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Ph.D. Dissertation

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Preface

When I finished the degree in business administration and I began to wonder what to do with my life, Prof. Agustí Segarra came to me and offered me a doctoral scholarship at the Economics Department of the Universitat Rovira i Virgili in Reus. I have always liked the academia, and the idea of becoming a professor was for me no passing fancy. This was in 2003, and was the beginning of one of the most exciting periods of my life, both personally and professionally. In the first year of my PhD dtudies I took lessons at the University of Barcelona, where prof. Enrique López-Bazo and prof. Rosina Moreno taught me the essential of econometrics and computational statistics. I remember as well the numerous train trips from Reus to Barcelona, during which I enjoyed the estimable company of my dear colleagues Rosa Vidal and Jordi Andreu.

During the second year I started to grow interest in the topics analysed in this thesis. Responsible for such interest were Josep Maria Arauzo and Elisabet Viladecans, whose lessons I had the privilege to attend and enjoy. They enlightened me with their knowledge and understanding, and they transmitted to me the passion for research. At the end, they kindly accepted to be the directors of this thesis, for which I will never be grateful enough. They have devoted a lot of time and effort to this project, and their advice and guide have been crucial to the thesis' success. During the second year I also enjoyed the fruitful pieces of advise from Christian Durán and Miquel Manjón, and to them I am also very grateful, since whenever I had a question or comment they were there for me.

In 2005 and 2006 I had the chance to be at Max Planck Institute of Economics in Jena (Germany), and it was due to Prof. David Audretsch's kind invitation. The atmosphere I enjoyed there was indescribable, and I could work in an intellectual and motivational environment. I thank my colleagues over there for those countless

shared moments and talks: Raquel Ortega, Andrea Conte, Christina Schneider, Jörg Zimmermann, Werner Bönte, Erik Monsen, André Van Stel, Torsten Weiland and the personnel at the institute. I also acknowledge the insightful comments by Marco Vivarelli, Michael Fritsch, Rui Baptista, Georgios Fotopoulos, Zoltan Acs and Simon Parker.

Back in Reus, I would like to mention my colleagues Mercedes Teruel, Daniel Miravet, Maite Fibla, Sebastián Cano, Jaume Abadia, Javier Gutiérrez, Laia Pié, Raquel Laguado, Mabel Ficosecco, Víctor Garro, Olga Slivko, Vero Gombau, Aleix Gregori, Xiaoni Li, Eleni Papaikonomu, Carmen Cincunegui, Belén Guercio, Tatiana Gorjub, Andrés Pazzi, Claudia Pezoa and Fabiola Baltar. PhD studies might be very demanding sometimes, and being together was very important for us. A special mention is to Marc Sáez from the University of Girona, who gave me key insights into bayesian statistics and kindly answered my questions. I would not like to forget Magda Lleixà, an efficient and friendly research assistant from the Economics Department, because her help with the edition of this thesis has been fundamental and worth being acknowledged. Moreover, I would like to express my deep and eternal gratitude to my parents and to my brother, they know why.

The thesis that you have in your hands is the result of five years of research. There were hard times as well, since the results of research are not always certain and guaranteed. Back in Jena, I remember a conversation I had with Simon Parker and Mark Sanders. As I expressed my concerns about the results and usefulness of so many hours of research, they told me that research is just like building a brick wall. Each researcher contributes a brick to the wall, and since each brick line is placed upon another one, the contribution of each scholar might seem insignificant individually, but all bricks together form a wall of knowledge which is in turn a part of a huge building called science. So, I hope that you enjoy reading this brick as much as I enjoyed doing it, and let us hope that this contribution promotes and fosters an interest in the topics dealt with here, so that many more bricks will be produced. Let the wall expand and grow forever!

