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Mercedes Teruel Carrizosa
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CHAPTER 3

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

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CHAPTER 3

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

"*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,

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

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

Assuming that $\varepsilon_{i,t}$ is a random variable with average μ and variance σ^2, when $t \to \infty$ 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.

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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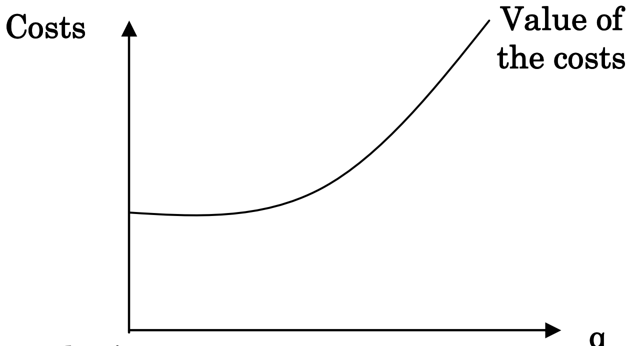
$c(q_{it})x_t$

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

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

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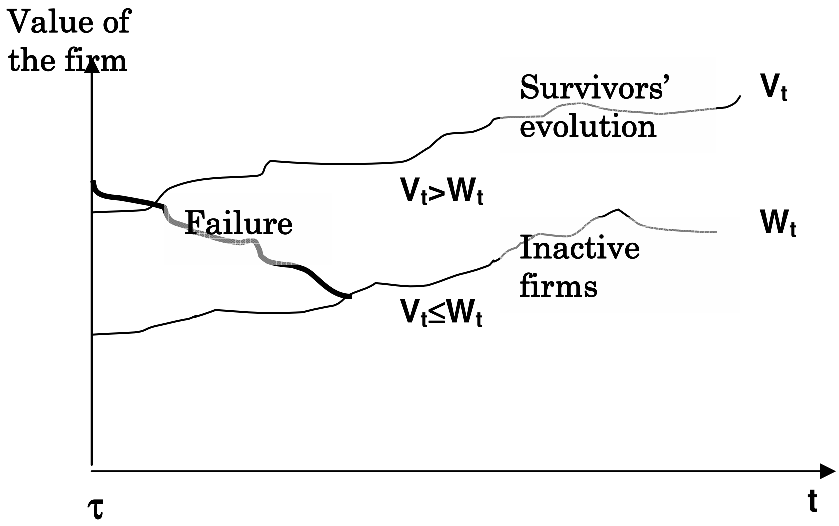
$$\frac{\delta c}{\delta \theta} > 0 \quad \frac{\delta q}{\delta \theta} < 0$$

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:

$$\bar{\theta} \;\Rightarrow\; \textit{Efficiency level}$$

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

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

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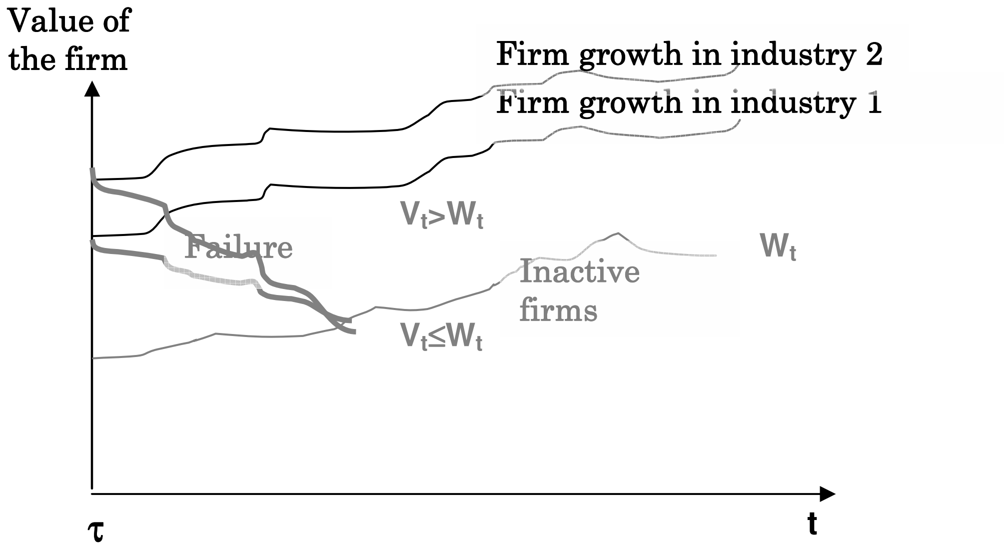
Graph 3.2 shows the evolution of the value of a firm regardless of its industry. Graph 3.3 shows the evolution of the firm depending on the industry it belongs to. A manufacturing firm with the same efficient level as a service firm may increase more or less depending on different industrial factors 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	$g\left(X\middle\vert\bar{\theta}_M\right)$	$g\left(X\middle\vert\bar{\theta}_M, Age_t\right)$
SERVICE INDUSTRIES	$g\left(X\middle\vert\bar{\theta}_S\right)$	$g\left(X\middle\vert\bar{\theta}_S, Age_t\right)$

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

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 (0.0022)*	-0.1851 (0.0012)*	-0.7250 (0.0028)*	-0.1261 (0.0012)*
Coefficient	1.8815 (0.0054)*	0.4781 (0.0030)*	1.5052 (0.0057)*	0.2987 (0.0026)*
F	115856.71 (0.0000)		66167.76 (0.0000)	
Chi2		24558.20 (0.0000)		12022.40 (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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Mercedes Teruel Carrizosa
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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.