that did not receive them.

Another example is the creation of incubating ventures whereby entrepreneurs receive public and private support to create their firm. This financial and administrative support modifies the distribution of

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firms in the market. This modification can be positive, if the firms receiving the support are efficient, or negative, if the firms are inefficient. Firms located in the incubating centers may therefore increase their potential efficiency in the market artificially and take the place of efficient firms that do not receive external help. Consequently, public policy can cause inefficient firms to supplant efficient firms in the market. If these firms do not receive help, they may leave the market. The end result would be an increase in market concentration[16].

Stochastic determinants of market structure

Other studies in the economic literature have focused on random determinants of firm growth such as managerial talent. In section 2.3 we will see that the heterogeneous pattern of firms in an industry is down to pure historical chance.

Authors such as Hoogstra and Dijk (2004) suggested that other *external factors* are related to a firm's location or environment. So far, most studies have mainly focused on firm- and entrepreneur-associated factors that influence firm growth. Almus and Nerlinger (1999) considered as external factors, as well as local factors, the average rates of wages and salaries. As these are cost factors, they can prevent the hiring of new employees and thus have a negative influence on growth[17]. Therefore, scholars have introduced internal and external firm characteristics to analyse firm growth.

[16] Hyytinen and Toivanen (2005) and Lerner (1999) showed that there is a significant positive relationship between public R&D subsidies and firm growth.
[17] Almus and Nerlinger (1999) studied the new technology-based firms (NTBFs). As these firms are characterised as being capital intensive, we can assume that labour costs have only a minor impact on growth.

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2.2.4. Different approaches to firm growth

This wide range of determinants is represented by several theories. These different theories are the result of the relevance of the topic and the difficulty in analysing it (Correa, 1999).

The main schools of thought can be divided into four groups[18]: (i) classical economists; (ii) behaviourist economists, who emphasise the role of managers on increases in firm size; (iii) stochastic theory, which assumes that firm growth follows a stochastic process; and (iv), models of learning and selection, which are linked to the stochastic firm growth theory.

- *Classic economists*
  - *Static approach*
  - *Dynamic approach*
- *Behaviourist economists*
  - *Managerial approach*
- *Stochastic theories*
  - *Gibrat's Law: Gibrat* (1931)
  - *Kalecki* (1945)
  - *Champernowne* (1973)
- *Models of learning and selection*
  - *Passive learning approach*
  - *Active learning approach*

[18] For a survey of the literature, see Hart (2000), Mazzucato (2000) and Geroski (1999). Hart (2000) analysed the neo-classical theory of the firm, imperfect competition, technical economies of scale, pecuniary economies of scale, external economies of scale and dynamic economies of scale. Mazzucato (2000) divided theories of firm growth and market structure into three: the Static Approach, the Dynamic Approach and the Stochastic Approach. Geroski (1999) focused on four types of growth theories: models of optimum firm size, stage theories of growth, models with Penrose effects and models of organizational capabilities.

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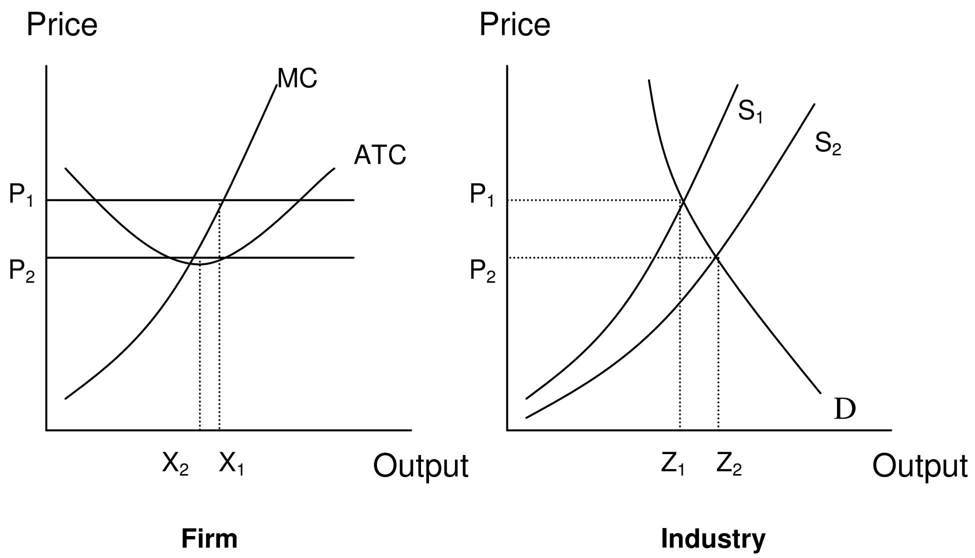
A. Classical economists

Classical economic theory has studied firm growth indirectly because its aim is to find the optimum size (Viner, 1932). Firm growth is therefore the change between one equilibrium situation and another.

This approach shows a negative relationship between firm size and growth. The reason for this negative relationship is that firms search for the optimum, most efficient size. The benefits of efficiency are related to economies of scale: the larger the firm, the higher its profits.

Graph 2.3 Firm size equilibrium from a classical point of view.



Source: Scherer (1970: 12)

Note: MC is the Marginal Cost, S is the Supply, D is the demand for output and ATC is the Average Total Costs.

This kind of model suggests that competition will drive firms to the bottom of their U-shaped average cost curves. However, other

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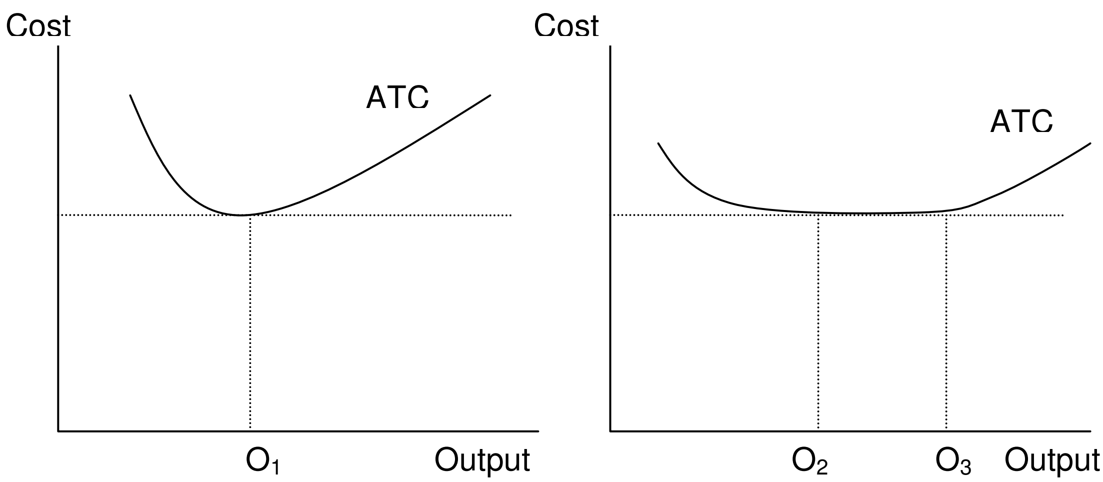
determinants, such as sunk costs, the intensity of the competition and organizational factors also play a key role in defining optimum size.

Graph 2.3 shows how the equilibrium size is reached. This is mainly due to market forces. For example, when an active firm in the market knows that the market price is p_1, it produces X_1 units of output. The firm has positive profits per unit of output because the price is higher than the average total costs (ATC). Consequently, it cannot represent a long-run equilibrium position because these positive profits will attract new firms to produce this output and will add their marginal cost function to the industry's supply curve and shift the supply curve to the right. This increase in output will reduce the price in the market and new firms will continue to enter the market until the marginal cost equals the average total costs (ATC).

However, to adjust to reality, the cost-minimising part of the curve should cover a wide range of output levels and diseconomies appear when the firm reaches a high level of production (Graph 2.4).

Graph 2.4 Relationship between output and levels of cost in an industry.



Source: Stigler (1958)

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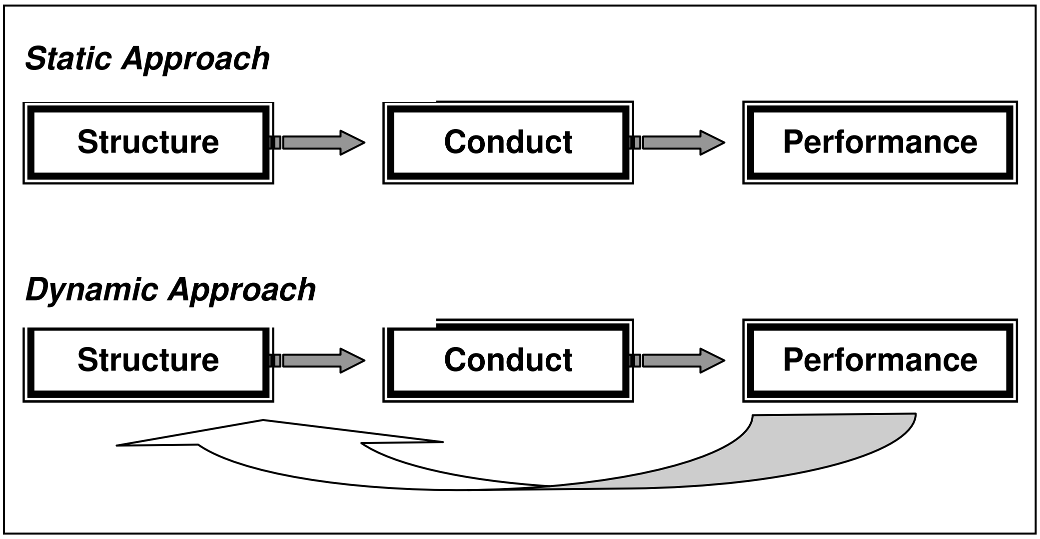
The new ATC curve reconciles the observation in the empirical evidence that heterogeneous firms coexist in the same industry. According to Stigler (1958), this would be because there is a wide range of outputs, between points O_2 and O_3, for which the unit cost is more or less constant. Consequently, the hypothesis that diseconomies appear immediately after the point at which economies of scale disappear would be incorrect. There is a range of levels of output in which the firm can eliminate the different sources.

The relationship between firm size and the post-entry performance of firms has been analysed by classical economists. Graph 2.5 shows the differences between the Static Approach and the Dynamic Approach (Mazzucato, 2000).

Graph 2.5 Static and Dynamic approaches to the classical model of firm growth.



Source: author.

The Static Approach is based on microeconomic theory and refers to the Structure-Conduct-Performance framework, in which there is a linear

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connection between the parameters. Given the structure of the market, it is possible to quantify a firm's production and hence the formation of prices.

The Dynamic Approach focuses on the feedback process between performance and structure. The central question is not the state of the production structure but the ongoing changes within it. It is no longer a matter of producing a specific quantity in order to maximise profits. With increasing returns to scale in a dynamic sense, we may see firms act in a way that would be considered irrational in the basic microeconomic context. However, this Dynamic Approach ignores the issue of long-run growth dynamics.

Geroski (1999) presented a model for reconciling this classical model with the stochastic firm growth model. He suggests that S^* drifts unpredictably over time and so the random variable $\mu_{i,t}$ will collect small, independent, firm-specific shocks that will alter the optimum size of reference. The proposed solution is therefore to let S^* vary unpredictably. To formulate the equation from a classical perspective, Geroski (1999) suggested a model based on the partial adjustment equation:

$$\Delta \log S_{i,t} = \lambda \{\log S^* - \log S_{i,t-1}\} + \mu_{i,t}$$

This kind of model shows changes in firm size as a transitional process of convergence to S^*, the optimum size. The most interesting feature of the above equation is the parameter λ since it determines the velocity of convergence. When λ is equal to 0, convergence never occurs. When λ is equal to 1 there is a perfect coincidence between size and the optimum size.

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The main implication of the classical model is that firm growth is always limited by this optimum size. However, evidence from the 1970s showed that there was a process of concentration inside industries. Consequently, one of the main criticisms of this model is that it cannot explain the presence of large firms whose size is greater than the optimum size or how the process of firm growth evolves over time.

B. Behaviour economists

The above criticisms in classical economic theory are addressed by the Behaviour approach. This theory considers that firms can be oversized because of the division between the objectives of control and ownership structures. When the owner does not control the firm, the managers maximize their own satisfaction instead of the firm's value. Behaviourist economists (Baumol, 1959, 1962; Penrose, 1959; Chandler, 1962; Marris, 1964) explain that managers can enhance their own satisfaction through an increase in the size of the firm.

This maximization of individual utility is a continuous process the limit to which is the managers' ability to coordinate and inspire confidence and security in others. Penrose (1959) argued that firms did not have a long-term optimum size but a constraint on current period growth rates. This means that rapid growth can imply a reduction in organisational efficiency (Penrose, 1959; Richardson, 1964; Williamson, 1967).

Another hypothesis is the *resources push* theory of growth, the basic premise of which is that competitive advantage lies in the possession of resources and routines, organizational capabilities or core competencies. This theory suggests that there are different types of firm behaviour and different levels of performance, so profitability (based on organizational

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capabilities) is also different. However, this explanation does not explain why firm growth seems to be quite transitory, as if it were a random process.

The purpose of the Behaviour Approach is therefore to explain why some firms are more competitive. To do so, they focus on a firm's specificities and the internal elements that account for its performance. Heterogeneity in a firm's characteristics leads to a heterogeneity in performance.

This managerial approach highlights the importance of knowledge assets and processes of co-ordination within a firm (Penrose, 1959) and assumes that firm growth is due to an internal and endogenous creation and accumulation process of specific resources (Penrose, 1959; Chandler, 1962). However, this perspective has drawbacks such as the generality of managerial abilities and a lack of empirical studies that investigate the relationship between knowledge structures and firm growth.

C. Stochastic economists

The stochastic firm growth theory has developed simultaneously to these theories. Stochastic growth models have two main objectives: to detect the existence and persistence of the stochastic factors affecting firm behaviour and to detect the presence of inequality and concentration among firms. Three of the main stochastic growth models are those of Gibrat (1931), Kalecki (1945) and Champernowne (1973). Broadly speaking, the models of Gibrat (1931) and Kalecki (1945) follow a lognormal distribution of firm sizes, while that of Champernowne (1937) follows a Pareto distribution.

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Gibrat (1931)[19] suggested that there is no relationship between the size of a firm and its growth. This is known as Gibrat's Law or the Law of Proportionate Effect. In fact, firm growth is the result of a multiplicative process that affects the initial size. The factors that can affect firm growth relate not only to the firm, but also to its environment. The main consequences of Gibrat's Law[20] are as follows (Sutton, 1997).

- There is no optimum size to which firms will converge.
- The likelihood of growth is independent of initial size, so expected growth and its variability are the same for all firms[21].
- Past growth does not affect current growth since there is no serial correlation (both between firms and over time).
- Firm size dispersion increases over time, so market concentration is higher if the number of firms remains constant.
- The variance of firm growth rates is equal for all sizes. This means that the variance of firm growth rates for small firms is equal to the variance of firm growth rates for large firms.

In other words, Gibrat's Law postulates that the "*probability that the next opportunity is taken up by any particular active firm is proportional to the current size of the firm*" (Sutton, 1997).

Kalecki (1945) formulated a stochastic growth model that assumes that the logarithmic variance of size is constant over time and, therefore, that the logarithm of size and the logarithm of the random variables are

[19] In section 2.3 we will see a deeper approximation of Gibrat's Law.
[20] Gibrat tested this growth process not only with respect to firm size but also with respect to income distributions. We should also point out that the so-called Gibrat's law of firm growth is named differently in other research fields in reference to other "organisms".
[21] This is why Gibrat's Law has been called the Law of Proportionate Effects.

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negatively correlated. Specifically, to express the current firm size he defines the following equation:

$$Y_n = Y_0 + \sum_{i=1}^{n} y_i = Y_0 \prod_{i=1}^{n} (1-\alpha_i) + \sum_{j=1}^{n} \prod_{i=1}^{n} z_j (1-\alpha_i)$$

where Y_n is the firm size at period "n". Consequently the size will be the sum of small independent random increments $z_k \Pi(1-\alpha_k)$. When the central limit theorem is applied, the distribution to Y_n implies that as $n \rightarrow \infty$ the distribution is normal.

Kalecki's (1945) model therefore has two main consequences.

- The stochastic process of firm growth is as in Gibrat's Law.
- There is no increase in the concentration of the market since large firms find impediments to grow proportionate to their size.

Champernowne (1937) presented a model of income distribution that can be applied to the distribution of firm assets (Simon, 1955). In this case, the model assumes that firm size follows a Markov process that depends on the previous state and a random element. The possibility of changing state (firm size, in this case) is called the transition probability and all the possibilities are compiled in a transition matrix. The probabilities of changing firm size will depend on the distance: the greater the difference between the current size and the desired size, the lower the probability that this change occurs. Consequently, firm size in period t+1 will depend on the following formula:

$$X_x(t+1) = \sum_{u=-\infty}^{1} p_u X_{(s-u)s}(t)$$

where u is the distance between the current size (r) and the future size (s). When there is a sufficiently long period, the distribution reaches an equilibrium called the stationary distribution. Champernowne (1937)

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determined that the stationary distribution would approach a Pareto distribution:

$$\log F(Y_s) = \gamma - \alpha \log Y_s$$

where Y_s is the lower limit of size and $F(Y_s)$ is the number of firms whose size exceeds *s*. The main conclusions of Champernowne's model are as follows.

- As in Gibrat's Law, firm growth is independent of firm size.
- As in Kalecki, the "growth" process remains non-dissipative but in a much more restrictive sense. Champernowne imposes a stability condition that causes the expected value of variations to be negative for all firms. Consequently, concentration decreases.

Other authors, such as Ijiri and Simon (1977) and Scherer (1980), state that stochastic factors have a high impact on the distribution of firms in the market. The result is a highly skewed firm distribution in which a large number of small firms live with a low number of large firms. This approach has been criticised in the literature, however, because it assumes that the firm growth process is a random walk in which factors such as luck have a high weight.

Scherer (1970: 128) pointed out some firm determinants in which there is a component of stochasticity. Some of these are "*the hiring of key executives, research and new product development decisions, legal disputes involving critical patents, the choice of an advertising campaign theme, or a thousand and one other decisions among attractive but uncertain alternative courses of action. Given the operation of chance in these elemental decisions, high or low sales growth follows in a more*

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traditionally deterministic manner". Therefore, from a managerial point of view, firm growth is full of characteristics that can cause the randomness of firm growth.

D. The models of learning and selection

More recently, the learning theory has appeared in the economic literature. Geroski (1995) emphasized that firm growth and survival depend on a firm's capacity to learn. Empirical evidence shows that the survival and post-entry performance of new firms depends on their capacity to adapt to the environment and apply the correct strategies. The learning and selection approach emphasizes the ability of firms to learn, their capacity for innovation and sectorial features.

There are several outstanding models of the learning and selection processes. These include those of Jovanovic (1982), Ericson and Pakes (1995) and Pakes and Ericson (1998). The main characteristics of these models are the fact that they take into account the dynamics of firms and their level of efficiency, which determine their chances to survive.

Jovanovic (1982) provided a model in which firms do not know their level of efficiency until they enter the market. This learning process is called a Bayesian or passive learning process. Once in the market, the most efficient firms grow faster until they reach a minimum efficient size. Inefficient firms disappear with the course of time. This is the *Theory of "noisy" selection*. These types of model introduce variables such as age to measure this ability of a firm to learn its economic efficiency.

Specifically, firms are created with a number of workers (l) and are affected by a productive shock. The distribution of the probability of profits is unknown at the initial moment and does not vary with time.

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Entrepreneurs use past information to know their expected profits in the future. Their profit function is:

$$\Pi_t = \Pi(\eta_t; a_t \varsigma) \equiv \max(l)\left\{a_{1t}\eta_t F(l) - a'_{2t} l\right\}$$

where Π_t are profits determined by a productive shock η, which affects the efficiency of all firms and is independent, l is the number of inputs and a is a vector of prices (1 implies the price of output and 2 implies the price of the input).

Each firm maximises the expected value of profits conditioned to the current information. The expected value of a firm, which lives for "t" periods and has been affected by η productive shocks, will be the expected value of the firm in the next period (closed down or still active):

$$V_t(n^t) = E\left[\Pi(\eta_{t+1}) \middle| n^t\right] + \beta E\left[\max\left\{\phi, V_{t+1}(\eta^{t+1})\right\} \middle| n^t\right]$$

The main result is that firms whose size is inferior to the minimum efficient size do not accept Gibrat's Law. If these small firms survive, they will increase their size. However, for firms above the minimum efficient scale (MES), Gibrat's Law is accepted. Jovanovic (1982) therefore models the heterogeneous behaviour of firm growths depending on firm size and their level of efficiency.

Ericson and Pakes (1995) and Pakes and Ericson (1998), on the other hand, presented an active learning process in which firms not only know their efficiency level when they participate in the market but can also can modify it through investment. During each period of time, firms

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decide whether to continue in the market or to leave it, depending on both their own and their competitors' investment[22].

In this model, active firms maximise the following profit function:

$$V(\omega, s) = max\left[\sup_{x\geq 0}\left\{R(\omega, s; x) + \beta\sum_{\eta'}\sum_{s'}\sum_{\omega'} V(\omega', s')p(\omega'|\omega, x, \eta')q_{\omega}(\hat{s}'|s, \eta')p_{\eta'}\right\}, \phi\right]$$

where V(·) represents the expected value of future profits given the probability of the state ω and the industrial structure *s*. This value depends on the decision of the firm to still be active or to close (the opportunity cost is ϕ in the case of closure.

The expected profits take into account the current revenue *R(·)* but also the future revenue. Future revenue is the discounted value of the expected profits *V(ω', s')* by the transition function *p(·)*, which depends on the future probability (ω') conditioned to the current probability (ω), past investments (x) and the future productive shocks (η').

Moreover, the transition function $p(\cdot)$ is multiplied by the opinion of the firm with regard to the transition probabilities of the other firms ($q(\cdot)$), which depends on the number of future active firms $\hat{s}'$. The number of future active firms depends on the current number of firms (s) and the future productive shocks (η').

Moreover, two factors affect the expected future profits—the probability of future productive shocks ($p_{\eta'}$) and the discounting value β. New entrants maximise their expected profits:

[22] This model is similar to the ecological perspective of Nelson and Winter (1982), who introduce investment in R&D.

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$$V^e(s,m) \equiv \beta \sum_{\eta'} \sum_{s'} \sum_{\omega'_m} \sum_{\omega^0} V(\omega^0, s' + e_{\omega^0} + \hat{\omega}_m) \cdot \pi^e(\omega^0 - \eta') \times \Pi_{j=1}^{m-1} \pi^e(\omega_j^0 - \eta') \cdot q^0(\hat{s} | s, \eta') \cdot p_{\eta'} \phi$$

The entry decision is sequential since firms enter the market until the expected value of profits falls to a point at which the sunk costs are not recovered ($x^e{}_m$). This means that the entry of one more firm (m+1) represents a negative profit. Analytically:

$$V^e(s, m+1) - x^e_{m+1} \leq 0 \leq V^e(s,m) - x^e_m$$

Ericson and Pakes (1995) and Pakes and Ericson (1998) found an equilibrium with rational expectations and a finite number of heterogeneous firms in an environment with idiosyncratic *shocks*. Simultaneously, the equilibrium is an ergodic stochastic process i.e. a dynamic process is generated by optimal strategies of investment. The consequences of ergodicity are: a) the industrial structure evolves over time; b) there appears to be a regularity in the evolution of the industry; and c) the influence from the initial situation disappears with industrial development (i.e. the future is independent of the past; there is a Markov process).

Lucas (1978) presented a theoretical model where Gibrat's Law is the driving force. The production function depends on "production technology" and "managerial or entrepreneurial technology". Gibrat's Law is accomplished under the condition of heterogeneity of managers' skills levels and the presence of costs of rearranging assets between managers. The former presents constant returns to scale and the latter presents decreasing returns to scale. The results of this author show how every firm size depends on the level of managerial talent.

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On the other hand, Cabral (1995) showed how small firms grow faster because of sunk costs. In this case, the initial investment is a small portion of the optimum production in the long run. In a recent paper from Aquilina et al. (2006), and based on Lucas's (1978) model, it is proved that an inverse relationship between the elasticity of substitution and average firm size exists. Their model therefore explains the positive relationship between the importance of SMEs in a country and the openness of the economy. In order to obtain this result, they introduce a normalized CES production technology to treat the elasticity of substitution as an explicit parameter of the model.

To sum up, our analysis of the different approaches to firm growth shows that there is a common aim: to measure firm growth. Moreover, these approaches have one common feature: the nature of the competencies and the process by which they are accumulated is difficult to reconcile with the erratic growth performance displayed by most firms (Geroski, 1999).