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Résumé

If this thesis had to be defined just by using just few terms, one of them would surely be *entrepreneurship*. Many contributions coming from different disciplines have shown to what extent entrepreneurial initiatives are an important source of economic development. Such initiatives can have many forms and come from many sources, and an important vehicle through which such initiatives have an effect in the economy is the entry of new economic business ventures. In this respect, several streams of the literature have focused on the characteristics, determinants and effects of such entries. This is the general framework of this work, which focuses on two fundamental and relevant questions: (a) the territorial determinants of new economic ventures' location and (b) the effects of such entries in terms of dynamic factor demand. Although such questions can be analysed separately, they belong to the same economic phenomenon, that is, the causes and consequences of new economic ventures, and the results obtained in each analysis can be interpreted in a broader and more general context. The work presented in this thesis is grouped into three main blocks, corresponding to the three first chapters, the fourth chapter being devoted to the general summary, a discussion and insights for further research.

Chapter one serves as the introduction, and it starts with a broad and detailed overview of the motivation and relevance of the research, specifically linking the two main research questions proposed here. Such link works like this: there are certain characteristics of spatial units (such as agglomeration economies) that determine the location of new establishments. Once such establishments start their productive activity, they exert a multiple impact on the geographic place where they are located, on their sector of activity and on the whole economy as well. Such effect is multiple and is related to output growth, changes in factor demand, increased competition and efficiency and productivity growth, to name some of them. Besides, the effect is not restricted to the moment when the entry takes place,

but lasts over time, which points out the importance of distinguishing between short term and long term effects. Next, the chapter gives a broad overview of the seminal contributions to the topics studied in this thesis. In an attempt to classify such contributions in a clear way, they are related to the dimensions space and time. Although the space dimension has been related to the study of economics for a longer period of time, it was Alfred Marshall at the beginning of the XXth century with the concept of external economies one of the first and most crucial contributions, which lay the basis for a wide array of literature streams taking into account the role of space in the economy. In this respect, the contributions of Walter Isard in mid-XXth century are also worth mentioning, since he brought the first locational theories into the mainstream economics and gave birth, along with other scholars, to the regional economics discipline. The other dimension, time, was gradually introduced in the industrial organisation field during the XXth century. Specifically, the initially static concept of firm entry considered by the first contributions in the field, which rendered firm entry just as an error correction mechanism, was being gradually rendered obsolete as new evidence revealed the dynamic nature of industry through its evolution over time. Such new evidence was very heterogeneous and covered aspects such as determinants of firm entry, exit and survival, effect of new firms on economic performance, equilibrium prices and incumbent's behaviour over time, to name some of them. Despite such heterogeneity, these contributions are often referred to as belonging to the field of industrial dynamics or firm demography. The rest of the chapter is devoted to a broad, albeit essential, review of the literature. The first part of such review covers the main spatial determinants of industrial location both from a theoretical and empirical point of view, which are agglomeration economies, public infrastructures, human capital, public policies, technological factors and internal factors of the firm. The second part of this review focuses on the theoretical and empirical contributions dealing with the short term and long term effect of new firms upon the economy. Since this literature is very broad and heterogeneous, it has been decomposed into the following categories: economic growth, competition, innovation and productivity. A brief summary closes this chapter.

The second chapter deals with the geographic determinants of industrial location, and stands for the first part of the empirical analysis. The aim of this chapter is to study the geographic determinants of industrial location at the municipality

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level for the case of Catalonia. The chapter begins with a motivation of the study and an explanation of the relevance of the presented research. The starting point is a methodological review of count data analysis, which explains analytically how the basic Poisson regression model has been developed to account for the main industrial location data problems, i.e. overdispersion and excess of zeros. Next, three problems related to the location phenomenon that are to be dealt with are presented and explained, and also some solutions are proposed. The first of such problems is the presence of spatial effects, which are likely to be present since data on location is geo-referenced. Spatial effects influence the estimation results, and they ought to be included when the model is specified. The second problem highlighted in this chapter is the measurement of nonlinearities, arising when the relationship between a regressor and the dependent variable in a model explaining the determinants of the number of locations is not linear. The third problem has to do with the interpretation of zeros, that is, to what extent the determinants of the existence or not of locating firms are the same as the determinants of the number of them. The next part of the chapter deals with the empirical analysis for Catalonia, which begins with a detailed description of the data used in the study and is followed by a thorough descriptive statistical analysis which sheds light on the distributional characteristics of the number of entries per municipality. Such statistics show that the excess of zeros is a fact, that the geographic characteristics of those municipalities with entries differ from those municipalities that receive no entries at all, and also that the distribution of entries differ if data per aggregate sectors is analysed separately. The next part of the empirical analysis studies the spatial distribution of entries in depth by means of spatial econometrics methodology, and strong evidence for the presence of spatial correlation is found and reported. Moreover, such spatial effects are proven to cause autocorrelation in the residuals of the location determinants model if such effects are not properly accounted for. The last part of the empirical analysis consists of the estimation of a Zero Augmented Inverse Gaussian model with spatial lags and accounting for nonlinearities. Such estimation allows to take into account the zero structure by accomodating the right-skewness of the entries distribution of the data, and studies to what extent the variables determining whether or not there are any entries in a municipality differ from those determining the amount of entries in those municipalities that receive a positive number of them. A conclusion summarising all the results closes the chapter.

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The third chapter aims at the study of the relationship between the entry of new establishments and factor demand for the Spanish manufacturing sectors. The motivation behind this research is to study the short term and long term effects of establishment entries upon the dynamic demand and substitution of labour and capital productive factors. The chapter begins with a discussion about the relationship between new firms and labour demand, highlighting the relevance of this topic of research and then reviewing the different approaches that many different contributions have adopted to empirically tackle this issue as well as the results obtained up to now. However, the effect of entries on labour demand is only a part of the whole story, since the capital factor is demanded as well. Because the demand and substitution of both factors and technological change are closely related phenomena, the next part of the chapter is devoted to the relationship between these concepts, which reviews the different types of innovation that can take place, under which circumstances technological change is to raise or lower labour demand in the short-term and the long term, and moreover the role that new firms can play in this complex process. Next, an empirical research for the Spanish regions is undertaken first by presenting the data at a regional, industrial and temporal level and the variables to be used in such analysis. Then, a broad descriptive analysis consisting of a correspondence analysis, an analysis of variance (ANOVA) and a decomposition of growth rate components is presented. These methodologies are intended to pierce the thick three-dimensional wall of the variables, and to give insights into the variables' heterogeneity and evolution over time. The empirical research consists mainly of two blocks. The first one deals with the dynamic effect of new firm entry on labour demand changes, and it consists of the estimation of dynamic panel models, which are intended to unveil the short term and long term effect of establishment entry gross rates upon changes in labour demand. Such analysis is performed both for the aggregated manufacturing sectors and for different sectoral groups, in order to assess the specific dynamic effects for different sectors. The second analysis extends the analysis to the dynamic demand and substitution of labour and capital factors, and by means of the estimation of dynamic models the effect of entry gross rates on the demand and substitution of labour and capital is studied. Finally, the results and findings are summarised at the end of the chapter.

The last chapter contains a general summary of the results obtained in the re-

search presented here as well as a comparison and an interpretation of such results in a broader and more general context. Then, issues deriving from the findings are discussed and related to those found in other similar contributions. Finally, several proposals for further research are made, these including both specific issues which have not been given enough attention so far and also methodological advances that could be used in the research context presented in this thesis. A methodological appendix, a list of figures and tables and the bibliography close the thesis.

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Chapter 1

Conceptual and Theoretical Framework

1.1 Motivation of the Thesis

During the last decades new contributions and thus new evidence on the nature and the impact on the economy of new firms has arisen. Factors such as the increasing availability of new data bases, the development of new econometric models and estimation procedures and also a deeper understanding of the firm creation process have allowed the development of an emerging and also heterogeneous literature stream over the last half century. Many of these contributions can be directly or indirectly linked to the concept of *entrepreneurship*. Although there exist many definitions of such concept, since it is a multidisciplinary field[1], the basic underlying idea behind it is that entrepreneurs constitute an engine of economic and social development all over the world. AUDRETSCH (1995), ACS AND AUDRETSCH (2003) and DAVIDSSON (2004) review many definitions given to entrepreneurship throughout many years of research, the main ones being the following: new entry, creation of new firms and organisations, novel combination of resources having an impact on the market, the act of pursuing opportunities, the process of creating something different with value and the willingness to take risks.