As a starting point, we will adopt the stochastic model. However, we will introduce a number of variables to provide a model of learning and selection. This evolution will be explained more thoroughly in the third point from this chapter. However, "*it would be unwise to reject more conventional explanations of market structure out of hand. Economies of scale, government policies, and the like are surely influential and not merely in a random way*" (Scherer, 1970: 130). For this reason next chapters will introduce other internal and external characteristics related to territory, economic growth, and the sector where the firm operates.

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2.3. GIBRAT'S LAW

Gibrat (1931) develops a theoretical model to measure the relationship between firm growth and its initial size. Gibrat's Law shows how firm growth depends on random shocks that are independent of each other and on initial firm size. Gibrat's model is written in the following form:

$$\Delta \log S_{i,t} \equiv \log S_{i,t} - \log S_{i,t-1} = \mu_{it} \quad \textit{where} \quad \mu_{it} \approx N\left(0, \delta^2\right) \qquad (2.1)$$

where $S_{i,t}$ is the number of employees working in a firm "*i*" in a period "*t*" and μ_{it} is a normally distributed random variable with a mean of zero and a variance of δ^2.

Equation (2.1) implies that an unexpected shock can occur because: a) we do not know what will happen, or b) we know what will happen but we do not know when it will happen (Geroski, 1999). This means that the process is hard to predict.

This equation also means that the unexpected shocks have permanent effects on the size of the firm. Another way to illustrate this is to decompose each size until the period of creation (*"t" = 0*):

$$\log S_{i,t} = \left(1 + \mu_{i,t}\right)\log S_{i,t-1} = \log S_{i,0}\left(1 + \mu_{i,1}\right)\left(1 + \mu_{i,2}\right)\ldots\left(1 + \mu_{i,t}\right) \qquad (2.2)$$

Rearranging this equation, we get:

$$\log S_{i,t} = \log S_{i,0} + \sum_{s=1}^{t} \mu_{i,s} \qquad \text{if} \qquad \log\left(1 + \mu_{i,s}\right) \cong \mu_{i,s} \qquad (2.3)$$

where the logarithm of the employees working in a firm in a period "*t*" ($S_{i,t}$) depends on two factors: (*i*) the initial firm size ($S_{i,0}$) measured in

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terms of the number of employees, and (ii) a set of random terms ($\mu_{i,t}$) which are the same for all the active firms in the market and independent of firm size[23].

Consequently, Gibrat's Law is characterised by a first-order Markov process, which does not imply a serial correlation between the different temporal rates of firm growth (Singh and Whittington, 1975).

Any firm "*i*" is therefore the sum of all the shocks (both expected and unexpected) the firm has received since its creation. Because of the unpredictable nature of these shocks, it is difficult to predict the future firm size.

We should mention certain aspects of random growth rates. First, the growth rates are assumed not to correlate with each other either across firms or over time. Second, the growth rates are assumed to be independent of firm size, which is why we also refer to this proposition as the Law of Proportionate Effect. Third, the random growth rates are normally distributed because random shocks are small effects from many forces.

Gibrat's Law predicts that all firms have the same likelihood of growth, regardless of their initial size. If we extrapolate this result to the future, we see that the market will tend to concentrate because the largest firms will increase their weight in the market. This means that firm size will inevitably become log-normal (right skewed) because of the central limit theorem. Due to random event, firms will eventually diverge in size, and the market concentration will increase even though the firms' growth prospects are still the same.

[23] This equality is accepted as long as the error terms are small enough (Sutton, 1997).

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To test this result, the economic literature has estimated Gibrat's Law using various equations. There are three equations in particular that confirm Gibrat's Law.

Firstly, the logarithm of the number of employees belonging to firm "*i*" during the period "*t*" ($S_{i,t}$) depends on the logarithm of the number of employees from the previous period ($S_{i,t-1}$):

$$\log S_{i,t} = \alpha + \beta \log S_{i,t-1} + \mu_{i,t} \qquad (2.4)$$

Gibrat's Law is accepted as long as coefficient β is equal to 1, so firm growth is independent of initial size. If β is less than 1, the smaller the firm, the higher the growth. If β is more than 1, the larger the firm, the faster the growth.

Secondly, firm growth has also been estimated as a function of initial size. Rather than obtaining the size for the following period, we obtain the growth of the firm during the periods "*t-1*" and "*t*" ($\Delta \log(S_{i,t})$):

$$\Delta \log S_{i,t} = \alpha + \beta \log S_{i,t-1} + \mu_{it} \qquad (2.5)$$

If Gibrat's Law is satisfied, β will be equal to 0. A positive value implies that larger firms will grow more than smaller firms, so there will be a divergence in firm size. A negative value implies that smaller firms will have a higher growth rate than larger firms, so there will be convergence in the industry.

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Thirdly, there is another dynamic model of firm growth that is linked to the implication of the absence of any dynamics associated with lagged dependent variables:

$$\Delta \log S_{i,t} = \alpha + \beta \Delta \log S_{i,t-1} + \mu_{i,t}$$

where the logarithm of the growth in the period "t" belonging to firm "i" depends on the firm growth rate from the previous period. In this case, Gibrat's Law is accepted if β is equal to 0. Both equations have an error term ($\mu_{i,t}$) that depends not only on the period of time but that is also individual to each firm.

During the 1950s and 1960s, the literature developed stochastic models to explain firm growth and industrial dynamics. Ijiri and Simon (1974, 1977) introduced firm entries and exits to explain how market distribution evolves over time. These authors define equations that tackle firm distribution depending on the number of employees. Their results show the presence of concavity and a concentration of firms in the market due to autocorrelation of firm growth, new entries and firm acquisitions. In general, their lognormal distributions are right skewed, which means that they are asymmetric with much of the probability mass to the right of the modal value. The upper tail of the firm size distribution is described by the Pareto distribution, which is also known as a power law or scaling distribution[24].

[24] Ijiri and Simon (1977) estimated the growth equation for N firms and T time periods as:

$$\frac{S_{it}}{S_{it-1}} = \alpha S_{it-1}^{\beta-1} e_{it}$$

where S_{it} is the revenue of firm "*i*" in period "*t*", α is a constant that drives the growth equation, β is the speed of growth, and e_{it} is the error term.

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The initial empirical evidence confirmed Gibrat's Law, so the independence of firm growth and initial firm size was confirmed. However, Mansfield (1962) found that Gibrat's Law was only confirmed by firms that had survived the observed period and surpassed the minimum efficient scale (MES). Based on Mansfield's results, the studies described below attempted to determine the correct relationship between firm growth and firm size.

Gibrat's Law will have crucial implications for the evaluation of the firm growth process and economic growth. As well as the capacity of firms to create employment in the short and long runs, policy-makers should take into account the characteristics that enhance the capacity of firm to create new jobs. Furthermore, firm growth is rather important for firm survival.

In the rest of this section we will analyse the expansive body of empirical results on Gibrat's Law and classify them according to whether the Law is accepted or rejected. Furthermore, we classify the literature depending on some characteristics such a the database, the sectorial analysis, the econometric methodology and others. Finally, we will present the Spanish evidence.

2.3.1. The evolution of Gibrat's Law

As such studies are easy to compare, the literature contains many contributions. In general, the results do not confirm the independence between growth and size. Following McCloughan (1995), and based on equation (2.4), we summarize the main results of Gibrat's Law in points 1–5 below.

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1) Gibrat's Law or Law of the Proportionate Effect

The first results of the relationship between firm growth and firm size accepted Gibrat's Law (for example, Mansfield, 1962; Ijiri and Simon, 1974, 1977; Wagner,1992, 1994). As a result, the vast majority of active firms remain small and there is a scarcity of large firms in the market.

Mansfield (1962) showed that if we include all firms (surviving and non-surviving) in the sample, Gibrat's Law is rejected. If we group firms according to whether they survived or failed during the observed period[25], the results do not provide any conclusion about Gibrat's Law. Finally, Gibrat's Law holds when the number of employees in a firm is higher than the minimum efficient scale. Therefore, firms behave differently depending on whether they surpass the minimum efficient size.

Although Mansfield's study confirms Gibrat's Law, the author observes that the variability of firm growth depends on firm size. Specifically, the larger the size, the less variability. Some authors have argued that this is because large firms diversify their portfolio, so they can offset the results of one activity against another.

Ijiri and Simon (1974, 1977) suppose Gibrat's Law to obtain the concavity of the function of firm distribution. That implies the existence of a large number of small firms and a small number of large firms. Mansfield was therefore the first author to raise doubts about the existence of Gibrat's Law.

[25] The purpose is to avoid the market selection, because there is international empirical evidence which shows that small firms have a higher probability of failure but those that survive have higher growth rates. To prevent the two processes from cancelling each other out, Mansfield (1962) selected surviving firms.

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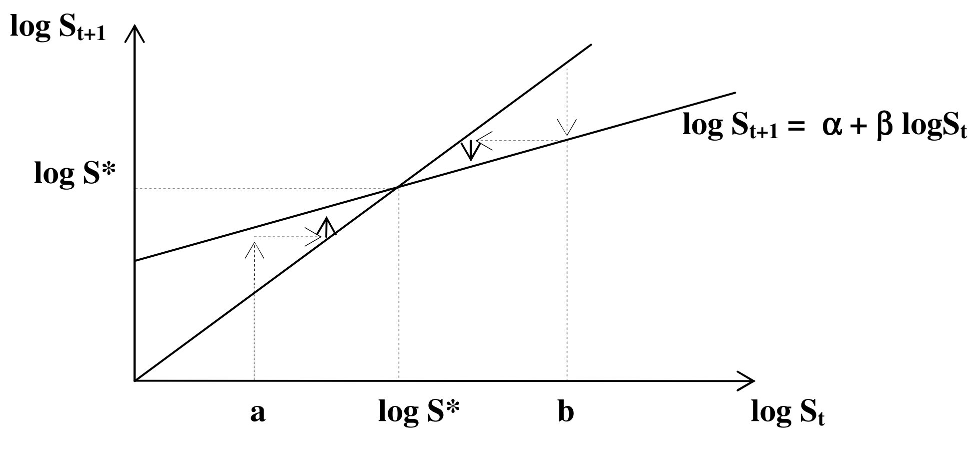
2) Favourable perspectives for small firms

We encountered this situation when the coefficient β ranges from 0 to 1. In this case, small firms grow faster than larger firms up to a limit. This limit is the optimum size of the market. The asymptotic distribution by sizes is still lognormal, as in the previous situation, but the difference lies in the variability in the steady state $\sigma^2 = S^2 / (1 - \beta^2)$. Variability is therefore a multiple constant of firm size.

Evans (1987a, 1987b), Hall (1987), Dunne et al. (1989), Variyam and Kraybill (1992), Mata (1994), Mata and Portugal (2004), Dunne and Hughes (1994), Audretsch and Mahmood (1994a), Harhoff et al. (1998), Hart and Oulton (1999), Fariñas and Moreno (2000) and Lotti et al. (2001) later observed an inverse relationship between size and firm growth.

Graph 2.6 Perspective favourable to small firms



Source: Reid (1995)

In graph 2.6, Reid (1995) showed that firm size converges to an equilibrium (*log S**), which is the intersection between the 45º line and

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the function that determines the relationship between the initial size (S_t) and the size in the following period (S_{t+1}). The horizontal axis shows the logarithm of firm size in the period "*t*", and the vertical axis shows the logarithm of firm size in the period "*t+1*".

In this situation, a firm with a size smaller than the equilibrium (*case a*) will have positive growths but every time its capacity to grow will be smaller. The firm will stop growing when it reaches the optimum size. At this point, the size of the firm will remain constant. When it is higher than the optimum size (*case b*), the firm will have negative growths and reduce its size until it reaches equilibrium. The process of adjustment in sizes between one period and another is indicated by arrows. Once the firm is in equilibrium, the average firm size is obtained from the following equation:

$$\log S_{t+1} = \alpha + \beta \log S_t$$

$$if \quad \log S_{t+1} = \log S_t, \quad ie. \quad \log S^*$$

$$\log S^* = \alpha + \beta \log S^*$$

$$\log S^* = \frac{\alpha}{(1-\beta)}$$

$$S^* = \exp\left(\frac{\alpha}{1-\beta}\right)$$

Other contributions include that of Dunne et al. (1989), who also assumed Jovanovic (1982)'s theoretical framework with heterogeneous firms. Firm growth (*g*) is as follows (where *S* is the number of employees):

$$g'_t = \frac{(S_{t+1} - S_t)}{S_t}$$

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This means that firm growth is the variation in the number of employees in the period "*t+1*" with respect to the period "*t*", divided by the number of employees in the initial period "*t*".

Dunne et al. (1989) also defined a set of functions related to the probability function of growth:

a) Probability function of density: $j(g'|x)$ belongs to firms with a set of characteristics *x*. This function represents the rates of the <u>potential firm growth</u>.

b) The difference between potential <u>growth</u> and <u>achieved</u> growth is due to the existence of a critic value of size growth: *g**. If the firm has growth rates below this critic value, the firm will disappear and its growth will be recorded as -1. If the firm has growth rates above this critic value, its growth will be the same as the expected value.

$$\begin{cases} g_t = g'_t & if \quad g'_t \geq g^* \\ g_t = -1 & if \quad g'_t < g^* \end{cases}$$

c) Since there are differences between potential growth and real growth, the <u>real density function</u> will include firms that disappeared before "*t+1*" and will be $f(g|x) \in [-1, \infty)$. This function represents the interaction between the potential growth distribution and the exit condition from the market.

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d) The density function belonging to the surviving firms depending on its growth is represented by $h(g|x)$, which is equal to $f(g|x)$ but with a probability of 0 for firms with growth equal to –1.

Dunne et al. (1989) represented the average growth as:

$$\mu_h(x) \equiv \frac{\left(\int_{-1}^{\infty} gh(g|x)dg\right)}{P_s(x)} \qquad \text{where} \qquad P_s(x) \equiv \int_{-1}^{\infty} h(g|x)dg$$

and where P_s is the probability that a firm does not disappear.

$$\mu_f(x) \equiv \int_{-1}^{\infty} gf(g|x)dg = \mu_h(x)P_s(x) - (1 - P_s(x))$$

This means that the average size growth (μ_f) coincides with the average growth probability of the surviving firms (μ_h) minus the average size growth probability of the non-surviving firms.

Dunne et al. (1989) concluded that the deviations of μ_h depending on *"x"* are a good sign of how μ_f changes with *"x"*, as long as failure rates do not change with *"x"*.

The previous definitions of density functions are similar to those of Jovanovic (1982), where firms maximize their profits and have to determine their production (*q*). This production depends on random shocks to the efficiency levels. Efficiency affects costs, so the cost function is: $\gamma(q_t)\theta(c+\varepsilon_t)$, where $\gamma(q_t)$ is a strictly convex cost function and where

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$\theta(c+\varepsilon_t)$ is a multiplicator that reflects different levels of efficiency. The properties of this multiplicator are:

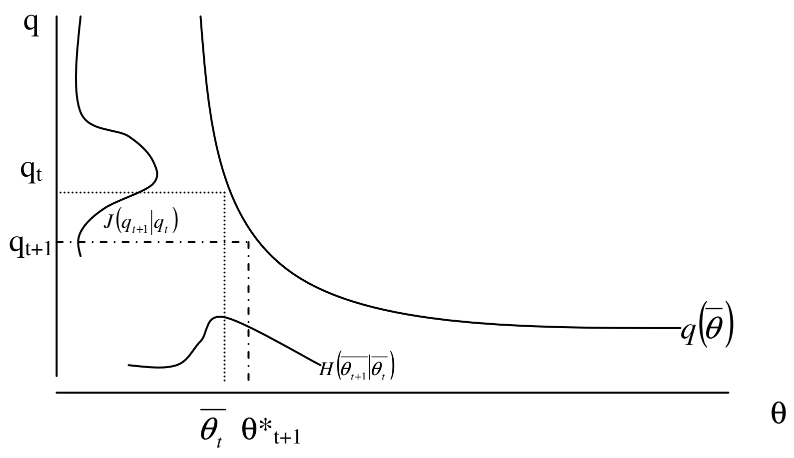
$$\lim_{z\to 0}\theta(z)=\vartheta_1>0 \quad \text{and} \quad \lim_{z\to\infty}\theta(z)=\vartheta_2<\infty .$$

As the efficiency levels of the following period are unknown, there must be some hypotheses from a probability function $H\left(\overline{\theta_{t+1}}\middle|\overline{\theta_t}\right)$ of the expected values in "*t+1*" from variable θ where $E\left(\overline{\theta_{t+1}}\middle|\overline{\theta_t}\right)=\overline{\theta_t}$.

Maximizing the production function gives a decreasing function from the maximizing output $q_t\left(\overline{\theta_t}\right)$. This means that firm production will decrease if the expected efficiency level is not the same as the real level.

Given the previous functions (the probability function of efficiency levels, $H\left(\overline{\theta_{t+1}}\middle|\overline{\theta_t}\right)$, and the maximizing production function $q_t\left(\overline{\theta_t}\right)$), we can obtain the density function $J\left(q_{t+1}\middle|q_t\right)$ of the production.

Graph 2.7. Maximization output function and distribution of efficiency



Source: Jovanovic (1982)

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Graph 2.7 represents the function that maximizes the output ($q(\overline{\theta})$), where the independent variable is the efficiency level. If we draw the density function of the different efficiency levels ($H(\overline{\theta_{t+1}}|\overline{\theta_t})$), and represent the efficiency level that maximizes the output ($\overline{\theta_t}$), we can obtain the value of the production function (q_t), which coincides with the maximum output from the density function of production ($J(q_{t+1}|q_t)$).

What would happen if our prediction does not correspond to reality i.e. if the efficiency level in the period "*t+1*" is below the expected one (θ^*_{t+1} is higher than $\overline{\theta_t}$ and we therefore have higher costs)? The production would be smaller than the production for the previous period.

Therefore, Dunne et al. (1989)'s model explains why the efficiency and production levels are different. The reason is that expected efficiency levels may not correspond with the real level of efficiency. This mismatch produces that the expected and the final production of a firm will be different.

3) Perspectives favourable to large firms

One branch of the literature has found evidence of perspectives that are favourable to large firms. This implies that the value of β will be larger than 1. In this situation we have a lognormal function of distribution but there is a difference in the expression of the central limit theorem:

$$\beta^t y_i(0) \rightarrow \infty \quad \text{when} \quad t \rightarrow \infty$$

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The function therefore diverges and the inequalities remain. In this case, industrial concentration into a small number of firms is inevitable.

There is a scarcity of empirical evidence for this situation, though Singh and Whittington (1975) found that large firms grow faster. This means that as firms grow at a higher rate than unity ($\beta > 1$), market concentration of all the firms in the industry increases. These results may contain errors, however, since they have been estimated with ordinary least squares or even with a measure error of the initial firm size. Keating (1974) also found that Australian financial firms grow faster than smaller ones. Obviously, however, the scale of financial service industries is large (Audretsch et al., 2004).

4) Serial correlation of growth (Chesher, 1979)

The above results involved the relationship between current growth and past size. Another branch of the literature has studied the relationship between past firm growth and future firm growth i.e. whether firms that grew in the past will have a greater probability of growing in the future.

A certain relationship between these different growth rates has been found. Singh and Whittington (1975) began the analysis of growth persistence by introducing past growth to the initial Gibrat's Law. Their results show that firm size was not as important as the past growth. The analytical description of growth persistence was developed by Chesher's seminal work in 1979. The following equations determine the relationship:

$$\begin{aligned} y_{i,t} &= \beta \quad y_{i,t-1} + u_{i,t} \\ u_{i,t} &= \gamma \quad u_{i,t-1} + \eta_{i,t} \end{aligned} \qquad (2.6)$$

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where $y_{i,t}$ is the size of firm "*i*", β is the impact of firm size "*i*" in the period "*t-1*", η_{it} is a white noise, and γ measures the transmission of luck or success from "*t-1*" to the following period and has a value of between 0 and 1. When γ is close to 1, the reiteration of past situations is greater. If we substitute reiteratively the last two equations until we reach the initial period, we obtain the following equation:

$$y_{i,t} = \beta^t y_{i,0} + \gamma \sum_{\tau=1}^{t} \beta^{t-\tau} u_{i,\tau-1} + \sum_{\tau=1}^{t} \beta^{t-\tau} \eta_{i,\tau} \quad (2.7)$$

This new equation is still lognormal because u and η are normal. So, for any β, the higher γ is the faster size inequalities will increase.

Chesher's main conclusion is that serial correlation between error terms in the equation produces a dependence between past size ($y_{i,t-1}$) and the error terms ($u_{i,t}$). Since Chesher's study, growth persistence has been further studied.

Growth persistence in one period with respect to another may produce a serial correlation. Moreover, with the ordinary least squares this serial correlation produces inconsistent estimators. The previous results, for example, would be biased downwards so small firms would grow at a higher rate (Dunne and Hughes, 1994).

In general, the proposed model determines the relationship between current firm growth and its past growth. If we express equation 2.6 in logarithms, we obtain the following expression:

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$$z_{i,t} = \beta \; z_{i,t-1} + u_{i,t}$$

$$u_{i,t} = \gamma \; u_{i,t-1} + \eta_{i,t}$$

Where $z_{i,t}$ is the logarithm of firm growth belonging to firm "*i*" between "*t*" and "*t-1*". If we join the two equations, we get:

$$z_{i,t} = \beta \; z_{i,t-1} + \; \gamma \; u_{i,t-1} + \eta_{i,t} \qquad (2.8)$$

If

$$z_{i,t} = \beta \; z_{i,t-1} + u_{i,t} \; ,$$

by isolating the error term $u_{i,t}$:

$$u_{i,t} = z_{i,t} \; - \beta \; z_{i,t-1} \qquad (2.9)$$

and substituting 2.9 in 2.8, we get:

$$z_{i,t} = \beta \;\; z_{i,t-1} + \;\; \gamma \left(z_{i,t-1} - \beta \;\; z_{i,t-2} \right) + \eta_{i,t}$$

Finally;

$$z_{i,t} = g_1 z_{i,t-1} + g_2 z_{i,t-2} + \eta_{i.t} \qquad (2.10)$$

where,

$$g_1 = \beta + \gamma$$
$$g_2 = -\beta * \gamma$$

We found a relationship between Chesher's equation and Gibrat's Law in the coefficients g_1 and g_2 of equation 2.10. Specifically, Gibrat's Law postulates that the value of β is 1 and that the value of ρ is 0.

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Empirical evidence in the literature has confirmed the presence of growth persistence. Therefore, firms that grew in the past will also grow in the future. Singh and Whitington (1975), Kumar (1985), Contini and Revelli (1989) and Wagner (1992, 1994) obtained a significant and positive sign for change persistence. Dunne and Hughes (1994), Almus and Nerlinger (2000) and Vennet (2001), on the other hand, found a non-significant relationship between growths in different periods, which indicates that firm growths are not serial correlated.

In the empirical research, authors analysing growth persistence have introduced different explanatory variables. Wagner (1994), for example, showed that macroeconomic conditions during entry do not influence future evolution, while industrial characteristics are not excessively important. Their results do not show growth persistence and they remembered the *Brown-Hamilton-Medoff Warning*: "*Do not judge firms by their size alone*!". Vennet (2001) introduced variables such as macroeconomic growth, bank operational efficiency, the quality of credit and capitalization. He observed that between 1985 and 1989, there was a convergence of bank size, but between 1990 and 1994 there was a proportional growth by all banks.

The major contribution from growth persistence models is the introduction of the dynamic firm evolution. In other words, if we want to know how firms will grow in the future, we must not only analyse firms currently but also analyse how they grew in the past.

5) Variability of firm growth

In the 1980s new lines of research related to Gibrat's Law were opened. Sutton (1997) reported two main subjects. Firstly, economists took into consideration econometric problems such as sample censorship, the

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functional function and the heterogeneity of firm behaviour (Hall, 1987; Evans, 1987a, 1987b; Dunne et al*.,* 1989). Secondly, the presence of variability of firm growth.

The heterogeneity of the variability of firm growth produces heteroscedasticity in ordinary least square regression (inefficient estimators). The differences in firm growth due to firm size is caused by the fact that large firms are more diversified in products and markets, so reductions in some products and markets are compensated by others (Bottazi et al., 2002).

However, Dunne and Hughes (1994) pointed out that heteroscedasticity is not due to different firm sizes but to firm age. Age is the variable that introduces heteroscedasticity because the majority of young firms are small. These authors introduced the age of the firm into Gibrat's equation and incorporate the estimated error terms adjusted by heteroscedasticity:

$$\log S_{i,t} = \alpha + \beta \log S_{i,t-1} + \gamma \log A_{i,t} + e_{i,t}$$

Simultaneously, there is an evolution of theoretical models, which try to emphasize the empirically proven stylised facts. More importantly, they introduce stochastic growth into the traditional maximisation models (Jovanovic, 1982; Jovanovic and MacDonald, 1994).