[1]Nowadays, entrepreneurship and its implications in the economy and society are the subject of a growing body of research, primarily in the disciplines of economics, geography, management, finance, strategy, psychology and sociology, being entrepreneurship a subfield in most of the above mentioned disciplines (ACS AND AUDRETSCH 2003).

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One of the fields to which this thesis can be related is the interdisciplinary field of entrepreneurship, and the definition adopted and studied here is the creation of new industrial establishments[2]. One basic assumption made in this thesis is that these new establishments are likely to play a role in the economy, and this role is going to be studied by using quantitative methods, that is, statistic and econometric tools. The basic questions to be answered in this work can be grouped into two different but strongly interrelated aspects, i.e. (a) the determinants of new establishments' location and (b) the outcomes and effects of these new establishments in terms of factor demand. This approach is suggested by DAVIDSSON (2004) when outlying and analysing the *"entrepreneurship research as the study of processes of emergence of new ventures"*. This author states that, after matching data on new ventures with a level of analysis, i.e. individual, firm, industry, region, nation, etc., research should pay attention to antecedents and outcomes as well. This structure is adopted in this thesis and the resulting research framework is shown in Figure 1.1.

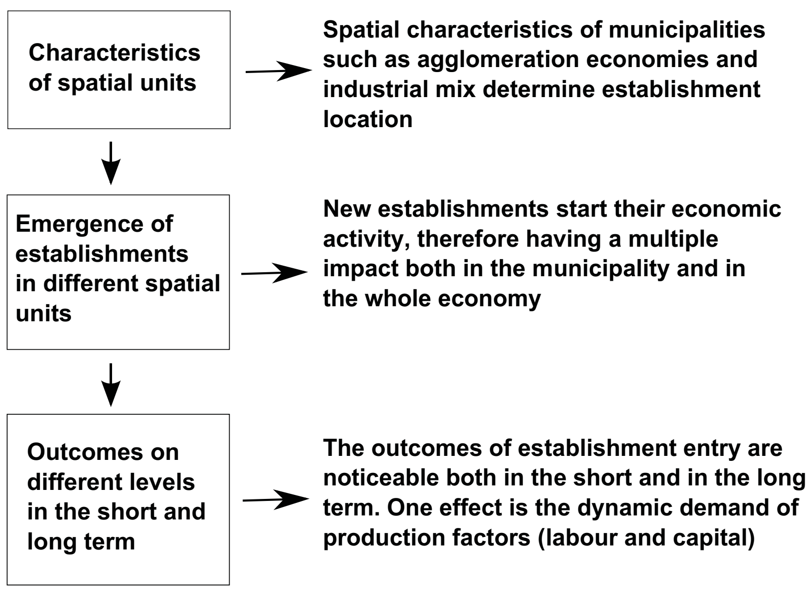

Figure 1.1: General research framework of the thesis

As it can be seen in Figure 1.1, this framework puts the creation of establishments into perspective, analysing both the creation and location processes and the

[2]The empirical analysis carried out in this thesis uses data on manufacturing establishments. Because a single firm can have several establishments, and in order to avoid confusion over these terms, the terminology *establishment* is henceforth to be used.

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outcomes that result from their entry. With respect to the creation of establishments, there are many factors leading to their creation, such as the entrepreneurial culture of the economy, sectoral characteristics and phase of the economic cycle (ACS AND AUDRETSCH 2003). In this thesis the focus is on those territorial characteristics that determine the number of new establishments that will locate in different municipalities. In fact, this is a *ceteris paribus* hypothesis, since we assume that all other factors determining establishment creation remain the same, focusing exclusively on those factors linked to the spatial unit where the location takes place, that is, the municipality. This framework also shows that new establishments are the key, the connector and the vehicle that links territorial characteristics to certain outcomes such as economic growth, increases in employment, technological change, etc. Because the effects of entries on the economy are very complex and multidimensional, they are not restricted to the specific spatial unit and sector where they take place, but to the whole economy, that is, territories and sectors. Besides, not only do new entries have an influence in the right moment when they enter the market, but also in the long term, specifically in terms of technological change and efficiency improvements. In this thesis the focus is on the effects on the labour and capital markets, that is, how new establishments demand productive factors (labour and capital) and how the stock of those factors vary over time.