Another characteristic we should point out is the introduction of firm characteristics that influence the profit function. The main consequence of this is that firm growth is not stochastic between the smaller firms (Sutton, 1997).

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2.3.2. Empirical evidence of Gibrat's Law

Many studies have analysed the relationship between firm growth and firm size. In this section, therefore, we will present some of the evidence of firm post-entry performance. We will analyse the empirical evidence from several perspectives: the type of estimation, the analysed sectors, the geographical scope and the econometric methodology[26].

- **Type of estimation**

As many studies have involved Gibrat's Law, some kind of classification is needed. Economists have used two approaches to assess the contribution of firm size to firm growth. In accordance with Piergiovanni et al. (2002) and Audretsch et al.'s (2004) classification, we will divide the empirical evidence into static and dynamic analyses.

Static analyses relate firm growth to previous firm size. The relationship between these variables is observed by two methods. The first method involves dividing firms into categories that depend on their initial size and then examining whether firm growth rates are equally distributed between categories. This kind of empirical evidence is used by Mansfield (1962), Hymer and Pashigian (1962), Singh and Whittington (1975), Acs and Audretsch (1990) and Audretsch et al. (2004). To construct these categories, firms are ordered by their initial size and divided into quartiles. The firm growth rates belonging to each quartile are then calculated. Finally, if the growth rates are not significantly different between the groups, Gibrat's Law is supported. Econometric methods may also be suitable for analysing the relationship between firm growth

[26] See Annex III to a more detailed classification of the literature.

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and initial firm size and, in fact, this is the most common way to apply the equation (2.5).

The second method is based on the Chesher's (1979) contribution, where the growth persistence indicates that Gibrat's Law is accepted. If growth turns out to be an autocorrelated process, on the other hand, Gibrat's Law is not accepted. Singh and Whittington (1975), Kumar (1985), Almus and Nerlinger (2000) and Lotti et al. (2001) used this method.

Both categories can be subdivided into three groups according to the sample they analysed. Following Mansfield's (1962) classification, these groups are:

Type 1: Surviving and non-surviving firms regardless of their initial size.

Type 2: Surviving firms only. This avoids the bias caused by the non-surviving firms.

Type 3: Surviving firms that surpass the minimum efficient size. There are behavioural differences between firms that surpass the minimum efficient size and firms that do not because the latter do not have scale economies that encourage them to increase.

To sum up, there are 6 classifications depending on sample selection and the method used to analyse firm growth behaviour:

	STATIC	DYNAMIC
Surviving and non-surviving firms	Static - 1	Dynamic - 1
Surviving firms	Static - 2	Dynamic - 2
Surviving firms that surpass the minimum efficient size	Static - 3	Dynamic - 3

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Below we analyse the empirical evidence that agrees with Mansfield's (1962) classification.

For the static version that includes surviving and non-surviving firms (Static-1), we find Mansfield (1962), Acs and Audretsch (1990) and Stanley et al. (1995). The acceptance of Gibrat's Law is the main result with this type of estimation. However, these results are biased by sample censorship since they "*suppose that small firms with low growth rates are more likely to exit, then the proportional rate of growth, condition on survival, will be smaller for large firms*" (Sutton, 1997).

A second static version analyses surviving firms regardless of their size (Static-2). Mansfield (1962) interpreted Gibrat's Law differently depending on how the firms disappear from the sample.

Mansfield (1962), Variyam and Kraybill (1992), Evans (1987a, 1987b), Dunne and Hughes (1994) and Botazzi et al. (2001) included only surviving firms. Their results reject Gibrat's Law because of the introduction of small firms. These are smaller than the minimum efficient scale and tend to increase at a higher rate than large firms.

A third line of research, developed by Mansfield (1962), includes surviving firms whose size larger than the minimum efficient scale (Static-3). This version tends to accept Gibrat's Law (Mansfield, 1962; Wagner, 1994), whereas other studies tend to reject it [27].

The fourth line of research is the dynamic version in which the whole pool of firms (surviving and non-surviving) is estimated regardless of their size (Dynamic-1). This version introduces past firm growth to

[27] Singh and Whittington (1975) showed that larger firms grow faster, while Hall (1987) and Faggio and Konings (1999) presented results where smaller firms grow faster

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analyse its impact on current firm growth and contrast Gibrat's Law. Some of the main estimations are by Mansfield (1962), Contini and Revelli (1989), Wagner (1992), Fariñas and Moreno (2000), Vennet (2001), and Lotti et al. (2003). In general, their main results reject Gibrat's Law in favour of faster growth by smaller firms.

The fifth line of research involves the Dynamic-2 group of firms, which contains surviving firms regardless of size. Contributions include those from Hart and Prais (1956), Singh and Whittington (1975), Chesher (1979), Kumar (1985), Wagner (1992), Audretsch (1995a), Geroski et al. (2000) and Piergiovanni et al. (2002). Their main findings are the existence of a positive relationship between past and current firm growth. Hence Gibrat's Law is rejected. Note, however, that the results of Lazarova et al. (2003) accept Gibrat's Law for firms that survived thirty years.

Finally, Dunne et al. (1988, 1989), Mata (1994), Santarelli (1997), Almus and Nerlinger (2000) applied a dynamic estimation to surviving firms that are larger than the minimum efficient scale (Dynamic-3). Their main results reject Gibrat's Law. One exception is the contribution from Santarelli, who accepted it in 14 out of 20 Italian regions.

- **The measure of firm growth**

Heshmati (2001) analysed Gibrat's Law with sales, assets and employees. His results depended on the variable that was taken into account. This author found a negative relationship between firm growth and size (the number of employees) and a positive relationship between firm growth and sales, but found no relationship between firm growth and assets. The positive relation between firm growth and sales is due to scale effects on sales.

However, the results of testing Gibrat's Law using different measures of size and growth rate depend on the time period (Kirchhoff and Norton, 1994). One of the most often used variables is therefore the number of employees, since this is not as volatile as sales or as rigid as productive capacity.

Obviously, the concept and measurement of firm growth can be looked at from several perspectives. We believe, however, that the number of employees is a much more stable variable for measuring firm growth since it avoids some of the above disadvantages. However, the performance of each variable will depend on the industry analysed (see section 2.2.2).

- **Sector**

Since the first studies of firm growth, researchers have focused mainly on the manufacturing sector (Simon and Bonini, 1958; Evans, 1987a, 1987b; Dunne et al., 1989; Mata, 1994; Fariñas and Moreno, 2000) and on one or more sectors differentiated by the degree of labour or technology intensity, etc. Examples of such studies in the literature are those by Mansfield (1962), who analysed the steel, petroleum and tyre industries, FirtzRoy and Kraft (1991), who analysed the metallurgic industry, Das (1995), who analysed the computer hardware industry, Botazzi et al. (2001), Botazzi et al. (2002) and Fabritiis et al. (2003), who analysed the pharmaceutical industry, Lotti et al. (2003), who analysed the telecommunication, radio and TV equipment industries, and Scherer et al. (2000), who analysed high technological firms in the United States.

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The results of these early studies, which introduced variables such as age and size, were that small and new firms had an above-average growth potential (Evans, 1987a, 1987b; Hall, 1987; Dunne et al., 1989). This is because firms have to reach a size that enables them to exist in the market i.e. the minimum efficient scale (MES) of production. This MES varies from sector to sector, thus reflecting the heterogeneous behaviour of the production function.

Small firms operating in industries with a high MES should have a higher propensity to grow, since crossing the MES threshold ensures that the firm is large enough to survive. Audretsch (1995b) found a positive relationship between the MES and growth for various industries. We should therefore expect active firms in the service industries to behave differently from those in the manufacturing industries.

Service industries, however, have been largely ignored (Delmar, 1997). Some authors have placed firms in service industries in the same pool as firms in manufacturing industries. Clearly, as the service sector has different characteristics, joining the service sector with the manufacturing sector may lead to biased results since the pattern of firm growth is heterogeneous and it is difficult to observe service firms, which are usually smaller. In fact, Sutton (1997) analysed the evolution of firm growth applying states that within markets and submarkets there are exponential bounds to firm size, with parametric heterogeneity across markets and industries. Therefore, the analysis of different market would be justified in order to detect the heterogeneous behaviour of each industry.

Singh and Whittington (1975) studied the distribution of manufacturing and service industries. Chesher's (1979) sample for dynamic estimation

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includes firms in both the service and manufacturing industries. Variyam and Kraybill (1992) also estimated the service and manufacturing industries together. Kumar (1985) and FirtzRoy and Kraft (1992) introduced a limited number of firms from the service industry in a pool of manufacturing firms. The manufacturing industry is analysed together with the construction and service industries by Harhoff et al. (1998).

Tschoegl (1996) and Vennet (2001) analysed Gibrat's Law with respect to the banking sector, while Santarelli (1997) analysed the hospitality sector. More recently, Piergiovanni et al. (2002) analysed the service industries. Finally, Audretsch et al. (2004) analysed the hospitality sector.

More recently, Oliveira and Fortunato (2004a, 2004b, 2005) and Bottazzi et al. (2006) analyse the possible heterogeneity between manufactures and service industries. Both authors determine that there are not differences between both industries at the aggregate level.

- **Countries and data bases**

There is a clear relationship between the frequency of studies in a country and the availability of large data bases.

Some studies, such as those by Fabritiis et al. (2003) using the *Pharmaceutical Industry Database* and Faggio and Konings (2003) using the *AMADEUS database*, analysed worldwide statistics.

However, most studies have concentrated on the United States because of the availability of large data bases (the *Small Business Data Base*, the

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Census of Manufactures, the *United States Establishment Longitudinal Microdata*, *Compustat*, the *OneSource database* and the *LEEM registry*).

The United Kingdom also has a great deal of literature testing Gibrat's Law both with general data bases (the *Company Accounts Databank* and the *EXSTAT database*) and specialised data bases (the *Synthesis Life Database*).

Other European countries, such as Germany (*CREDITREFORM from the ZEW Foundation Panel*), Italy (*National Institute for Social Security* and *Mediocredito survey*), Portugal (*Ministry of Employment* and *Central Balance Sheet Office*) and Spain (*Encuesta sobre Estrategias Empresariales*) have also analysed the firm growth pattern. However, the Spanish studies are contemporary since until recently there was no tradition in Spain of compiling statistical information about firms. Spain therefore no data base with which to study firm growth in the long term.

There are also empirical contributions from non-western countries such as Japan (*Japan's Expanding US Manufacturing Presence by the Japan Economic Institute* and *Nikkei Kaisha Jouhou*) and India (*Dataquest*).

- **The time period**

Depending on their statistical tradition, some countries have more longitudinal data bases than others. Researchers usually focus on the previous decade and a time period of between 5 and 10 years. Some authors e.g. Amaral et al. (1997) and Tschoegl (1996) used data bases for the previous two decades. The longest data base is the one used by Hart and Prais (1956), which analysed the period between 1885 and 1950.

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- **Econometric methodology**

The econometric methodology for testing Gibrat's Law has evolved over the years. The first method used (e.g. in Mansfield,1962 and Hymer and Pashigian, 1962) was ordinary least squares.

In the 1980s researchers were interested in new issues such as sample censorship, the appropriate functional relationship and heteroscedasticity (Sutton, 1997). Specifically, Hall (1987), Evans (1987a, 1987b) and Dunne et al. (1989) analysed all these issues and found a double effect: large firms increase less but are more likely to survive than small firms.

Lazarova et al. (2003) used methods such as the Augmented Dickey-Fuller test to analyse the relationship between the logarithm of current firm growth and the logarithm of past firm growth[28]. Scherer et al. (2000) and Goddard et al. (2002) analysed the relationship between initial firm investment and final firm investment using a Monte Carlo experiment. Fariñas and Moreno (2000) and Fotopoulos and Louri (2004) estimated kernel non-parametric density functions and quantile regressions to test Gibrat's Law.

Finally, Heshmati (2001) compared results obtained with ordinary least squares, generalised least squares and adjustment models, as well as within and between estimations. Del Monte and Papagni (2003) and Vennet (2001) applied a data panel to estimate Gibrat's Law.

[28]These authors used an Augmented Dickey-Fuller test with a lagged dependent variable, with and without trend, to control the interdependence between firms.

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Das (1995) estimated an OLS equation and panel data with fixed and random effects and compared the results in order to find the most suitable estimation.

Some authors have used the unit root test to estimate the relationship between firm growth and initial firm size. Oliveira and Fortunato (2003a) used a unit root test for a panel data of Portuguese manufacturing firms and showed that Gibrat's Law was not satisfied because of the existence of a unit root.

Other authors have recently emphasized the problem of endogeneity due to time-varying factors that are not included in the estimation but are correlated with the explanatory variables and with growth. To solve this problem, the Generalised Method of Moment (GMM) proposed by Arellano and Bond has been used. Nkurunziza (2005)[29] found convergence in size with all econometric methods except GMM equations. Oliveira and Fortunato (2004a) estimated Gibrat's Law for manufacturing and service industries using a GMM estimator and rejected Gibrat's Law in all cases because they found that smaller firms grew faster than larger ones.

More recently, Calvo (2006), Nkurunziza (2005), Niefert (2005) and Santarelli and Vivarelli (2002) used Heckman's equation to control for attrition bias. This method is useful for observing whether firms survive and for analysing the post-entry performance of the surviving firms in order to determine whether firms that survive have a greater propensity to grow than those that did not. Heckman's (1979) equations help to control the selection bias caused by the interdependence between past and present performance.

[29] Nkurunziza (2005) studied the African manufacturing industries.

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Botazzi and Secchi (2005) applied the unit root test for the analysis of the pharmaceutical companies. Recently, Goddard et al. (2006) applied the Augmented dickey Fuller autoregressions to analyse the mean reversion of profit rates. Their results show that there is evidence of the existence of mean reversion among profit rates when controlling for individual heterogeneity. While there is contradictory results among the different tests applied to the mean size of the firm (measured in net assets).

Many studies have therefore used panel data econometric methods to estimate the relationship between firm size and firm growth. Recent contributions, however, have included methods to take into account the selection process of firms with more capacity to grow than firms which disappear from the market.

2.3.3. Spanish literature

Most studies, because of the available data bases, have analysed countries such as the United States, Germany and the United Kingdom. Some Spanish contributions have been made by Suárez (1977), Pisón (1983), González (1988), Fariñas and Moreno (2000), Correa et al. (2003) and Calvo (2006).

The Spanish empirical and theoretical contributions are scarce, however. This is not because the topic is unimportant but because of the lack of data. One of the challenges is therefore to improve the data bases. Extending the summary of the literature conducted by Correa (1999) and Correa et al. (2003), here we review some of the most outstanding studies.

Maravall's (1976) contribution was the first Spanish empirical estimation of Gibrat's Law. Previous studies had compared the distribution of firms in the market. The main aim of this study was to show the characteristics of the market structure. The relationship between the growth and size of manufacturing firms between 1964 and 1973 was analysed. The data-base comprised 254 Spanish firms from "Las grandes empresas industriales en España" published by the Spanish Department of Industry. All the firms survived during the period. Added value and sales were used as indicators of size. In this study Gibrat's Law was satisfied for medium-sized firms (sales of between 3 and 12 million euros), while the smallest and largest firms grew more rapidly.

However, analysis of variance showed a negative relationship between size and variance. This means that firms with a large number of workers, probably because of the diversification process, obtained a smaller variance. As Gibrat's Law assumes that the variance of firm growth is independent of firm size, Gibrat's Law was rejected. Moreover, study of the matrix of probabilities showed that the mobility of firms is scarce.

In another study, Suárez (1977) analysed Gibrat's Law for 46 firms between 1962 and 1972. The data came from "Agendas Financieras" provided by the Bank of Bilbao. The sectors included in the study were electrical, water and gas manufactures, real estate, chemical and textile manufactures, and miner manufactures.

The variable used to measure firm growth was total net assets. Suárez's (1977) results satisfied Gibrat's Law. However, as he pointed out, the small number of observations may have produced biased results.

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In a third study, Pisón (1983) focused on large manufacturing firms in Galicia between 1975 and 1980. The sample comprised only 18 firms, which showed how difficult it is to obtain data and how few large firms there are in this Spanish region. As the small sample may have led to biased results, these should be viewed with caution. Gibrat's Law was not rejected because there was no relationship between profitability and size.

Recently, González (1988b) analysed Gibrat's Law for the Catalan textile industry between 1973 and 1983. This sample comprised 283 small firms and firm growth was measured in terms of the number of employees[30]. The main conclusion was that Gibrat's Law was satisfied. This result contradicted that of a previous study by the same author (González, 1988a)[31]. However, the previous study was based on a sample of large banks. Clearly, as the characteristics of the textile and banking sectors are very different, the results are also expected to be different.

In 1983 Lafuente and Salas tested Gibrat's Law for firms present in the Bank of Bilbao between 1972 and 1978. Their results depended on the time period of time analysed. When the whole period was considered, Gibrat's Law was satisfied. For the period between 1974 and 1976, however, the relationship between profitability and size was significantly negative.

Fariñas and Rodríguez (1986) tested Gibrat's Law for the largest firms in the European Union. The sample comprised the largest 100 surviving firms among *Europe's 10,000 Largest Companies*. The results showed a

[30] Correa (1999) pointed out that measuring firm growth in terms of the number of employees introduced a certain bias because technological differences during the analysed period were omitted.
[31] In this study Gibrat's Law was rejected because there was a negative relationship between size and growth.

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significant negative relationship between firm growth and size for Spanish firms. For the firms from other European countries, however, Gibrat's Law was accepted. The rates of growth and profitability of Spanish firms were lower than those of the other European firms, though the causes were not related to differences in size.

The PhD thesis of Correa's (1999) analysed the relationship between the growth and size of 1,278 non-financial firms from Santa Cruz de Tenerife. The data were provided by the "Central de Balances" of the University of La Laguna, which collects the data of all firms that present their Annual Accounts to the Mercantile Register. The period analysed was between 1990 and 1996.

Her results showed that small firms grew faster than large ones, so Gibrat's Law was rejected. She suggested that these results may have been due to the greater ability to adapt of small firms and their lower initial investment.

The above study also analysed the learning model of introducing the age of the firm. The main results were an inverse relationship between firm growth and age for microfirms. Another conclusion was the importance of insularity: the insularity of the Canary Islands means that firms have a greater capacity for future growth.

In an article published in the *Review of Industrial Organization* in 2000, Fariñas and Moreno applied a non-parametric approach to analyse firm growth toward a mean size and showed that regression towards the mean does not justify the existence of a negative relationship between size and firm growth rates. The variable used to measure firm growth was the number of employees.

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Their unbalanced panel comprised 1,971 manufacturing firms from the *Encuesta sobre Estrategias Empresariales* (ESEE). The main contributions were:

a) They solved the problem of selection or censorship using Dunne et al.'s (1989) method.
b) They applied non parametric methodology to analyse firm growth rates and survival likelihood. First they applied a standard regression and then applied a model based on estimates of kernel.
c) They introduced heterogeneity in the firm, autocorrelation in the variance of growth and failure equations. They also introduced a linear model of failure probability.

Although their results show an inverse relationship between firm growth and size, this may also indicate a regression to the mean. Regression to the mean may be due to transitory or temporary fluctuations.

To avoid the fallacy to-the-mean[32], they controlled firms' boundary-crossing from one size group to another by introducing dummies. Their results showed that the growth rates of surviving firms diminished sharply in the first three size groups. Consequently Gibrat's Law was rejected.

More recently, Correa et al. (2003)[33] examined the factors affecting the growth of small and medium-sized firms. In their study the main variables (size, age and economic activity) were used to determine the

[32] The fallacy to-the-mean rises whenever measurement error introduces transitory fluctuations in observed size.
[33] This article is the publication of Correa's (1999) PhD Thesis.

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existence of Gibrat's Law and the Learning Theory. The results showed that firms located in the Canary Islands have a higher propensity to grow than in the rest of Spain, probably because of the economic features of that region. They found a negative relationship between firm growth and size, while age produces ambiguous effects. Moreover belonging to a tertiary sector was not a significant explanatory variable for firm growth.

Peña (2004) analysed the survival and growth of incubating ventures in the Basque Country. The sample contained 114 start-ups that eventually became firms. The author described a firm growth model based on the entrepreneur's human capital, the firm's resources and strategies, and incubation variables. Firm growth is measured in terms of sales and employees[34]. The relationship between firm growth and initial size is "puzzling": the larger the initial investment, the more negative the sales growth. Policy implications are that the enhancement of human capital and firm resources appears to be a more important goal than other policy strategies.

More recently, Calvo (2006) analysed the existence of Gibrat's Law for 1272 manufacturing firms from *Encuesta sobre Estrategias Empresariales* between 1990 and 2000. His results show that Gibrat's Law is not accomplished in favour to small firms and that the innovating behaviour has a positive impact in the survival likelihood and the firm growth. Since his database includes surviving and non-surviving firms, he controls for the selection bias estimating a survival likelihood function. Afterwards, he analysed Gibrat's Law with the Heckman's equation and a maximum likelihood estimator.

[34] Peña (2004) excluded profit growth because the explanatory power is low. This justifies his decision because profits are not an accurate measure of venture growth in the first 3-4 years.

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The scarcity of observations has been the main characteristic of the studies in the last few decades. The only exceptions are the contributions by Calvo (2006) and Fariñas and Moreno (2000), which include Spanish manufacturing firms.

2.4. SUMMARY AND CONCLUDING REMARKS

Firm growth has been extensively studied. However, the variety of theoretical approaches in the literature reveals the complexity involved in studying this process. The difficulties in determining the factors as well as the consequences in the distribution of firms in the market are the main characteristics of the literature review.

This chapter is a review of the literature on Gibrat's Law. First we analysed the main approaches to tackling the issue of firm growth and then focused on Gibrat's Law. The evolution of the theoretical literature and the empirical evidence are the main aspects of this chapter. We have made a special reference to what little Spanish evidence there is.

Clearly, results since Mansfield (1962) have not been conclusive. Authors such as Das (1995) have pointed out that this heterogeneity may be due to the different industries analysed. Each industry has different technologies, and perhaps different growth processes, which might explain the mixed nature of the results (Das, 1995).

Gibrat's Law relies on an explanation of the firm growth process that depends on a stochastic process. Later models have attempted to be more accurate by introducing variables such as age in order to explain the trends in the growth of firms during the different phases of their life

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cycle. Obviously, models try to explain firm behaviour in a stylized way and may sometimes be too unrealistic or too rigid. Empirical evidence has solved this lack by introducing different variables into the analysis of firm growth.

The most important conclusions of this chapter are as follows.

- Firm growth is a complex process that is affected by internal and external characteristics.
- Several theoretical approaches have analysed this process. However, the economic predictions depend on the economy concerned.
- Gibrat's (1931) Law, or the Law of Proportionate Effects, seems to be a good approach to the unequal distribution of firms in the market.
- The initial empirical studies seemed to accept Gibrat's Law (Ijiri and Simon, 1977). Lately studies (Mansfield, 1962) have been contradictory, however.
- These contradictory results were solved with Mansfield's (1962) article. The probability of growth is conditioned by firm survival and firm size. Surviving firms whose size is lower than the minimum efficient size will not satisfy Gibrat's Law, whereas surviving firms whose size is greater than the minimum efficient size will.
- The results and rate of growth depend on the country concerned, available databases , time period, etc.

This review of the literature has focused on firm growth. However, entry, exit, likelihood of survival and growth are different phases of the same process: the life cycle of a firm. Like live organisms, firms are born with certain characteristics and according to the conditions of a market. All these factors affect their growth and their survival or exit from the market. Future research should therefore consider the theoretical

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perspective and the empirical evidence of all the phases in the firm life cycle that affect firm growth.

In the last fifty years we have seen the world's advanced industrial economies shift from primarily industrial to primarily service economies. After several technological revolutions, the service sectors have gained weight in national production. However, the literature on firm growth has not evolved at the same speed—sometimes for lack of information or interest—and the number of studies of service industries has not matched their economic development. In fact, it is important to note the lack of empirical studies related to the service industries (Audretsch et al., 2004).

There are two main reasons for studying the differences. First, each industry has different characteristics that lead to firms of different sizes. Second, a firm's initial characteristics can influence its long-term behaviour. Size and age are the variables that are mainly studied in the literature.

The Spanish evidence is scarce. There is therefore a field of research between firm growth and other significant variables which have been point out in different studies such as R&D, financial variables, etc.. Past contributions are characterised by the scarcity of data on Spanish firms and the majority of samples in these studies have included only firms in the manufacturing industries.

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CHAPTER 3

DOES GIBRAT'S LAW HOLD FOR MANUFACTURING AND SERVICE INDUSTRIES?

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"*The question is not how things stabilize themselves in a 'static state', but how they endlessly grow and change*".

Torstein Veblen (1898)

3.1. INTRODUCTION

Firm performance crucially influences the evolution of economic environment. Macroeconomic growth rates, employment and standards of living, to mention but a few examples, are highly correlated with the economic performance of firms. So, to explain the performance of the economy in general we have to analyse the microeconomic agents of the economy and their behaviour.

In this chapter we analyse the relationship between firm growth and size for Spanish firms in the manufacturing and service industries between 1994 and 2002. The relationship between firm growth and size has been studied using several theoretical approaches. Here we adopt Gibrat's (1931) stochastic firm growth approach, which is based on the hypothesis that firm growth is independent of initial size. We therefore analyse Gibrat's Law for Spanish firms between 1994 and 2002.

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Since Gibrat's work (1931), several studies in the stochastic growth literature have sought to explain the relationship between growth of a firm and its size. The main characteristic of Gibrat's Law is the constant probability that a firm grows independently of its initial size. As Simon and Bonini (1958) postulated, the consequence of this is that the firm distribution has a skewed tail. This implies that the vast majority of firms in the market are small and medium sized and the majority of employees in the industry are concentrated in a just few firms.

Gibrat's Law is an alternative to classical economic theory that postulates that there is an equilibrium firm size to which all firms converge. Classical economists found it difficult to explain why there were firms of heterogeneous sizes in the market. The initial importance of Gibrat's Law lies in its capacity to provide a better explanation for the empirical evidence (Ijiri and Simon, 1977).

Most economic literature has focused on countries such as the United States (Evans, 1987a, 1987b; Audretsch, 1995a), the United Kingdom (Dunne and Hughes, 1994; Hart and Oulton, 1999) and Germany (Wagner 1992, 1994; Almus and Nerlinger, 1999, 2000), and these contributions have studied the performance of manufacturing firms.

Many empirical contributions have studied the evolution of firm growth. However, most them have focused on the manufacturing industries, while few have analysed the services (Audretsch et al., 2004). There are several reasons why we think the service industries are important. First, services have increased their weight in the last few decades. Second, we believe that the different characteristics of the service industries with respect to the manufacturing industries are crucial to their economic

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performance. Third, the service industries are directly connected with demand, which means that they locate near their customers.

Despite the ample international empirical evidence, few studies have analysed the Spanish case. Fariñas and Moreno (2000), Correa et al. (2003), Peña (2004) and Calvo (2006) are some of the Spanish contributions to the analysis of firm growth. These Spanish contributions have several weaknesses, however. For example, Correa et al. (2003) and Peña (2004) only analysed specific Spanish regions and Fariñas and Moreno (2000) and Calvo (2006) analysed Spanish manufacturing firms but did not analyse the service industries.

From a theoretical approach, Jovanovic (1982), Ericson and Pakes (1995) and Pakes and Ericson (1998) introduced the theoretical models of learning and selection. First, Jovanovic (1982) presented a model characterised by passive learning; i.e. firms know their efficiency level once they enter the market. Ericson and Pakes took a step forward and analysed an industry with active learning, which implies that firms are able to modify their own levels of efficiency.

Like most of the literature, our results reject Gibrat's Law. Moreover, while age has a positive and significant impact on the evolution of firm growth (Geroski, 1995), its impact is relatively low compared to the effect of size. Differences between industries show several patterns, each of which depends on the sector concerned. Therefore, while we can extrapolate the main conclusions of Gibrat's Law, we should be careful not to generalise since the characteristics can be rather different depending on the industry.

In this chapter, we examine the following questions: "Does size matter in Spanish firm growth?", "Are there any differences between the

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manufacturing and service industries?" and "Is there an active or a passive learning?" This chapter is structured as follows. In section 3.2 we review the literature. In section 3.3 we show the importance of the service industries. In section 3.4 we present Jovanovic's (1982) model. In section 3.5 we present the data used in the estimation. In section 3.6 we show the estimation and the results, and in section 3.7 we summarize our main conclusions from this chapter.

3.2. A REVIEW OF THE LITERATURE

In this section we analyse the relationship between firm growth and size. Our starting hypothesis is Gibrat's Law. We will focus on the theoretical and empirical literature. First we review Gibrat's Law, then study the methods used in the empirical literature, third we analyse the evolution of the empirical literature on Gibrat's Law and, finally, we review the literature related to service industries.

3.2.1. Firm growth and Gibrat's Law

Like any natural organism, a firm evolves and adapts to its environment. Firm Demography analyses the evolution of firms from their creation to their failure and observes their growth and decline (Wissen, 2002). The literature on firm growth focuses on the increases and decreases in firm size while the firms are active. Growth may be a reflection of the firm's adaptation to and learning of market competitiveness. In this sense, an analysis of firm growth may produce interesting results concerning the ability to compete, to create employment and to enhance economic growth.

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The literature on firm growth has been prolific and several approaches have been used to analyse this economic phenomenon. From the classical economists to the evolutionary economists, firm growth has been the main point of reference. This diversity of approaches highlights one important fact: the complexity of growth (Delmar et al., 2003). Of all the theories for analysing firm growth, Gibrat's Law seems to best explain the empirical evidence (Ijiri and Simon, 1977). This stochastic growth model assumes that all firms grow in the same proportion[1].

The starting point in this area is Gibrat's Law. As Gibrat predicts in order to justify the skewed distributions of firms in a certain market (log-normal or Pareto), the growth rate of an individual firm is independent of its initial size (Gibrat, 1931). This law determines the independence of firm growth with respect to initial size by applying a stochastic growth model to explain growth rates and variance in growth rates in terms of size, age and other firm profiles (Sutton, 1997). In the stochastic growth model, the growth of the firm follows a random walk.

According to Gibrat's Law, the rate of firm growth is independent of its past size and growth trajectory. The starting point in the analysis is directly related to firm size and growth rates. Stochastic models of firm growth predict that the expected growth in a current year is the same for all firms regardless of their initial size. The assumptions of Gibrat's Law are violated when the variance of growth rates is correlated with firm size. The Law of Proportionate Effect suggests that the current rate of growth for the individual firm is:

$$S_{i,t} - S_{i,t-1} = \varepsilon_{i,t} S_{i,t-1}$$

[1] This means that a firm with 10 employees and a firm with 1000 employees will have the same probability of increasing in size by one employee, independently of their initial size.

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where $S_{i,t}$ is the firm size "*i*" in the period *t*; $S_{i,t-1}$ is the firm size in the period *t-1*, and $\varepsilon_{i,t}$ is an independent random variable of $S_{i,t-1}$ that determines the firm growth rate between *t-1* and *t*. From a logarithmic expression, we can observe the current size of firm "*i*" as a sequence of past growth rate and start-up size. The growth rate history of a certain firm for short intervals of time is described by the expression:

$$\log S_{i,t} \cong \log S_{i,0} + \varepsilon_{i,1} + \varepsilon_{i,2} + \varepsilon_{i,3} + \ldots + \varepsilon_{i,t}$$

where,

$$E\left(\varepsilon_{i,t} \middle| s_{i,t-s}, s > 0\right) = 0$$

$$E\left(\varepsilon_{i,t}\varepsilon_{j,\tau} \middle| s_{i,t-s}, s > 0\right) = \begin{cases} \sigma^2 & i = j, \; t = \tau \\ 0 & otherwise \end{cases}$$

Assuming that $\varepsilon_{i,t}$ is a random variable with average μ and variance σ^2, when $t \rightarrow \infty$ and the Theorem of Central Limit is applied, the distribution of the logarithm of the firm size ($S_{i,t}$) approaches a normal distribution with average μt and variance $\sigma^2 t$, so firm size adopts a log-normal distribution.

3.2.2. Applied methodology

The previous equation shows the essence of Gibrat's Law: current firm size depends on its initial size and a set of random errors affecting the firm while it remains active in the market. The empirical treatment of this relationship has been reflected in several empirical equations. All of them are basically equivalent. However, we consider it is important to spend a short time differentiating them in order to compare the empirical results in the literature.

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Firstly, some of the empirical literature (Santarelli and Vivarelli, 2002; Machado and Mata, 2000; Hart and Oulton, 1999) has related current firm size to past firm size measured in logarithmic terms. This relationship can be formulated as:

$$\log S_{i,t} = \alpha_i + \beta \log S_{i,t-1} + \varepsilon_{i,t} \qquad (3.1)$$

where $S_{i,t}$ represents the firm size from firm "i" in period "t", α is a constant parameter affecting firm growth, β signals the impact of firm size on firm growth and ε is a normally distributed random error with mean equal to 0 and constant variance σ_ε^2.

Secondly, some authors wonder whether firm growth depends on firm size. If we subtract the previous logarithmic size ($S_{i,t-1}$) from equation 3.1, we obtain:

$$\log S_{i,t} - \log S_{i,t-1} = \alpha_i + \beta \log S_{i,t-1} - \log S_{i,t-1} + \varepsilon_{i,t} \qquad (3.2)$$

and

$$\Delta \log S_{i,t} = \alpha_i + \beta_1 \log S_{i,t-1} + \varepsilon_{i,t} \quad \textit{where} \quad \beta_1 = \beta - 1 \qquad (3.3)$$

In this case, Gibrat's Law is satisfied when β_1 is equal to 0. If β_1 is negative, small firms grow faster than large firms. If β_1 is positive, large firms grow faster than small firms.

As we shall now see, our estimations depart from equation 3.3. The differentiation between both types of equations is basic when comparing our results with the empirical literature.

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3.2.3. Empirical evidence

Interest in investigating firm distribution in the market has led to the publication of many studies. Gibrat (1931) suggests that the skewed distribution of firms in the market is directly related to the evolution of the firms in the market. From this starting point, Gibrat's Law has been the centre of attention for many researchers. Sutton (1997) reviewed the previous theoretical and empirical contributions and proposed a stochastic firm growth model based on Gibrat's Law to explain market structure.

The literature on Firm Demography is divided into three types of methods and results (Sutton, 1997). First, the results of Hymer and Pashighian (1962), Prais (1976) and Singh and Wittington (1975) accepted Gibrat's initial hypothesis. The data of these authors included both surviving firms and those that closed during the period analyzed.

Second, introducing firms leaving the market causes bias. Mansfield (1962) solved this problem by selecting the surviving firms during the whole period. This author found ambiguous results when comparing the distributions of firm growth and firm size. For firms below the minimum efficient scale (MES), Gibrat's Law is rejected and there is an inverse relationship between initial size and later growth.

Third, to identify possible differences between firms, Evans (1987a, 1987b), Hall (1987), Dunne and Hughes (1994) and Kumar (1985) selected companies above the MES and whose efficiency levels therefore guarantee the survival of the company in the short term. In this case, Gibrat's Law is accepted, so there is an independent relationship between the growth of a company and its initial size. These results are

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consistent with Jovanovic's (1982) model, in which small firms have an inverse growth related to firm size and firms above the minimum efficient scale accept Gibrat's Law.

With regard to this heterogeneous behaviour depending on firm size, Mata and Portugal (2004) suggested several reasons why surviving firms may grow more quickly. Firstly, firms are created downsized because they do not know their efficiency level (Jovanovic, 1982). Over time, surviving firms obtain more information about their efficiency level and adjust their size.

Second, in every time period, firms do not know the number of new entrants. Consequently, they do not know whether there will be an excess of production in the market or whether the market price will fall (Camerer and Lovallo, 1999). Camerer and Lovallo (1999) presented a model in which entrepreneurs have different skill levels. They examined entrepreneurs' overconfidence by comparing entry rates between entrepreneurs with random and skill conditions and showed that there is greater entry under the skill condition. They also found greater skill differences among participants who had selected themselves into the skill condition[2].

Third, new firms face cash constraint problems. Evans and Jovanovic (1989) argued that small firms in the United States are more cash constrained than large firms and that cash constraints are essential in the decision to become an entrepreneur. More recently, Cabral and Mata (2003) incorporated the assumption that initial firm size depends on the entrepreneur's wealth, whereas mature surviving firms are not financially constrained.

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Geroski (1995) pointed out that firm growth is positively correlated with size and age[3]. This is because small firms have less likelihood of survival than large firms, and firm size is found to be negatively related to growth. Consequently, larger and older firms will grow faster. However, Geroski did not take into account that the small surviving firms grow more rapidly than the large ones.

Sutton (1997) discussed the empirical and theoretical literature on Gibrat's Law and presents a stochastic growth model that depends on two basic assumptions. First, the probability of an incumbent occupying a new market opportunity is a non-decreasing function of firm size. Second, the probability of an entrant occupying a new market opportunity is constant over time.

Gibrat's Law has also been reflected in the theoretical literature. We should mention two complementary theories: the passive learning model and the active learning model. The passive learning model was developed by Jovanovic (1982) and is characterised by an industry in which potential entrants decide to enter in a period. These potential entrants ignore their own level of efficiency until they decide to enter the market but their efficiency is not altered by the passing of time. This last feature is the main reason why this is called the "passive" learning model.

Ericson and Pakes (1995) and Pakes and Ericson (1998) developed a similar model but one in which firms may modify their own level of efficiency increase their investments[4]. However, these firms have to consider investment by other firms and external shocks. This means that, while a firm makes a great effort to invest, it should also take into account investment by its competitors.

[2] Camerer and Lovallo (1999) called this finding "reference group neglect".
[3] Geroski (1995) determined this relationship in the eighth Stylised Result.

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3.2.4. Literature related to service industries

A drawback of most studies that have examined Gibrat's Law is that they only use manufacturing data. As a result, Gibrat's Law appears to have a low explaining power. A possible explanation is that growth in manufacturing industries depends on sunk costs, scale economies and capital requirements rather than on stochastic growth process.

One may therefore wonder whether Gibrat's Law also fails to hold in services, where there are fewer sunk costs and capital requirements, and less dependence on scale economies. This is exactly what Audretsch et al. (2004) did.

While the literature on firms in the manufacturing industry has been prolific, recent studies of the service sector have been scarce (Audretsch et al., 2004). Audretsch et al. (2004) analysed the Dutch hospitality sector (restaurants, cafeterias, cafes, hotels and camping sites). Their results showed that Gibrat's Law is accepted in most cases, though behaviour appears to be heterogeneous in some subsectors[5]. The authors suggested that Gibrat's Law is accepted in service industries because of the absence of scale economies. Whether Gibrat's Law works or not depends on the scale of the firm and on sectoral characteristics: services are expected to show a random growth process but manufacturing firms have opportunities to influence this process.

[4] This is why this model is called "active" learning.

[5] These authors applied a Chi-square test and the equation of the persistence of firm growth. With the Chi-square test, Gibrat's Law was accepted for firms operating above the Minimum Efficient Size. With the equation of persistence of firm growth, Gibrat's Law was accepted in 11 out of 15 cases. However, their results varied according to year and business group.

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Oliveira and Fortunato (2004a and 2004b) analysed the firm growth patterns of Portuguese firms in the manufacturing and service sectors[6]. Their results show that firms in the service sectors behave in the same way as those in the manufacturing sector and reject Gibrat's Law[7]. Their results also show that small firms grow faster than large ones.

Audretsch, Klomp and Thurik (1999) argued that the performance of firms in the service sector will be different from that of firms in the manufacturing sector since firms in the service sector grow more slowly than new firms in the manufacturing sector. This is because the scale economies in the service sector are lower than in the manufacturing sector and manufacturing firms are not constrained to reach a minimum efficient scale in order to survive. The lower level of scale economies in the service sector implies that firms will have no incentive to increase in size in order to diminish their total average costs.

The scarcity of such comparisons led us to compare the performance of firms in both sectors during the same period and using the same source of information[8]. Given the previous empirical evidence, we expected to obtain different patterns of growth in the two sectors. Our results should show that firm growth in the manufacturing and service sectors is heterogeneous.

[6] Oliveira and Fortunato (2004a and 2004b) used an unbalanced panel data with 8072 firms, but with only 419 firms from the service sectors.
[7] As dependent variable they used current size and as independent variable they used previous size. In this case, their coefficient was less than 1.
[8] We believe that homogeneity of the data is crucial to examining Gibrat's Law. If the sources of information are different, comparability may be reduced and the results may be distorted.

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3.3. DIFFERENCES IN THE MANUFACTURING AND SERVICE INDUSTRIES[9]

The literature on firm growth has focused on manufacturing industries and studies of the service industries are scarce. Intuitively, manufacturing and service industries should behave heterogeneously, not only because of the different characteristics of each sector but also because of the differences between industries. The main aim of this section is to justify analysing both manufacturing and service industries.

The most relevant fact about the service industries is their spectacular increase. Most advanced economies today are service societies but their economic importance is not reflected in the research. Channon (1978) labels the service industries as the "Cinderella" of economic research, while Fuchs (1968) labels them as the "stepchild of economic research".

Reasons for the lack of studies on the service industries are:

- the fact that service industries are related to traditional activities with low productivity growth, and
- the heterogeneity of service sectors and the greater difficulty in obtaining data.

Audretsch, Klomp and Thurik (1999) pointed out that the patterns of firm growth in the service and manufacturing industries are different. Specifically, they compare Geroski's (1995) stylised facts. Their main argument is the presence of sunk costs. Initial investment in the service

[9] In the next section we will analyse the empirical evidence on the manufacturing and service industries. Manufacturing industries analysed are those with CNAE codes (*Clasificación Nacional de Actividades Económicas*) between 15 and 36, except sectors 16 (petroleum) and 23 (the tobacco industry). Service industries have codes 50 to 74. For a description of the sectors, see Annex I.

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industries is generally assumed to be lower than in the manufacturing industries.

Much literature is related to small size of new firms (Audretsch, 1995b). It is a stylised fact that entrepreneurs start downsized businesses because:

- they cannot obtain enough financial support from public or private organisms[10],
- young firms have high failure levels and, as expectations are unknown, entrepreneurs may decide not to invest a large amount of money,
- they misunderstand the real investment needed to take advantage of, for example, scale economies.

Manufacturing industries generally have higher MES and higher investment levels. Downsized firms in a manufacturing industry therefore find it difficult to survive and grow. New firms in the service industries may remain under a lower threshold because the scale economies in such industries are not as high as in manufacturing industries[11].

Table 3.1 shows the relationship between the number of firms and the number of employees in the Spanish manufacturing and service industries in 2003.

[10] Storey (1994b) pointed out that entrepreneurs find it difficult to create businesses because of liquidity constraints. Moreover, banks lending seem to be unrelated to the personal characteristics of entrepreneurs, which have a significant impact on firm growth.

[11] There is an important type of behaviour that we do not take into account. There is evidence that some entrepreneurs create their own business as a strategy against temporary unemployment. Therefore, as soon as they find an interesting job, they may not continue the business.

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These results show that over 60% of employees work in the service industries. Service industries create more employment and have an important weight in our economy, which tends to be highly service intensive. Table 3.1 also presents information about the number of firms in each sector. As we can, 87% of firms belong to the service industries.

Table 3.1. Employees and the number of firms. 2003.

	MANUFACTURING		SERVICES	
	Absolute values	*%*	*Absolute values*	*%*
Employees	2,532,269	37%	4,391,072	63%
Number of firms	152,915	13%	992,338	87%
Employees per firm	16.56		4.42	

Source: author's own from the Encuesta Industrial and the Encuesta Anual de Servicios (Spanish Statistics Institute).

From the above we can observe a significant difference between the percentage of workers in the service sector and the number of firms in that sector. Both rates are high but the percentage of workers is substantially higher than the percentage of firms in service industries. Therefore, the MES of service firms is smaller than that of firms in the manufacturing sector.

This statement is corroborated by estimating the number of employees per firm (MES): firms in manufacturing industries have an average of 17 employees and those in the service industries have an average of four.

There is therefore evidence to support the heterogeneous behaviour between the manufacturing and the service industries. This diverse pattern is reflected in the different structures[12]. Our main objective is to determine whether these differences affect firm growth.

[12] Though the data presented is for 2003, this pattern remain has remained constant over the last ten years.

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We are also interested in determining the dynamic perspective of the industries. We will therefore analyse in greater detail the evolution of the manufacturing and service industries between 1999 and 2005 and examine the differences between them according to size. Specifically, we will analyse the rates of entry, exit, turbulence and net entry[13].

Table 3.2. Entry, exit rate, turbulence and net entry rate for 1999 and 2005.

	1999				2005			
	Entry rate	**Exit rate**	**Turbulence rate**	**Net entry rate**	**Entry rate**	**Exit rate**	**Turbulence rate**	**Net entry rate**
	MANUFACTURES							
Total	9.52	9.35	18.87	0.18	7.96	7.48	15.44	0.48
0 workers	14.26	17.39	31.65	-3.13	16.38	13.18	29.56	3.20
1-5 workers	9.52	7.60	17.11	1.92	5.86	6.76	12.63	-0.90
6-9 workers	6.03	4.07	10.10	1.96	3.58	3.98	7.56	-0.40
10-19 workers	4.44	2.89	7.32	1.55	2.62	2.86	5.48	-0.24
More than 20	2.27	1.53	3.80	0.73	1.32	1.42	2.74	-0.10
	SERVICES							
Total	15.24	13.98	29.22	1.26	13.75	9.50	23.25	4.25
0 workers	18.07	18.07	36.14	0.00	19.48	12.23	31.71	7.26
1-5 workers	12.38	9.34	21.71	3.04	8.14	7.20	15.34	0.93
6-9 workers	7.71	4.48	12.19	3.23	5.52	4.21	9.72	1.31
10-19 workers	6.05	3.44	9.49	2.61	3.92	3.09	7.00	0.83
More than 20	4.64	2.72	7.36	1.92	2.32	1.70	4.03	0.62

Source: author's own from the DIRCE (Directorio Central de Empresas).

Table 3.2 classifies the rates for different sizes of firms and shows the dynamics for each type of industry. In both years, the entry and exit rates decrease as the firm size increases. The relationship between the

[13] The rates are estimated using the following equations:

$$Entry \quad rate = \frac{Number \quad of \quad new \quad entrants \quad in \quad year \quad "t"}{Number \quad of \quad incumbents \quad in \quad year \quad "t"} \times 100$$

$$Exit \quad rate = \frac{Number \quad of \quad exits \quad in \quad year \quad "t"}{Number \quad of \quad incumbents \quad in \quad year \quad "t"} \times 100$$

$$Turbulence \quad rate = Exit \quad rate + Entry \quad rate$$

$$Net \quad entry \quad rate = Entry \quad rate - Exit \quad rate$$

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turbulence rate and firm size is also negative. We can also see that the differences in net entry rates are small, though there are slight differences between the manufacturing and service sectors. Finally, the net entry rate is slightly higher in 2005 than in 1999 but there is no clear pattern between this rate and firm size.

These results are in agreement with those in the literature on Firm Demography. For international results, Geroski (1995) and Caves (1998) reviewed the stylised facts and results on Firm Demography[14]. For Spain, see Callejón and Segarra (1999) and Segarra et al. (2002). However, all of these contributions analysed manufacturing industries alone.

If we compare the results for manufacturing industries with those for service industries, from Table 3.2 we can see that the entry and exit rates are higher for service industries regardless of size or year. Turbulence is therefore higher in the service industry than in the manufacturing industry. Also, though turbulence between different group of sizes is higher among services, the net entry rate is generally positive. From this table we can also see that the net entry rate for the service sector is higher than that for the manufacturing sector. However, if we analyse by size group, we observe that the increase in the net entry rate in the service sector is mainly due to firms without workers.

Having analysed entries and exits, we will now analyse the evolution of a cohort of firms created in 1994. Specifically, we will analyse the period between 1994 and 2001 and examine their growth pattern at the end of this period in order to determine whether the small firms have remained small or whether they have joined a different group.

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Table 3.3. Percentages of firms in the cohort created in 1994 and observed in 2001 that have maintained , changed their size or failed.

	Equal size	Changing size	Failures
Manufacturing	20.72	25.21	54.07
Services	23.81	17.33	58.86

Source: author's own from the DIRCE (Directorio Central de Empresas).

Table 3.3 shows that more than half of the firms created in 1994 had disappeared by 2001[15]. This means that firms suffer from a high infant mortality rate, which is in agreement with the literature (Audretsch and Mahmood, 1994b, 1995; Audretsch, Santarelli and Vivarelli, 1999; Audretsch et al., 2000; Segarra and Callejón, 2002; Segarra et al., 2002).

However, there are several differences between the manufacturing and the service sectors. First, in the medium term, firms in the service sector are more likely to fail: 58.86% of firms in this sector had failed by the end of the period. This may be related to the lower sunk costs and more short-term strategies for facing unemployment situations in the service sector. Second, the minimum efficient size of service firms is usually lower than in manufacturing firms so service firms have a higher turnover rate.

To sum up, there are clearly considerably differences between these two types of industry. Not only are there more firms in the tertiary sector but there are also more workers. It is therefore justified to differentiate between the two industries. Our interest, however, lies in determining the effect of these differences on the growth trends of the firms.

[14] See Annex II for a revision of Geroski's (1995) stylised facts.

[15] We consider that a firm increases or decreases in size, when it moves from one group in the classification (0, 1-5, 5-9, 10-19 or more than 20 workers) to another. One disadvantage of using the DIRCE database is that we only observe groups of firms by industry and ignore a firm's individual trajectory.

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3.4. The Theoretical Model

Before starting the empirical analysis, in this section we will present the theoretical model behind our estimations. Lucas (1978), Ericson and Pakes (1995), Pakes and Ericson (1998) proposed theoretical models that incorporate Gibrat's Law. However, we will use the Passive Learning Model, or Jovanovic's (1982) model, which is one of the most used theoretical models. However, we will make several small changes to the model's basic hypothesis. Specifically, we define a new version of Jovanovic's model depending on the sector in which the firm remains active.

3.4.1. Jovanovic's (1982) Passive Learning Model

Jovanovic (1982) proposed the *Theory of "noisy" selection*, which is characterised by a model in which the efficiency of a firm determines its evolution. Specifically, there is a pool of firms that decide to enter the market in every period. The level of efficiency of these firms is unknown but they can decide either to continue in the market or to leave it. However, firms will know their level of efficiency indirectly through the cost function once they have entered the market .

Firms have a cost function with the following characteristics. This cost function can be represented in Graph 3.1.:

$$c(0)=0 \qquad c'(0)=0 \qquad c'(q)>0 \qquad c''(q)>0 \qquad \lim_{t\to\infty} c'(q)=\infty$$

The main cost function is represented by the following formula:

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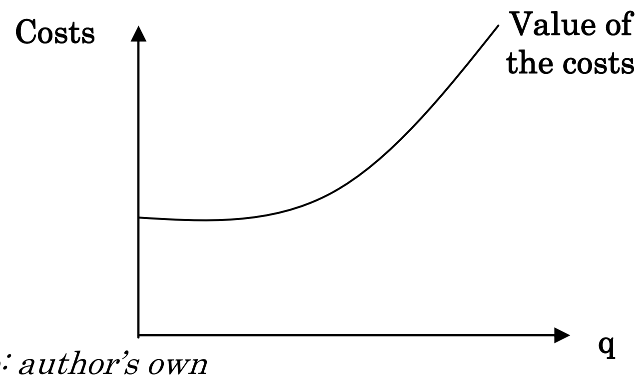
$c(q_{it})x_t$

$$x_t = \zeta(\eta_t)$$

$$\eta_t = \theta + \varepsilon_t \qquad where \quad \varepsilon_t \approx N(0,\sigma_\varepsilon^2) \quad and \quad \theta \approx N(0,\sigma_\theta^2)$$

where x_t is a shock related to firm efficiency, which is made up of several variables: η is an independent productive shock affecting the firm efficiency, ε_t is an independent productive shock affecting the firm efficiency. This productive shock is equal for all active firms, and θ is the productive shock signalling the efficiency for each firm.

Graph 3.1. Cost production function.



Source: author's own

What is the difference between a new entrant and an active firm? As we pointed out earlier, new firms ignore their own level of efficiency but they know the distribution of probability of the efficiency levels in the market ($\theta \approx N(0,\sigma_\theta^2)$).

Another aspect to consider is the relationship between efficiency and costs. Firms will know their real level of efficiency once they enter the market and estimate their costs. Indirectly, they will estimate their level of efficiency. In fact, there is a positive relationship between $\boldsymbol{\theta}$ and cost, while there is a negative relationship between the output and the efficiency level.

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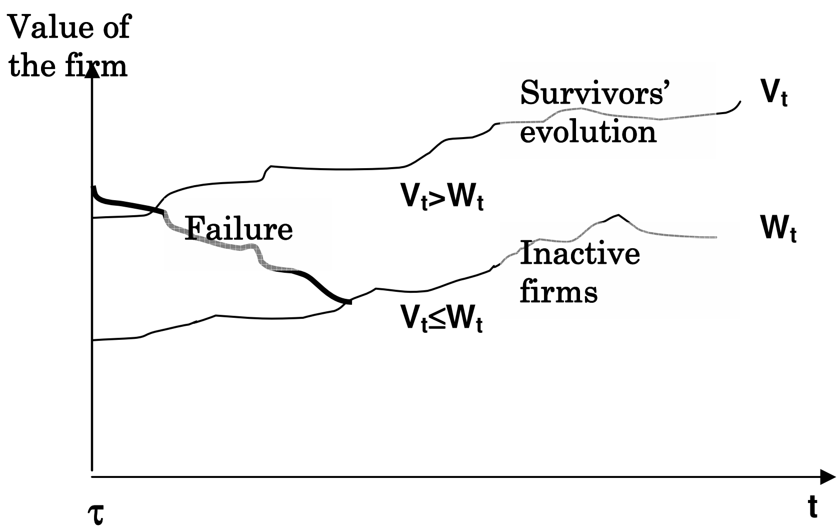
$$\frac{\delta c}{\delta \theta} > 0 \quad \frac{\delta q}{\delta \theta} < 0$$

Therefore, the larger the value of θ, the smaller the level of efficiency. Once the firm infers its intrinsic value of θ, the firm will maximise the value of the firm each period:

$$\underset{q_t}{Max}\left[p_t q_t(p_t / x) - c(q_t(p_t / x))x_t^*\right]$$

where p is the market price, x_t^* is the expected production in period "t". Given this function of profits, firms maximise the expected value of profits conditioned to the current information.

Graph 3.2. Evolution of a firm in the industry.



Source: Jovanovic (1982)

The firm decides to enter the industry depending on the discounted value at time "t" of staying for one period in the industry (V_t) or the expected present value of remaining inactive[16] (W_t). Graph 3.2 shows that if $V_t > W_t$, firms will enter. However, their expectations depend on an

[16] In fact, Jovanovic (1982) defines W_t as the expected present value of a firm's fixed factor. This fixed factor is equivalent to the "managerial ability" or the "advantageous location".

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expected profit. This expected profit is unknown until the firm enters the market. The profit of each firm depends on its efficiency level. If the firm overestimates its own efficiency, the firm will decline until it exits the market[17].

When a firm decides to remain active or to leave the market, not only current profits but also future expected profits must be maximised. The firm will therefore maximise the following function:

$$V(x,n,t,p) = \pi(p_t, x) + \beta \int \max[W, V(z, n+1, t+1, p)] P(dz|x,n)$$
$$= p_t q(p_t|x) - c[q(p_t|x)]x + \beta \int \max[W, V(z, n+1, t+1, p)] P(dz|x,n)$$

V_t will depend on the expected profits. How are the expected profits formed? The firm will estimate the distribution of profits using past information. The expected value of profits for a firm that has survived "z" periods[18] and received "t" productive shocks (η) are equal to current profits plus the discounted value of the future profits expected in the following period.

When a new firm discovers that its level of efficiency is above the critical efficiency level, it will remain in the market and grow in order to close the gap between its start-up size and the MES (Santarelli and Vivarelli, 2002).

[17] This negative evolution would be equivalent to saying that in every period firms analyse their future expected profits. However, in every period this V_t will continue to approach W_t (the value of remaining inactive in the market). In this case, the firm will value their expected profits less, V_t will diminish, and the firm will reduce the number of workers until it disappears.
[18] "*z*" refers to years or experience in the market from τ (when the firm was created) to "*t*" (the current year).

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Finally, Jovanovic's model is characterised by passive learning, which means that firms will not modify their initial efficiency. Ericson and Pakes (1995) and Pakes and Ericson (1998) therefore introduced a model characterised by firms which are able to modify their own level of efficiency.

3.4.2. Enlargements of the model

Now that we have presented these theoretical models, we will try to determine the relationship between Jovanovic's (1982) model and Gibrat's Law. To do so, we will analyse the incomplete information with unknown efficiency levels that causes firms either to disappear or to grow when they correct their production. If a firm declines, the number of employees will decrease, and if a firm grows, the number of employees will increase.

Gibrat's Law is therefore only for firms that exceed the MES in an industry and have survived infancy. The smallest and youngest firms will have the most variable growth rates.

Using the above model, we will analyse the evolution of firm growth in the manufacturing and service sectors to determine whether there are any differences. For several reasons, we expect the two sectors to behave heterogeneously .

Each firm must be assigned a different level of efficiency according to its industry:

$$\bar{\theta} \Rightarrow \text{Efficiency level}$$

$$\bar{\theta}_M \Rightarrow \text{Efficiency level } \bar{\theta} \text{ of manufacturing industries}$$

$$\bar{\theta}_S \Rightarrow \text{Efficiency level } \bar{\theta} \text{ of service industries}$$

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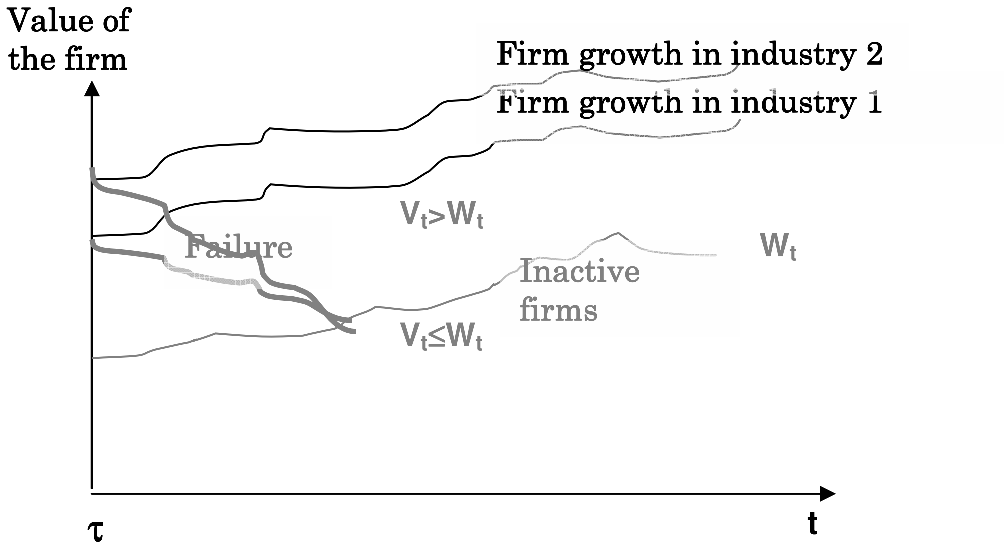
Graph 3.2 shows the evolution of the value of a firm regardless of its industry. Graph 3.3 shows the evolution of the firm depending on the industry it belongs to. A manufacturing firm with the same efficient level as a service firm may increase more or less depending on different industrial factors such as the economies of scale, the barriers to grow and survive.

Graph 3.3. Evolution of a firm in two industries.



Source: author's own from Jovanovic (1982)

The path growth of a firm in a manufacturing industry is therefore different from that of a firm in a service industry. A firm's growth rate is affected by both its previous size and its industry.

These hypotheses are shown in the following table:

	PASSIVE LEARNING	ACTIVE LEARNING
MANUFACTURING INDUSTRIES	$g\left(X\middle\|\bar{\theta}_M\right)$	$g\left(X\middle\|\bar{\theta}_M, Age_t\right)$
SERVICE INDUSTRIES	$g\left(X\middle\|\bar{\theta}_S\right)$	$g\left(X\middle\|\bar{\theta}_S, Age_t\right)$

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$g(X|\bar{\theta}_M)$ is the growth function depending on the efficiency level needed for a firm in the manufacturing sector, and $g(X|\bar{\theta}_S)$ is the growth function depending on the efficiency level needed for a firm in the service sector.

Under these hypotheses, we expect there to be differences between firms in the manufacturing industry and those in the service industry:

$$g_M(\bullet) = g_S(\bullet) \qquad or \qquad g_M(\bullet) \neq g_S(\bullet)$$

Moreover, the assumption of passive learning implies that age does not affect firm growth. For a passive learning model the following equations will be satisfied:

$$\frac{\delta g_M}{\delta A_M} = 0 \qquad and \qquad \frac{\delta g_S}{\delta A_S} = 0$$

For an active learning model, the age or experience of a firm in the market will have a coefficient that is different from zero:

$$\frac{\delta g_M}{\delta A_M} \neq 0 \qquad and \qquad \frac{\delta g_S}{\delta A_S} \neq 0$$

In summary, our two main objectives are:

a) to analyse the differences between the manufacturing and the service sectors, and

b) to determine which kind of learning process, active or passive, drives the evolution of firms in the industry.

Both of these questions are important for obtaining a full description of the pattern and future evolution of a firm's post-entry performance. The presence of a learning model has crucial consequences for a firm's investment possibilities and survival. For example, with passive learning, firms will not be able to survive if they have low levels of

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efficiency. The most important thing is that firm' investments may not modify its own level of efficiency.

For active learning on the other hand, firms will be able to modify their efficiency levels making more effort in their investments.

3.5. DATA DESCRIPTION

An empirical estimation of firm growth requires individual data bases but, until recently, there were no large Spanish samples. Having analysed the theoretical framework, our interest now focuses on analysing the data used in this section. First we present the *Sistema de Análisis de Balances Ibéricos* database and then describe the data.

3.5.1. Data base

Our data set comprises roughly 500,000 surviving firms from all business sectors before 2002 from the *Sistema de Análisis de Balances Ibéricos* database. This database constructs data from the regional registers of Spanish and Portuguese firms. The subjects analysed are firms, as opposed to plants or establishments. In other words, a firm with several active plants is considered as only one observation. We should clarify from the outset that firms provide yearly information about their balance sheets if they have over 10 employees or a quantity of incomes over 60,000 euros.

Each firm is given a variable that records each year whether it is new, whether it has continued its activity or whether it has disappeared during the period analysed. The time span is 9 years, from 1994 to 2002. Our economic information for each of these years is obtained from

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balance sheets and from income and expenditure accounts, e.g. cash, sales and total assets. Other variables available are the number of employees and the economic sector (as a 4-digit detail) according to the NACE[19].

The geographical area of reference is Spain and the variables have a timescale of one year from 1994 to 2002[20]. We will analyse firms that survived until 2002, i.e. though the firms will have different years of creation, the main characteristic is that all firms were active in the market until 2002.

The economic sectors are classified in terms of manufacturing or service industries. Following the NACE classification, we chose sectors 15–36, corresponding to manufacturing industries, and sectors 50–74, corresponding to service industries[21].

3.5.2. Data description

As we aim to distinguish between industries, our first table (Table 3.4) shows the most representative summary statistics (number of observations, mean and standard deviation). We present the number of employees and the age according to the individual sectors.

We found considerable differences between sectors in terms of the number of employees. The *Transport equipment* industry had the most, with a mean of 124 employees per firm. The *Chemical manufactures*

[19] NACE is a general industrial classification of economic activities within the European Union. This classification is officially recognised by the Accounting Economic System (National Institute of Statistics).
[20] Although the SABI database provides information between 1992 and 2005, the availability of information in the initial and final years of the period is scarce. For this reason, we decided to shorten the period of analysis.

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industry had a mean of 58 employees. In the service sector, the *Telecommunications* industry had the highest number of employees, with 122 employees. However, it also had the highest standard deviation. From these results, we can conclude that the *Telecommunications* industry and the *Transport equipment* industry are more heterogeneous than the other industries.

Table 3.4. Descriptive table of the number of employees and age by sector from 1994 to 2002.

		Employees		Age	
	Obs	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
Manufacturing firm					
Food and beverages	40280	33.66	319.30	12.80	12.18
Textile and leather clothes	41484	22.11	63.59	10.32	9.94
Wood and cork	16220	17.64	117.70	9.01	7.88
Paper products and media	37617	21.23	97.25	9.79	9.84
Chemical manufactures	11493	58.34	233.27	16.01	15.04
Rubber and plastic products	14350	35.19	324.18	11.64	9.69
Other non-metallic products	19775	35.50	247.42	11.67	10.73
Metal products	62648	22.92	176.16	9.84	9.23
Machinery and equipment	18851	28.76	117.27	11.80	10.23
Electric and optic apparatus	12522	48.77	321.71	11.19	10.53
Transport equipment	7194	124.24	629.47	12.83	13.02
Furniture	22858	17.45	46.17	8.99	7.89
Services					
Motor vehicles	79167	13.43	64.39	10.75	8.18
Wholesale trade	17713	10.85	50.55	9.00	8.32
Hotels and restaurants	61967	27.63	244.14	8.33	8.11
Transport	75176	26.99	479.21	9.85	10.10
Telecommunications	6049	121.61	1598.50	5.74	6.06
Finances	8895	37.24	485.19	8.58	8.03
Renting	10659	12.71	33.94	7.98	7.08
Computer activities	18349	30.36	205.91	5.90	5.34
R&D	1316	49.75	264.66	8.16	7.42

Source: author's own from SABI database.

The manufacturing industries with the smallest average size, with 17 employees per firm, were *Furniture* and *Wood and Cork*.

[21] We have excluded sectors 16 (industries related to tobacco products) and 23 (industries related to coke, refined petroleum products and nuclear fuel).

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With regard to services, the average size of the *Wholesale trade* industry was the lowest (11 employees per firm). This was closely followed by the *Motor vehicles* and *Renting* industries (13 workers per firm). Note also the high standard deviations of the *Finances* and *Transport service* industries.

Age, measured as the number of years a firm is active in the market, also presents a differential pattern. Firms in the manufacturing industry seem generally to be older than those in the service industry. Firms in the *Chemical manufactures* industry, for example, had an average of 16 years in the market. However, this industry also has the highest standard deviation, which indicates that this is an industry in which young and old firms coexist.

In the service sector, the *Motor vehicles* industry had the highest average age, with 11 years. The *Computer activities* industry, on the other hand, had the lowest average age, with 6 years. This sector also had the lowest standard deviation, which implies that few firms survive in this sector. The economic explanation for this behaviour could be the high competitiveness or high turbulence in the sector, which affects all the firms in the market.

Finally, the *Furniture*, *Wood and cork* and *Paper products and media* industries had the lowest average age, with 9 years.

In summary, though there are clear differences between the two sectors, there are also heterogeneous patterns in each individual industry. This diversity should therefore be taken into account when analysing the firm growth patterns of each industry.

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Table 3.5 shows the correlation between the number of employees, the age of the firm, income per worker, added value per worker and sales per worker. It also shows the values for the whole database and for both types of industry (manufacturing and service industries).

As we can see, there is a high positive correlation between sales and income per worker (0.9973), which is mainly due to their direct dependence[22]. There is also a high correlation between the added value per worker with respect to income per worker and the added value per worker with respect to sales per worker (roughly 0.4).

Table 3.5. Correlation between the number of employees, age, income per worker, added value per worker and sales per worker.

	Employees	Age	Income p.w.	Added value p.w.	Sales p.w.
Employees	1.0000				
Age	0.1062	1.0000			
Income p.w.	-0.0014	0.0214	1.0000		
Added value p.w.	0.0004	0.0254	0.4218	1.0000	
Sales p.w.	-0.0015	0.0208	0.9973	0.4177	1.0000
Manufacturing					
Employees	1.0000				
Age	0.1469	1.0000			
Income p.w.	0.0040	0.0570	1.0000		
Added value p.w.	0.0114	0.0848	0.5310	1.0000	
Sales p.w.	0.0039	0.0580	0.9919	0.5359	1.0000
Services					
Employees	1.0000				
Age	0.0857	1.0000			
Income p.w.	-0.0025	0.0277	1.0000		
Added value p.w.	-0.0011	0.0185	0.6038	1.0000	
Sales p.w.	-0.0026	0.0265	0.9962	0.5978	1.0000

Source: author's own from the SABI database.

[22] The income per worker includes the sales per worker plus other incomes obtained by the firm.

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There appears to be a positive relationship between age and the rest of the variables regardless of the industry. However, this relationship is weak since the coefficient is almost zero.

Table 3.6. Number of firms, employees and age. Average and standard deviation (in brackets).

	Number of firms	*Employees*	*Age*	*% firms*	*Relative index of Employees*	*Relative index of Age*
ANDALUSIA	21584	16.31 (71.58)	8.27 (8.11)	12.49	0.67	0.77
ARAGON	7829	21.47 (165.26)	10.60 (9.40)	4.53	0.88	0.99
ASTURIAS	4243	25.02 (323.98)	10.30 (9.73)	2.45	1.03	0.96
BALEARIC ISLANDS	4448	29.49 (267.89)	11.22 (9.16)	2.57	1.21	1.04
CANARY ISLANDS	3345	29.16 (70.70)	9.70 (9.47)	1.94	1.20	0.90
CANTABRIA	1146	38.09 (38.09)	11.85 (11.09)	0.66	1.56	1.10
CASTILE LA MANCHA	8296	15.49 (55.64)	9.06 (8.12)	4.80	0.64	0.84
CASTILE LEON	9593	18.46 (132.60)	9.74 (8.58)	5.55	0.76	0.91
CATALONIA	37927	26.84 (209.03)	11.09 (10.66)	21.94	1.10	1.03
CEUTA	65	18.02 (40.61)	16.28 (14.84)	0.04	0.74	1.51
VALENCIA	21725	15.60 (38.66)	9.01 (7.84)	12.57	0.64	0.84
EXTREMADURA	2025	13.53 (28.22)	8.47 (7.90)	1.17	0.56	0.79
GALICIA	8171	22.96 (152.71)	9.62 (9.20)	4.73	0.94	0.89
MADRID	24475	55.90 (701.10)	10.23 (10.23)	14.16	2.30	0.95
MELILLA	98	12.09 (11.78)	14.87 (14.03)	0.06	0.50	1.38
MURCIA	4512	18.05 (48.60)	8.47 (7.50)	2.61	0.74	0.79
NAVARRE	2959	35.73 (189.50)	11.63 (10.57)	1.71	1.47	1.08
BASQUE COUNTRY	8782	30.86 (128.10)	11.74 (11.83)	5.08	1.27	1.09
RIOJA	1625	19.47 (31.86)	12.23 (10.79)	0.94	0.80	1.14

Standard deviation in brackets.
Source: author's own from the SABI database.

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There appears to be a null correlation between the number of employees and the value of income, added value or sales per worker. In other words, large firms do not imply higher incomes, sales or added value. To sum up, there appear to be weak relationships between the variables, except obviously for sales and income.

Table 3.6 shows the number of firms, the average number of employees and their standard deviation (in brackets), and the age of the firms classified by Spanish autonomous region. The main aim of this classification is to analyse these regions in terms of the number, size and experience of firms. There appears to be heterogeneity with regard to the distribution of firms in the territory. Sixty per cent of the firms in our database are concentrated in four Spanish regions: Catalonia (22%), Madrid (14%), Valencia (13%) and Andalusia (12%).

Finally, Table 3.6 presents that the largest firms are concentrated in Madrid, with 56 employees per firm and a relative coefficient of 2.30 with respect to the Spanish average. The next region is Cantabria, with an average of 38 employees. The youngest firms are located in Andalusia and Extremadura (with relative coefficients of 0.77 and 0.79 above the average). The oldest firms are located in Ceuta and Melilla, with averages of 16 and 15 years of experience. The region in which most of the firms are concentrated is Catalonia, with an average coefficient of 1.03. Other figures are those for Andalusia (0.77), Valencia (0.84) and Madrid (0.95).

3.6. METHODOLOGY AND EMPIRICAL ESTIMATIONS

We have analysed the most important literature on Gibrat's Law and our own data base. Now we present the econometric methodology used in the

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estimations of Gibrat's Law. We also present the estimations for determining the relationship between firm growth and size and comment on the results.

The aim of this section is to determine the relationship between firm growth and size. Our first estimation will test Gibrat's Law. However, we will also evaluate the learning process of firms, analysing aggregate values as well as the values for individual sectors.

3.6.1. Econometric methodology

Several econometric methods have been used to estimate Gibrat's Law. The first attempts used cross-section regression (Dunne and Hughes, 1994; Audretsch and Mahmood, 1994a; Kumar, 1985). However, if some unobserved factors affect firm growth rates (e.g. management attitude, innovation, changes in demand or taste, and luck), which are positively correlated with firm size and not controlled for in regressions using cross section data, the estimated coefficient of firm size will be biased upwards.

Panel data can be used to control for unobserved heterogeneity (Baltagi, 1995). The standard methods of panel estimation are fixed effects or random effects. The main difference between these approaches is the information used to calculate the coefficients. Fixed Effects coefficients are calculated from differences within each firm over time.

These differences are reflected in the treatment of the error term. Fixed Effects models assume that the error component (the individual difference) is *fixed* or *nonstochastic* (though it varies across individuals)[23]. Random Effects models, on the other hand, assume that

[23] The individual effects are therefore defined as the error component plus the intercept.

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the error component is random (see Annex IV for a description of these two econometric methods).

However, as Cefis et al. (2002) point out, this approach forces the parameters to be identical across individuals. If the firms are heterogeneous, the fixed-effects estimates may create bias. Neglecting heterogeneous coefficients in dynamic models creates correlation between the regressors and the error term and causes serially correlated disturbances (Pesaran and Smith, 1995 and Hsiao et al., 1997).

The random-effects estimates are more efficient, since they incorporate information across individual firms as well as across periods. The major drawback with random effects is that they are consistent only if the firm-specific effects are uncorrelated with the other explanatory variables. A Hausman specification test can evaluate whether this independence assumption is satisfied.

Arellano and Bover (1990) suggest that using panel data in this type of research is better because they allow for firm heterogeneity and reduce collinearity among the variables. One crucial question in panel data is whether the unobservable individual effects are fixed or random. To verify the nature of the individual effects, Hausman's (1978) specifications test is used.

In our case, the Hausman test indicates that it is appropriate to use the Fixed Effects Model (see Tables 3.7 to 3.12), which requires us to transform our original model by subtracting the average of the variables from it. However, we also present the results of the random effects model in order to compare both results. Authors such as Voulgaris et al. (2003) and Das (1995) recently used panel data to analyse the effect of firm size on firm growth.

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3.6.2. Specification of the growth equation

Section 3.2.2 presents the methods used to analyse Gibrat's Law. As we have seen, there are several approaches but for our estimations we will use equation 3.3 which is as follows:

$$\Delta \log S_{it} = \alpha_i + \beta_1 \log S_{it-1} + \varepsilon_{it} \quad where \quad \beta_1 = \beta - 1$$

As we said earlier, Gibrat's Law is satisfied when β_1 is equal to 0. If β_1 is negative, small firms grow faster than large firms, and if β_1 is positive, large firms grow faster than small firms.

Many studies have analysed the effects of age or experience on firm growth (e.g. Audretsch and Lehman, 2005; Oliveira and Fortunato, 2004a and 2004b; Voulgaris et al., 2003; Lotti et al., 2003; Fotopoulos and Louri, 2004). These studies are closely related to Jovanovic's (1982) model, which found that Gibrat's Law is not satisfied when firms are young and smaller than the MES. From the empirical approach, Evans' (1987a, 1987b) flexible functional form allows us analyse the relationship between size and age. Let S_{it} be the size at "*t*" of firm "i" and A_{it} the age at "*t*" of firm "*i*". Then, in logarithmic form, the firm growth at "*t*" may be written as follows:

$$\Delta \log S_{it} = \alpha_i + \beta_1 \log S_{it-1} + \beta_2 (\log S_{it-1})^2 + \beta_3 \log A_{it} + \beta_4 (\log A_{it})^2 + \varepsilon_{it}$$

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This is the form of the equation estimated by Evans (1987a, 1987b)[24]. Dunne et al. (1989) introduced firm size in the previous year (S_{it-1}) to allow for the impact of fixity of capital and related it to firm growth (Das, 1995).

The first estimation (*Estimation 3.1*) directly analyses Gibrat's Law, or the Law of Proportionate Effects. Therefore, we relate firm growth to initial size:

$$\Delta \log S_{it} = \alpha_i + \beta_1 \log S_{it-1} + \varepsilon_{it} \qquad \text{(Estimation 3.1)}$$

Also to analyse the learning process of firms in the market, *Estimation 3.2* introduces age and its quadratic value in the previous estimation:

$$\Delta \log S_{it} = \alpha_i + \beta_1 \log S_{it-1} + \beta_2 \log A_{it} + \beta_3 (\log A_{it})^2 + \varepsilon_{it} \qquad \text{(Estimation 3.2)}$$

Both equations differentiate between manufacturing and the service industries. The next step is to analyse the differences between each individual industry in the manufacturing and service sectors.

3.6.3. Estimation

In this section we present the results of Gibrat's Law. We also analyse any differences between the manufacturing and service industries as well as the possible effect of the learning model. To do so, we will analyse

[24] Evans (1987a, 1987b), Hall (1987) and Dunne et al. (1989) differentiated between a latent firm growth equation and a real firm growth equation. The former includes surviving and non-surviving firms and would raise a sample selection bias arising from exit. The latter estimates the growth of surviving firms.

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the Gibrat's Law, study the effect of introducing age into the analysis of firm and search for differences between individual industries.

As we reported in earlier sections, there are obvious differences between manufacturing and service industries. We are interested, therefore, in searching for the effects of these differences on the firm growth pattern. Few studies have analysed the differences between these industries. Oliveira and Fortunato (2004a and 2004b) found that aggregate data on manufacturing and service industries do not satisfy Gibrat's Law. Audretsch et al. (2004), however, found that service subsectors may not reject Gibrat's Law.

Armed with this empirical evidence, we aim to highlight the differences between manufacturing and service industries. The results may show a heterogeneous or homogeneous pattern of behaviour, depending on the reaction of firms once they enter the market. We will therefore analyse individual industries in order to detect any different behaviour.

3.6.3.1. Gibrat's Law

Like most of the recent literature on Gibrat's Law, our results reject the hypothesis that all firms, regardless of their size, have an equal probability to grow[25]. Specifically, the negative and significant coefficient of initial firm size reveals that small firms tend to grow more quickly than large firms. Large firms therefore have less tendency to grow in the market (the fixed effects coefficient is –0.7449).

[25] Although the coefficients between random and fixed effects are large (due to differences between the two specifications; see Annex IV), both equations lead to the same interpretation of the coefficients.

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Table 3.7. Determinants of firm growth (GLS Random and Fixed Effects Model).

	Fixed Effects	*Random Effects*
S_{t-1}	-0.7449	-0.1550
	(0.0016)*	(0.0007)*
Coefficient	1.6939	0.3805
	(0.0036)*	(0.0019)*
F	203489.05	
	(0.0000)	
Chi2		39818.53
		(0.0000)
R^2	0.4260	
Hausman test	163878.18	
	(0.0000)	
Breusch and Pagan test	695.74	
	(0.0000)	
Observations	414123	

Standard deviation in brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

This negative relationship between firm growth and size is in agreement with results from most recent contributions e.g. Audretsch and Lehman (2005), Lotti et al. (2001), Audretsch (1995a) and Dunne and Hughes (1994). The main consequence for market structure is the convergence of firm size. This means that firm size will not tend to explode, so a kind of equilibrium will exist where firms converge.

Table 3.8 shows the estimations for both the manufacturing and the service industries. The results show a similar picture since both estimations reject Gibrat's Law. This means that, while firm growth depends on firm size, the differences between the manufacturing and service industries do not seem to be significant.

We therefore agree with Oliveira and Fortunato (2004a, 2004b), who concluded that firms grow at the same rate. There are therefore no significant patterns to firm growth so, in terms of policy strategies, the effects of public resources on firm growth in the two sectors will not be significantly different. However, other factors may affect both the sectors

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and the individual industries. In the next sections, therefore we will analyse these differences in greater detail.

Table 3.8. Determinants of firm growth (GLS Random and Fixed Effects Model) for manufacturing and service sectors.

	Manufacturing sector		*Service sector*	
	Fixed Effects	*Random Effects*	*Fixed Effects*	*Random Effects*
S_{t-1}	-0.7682	-0.1851	-0.7250	-0.1261
	(0.0022)*	(0.0012)*	(0.0028)*	(0.0012)*
Coefficient	1.8815	0.4781	1.5052	0.2987
	(0.0054)*	(0.0030)*	(0.0057)*	(0.0026)*
F	115856.71		66167.76	
	(0.0000)		(0.0000)	
Chi2		24558.20		12022.40
		(0.0000)		(0.0000)
R^2	0.4467		0.4040	
Hausman test	91932.38 (0.0000)		54171.64 (0.0000)	
Breusch & Pagan test	512.36 (0.0000)		111.72 (0.0000)	
Observations	202683		165310	

Standard deviation in brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

3.6.3.2. Gibrat's Law and the Learning Process

In this section we evaluate the relationship between firm growth and age and determine how experience can modify the firm growth process. Jovanovic (1982) presented a model in which firms learn from their own experience i.e. active firms learn from their own levels of efficiency and the market possibilities in the industry. Subject to Jovanovic's model, firms are incapable of modifying their own levels of efficiency. In Jovanovic's passive learning model, therefore, experience does not affect the evolution of firm growth.

Ericson and Pakes (1995) and Pakes and Ericson (1998) presented a more realistic model in which firms know their own efficiency levels once they enter the market. This model is an improvement since it knows where the firms are. Specifically, firms can modify their efficiency while

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they are in the market. Consequently, a firm's experience directly affects its growth because time can increase a firm's chances of improving its growth rate and, therefore, its chances of survival.

Table 3.9 shows the relationship between firm growth and age using a GLS estimation with Fixed and Random Effects. With regard to previous firm size, the results are quite similar[26] and reject Gibrat's Law.

Firm age (*Age*) shows a positive and significant effect on firm growth. This means that firms with more experience in the market will have higher growth rates. However, the impact of age is not quantitatively large so it cannot compensate the impact of the firm size.

Table 3.9. Determinants of firm growth and the learning process (GLS Random and Fixed Effects Models).

	Fixed Effects	*Random Effects*
S_{t-1}	-0.7867 (0.0017)*	-0.1718 (0.0008)*
Age	0.0401 (0.0005)*	0.0020 (0.0002)*
Age2	-0.0003 (0.00001)*	0.0001 (0.00001)*
Coefficient	1.4107 (0.0047)*	0.3812 (0.0021)*
F	73699.16 (0.0000)	
Chi2		43509.55 (0.0000)
R^2	0.4464	
Hausman test	181644.94 (0.0000)	
Breusch & Pagan test	686.66 (0.0000)	
Observations	414123	

Standard deviation in brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

When the Fixed Effects estimation is used, the quadratic age (*Age2*) has a negative impact, which implies that older or obsolete firms have less

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capacity to grow. However, this effect is positive when the Random Effects estimation is used. Also, the coefficient is not large enough to change the process.

Therefore, if two firms have the same size but different experience in the market, the older firm will converge more slowly towards the central point than the younger firm, though this difference will not be too great.

However, we are interested in analysing the differences between firms in the manufacturing sector and firms in the service sector and their capacities to achieve better growth rates. Following Evans (1987a, 1987b), we include age in order to analyse the presence of active or passive learning.

Table 3.10. Determinants of firm growth and the learning process (GLS Random and Fixed Effects Model) for manufacturing and service industries.

	Manufacturing industries		*Service industries*	
	Fixed Effects	*Random Effects*	*Fixed Effects*	*Random Effects*
S_{t-1}	-0.8161	-0.2204	-0.7636	-0.1275
	(0.0023)*	(0.0013)*	(0.0029)*	(0.0012)*
Age	0.0453	0.0071	0.0428	-0.0031
	(0.0006)*	(0.0003)*	(0.0012)*	(0.0003)*
Age2	-0.0003	0.00004	-0.0006	0.0001
	(0.00001)*	(0.00001)*	(0.00003)*	(0.00001)*
Coefficient	1.5418	0.4710	1.2648	0.3149
	(0.0065)*	(0.0034)*	(0.0081)*	(0.0031)*
F	44130.11		22994.62	
	(0.0000)		(0.0000)	
Chi2		29199.53		12363.66
		(0.0000)		(0.0000)
R^2	0.4798		0.4141	0.3973
Hausman test	107907.52		57570.22	
Breusch & Pagan test	395.89		162.05	
Observations	202683		165310	

Standard deviation in brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

[26] The previous coefficient was –0.7449 while the estimation of the learning process is around –0.7682.

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When the effect of age is introduced, the differences in the effect of size between the manufacturing and service industries appear to be greater. For example, Table 3.10 shows that the speed of convergence (-0.7636) is faster in the service industries than in the manufacturing industries (-0.8161). From the empirical evidence (section 3.3.1), these results seem reasonable because firms in the service industries have a lower MES than those in the manufacturing industries and so do not have to increase their size in order to survive (Audretsch et al., 2004).

There appear to be no differences between the two sectors regarding the effects of market experience on firm growth.

3.6.3.3. Gibrat's Law and the Learning Process: the behaviour of individual industries.

Above are the aggregate results for the manufacturing and service industries. This aggregation may provide a broad description of the firm growth pattern. However, by analysing each individual sector we may obtain a more accurate picture. In this section, therefore, we will study the sectors individually, beginning with the manufacturing sector.

In both sectors Gibrat's Law is rejected, so our results are consistent with previous ones. However, the results also shed some light on the differences between sectors and our main conclusion is that, as each sector has its own characteristics, generalisations should not be made.

Tables 3.11 and 3.12 show the results for the manufacturing and service sectors. From Table 3.11 we can see that:

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Table 3.11. Determinants of firm growth and the learning process (GLS Random and Fixed Effects Model) for the manufacturing sector.

	Fixed Effects						Random Effects						TESTS		
	St-1	Age	Age2	Coeffic.	F	R^2	St-1	Age	Age2	Coeffic.	Chi2	R^2	Hausman test	B. and P. test	Obs.
Food and	-1.0183	0.0589	-0.0005	1.8339	10044.66	0.5983	-0.3856	0.0289	-0.0002	0.6015	8605.29	0.5866	24882.43	6.41	29283
beverages	(0.0061)*	(0.0015)*	(0.00002)*	(0.0200)*			(0.0042)*	(0.0010)*	(0.00002)*	(0.0125)*			(0.0000)	(0.0113)	
Textile and	-0.7209	0.0093	-0.00006	1.6374	5397.73	0.4105	-0.2098	0.0032	.00006	0.4694	4407.23	0.4091	11934.12	9.21	32373
leather clothes	(0.0058)*	(0.0019)*	(0.0001)	(0.0172)*			(0.0033)*	(0.0009)*	(0.00002)*	(0.0084)*			(0.0000)	(0.0024)	
Wood and	-0.7433	0.0304	-0.0004	1.409	1895.45	0.4170	-0.1848	-0.0004	0.0001	0.4103	1405.05	0.4107	4372.42	1.29	12086
cork	(0.0100)*	(0.0035)*	(0.0001)*	(0.0257)*			(0.0053)*	(0.0014)	(0.00003)*	(0.0123)*			(0.0000)	(0.2554)	
Paper products	-0.7193	0.0238	-0.0002	1.3163	4925.39	0.4117	-0.1617	0.0023	0.00004	0.3314	2869.19	0.4092	12195.73	47.37	29369
and media	(0.0060)*	(0.0017)*	(0.00004)*	(0.0144)*			(0.0032)*	(0.0008)*	(0.00001)*	(0.0072)*			(0.0000)	(0.0000)	
Chemical	-0.6506	0.0274	-0.0001	1.4369	1634.57	0.4144	-0.1277	-0.0020	0.0001	0.3904	853.16	0.3995	4190.71	0.88	9210
manufactures	(0.0094)*	(0.0028)*	(0.00005)*	(0.0332)*			(0.0047)*	(0.0012)***	(0.00002)*	(0.0144)*			(0.0000)	(0.3475)	
Rubber and	-0.7267	0.0451	-0.0006	1.4858	2322.77	0.4511	-0.1814	-0.0042	0.0002	0.5155	1526.00	0.4252	5692.80	6.29	11416
plastic products	(0.0088)*	(0.0030)*	(0.0001)*	(0.0256)*			(0.0050)*	(0.0014)*	(0.00003)*	(0.0139)*			(0.0000)	(0.0121)	
Other non-	-0.7070	0.0335	-0.0003	1.5347	2667.30	0.4234	-0.2052	-0.0005	0.0001	0.5417	2206.76	0.4140	6001.21	0.41	15338
metallic prod.	(0.0080)*	(0.0026)*	(0.0001)*	(0.0241)*			(0.0047)*	(0.0011)	(0.00002)*	(0.0123)*			(0.0000)	(0.5199)	
Metal	-0.7486	0.0405	-0.0004	1.4596	8895.93	0.4377	-0.2026	0.0003	0.0001	0.5049	6711.87	0.4252	20625.46	32.47	48466
products	(0.0047)*	(0.0015)*	(0.00004)*	(0.0119)*			(0.0026)*	(0.0006)	(0.00001)*	(0.0063)*			(0.0000)	(0.0000)	
Machinery and	-0.6865	0.0294	-0.0002	1.4651	2678.00	0.4227	-0.1799	-0.0017	0.0002	0.4907	1935.87	0.4121	6334.98	1.10	14913
equipment	(0.0079)*	(0.0025)*	(0.0001)**	(0.0221)*			(0.0045)*	(0.0011)*	(0.00002)*	(0.0114)*			(0.0000)	(0.2953)	
Electrical and optical	-0.6504	0.0390	-0.0004	1.3716	1552.63	0.3966	-0.1715	0.0018	0.0001	0.4432	1173.70	0.3880	3561.87	0.44	9805
apparatus	(0.0097)*	(0.0032)*	(0.0001)*	(0.0279)*			(0.0054)*	(0.0015)	(0.00003)*	(0.0144)*			(0.0000)	(0.5055)	
Transport	-0.6350	0.0187	-0.0001	1.8798	961.25	0.4109	-0.1091	-0.0085	0.0001	0.4701	496.88	0.3732	2464.20	0.10	5666
equipment	(0.0123)*	(0.0038)*	(0.0001)***	(0.0415)*			(0.0058)*	(0.0016)*	(0.00002)*	(0.0196)*			(0.0000)	(0.7570)	
Furniture	-0.7573	0.0286	-0.00044	1.5507	2924.47	0.4349	-0.1962	0.0018	0.00005	0.4532	2260.51	0.4322	6632.36	3.48	17131
	(0.0083)*	(0.0030)*	(0.0001)*	(0.0219)*			(0.0044)*	(0.0012)	(0.00002)**	(0.0103)*			(0.0000)	(0.0622)	

Standard deviation in brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

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Table 3.12. Determinants of firm growth and the learning process (GLS Random and Fixed Effects Model) for the service sector.

	Fixed Effects						Random Effects						TESTS		
	S_{t-1}	Age	Age2	Coeffic.	F	R^2	St-1	Age	Age2	Coeffic.	Chi2	R^2	Hausman test	B. and P. test	Obs.
Motor	-1.4434	-0.0096	-0.0005	2.8918	7826.10	0.6424	-0.1215	0.0018	0.00004	0.2153	2067.49	0.6361	21521.40	1375.73	31885
vehicles	(0.0095)*	(0.0061)	(0.0002)**	(0.0418)*			(0.0028)*	(0.0008)**	(0.00002)**	(0.0066)*			(0.0000)	(0.0000)	
Wholesale	-0.7361	0.0404	-0.0005	0.9673	2265.56	0.4096	-0.1577	0.0003	0.00004	0.3079	1300.92	0.3973	5651.67	5.59	13757
trade	(0.0090)*	(0.0030)*	(0.0001)*	(0.0197)*			(0.0047)*	(0.0012)	(0.00002)***	(0.0098)*			(0.0000)	(0.0180)	
Hotels and	-0.7796	0.0177	-0.0002	1.6729	6435.25	0.4211	-0.1593	0.0020	0.00005	0.3616	4023.55	0.4205	15374.72	45.52	44253
restaurants	(0.0057)*	(0.0023)*	(0.0001)**	(0.0172)*			(0.0026)*	(0.0008)*	(0.00002)*	(0.0067)*			(0.0000)	(0.0000)	
Transport	-0.7138	0.0431	-0.0006	1.1226	8256.22	0.3961	-0.1342	-0.0033	0.0001	0.3376	4608.17	0.3720	20686.82	43.20	56411
	(0.0046)*	(0.0016)*	(0.00004)*	(0.0120)*			(0.0022)*	(0.0005)*	(0.00001)*	(0.0051)*			(0.0000)	(0.0000)	
Telecomm.	-0.7043	0.0604	-0.0006	1.3741	692.62	0.4343	-0.1830	0.0159	0.0004	0.5798	577.87	0.3905	1527.69	1.25	4378
	(0.0162)*	(0.0093)*	(0.00040)*	(0.0399)*			(0.0085)*	(0.0038)*	(0.0001)*	(0.0245)*			(0.0000)	(0.2627)	
Finances	-0.7455	0.0524	-0.0010	0.8471	819.04	0.4075	-0.0730	-0.0024	0.00003	0.1775	213.43	0.3820	2280.89	16.30	6235
	(0.0151)*	(0.0065)*	(0.0002)*	(0.0411)*			(0.0054)*	(0.0017)*	(0.00003)*	(0.0138)*			(0.0000)	(0.0001)	
Renting	-0.6460	0.0552	-0.0008	0.8333	1031.62	0.3801	-0.1495	-0.0071	0.0002	0.3734	724.66	0.3474	2450.19	0.14	7855
	(0.0119)*	(0.0054)*	(0.0002)*	(0.0302)*			(0.0061)*	(0.0021)*	(0.00005)*	(0.0148)*			(0.0000)	(0.7105)	
Computer	-0.6661	0.0501	-0.0003	1.0665	1797.24	0.3943	-0.1612	-0.0110	0.0003	0.4493	1357.38	0.3599	4161.74	0.56	13317
activities	(0.0095)*	(0.0053)*	(0.0002)*	(0.0220)*			(0.0050)*	(0.0020)*	(0.00005)*	(0.0120)*			(0.0000)	(0.4535)	
R&D	-0.8344	0.1065	-0.0013	1.2098	209.06	0.4977	-0.1122	-0.0069	0.0002	0.3972	68.89	0.4063	583.09	583.09	976
	(0.0336)*	(0.0160)*	(0.0006)**	(0.0883)*			(0.0151)*	(0.0064)	(0.0001)	(0.0454)			(0.0000)	(0.0151)	

Standard deviation in brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

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- With regard to size (S_{t-1}):
    - Small firms in the *Food and Beverages* industry grow more quickly than those in other industries (coefficient = –1.0183).
    - The *Machinery and Equipment,* E*lectrical and Optical Apparatus, Transport Equipment* industries have the lowest coefficient and, therefore, the slowest speed of convergence.
- With regard to age (*Age*), all coefficients are positive and:
    - The *Food and Beverage* industry has the highest coefficient, which means that firms surviving in this sector will be able to learn and expand.
    - The *Textile and Leather Clothes* industry has the lowest coefficient, which means that experience in the market will not have a big impact on growth.

Table 3.12 shows the results for the service sector. From this table, we can see that:

- With regard to size (S_{t-1}):
    - In the *Motor Vehicles* industry, small firms grow more quickly than large firms (coefficient = –1.4434).
    - The *Renting* industry has the smallest coefficient of all the service sectors, which means that firms in this sector will converge more slowly.
- With regard to age (*Age*):
    - Industries closely related to *R&D* have the largest positive and significant coefficient (coefficient = 0.1065). Experience in the market will therefore be important in order to grow in the future. This result is in agreement with those of Audretsch and Lehman (2005), who found that R&D-intensive firms have the highest growth rates.

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- The *Hotels and restaurants* industry has a positive coefficient but the effect is less intense (coefficient is equal to 0.0177), which means that in this sector age does not help a firm to increase in size.
- The results are largely positive for this variable, though the *Motor Vehicles* industry has a negative but not significant coefficient.

In summary, although there are differences between the sectors, these differences do not show any conclusive pattern regarding the main characteristics of firms. For example, large firms do not seem to be the fastest growing.

3.7. SUMMARY AND CONCLUDING REMARKS

Though Gibrat's Law has been widely studied, it maintains its attraction for empirical researchers thanks to its powerful implications for the economy. From economic growth to job market creation, firm growth analysis is a powerful tool for modifying policies. Even so, the processes involved in firm growth are still a mystery.

We have focused on the inter-relationships between firm growth, firm size and firm age. Our results confirm several stylised results from the literature. One of these is the negative relationship between firm growth and size.

We have also attempted to solve other puzzles regarding differences between sectors. For example, firm growth presents a heterogeneous pattern depending on the manufactures or service industries. Briefly, the main results from this chapter are:

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- Although there is much literature on Gibrat's Law, many aspects are still largely unknown.
- Some of these aspects concern the differences between the manufacturing and the service industries. Much of the literature has reported heterogeneity between these two types of industry but few empirical comparisons have been made.
- A negative relationship between firm growth and firm size has been studied in the literature.
- *Age* has a significant and positive effect on the learning process. We can therefore accept Ericson and Pakes' (1995) active learning process.
- There are differences between the manufacturing and the service sectors but these differences depend on the industries. Industries that are more affected by high sunk costs will have a negative effect on the environment.

Our results in this chapter show that there is no explosion of the market, since small firms tend to grow more than large firms. This means that small firms have a greater impact on job creation and are crucial to economic growth.

The aim of this chapter is not only to analyse the relationship between firm growth and size, but also to further our knowledge of two industries: the manufacturing sectors and the service sectors.

Finally, firm growth requires further research and our analysis is but a step forward in this interesting economic field. In the next chapter, therefore, we will analyse firm growth from a dynamic perspective.

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CHAPTER 4

THE PERSISTENCE OF FIRM GROWTH

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CHAPTER 4

THE PERSISTENCE OF FIRM GROWTH

"*Success breeds success and failure breeds failure*".

Ginsberg and Baum (1994)

4.1. INTRODUCTION

Our experience shows that every day firms with different trajectories coexist in the market. While some firms seem to have been born under a lucky star, others are doomed to failure from their first day. This diversity of trajectories increase competition and makes the market efficient.

Economic literature has analysed the relationship between firm size and firm growth in depth. However, as the analyses of firm growth and size have had a static perspective, dynamic questions may remain unanswered. For example, are firms that grew in the past still growing? Or is there no pattern that relates past growth to future growth? Do different patterns appear when we analyse different industries? The starting point for analysing persistence is Chesher's (1979) model, which is based on Gibrat's (1931) Law. The main aim of this chapter is to analyse the persistence of firm growth by assuming that there is a relationship between past and future growth patterns.

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The focus on the persistence of firm growth is due to the impact on the labour market. Not only is it crucial to know whether small firms create more employment. It is also important to determine whether firms that grew in the past are more likely to grow in the future.

Obviously, the analysis of persistence is extremely important for policy makers. Wagner (1992) states that knowing the existence of persistence on firm growth is necessary for applying correct policies. For example, in times of recession unemployment increases. To maintain macroeconomic stability as much as possible, governments will propose expansive policies, such as subsidies to firms. However, it is important to know which firms will grow faster and help to end the recession.

Managers are also interested in the characteristics of firms in order to increase their growth rates. A firm's resources are limited, so when a firm decides to invest it usually has several alternatives. If, for example, a firm has two projects in two alternative plants, the firm's managers need to consider the persistence of firm growth in order to make full use of internal economies.

It is therefore crucial to analyse which factors determine a higher propensity to grow in order to ascertain whether past growth rates or age affect persistence. The main aim is for policy makers and managers to have some idea about whether it is worth investing in the firm.

Several Spanish contributions have anlaysed this field (Suárez, 1977; Pisón, 1983; Correa, 1999). All these studies have limited their scope to one Spanish region or to a small sample. Suárez (1977), for example, analysed a sample of 46 surviving Spanish firms between 1962 and 1972. Pisón (1983) analysed the presence of a serial correlation between past and future growth rates of 18 surviving firms in Galicia. There have been

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other studies of Spanish firm growth (Fariñas and Moreno, 2000; Peña, 2004; Calvo, 2006) but these have not analysed the relationship between past and future growth. Our aim, therefore, is to fill this gap in the recent literature.

This chapter has three main objectives. First we analyse a larger sample of firms located in Spain and identify their characteristics in the medium term. The *Sistema de Análisis de Balances Ibéricos* presents individual information about Spanish firms. It contains a large number of variables and covers the whole country.

In the last ten years much effort has been made in both the private and public sectors to provide better data bases. Our data base therefore includes both the manufacturing and service sectors. As few contributions in the international empirical literature have analysed the service sector (Audretsch et al., 2004), our second objective is to include this sector in our analysis.

Finally, a firm's recent evolution can condition its future trajectory. In other words, although we are interested in analysing the relationship between past growth and future growth, we may also be interested in the differences between firms that grew continuously in the past and those that behaved differently. In our third objective, therefore, we analyse the impact of different trajectories on persistence.

Our first result is that the relationship between past and future growth rates is positive, which is in agreement with recent studies by Oliveira and Fortunato (2005). Second, there appear to be clear differences between the manufacturing and the service sectors. Third, a firm's history is important for ascertaining its future; in other words, firms that were successful in the past will experience higher growth rates.

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This chapter is organised as follows. In section 4.2 we summarize the empirical literature on the persistence of firm growth. In section 4.3 we describe Chesher's theoretical model. In section 4.4 we present the data base and data description. In section 4.5 we describe how we estimated the persistence of firm growth and show our results for the Spanish manufacturing industry. Finally, in section 4.6 we report our main conclusions.

4.2. EMPIRICAL EVIDENCE

Gibrat's Law has been widely studied. One limitation of most studies is that they only consider the relation between firm growth and the initial firm size, thus ignoring any effect past growth might have on future growth (Oliveira and Fortunato, 2005).

The first empirical analysis of firm growth persistence was studied by Singh and Whittington (1975). These authors reported that the degree of persistence is likely to be greater over shorter periods of time and may disappear after more than 6 years. Chesher (1979) developed the analytical expression of persistence of firm growth. The persistence of firm growth is related to the temporal interrelationship between firm growth rates.

Why, though, does persistence occur? Ijiri and Simon (1977) pointed out that "*in studying business firm growth, we often encounter cases where a firm suddenly acquires an impetus for growth. Perhaps by innovating in production or marketing processes, or perhaps as an effect of new management staffs or techniques, the firm grows much more rapidly*

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than the other firms in the industry"[1]. Moreover, the evolutionary approach suggests that the growth of successful firms should persist over time, so there should be a positive serial correlation of growth between consecutive periods. Finally, older firms should have a faster average growth than younger companies (Hart, 2000).

Formally, Gibrat's Law can be derived from Chesher's model. The basic difference between these models is the static-dynamic dimension. In Gibrat's model, firm growth rate depends on a static variable such as size, while in Cheshers' model it depends on past rates. Chesher's model, therefore, emphasises the dynamic perspective in order to explain the firm growth process.

The empirical literature on the persistence of firm growth covers a wide range of regions, industries and periods (see Annex III for a review of the literature). It is therefore difficult to compare our results with those of other studies. In this section we will present our main results and make a special reference to other Spanish contributions.

The international literature contains conflicting results. Some empirical evidence e.g. the studies by Singh and Whittington (1975), Kumar (1985), Contini and Revelli (1989) and Wagner (1992, 1994), has confirmed the presence of growth persistence i.e. firms that grew in the past will also grow in the future.

Other authors, however, e.g. Dunne and Hughes (1994), Almus and Nerlinger (2000) and Vennet (2001), observed a non-significant

[1] Ijiri and Simon (1977) stated that a firm that grows more than the average "is likely to grow more rapidly than the average again this year as a result of the carry-over effects of an innovation that occurred in a previous year on operations in subsequent periods".

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relationship between growths in different periods, which means that firm growths are not serially correlated.

Authors who have analysed growth persistence have usually introduced several explanatory variables. Wagner (1994)[2], for example, showed that macroeconomic conditions during entry do not influence future evolution and that industrial characteristics are not terribly important. The results of that study do not show any evidence of growth persistence.

Vennet (2001) introduced variables such as macroeconomic growth, bank operational efficiency, the quality of credit and capitalization, and observed that between 1985 and 1989 there was a convergence of the bank size, but that between 1990 and 1994 there was a proportional growth of all banks.

The main contribution of growth persistence models is the introduction of dynamic firm evolution. In other words, if we want to know how a firm will grow in the future, we must observe both its current growth and its past growth.

One of the main problems in the literature is the fact that there are no studies of differences between industries. In fact, the service sector has largely been ignored, because of either lack of data or lack of interest. Recent authors such as Piergiovanni et al. (2002), Audretsch et al. (2004) and Oliveira and Fortunato (2005) have tried to fill this gap in the literature. Specifically, Piergiovanni et al. (2002) also analysed the persistence of firm growth. Their main contribution is an analysis of Italian services and a comparison of manufacturing and service sectors.

[2] This author remembers the *Brown-Hamilton-Medoff Warning*: "*Do not judge firms by their size alone*!".

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Audretsch et al. (2004) analysed Dutch service industries[3] using two approaches: Gibrat's Law (from a static perspective) and the persistence of firm growth (from a dynamic perspective). Their results show that there is heterogeneity of results between service subsectors and, more importantly, that "*industry dynamics in small scale services might not simply mirror that in manufacturing, with Gibrat's Law more likely to be confirmed in the former than in the latter*". The reason for this statement is that "*the structure of these services may be inherently different from manufacturing*". In this sense, "*new entrants are typically under pressure to grow to avoid being confronted by a greater likelihood of failure in manufacturing, but the absence of growth in the services does not apparently threaten the viability of the firm*".

More recently, Oliveira and Fortunato (2005) analysed the persistence of firm growth among Portuguese service and manufacturing industries. Their results show that the effect of innovation on firm growth is positive, the effect of past size on firm growth is negative and the effect of past growth rates is positive. This means that successful firms will exhibit higher growth rates in the future than those firms which did not exhibit positive growth rates.

Several contributions have provided Spanish evidence with regard to the growth of manufacturing firms (Peña, 2004; Fariñas and Moreno, 2000; Correa, 1999; and Pisón, 1983). As far as I am aware, there is only one study of persistence (Suárez Suárez, 1976). Also, there is a lack of studies related to the service industries[4].

[3] Audretsch et al. (2004) analysed small scale services such as restaurants, cafeterias, cafes, hotels and camp sites.
[4] There are some exceptions such as Villacorta and Ballina (2002) who analysed the Spanish hotel firm growth but not persistence.

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4.3. CHESHER'S MODEL

The persistence of firm growth has been widely analysed in the empirical literature. However, there is a lack of knowledge in the Spanish framework, especially with regard to the service industries.

In this section we present Chesher's (1979) formulation and its relationship with Gibrat's Law. We also present the hypothesis used to estimate Gibrat's Law and the persistence of firm growth.

Gibrat's Law shows that the relationship between firm size and firm growth is lognormal. It postulates that the proportionate growth of surviving firms is random and hence independent of previous success or failure. However, it seems reasonable that a firm's past evolution exerts some kind of impact on its future evolution.

To deal with this issue, the literature has evolved from the initial Law of Proportionate Effects, or Gibrat's Law, and focused on the persistence of firm growth. The main idea thus addressed is that future firm growth may be influenced more by past growth rates than by past firm size. This approach highlights past behaviour as another factor in addition to initial firm size.

Singh and Whittington (1975) began their analysis of growth persistence by introducing past growth into the initial Gibrat's Law. Their results showed that firm size had less impact than past growth. However, the analytical description of growth persistence was developed by Chesher's seminal work in 1979. Chesher suggested that Gibrat's Law may not be accomplished if there is a serial correlation between error terms and introduced another equation in which the error term was serially correlated. The following equations determine this relationship:

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$$y_{i,t} = \beta \quad y_{i,t-1} + u_{i,t}$$
$$u_{i,t} = \gamma \quad u_{i,t-1} + \eta_{i,t} \qquad (4.1)$$

where y_i is the size of firm "*i*", β is the impact of firm size "*i*" in the period "*t-1*" and is the parameter to be estimated, $\eta_{i,t}$ is a white noise, γ has a value of between 0 and 1 and belongs to the transmission of luck or success from "*t-1*" to the following period, and $u_{i,t-1}$ is an error term. When γ is closer to 1, the reiteration of past situations is more important. If we substitute the last two equations until the initial period, we obtain the following equation:

$$y_{i,t} = \beta^t y_{i,0} + \gamma \sum_{\tau=1}^{t} \beta^{t-\tau} u_{i,\tau-1} + \sum_{\tau=1}^{t} \beta^{t-\tau} \eta_{i,\tau} \qquad (4.2)$$

Equation 4.2 is still lognormal because *u* and η are normal. Therefore, for any β, the higher γ is, the faster size inequalities will increase. However, when β is less than 1 no result is predominant to any γ so we cannot know in advance the effect on size inequalities. Consequently, Gibrat's Law is valid if the estimation of equation 4.2 has a value of 1 for $\hat{\beta}$. This means that the growth of firms is not determined by size. If $\hat{\beta}$ is smaller (larger) than 1, then small (large) firms have a higher growth potential, which indicates a correlation between growth and size. However, β will be consistently estimated if the error terms $u_{i,t}$ are distributed independently over time (Chesher, 1979).

Chesher's main conclusion is that a serial correlation between error terms in the equation produces a dependence between the past size ($y_{i,t-1}$) and the error terms ($u_{i,t}$). The main consequence is that if the disturbances ($u_{i,t}$) are serially correlated, the firm growth rate in one

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period depends on the growth rate in the preceding period. Consequently, Gibrat's Law may be rejected even when the parameter β is around 1. Since Chesher's (1979) contribution, growth persistence has been studied in greater depth.

Growth persistence in one period with respect to another may produce serial correlation. Moreover, this serial correlation produces inconsistent estimators with ordinary least squares. The previous results, for example, would be biased downward, so small firms would grow at a higher rate (Dunne and Hughes, 1994).

In general, the Chesher's model determines the relationship between a firm's current growth and its past growth. If we insert equations 4.1 and express firm size in logarithms, we obtain the following expression:

$$z_{i,t} = \beta \quad z_{i,t-1} + u_{i,t}$$
$$u_{i,t} = \gamma \quad u_{i,t-1} + \eta_{i,t}$$

where $z_{i,t}$ is the logarithm of firm growth belonging to firm "*i*" between "*t*" and "*t-1*", and $z_{i,t-1}$ and $z_{i,t-2}$ would be equivalent to the two previous periods ("*t-1*" and "*t-2*", and "*t-2*" and "*t-3*").

$$z_{i,t} = \beta \quad z_{i,t-1} + \quad \gamma \quad u_{i,t-1} + \eta_{i,t} \qquad (4.3)$$

If:

$$z_{i,t} = \beta \quad z_{i,t-1} + u_{i,t}$$

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by isolating the error term $u_{i,t}$:

$$u_i(t) = z_i(t) - \beta \; z_i(t-1) \tag{4.4}$$

and substituting 4.4 in 4.3 we obtain:

$$z_{i,t} = \beta \; z_{i,t-1} + \gamma \left(z_{i,t-1} - \beta \; z_{i,t-2} \right) + \eta_{i,t}$$

Finally;

$$z_{i,t} = \gamma_1 z_{i,t-1} + \gamma_2 z_{i,t-2} + \eta_{i,t} \tag{4.5}$$

where,

$$\begin{aligned} \gamma_1 &= \beta + \gamma \\ \gamma_2 &= -\beta * \gamma \end{aligned} \tag{4.6}$$

The resulting quadratic equation from 4.6 has the following solutions (Almus and Nerlinger, 2000):

$$\left(\hat{\beta}, \hat{\rho}\right) = \frac{1}{2} \left\{ \hat{\gamma}_1 \pm \left(\hat{\gamma}_1^2 + 4\hat{\gamma}_2 \right)^{1/2} \right\}$$

Using the estimated parameters, the validity of Gibrat's Law can then be tested with the data. We found a relationship between Chesher's equation and Gibrat's Law in the coefficients $z_{i,t-1}$ and $z_{i,t-2}$ of equation 4.5. Specifically, Gibrat's Law postulates that β has a value of 1 and γ has a value of 0. This means:

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$\hat{\beta}=1,\ i.e.\ \ firm\ \ growth\ \ is\ \ independent\ \ of\ \ size\ \ and\ \ if$

$\hat{\rho}=0,\ ie.\ the\ \ error\ \ terms\ \ do\ \ not\ \ follow\ \ a\ \ first-order\ \ autoregressive\ \ process$

Consequently, the null hypothesis when testing the presence of Gibrat's Law is as follows:

$$H_0:\begin{pmatrix}\hat{\gamma}_1 & \hat{\gamma}_2\end{pmatrix}=\begin{pmatrix}1 & 0\end{pmatrix}$$
$$H_1:\begin{pmatrix}\hat{\gamma}_1 & \hat{\gamma}_2\end{pmatrix}\neq\begin{pmatrix}1 & 0\end{pmatrix}$$

The main objectives are to determine (i) whether firm growth persistence exists; (ii) if it does, whether it is positive or negative; and (iii) what the implications for Gibrat's Law are.

4.4. DATA DESCRIPTION

Having presented the theoretical model, in this section we will briefly present our database, describe the method we used to select our sample of Spanish firms between 1994 and 2002, and highlight the differences between the manufacturing and service industries.

4.4.1. The data base

The data source we used in this study is the SABI data base, which compiles information from the Mercantile Registry and provides individual information about Spanish firms in various sectors. Spanish companies with an annual turnover of over 6 million euros are obliged to present their annual accounts to the Mercantile Registry. Our date base

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therefore contains practically every Spanish firm. The data base provides annual observations from 1994 to 2002. Although this means that we will have biased data up towards, 95% of Spanish firms are represented in this database.

Data pre-treatment was as follows. First we incorporated all the firms in the manufacturing and service industries that were still active in 2003. We used data on the two-digit level industries. This database groups firms in accordance with the CNAE-93 (*National Classification of Economic Activities*) with two digits. The codes for manufacturing industries range from 15 to 36 and the codes for service industries range from 50 to 74. In some of these sectors the number of firms is negligible because of the high barriers to entry (e.g. sector 16 (tobacco) and sector 23 (petroleum)). We have therefore excluded them in order to avoid biased results. Also, to avoid long tables of different industries, we have classified the industries in accordance with the NACE-CLIO (R-25) classification[5].

Note that, to avoid bias caused by firms that failed during the studied period, our data base only includes surviving firms. We therefore include firms created before 1999[6], regardless of whether they were created before or after 1994 (our first year of observation). Our data are therefore organised in an unbalanced panel.

Some of the observations have been omitted, mainly because of lack of information on some of the chosen variables. For example, as a considerable number of firms in the database provide no information about the number of employees or the year they were set up, we were

[5] To observe the equivalences between the two classifications, see Annex I.
[6] Obviously we need at least four observations of a firm to estimate three growth rates over three years (we must estimate z_{it}, z_{it-1} and z_{it-2}).

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forced to leave them out of our analysis. Other observations have also been left out because of their extraordinary growth performance.

In short, the number of surviving firms observed between 1994 and 2002 is 42,280 (27,038 firms in the manufacturing sector and 15,242 firms in the service sector). As we analyse firm growth rates over two years, we will have eight observations for each firm.

4.4.2. Data description

In this subsection, we focus on the relationship between the different firm growth rates. Specifically, we will show the evolution of the number of employees in each firm during the period of analysis (1994-2002) and the growth rate between "t" and "t-1" (gworkers), the growth rate between "t-1" and "t-2" (L1gworkers) and "t-2" and "t-3" (L2gworkers). Obviously, this process of creating panel data with different lags will lose some of the firms we had previously selected. That means that while our original database included firms with at least two observations, we now need information from at least four periods of time.

Variable	Description
Workers	Number of employees
Growth	Difference in the logarithmic number of employees between two consecutive periods
Growth t-1	Lagged value of the difference in the logarithmic number of employees between two consecutive periods.
Growth t-2	Two lagged periods of the value of the difference in the logarithmic number of employees between two consecutive periods.

Table 4.1 shows the averages and standard deviations for the whole database, the manufacturing sector and the services sector. The mean

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average number of employees for the whole database is 27. The difference between manufacturing and services is just five employees (the average number of employees in the manufacturing and service industries is 30 and 25, respectively).

Table 4.1. Average and standard deviation

		Whole database	Manufacturing	Services
Workers	*Mean*	27.26	29.86	25.34
	Std. Dev.	305.42	219.36	390.00
Growth	*Mean*	0.0616	0.0604	0.0628
	Std. Dev.	0.4498	0.4501	0.4536
Growth t-1	*Mean*	0.0755	0.0703	0.0838
	Std. Dev.	0.4457	0.4499	0.4440
Growth t-2	*Mean*	0.0851	0.0780	0.100
	Std. Dev.	0.4522	0.4600	0.4427

Source: author's own from SABI database.

The main difference, however, is in the standard deviation. Obviously, the heterogeneity of service industries is higher than that of manufacturing indistries. For example, though it is difficult to find a manufacturing firm with just one employee, microfirms are common in the service industries. Conversely, some service industries are characterised by the presence of monopolies or oligopolies, with huge firms sharing the market. Examples of such industries are the financial market and former public monopolies such as the phone service and the energy industry. This heterogeneity is reflected in the higher standard deviation for the service industry.

We observed that the average firm growth rates have been decreasing in the last few years. This means that, in general, firms grew in the past more than they have done in recent years. This pattern is more clearly observed in service industries, where the difference between the averages

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is larger than in manufacturing. The literature has highlighted the differences in sunk costs. This greater variability in the evolution of service firms may be a reflection of a firm's ability to make and un-make an investment.

Table 4.2. Correlation between different growth rates.

	Whole database		
	Growth	*Growth t-1*	*Growth t-2*
Growth	1.0000		
Growth t-1	-0.2458	1.0000	
Growth t-2	-0.0064	-0.2217	1.0000
	Manufacturing		
	Growth	*Growth t-1*	*Growth t-2*
Growth	1.0000		
Growth t-1	-0.2883	1.0000	
Growth t-2	-0.0062	-0.2707	1.0000
	Services		
	Growth	*Growth t-1*	*Growth t-2*
Growth	1.0000		
Growth t-1	-0.1718	1.0000	
Growth t-2	-0.0056	-0.1211	1.0000

Source: author's own from SABI database.

Table 4.2 shows the correlation between growth rates for three different periods. Firstly, we can see that there is a negative relationship between the growth rate of one period and the growth rate of the previous one. However, as it is close to 0, this relationship is not a strong one. Secondly, the relationship is weaker among service industries, so service industries do not present a clear structure of dependence between sectors.

4.5. Methodology and estimations

In this section we present the econometric methodology for estimating the persistence of firm growth. We then show the results obtained for

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Spanish firms between 1994 and 2002 and, finally, present several extensions to the initial model, such as the learning process, the consideration of individual industries and past firm behaviour.

4.5.1. Econometric methodology

The methods used to estimate the persistence of firm growth have evolved over time. Initially, authors such as González and Correa (1998), Dunne and Hughes (1994), Kumar (1985) and Singh and Whittington (1975) applied Ordinary Least Squares (OLS). However, in the presence of dynamic models, the pooled OLS estimator is inconsistent and biased upwards. Recent studies, such as Vennet (2001), have introduced panel data estimations with Generalised Least Squares estimations.

Recent advances in methods for testing panel data have created opportunities for incorporating short panel data into empirical tests of the Law of Proportional Effects. Specifically, to estimate these dynamic regression models using panels containing a large number of firms and a low number of time periods, we used a Generalised Method of Moments (GMM)[7] estimator developed by Arellano and Bover (1990, 1991). GMM is based on analysing the distribution of the diverse moments that characterise a variable. Thus, taking advantage of the characteristics of the moments of a variable, GMM estimates the first moment characteristics of the moment.

[7] Arellano and Bond (1991) derived a Generalized Method of Moments estimator using lagged levels of the dependent variables, the predetermined variables and differences in the strictly exogenous variables. Our estimator is known as the ″Arellano–Bond″ dynamic panel data estimator. This method assumes that there is no autocorrelation in the temporal random errors.

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This estimator controls for the presence of unobserved firm-specific effects and for the endogeneity of the current-dated explanatory variables. GMM has made it possible to analyse short panel data, which are characteristic of microeconomics panel. Del Monte and Papagni (2003) and Oliveira and Fortunato (2005), for example, used GMM to estimate the persistence of firm growth.

The following equation is our starting point since it considers the relationship between the past and initial firm growth rates using the GMM estimator:

$$z_{i,t} = \gamma_1 z_{i,t-1} + \gamma_2 z_{i,t-2} + \beta_i X + \eta_{i,t} \qquad (4.7)$$

where $z_{i,t}$ represents the firm growth of firm "i" between period "t" and period "t-1", measured as the difference in the logarithmic number of employees, $z_{i,t-1}$ and $z_{i,t-2}$ would be identically defined, γ_1 and γ_2 are the parameters we are interested in estimating by measuring the impact of past firm growth ($z_{i,t-1}$ and $z_{i,t-2}$), X is a vector of exogenous variables, β_i *are* the parameters that indicate the impact of those exogenous variables on firm growth and $\eta_{i,t}$ is a disturbance that measures the impact of past firm growth on future performance. Also,

$$\gamma_1 = \beta + \gamma$$
$$\gamma_2 = -\beta * \gamma$$

where β is the impact of the firm size "*i*" from period "*t-1*" to the period "*t*" and γ is the parameter that determines the transmission of luck or success between one period and the previous one.

This study analyses the persistence of firm growth based on Oliveira and Fortunato (2005). The hypotheses to examine relate to the relationship between past growth rates and current growth rates, individual sectors

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and age. Our data base provides individual information at the business level for 179,318 observations from 59,459 Spanish firms belonging to the manufacturing and service industries.

4.5.2. Estimation of Chesher's equation

The persistence of firm growth refers to the relationship between intertemporal firm growths. Most empirical evidence shows that there is no persistence of growth (Acs and Audretsch, 1990; Dunne and Hughes, 1994). Chesher (1979), Kumar (1985); Wagner (1992) and Tschoegl (1996) also found no positive relation. Oliveira and Fortunato (2005) observed a positive growth persistence, while a smaller number of researchers have found evidence of a negative growth persistence (Contini and Revelli, 1989; Almus and Nerlinger, 2000; Goddard et al. 2002).

Positive growth persistence means that firms that grew in the past are more likely to grow in the future. This seems to be a sensible statement: firms that grew in the past usually continue to grow in the future since determinants that cause a higher growth do not usually disappear in the short term. The limit to this process of positive growth rates is the equilibrium firm size. Conversely, firms with a negative behaviour in the past often tend to decrease in size. These firms will decrease in size until they adjust or fail.

Consequently, our first estimation is:

$$z_{i,t} = \gamma_1 z_{i,t-1} + \gamma_2 z_{i,t-2} + \beta_1 \log(S_{i,t-1}) + \eta_{i,t} \qquad \text{(Estimation 4.1)}$$

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where $z_{i,t}$ represents the growth of firm "i" between period "t" and "t-1" measured as the difference in the logarithmic number of employees, $z_{i,t-1}$ and $z_{i,t-2}$ would be identically defined, γ_1 and γ_2 are the parameters we are interested in estimating by measuring the impact of past firm growth ($z_{i,t-1}$ and $z_{i,t-2}$), $log(S_{i,t-1})$ is the logarithmic firm size in the previous period, β1 is the parameter that measures the impact of the previous size on the current firm growth rate, and $\eta_{i,t}$ is a disturbance that measures the impact of past firm growth on future performance.

Table 4.3 presents the results of Estimation 4.1. We first estimated this equation for the whole pool of firms regardless of which sector each firm belongs to. We then estimated manufacturing firms separately from the service sectors and finally estimated the service sectors.

Table 4.3. The persistence of firm growth estimated with Generalized Method of Moments.

	Whole database	Manufacturing	Services
Growth t-1	0.0695 (0.0029)*	0.0851 (0.0033)*	0.0372 (0.0057)*
Growth t-2	0.0145 (0.0019)*	0.0232 (0.0021)*	-0.0034 (0.0040)
S_{t-1}	-1.2473 (0.0039)*	-1.2630 (0.0046)*	-1.2156 (0.0072)*
Coefficient	0.0357 (0.0006)*	0.0350 (0.0007)*	0.0372 (0.0013)*
Chi2	201041.30 (0.000)	150649.64 (0.000)	55264.57 (0.000)
Sargan Test	292.76 (0.000)	412.09 (0.000)	82.97 (0. 000)
Arellano-Bond test order 2	2.00 (0.0451)	1.45 (0.1470)	1.06 (0.2913)
Observations	119859	81147	38712
Firms	42280	27038	15242

Standard deviation in brackets. Sargan is a test of the overidentifying restrictions. Arellano-Bond test order 1 and test order 2 are tests for first-order and second–order serial correlation in the first differenced residual, asymptotically distributed as N(0, 1) under the nullity of no serial correlation. The p-value of Sargan's test for overidentifying restrictions and m2 test are reported in square brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

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With regard to past growth rates, there appears to be a positive relationship between past and current firm growth behaviour. In other words, firms that experienced a positive growth in the previous period will experience a positive impact on its current growth. However, this effect diminishes when we analyse firm growth from the two previous periods.

Persistence seems to have more effect among manufacturing industries than among service industries. For example, the value of previous growth (*Growth t-1*) is 0.0851 in manufacturing and 0.0372 in the service sector. There is therefore consistent evidence of positive serial correlation: in other words, firms with above average growth in one period will experience above average growth in the next. These results are consistent with those of Oliveira and Fortunato (2005) but they are not conclusive. Acs and Audretsch (1990) and Dunne and Hughes (1994) found no evidence of persistence. Some authors (e.g. Chesher, 1979; Kumar, 1985; Wagner, 1992; Tschoegl, 1996) found no evidence of positive persistence, while others (Contini and Revelli, 1989; Almus and Nerlinger, 2000; Goddard et al. 2002) found evidence of negative persistence.

As we showed in the previous chapter, Gibrat's Law is not satisfied since the coefficient of the lagged value of the logarithmic size is negative. Small firms therefore tend to grow more rapidly than large firms. Moreover, the values for the manufacturing and service industries are quite similar.

However, to ascertain whether Gibrat's Law is in operation, both β and ρ must be rejected. According to the Wald joint significance test, the null

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hypothesis regarding the nullity of coefficient is rejected at the 1% level of significance, so Gibrat's Law does not hold.

Finally, the Arellano-Bond test of second-order serial correlation of residuals shows the consistency of the GMM estimator. The null hypothesis in this test determines the presence of serial correlation among residuals. Our results show that this test rejects the null hypothesis, so there is an absence of serial correlation. However, when the whole database is analysed (manufacturing and service industries), the test accepts the null hypothesis. Separating the two industries leads to acceptance of the test, so the results obtained with separate industries are more consistent.

4.5.3. The learning process in the persistence of firm growth

According to the learning models, experience in the market is crucial to later performance since it provides information about a firm's efficiency. Estimation 4.2 therefore introduces variables related to the age of the firm. Here, age is the number of years between the year of creation and the current year.

$$z_{i,t}= \gamma_1 z_{i,t-1}+\gamma_2 z_{i,t-2}+\beta_1 \log(S_{i,t-1}) + \beta_2 \log\left(Age_{i,t-1}\right)+ \beta_3 \log(Age^2) + \eta_{i,t}$$

(Estimation 4.2)

where $z_{i,t}$ represents the growth of firm "i" between period "t" and period "t-1", measured as the difference in the logarithmic number of employees, $z_{i,t-1}$ and $z_{i,t-2}$ would be identically defined, γ_1 and γ_2 are the parameters we are interested in estimating by measuring the impact of past firm growth ($z_{i,t-1}$ and $z_{i,t-2}$), $log(S_{i,t-1})$ is the logarithmic firm size in the

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previous period, β_1 is the parameter that measures the impact of previous size on the current firm growth rate, $log(A_{i,t-1})$ and $log(A^2_{i,t-1})$ are the logarithm of firm age and its quadratic value, β_2 and β_3 are the parameters that measure the impact of experience on current firm growth and $\eta_{i,t}$ is a disturbance that measures the impact of past firm growth on future performance.

Table 4.4 shows the results of Estimation 4.2. First, there is a high increase in the impact of the previous growth (*Growth t-1*) of service industries (from 0.0372 to 0.0503). However, the value for *Growth t-2* is non-significant for the service industries.

Table 4.4. The persistence of firm growth and the learning process estimated with Generalized Method of Moments.

	Whole database	Manufacturing	Services
Growth t-1	0.0765 (0.0029)*	0.0894 (0.0034)*	0.0503 (0.0058)*
Growth t-2	0.0194 (0.0019)*	0.0265 (0.0022)*	0.0048 (0.0041)
S_{t-1}	-1.2553 (0.0040)*	-1.2674 (0.0046)*	-1.2320 (0.0073)*
Age	0.0534 (0.0010)*	-	0.0636 (0.0022)*
Age2	-0.0006 (0.00003)*	-0.0004 (0.00003)*	-0.0010 (0.0001)*
Coefficient	-	0.0486 (0.0012)*	-
Chi2	203659.06 (0.000)	150863.45 (0.000)	55997.69 (0.000)
Sargan Test	363.10 (0.0000)	497.86 (0.0000)	85.97 (0.0000)
Arellano-Bond test order 2	2.26 (0.0240)	1.57 (0.1173)	1.36 (0.1751)
Observations	119859	81147	38712
Firms	42280	27038	15242

Standard deviation in brackets. Sargan is a test of the overidentifying restrictions. Arellano-Bond test order 1 and test order 2 are tests for first-order and second–order serial correlation in the first differenced residual, asymptotically distributed as N(0, 1) under the nullity of no serial correlation. The p-value of Sargan's test for overidentifying restrictions and m2 test are reported in square brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

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Therefore, growth persistence dissolves over time. The first lagged growth rate has an impact on firm growth but the effect of growth rate is smaller when growth from two previous periods is analysed.

Moreover, this effect is the same for both types of industry. This means that the variables have similar coefficients, though the coefficients of the service industries are smaller (especially the effect of the growth rate from two previous periods).

The learning process appears to have a double effect. On the one hand, there is a learning process for young firms (there is a positive coefficient for the variable *Age*). On the other hand, there is also an unlearning process since the quadratic age has a negative impact on firm growth. In other words, older firms have a negative effect on the firm growth rate. However, the combined effect of the two variables is positive since the learning process is greater than the unlearning process.

4.5.4. The evolution of industries

The individual characteristics of an industry can create specific dynamics on firm growth. In this section we will analyse the evolution of growth persistence for individual sectors in the manufacturing and service sectors. The results of Estimation 4.1 for each sector are shown in Table 4.5 (for manufacturing) and in Table 4.6 (for services).

In the manufacturing sector, our results show that:

- *Rubber and plastic goods* (0.1411), *Textile and leather clothes* (0.1134) and *Furniture* (0.1013) have the higher positive impact. In other words, firms in these industries grow more than the average thanks to the transmission of luck from the first period.

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Table 4.5. The persistence of firm growth in manufacturing industries estimated with GMM.

	Coefficients				*Tests*			*Observations*	
	Growth t-1	*Growth t-2*	Size	constant	Wald test	Sargan test	Test order 2	Obs.	Firms
Food and beverages	0.0535 (0.0063)*	0.0193 (0.0036)*	-1.1321 (0.0095)*	0.0329 (0.0020)*	41705.63 (0.000)	269.20 (0.0000)	3.75 (0.0000)	9449	3426
Textile and leather clothes	0.1134 (0.0099)*	0.0501 (0.0067)*	-1.3178 (0.0130)*	0.0156 (0.0019)*	17965.67 (0.000)	45.40 (0.0148)	-0.06 (0.9511)	11704	3773
Wood and cork	0.0748 (0.0191)*	0.0201 (0.0131)	-1.2643 (0.0257)*	0.0164 (0.0036)*	4847.54 (0.000)	101.08 (0.0000)	-0.91 (0.3627)	3338	1248
Paper products and media	0.0487 (0.0106)*	-0.0064 (0.0076)	-1.2828 (0.0137)*	0.0294 (0.0017)*	16700.03 (0.000)	39.76 (0.0539)	-1.03 (0.3031)	10664	3402
Chemical manufactures	0.0389 (0.0165)**	0.0080 (0.0112)	-1.1984 (0.0206)*	0.0381 (0.0028)*	5679.82 (0.000)	46.35 (0.0117)	1.21 (0.2258)	3735	1111
Rubber and plastic goods	0.1411 (0.0155)*	0.0215 (0.0105)**	-1.4171 (0.0209)*	0.0524 (0.0029)*	8135.24 (0.000)	67.21 (0.0000)	-3.50 (0.0005)	4395	1390
Other non-metallic prod.	0.0536 (0.0130)*	-0.0114 (0.0095)	-1.2722 (0.0183)*	0.0438 (0.0024)*	8072.72 (0.000)	35.77 (0.1204)	1.02 (0.3091)	5225	1733
Metal products	0.0911 (0.0084)*	0.0136 (0.0059)**	-1.3553 (0.0114)*	0.0484 (0.0016)*	25643.31 (0.000)	125.84 (0.0000)	-0.05 (0.9578)	16419	5563
Machinery and equipment	0.0308 (0.0130)**	-0.0052 (0.0089)	-1.2336 (0.0174)*	0.0425 (0.0023)*	8982.45 (0.000)	69.55 (0.0000)	0.09 (0.9321)	5659	1781
Electric and optic devices	-0.0064 (0.0171)	-0.0188 (0.0117)	-1.1305 (0.0214)*	0.0421 (0.0032)*	5025.25 (0.000)	23.19 (0.6746)	-0.05 (0.9596)	3609	1155
Transport equipment	0.0315 (0.0207)	-0.0314 (0.0150)**	-1.1006 (0.0281)*	0.0224 (0.0038)*	2367.42 (0.000)	42.49 (0.0295)	-2.36 (0.0181)	2135	671
Furniture	0.1013 (0.0160)*	0.0286 (0.0107)*	-1.2832 (0.0212)*	0.0190 (0.0030)*	6661.63 (0.000)	78.71 (0.0000)	-3.63 (0.0003)	4815	1785

Standard deviation in brackets. Sargan is a test of the overidentifying restrictions. Arellano-Bond test order 1 and test order 2 are tests for first-order and second–order serial correlation in the first differenced residual, asymptotically distributed as N(0, 1) under the nullity of no serial correlation. The p-value of Sargan's test for overidentifying restrictions and m2 test are reported in square brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

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Table 4.6. The persistence of firm growth in (?) the service sector estimated with Generalized Method of Moments.

	Coefficients				*Tests*			*Observations*	
	Growth t-1	*Growth t-2*	Size	constant	Wald Chi2	Sargan test	Test order 2	Obs.	Firms
Wholesale trade	0.0475 (0.0159)*	0.0069 (0.0105)	-1.2221 (0.0211)*	0.0367 (0.0030)*	6152.28 (0.000)	23.97 (0.6318)	1.29 (0.1969)	4606	1665
Hotels and restaurants	0.1084 (0.0121)*	0.0299 (0.0083)*	-1.3252 (0.0157)*	0.0119 (0.0028)*	14701.43 (0.000)	76.41 (0.0000)	0.65 (0.5158)	9741	4059
Transport	0.0369 (0.0091)*	0.0008 (0.0064)	-1.2376 (0.0114)*	0.0397 (0.0019)*	23067.83 (0.000)	25.08 (0.5702)	-1.30 (0.1934)	16400	6278
Telecoms.	-0.0284 (0.0319)	-0.0300 (0.0229)	-1.0623 (0.0387)*	0.0790 (0.0099)*	1435.19 (0.000)	61.20 (0.0002)	0.48 (0.6287)	1028	433
Finances	-0.0079 (0.0317)	-0.0558 (0.0236)**	-1.0462 (0.0381)*	0.0283 (0.0071)*	1536.92 (0.000)	31.20 (0.2628)	1.60 (0.1104)	1286	585
Renting	0.0691 (0.0235)*	0.0241 (0.0174)	-1.2036 (0.0287)*	0.0691 (0.0063)*	3136.19 (0.000)	23.18 (0.6754)	2.47 (0.0134)	2037	798
Computer activities	-0.0232 (0.0183)	-0.0340 (0.0137)**	-1.0845 (0.0218)*	0.0605 (0.0054)*	4600.03 (0.000)	77.51 (0.0000)	-0.16 (0.8721)	3333	1318
R&D	0.1954 (0.0673)*	0.0873 (0.0459)***	-1.4278 (0.0819)*	0.14239 (0.0173)*	537.56 (0.000)	19.61 (0.8469)	-0.64 (0.5249)	281	106

Standard deviation in brackets. Sargan is a test of the overidentifying restrictions. Arellano-Bond test order 1 and test order 2 are tests for first-order and second–order serial correlation in the first differenced residual, asymptotically distributed as N(0, 1) under the nullity of no serial correlation. The p-value of Sargan's test for overidentifying restrictions and m2 test are reported in square brackets.
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- *Transport equipment* has a non-significant coefficient for the first lagged growth, but this is not significant. *Electrical and optical devices* has a negative impact but this is not significant.
- For the *Transport equipment* industry, there is a combined effect of one lagged growth (0.0315) and two lagged growth (-0.0314).

In the service sector, our results show that:

- The impact on current firm growth is highest in *R&D*, with a coefficient of 0.1954 for the one lagged growth and a coefficient of 0.0873 for the impact of the two lagged growth. Our results are in concordance with Raymond et al. (2006) who find that there exists a slight positive impact between past sales due to innovation and their future value. Also Cefis (2003) demonstrates that although in general manufacturing firms in UK do no show a strong persistence, those large innovating firms show certain persistence to innovate.
- *Transport* has the lowest values, which means that growth persistence across periods is low in this sector.
- *Finances* presents a negative estimated parameter but the significance level is low.

In summary, these results reveal heterogeneity between sectors. Since each sector shows different trends, each sector should be considered individually when the evolution of firm performance is analysed.

4.5.5. What about the influence of past behaviour?

At any point in time, the history of a firm has a significant effect on the configuration of its internal context through the organizational structure

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and procedures it has chosen in the past and through the experience that its members have acquired in the process (Canals, 2000). The history of a firm therefore has an impact on its future.

Only a few theories, however, have included the role of history in their models. Neoclassical theories, for example, introduced past decisions through the interaction between competitors in the market (Shapiro, 1989). The evolutionary theory (Nelson and Winter, 1982) is based on the routines[8]—the way things are done—that a firm is able to develop over time. The configuration of these routines is influenced by a large number of factors, particularly by how they interact with each other during the firm's evolution.

Clearly, growth may depend on a firm's past evolution. Investment in assets, employees or R&D are closely related to the firm's past evolution and, therefore, to its expectations in the market and the evolution of the industry. Here three factors are important:

- First, present strategic decisions determine a firm's path in the medium term. Managers' decisions, accumulated resources, available capabilities and the external context (interaction with customers, suppliers and competitors) will encourage the firm to take one path or another.
- Second, the path taken by firms with increasing returns[9] tends to consolidate the original decision. However, the fact that the path is reinforced is not unequivocally positive, i.e. a path that is favoured by increasing returns has positive effects for the company until the

[8] Nelson and Winter (1982) stated that the routines and procedures are determined by the organization's formal system (e.g. control mechanisms and compensation systems) and by its informal system (mainly culture).
[9] Increasing returns are an implicit mechanism in some industries by which a firm that is ahead gets further ahead.

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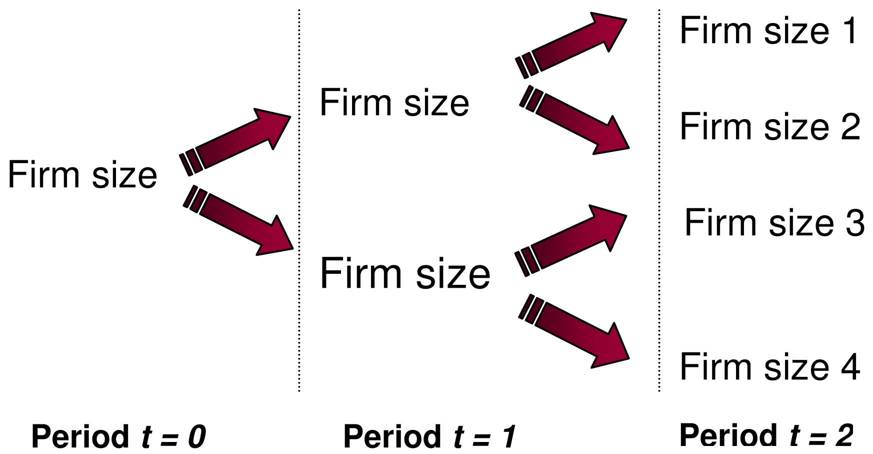
fateful moment is reached when a revolutionary innovation demands new ways of competing and makes the old ones obsolete.

- Third, learning developed by its staff and the knowledge accumulated by this means have a impact on firm growth. Knowledge refers to R&D and the routine or non-routine activities conducted by a firm over time to design which produce or sell its goods or services to its customers.

The picture may therefore be more accurate if we differentiate between different past patterns. As far as we know, no contribution has considered how a firm's past growth shapes its present and may constrain its future. In this section we respond directly to this question.

Let us suppose that the impact of past growth rates on future growth rates depends on their trajectory. For example, a firm that has grown in the last two periods is more likely to grow in the future. Similarly, a firm that is recovering from a decline (through investment or growth of its direct market) may influence its future firm growth.

Graph 4.1. The evolution of a firm depending on its past evolution



Source: own elaboration.

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Graph 4.1 shows four possible trajectories of a firm. In the initial period (*t=0*), the firm may grow positive or negatively. In the following period (*t=1*), the firm size may also grow positively or negatively. Finally, in the period *t=2*, firm size depends on 4 different trajectories:

- Firm size 1 represents the trajectory of a successful firm that has grown in two consecutive periods.
- Firm size 2 represents the trajectory of a firm that grew in the first period but declined in the second.
- Firm size 3 represents the trajectory of a firm that declined in the first period but grew in the second.
- Firm size 4 represents the negative trajectory of a firm in two consecutive periods.

These four alternative trajectories are incorporated in our initial equation through four dummies:

$$z_{i,t} = \gamma_1 z_{i,t-1} + \gamma_2 z_{i,t-2} + \beta_1 \log(S_{i,t-1}) + \beta_2 Dummy1 + \beta_3 Dummy2 + \beta_4 Dummy3 + \\ + \beta_5 Dummy4 + \eta_{i,t}$$

(Estimation 4.3)

where *Dummy1* represents a firm that grew in two consecutive periods, *Dummy2* represents a firm that decreased in two consecutive periods, *Dummy3* represents a firm that decreased in one period but grew in the next, and *Dummy4* represents a firm that grew in one period but decreased in the next.

Table 4.7 shows the results of Estimation 4.3. With regard to Gibrat's Law and the persistence relationship, the results are the same as for the

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previous estimations, though the coefficients of persistence are slightly lower.

Table 4.7. The persistence of firm growth and past history estimated with Generalized Method of Moments.

	Whole database	Manufacturing	Services
Growth t-1	0.0622 (0.0031)*	0.0784 (0.0035)*	0.0276 (0.0062)*
Growth t-2	0.0079 (0.0022)*	0.0172 (0.0024)*	-0.0120 (0.0046)*
S_{t-1}	-1.2504 (0.0039)*	-1.2661 (0.0031)*	-1.2185 (0.0072)*
Dummy 1	0.0245 (0.0028)*	0.0212 (0.0031)*	0.0321 (0.0057)*
Dummy 2	-0.0183 (0.0041)*	-0.0197 (0.0045)*	-0.0156 (0.0085)***
Dummy 3	0.0117 (0.0030)*	0.0099 (0.0033)*	0.0139 (0.0061)**
Dummy 4	0.0072 (0.0028)*	0.0060 (0.0032)***	0.0073 (0.0059)
Coefficient	0.0359 (0.0006)*	0.0352 (0.0007)*	0.0374 (0.0013)*
Wald Chi2	201409.42 (0.000)	150922.31 (0.000)	55369.25 (0.000)
Sargan Test	312.01 (0.000)	435.41 (0.000)	81.90 (0.000)
Arellano-Bond test order 2	2.09 (0.0367)	1.50 (0.1334)	1.11 (0.2666)
Observations	119859	81147	38712
firms	42280	27038	15242

Standard deviation in brackets. Sargan is a test of the overidentifying restrictions. Arellano-Bond test order 1 and test order 2 are tests for first-order and second–order serial correlation in the first differenced residual, asymptotically distributed as N(0, 1) under the nullity of no serial correlation. The p-value of Sargan's test for overidentifying restrictions and m2 test are reported in square brackets.
** significant at 1%, ** significant at 5% and *** significant at 10%.*

The dummies identifying past histories obtained a significant coefficient. Several conclusions can be drawn. First, *Dummy 1* obtained the highest coefficient (0.0245). Second, as expected, *Dummy 2* obtained a negative coefficient. Therefore, firms declining in two consecutive periods will be

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punished in the future, while firms growing in two consecutive periods will have higher growth rates in the future.

4.6. SUMMARY AND CONCLUDING REMARKS

In nature a variety of species coexist. Similarly, in the market both efficient and inefficient and large and small firms also coexist. Some firms therefore experience above average growth rates while others follow a continuously declining path.

In the previous chapter we analysed the relationship between firm growth and size following Gibrat's Law. This relationship offers a static perspective since it relates the evolution of a firm with reference to an initial position. In this chapter, on the other hand, we have widened our perspective by linking past changes in size to future growth rates.

One of our aims is to compare different industries and observe how the combination of interdependence and independence affects firm growth (Lotti et al., 1999).

Briefly, our main results are:

- There is evidence of positive persistence across temporal growth rates.
- As expected, there is a strong relationship between the growth rate in one period and the growth rate in the previous one.
- The manufacturing and service industries have similar patterns. However, there is heterogeneity of growth persistence between industries. This heterogeneity should therefore be taken into account in the future.

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- Firms with a brilliant history will have above average growth rates in the future. Firms declining in size are more likely to decline in future.

The contributions made in this chapter to the empirical literature are a differentiation between the manufacturing and service sectors with a large sample of Spanish firms and an analysis of persistence based on the past history of firms. This is the most recent study on the persistence of Spanish growth, a field that should not be ignored by the social agents.

It is important to determine the persistence of firm growth for two reasons. Firstly, policy-makers will have a useful tool for deciding which firms most deserve to receive a subsidy. For the sake of efficiency, public agents must know which firms are more likely to increase employment and contribute to economic growth. Secondly, it should help managers to identify businesses that are more likely to grow and thus increase the profitability of their investments.