Specifically, the main contributions of this work can be summarised in the following points:

a) Present some empirical evidence for the Spanish and Catalan economy.

b) Adopt new methods and models suitable for this area of research.

c) Propose new directions and insights for further research in the framework given by Figure 1.1.

With respect to the first part of the framework, this thesis deals with the location of new industrial establishments in Catalonia. The chosen geographical level is the municipality[3], and thus the effect of territorial characteristics on the emergence of

[3] The question about which territorial unit is to be considered when studying industrial location is not clear. So far, several studies using different territorial units have found different results. In this thesis the chosen agglomeration level has been the municipality because it allows to estimate more efficiently spatial effects among different spatial units. For a discussion about this topic, see ARAUZO (2008).

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new establishments is analysed[4]. The main questions to be answered are:

a) How do territorial characteristics determine the number of located establishments in each municipality?

b) Which are the main variables behind the location of new establishments?

c) How do municipalities' variables influence the location in other municipalities? In other words, how do interactions among municipalities in the form of spatial correlation work?

d) Is the effect of municipaities' characteristics different for several manufacturing sectors?

e) In comparison with the common methodology used so far in the literature, are there any econometric tools more suitable for dealing with spatial effects and other problems related to spatial data?

The second link of the framework analysed in this thesis deals with the outcomes resulting from establishment entries. As it is reviewed in the next section, the entry of new capacities has multiple effects over the economy, both of a static and a dynamic nature. New capacities have been proven to promote competition in the markets, an increased efficiency and productivity and, in the long term, a stimulus of technological change and economic growth[5]. Specifically, this part of the analysis deals with the demand of productive factors, that is, the demand for labour and capital. Thus, the main questions that this part intends to answer are:

a) What is the dynamic impact of new establishments over labour demand changes?

b) Are labour demand changes mainly driven by the expansion/contraction of existing establishments or by the entry/exit of establishments?

c) Apart from the labour factor, is there any relationship between new establishments and the dynamic demand for capital?

---

[4]The stream of the literature dealing with this relationship specifically names these new establishments *industrial location*. In Chapter 2 this name is therefore used.

[5]For a review of these multiple effects, see GEROSKI (1995), CAVES (1998) and AHN (2001).

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d) What is the role of new establishments in the capitalisation process that the Spanish industry has undergone in recent years?

e) In the long term, what is the relationship between the dynamic demand and substitution for labour and capital? Is there a dynamic complementarity or substitution between their demands?

At the end, both parts of the analysis shed light on a complete and dynamic process, that is, how different regions and territories are capable of attracting new establishments, which in turn demand productive factors and create added value. There exist two dimensions which are fundamental in this framework whose importance should not be dismissed: *space* and *time*. On the one hand, the creation of new establishments is a phenomenon closely linked to the physical *space* where it is located. The specific location that a new firm/establishment might choose has a direct effect on its future performance and survival. During the nineties there was a wave of contributions highlighting the fact that entry rates were unevenly distributed across regions (ASHCROFT ET AL. 1991; DAVIDSSON ET AL. 1994; AUDRETSCH AND FRITSCH 1994)[6]. In this context, an enormously influential contribution was KRUGMAN (1991), which, by means of a rather simple model considering scale economies, transportation costs and demand, determined the location of manufacturing firms and the emergence of core-periphery patterns. Yet another stream of the literature studied which geographic variables determined the entry and exit of firms[7]. These contributions highlighted the role that geographical variables, that is, variables at different levels such as region, labour market area, municipality, city, metropolitan area, etc., play in determining the entry of new capacities[8]. Among these determinants there are variables such as sectoral composition, size of markets, population, taxes, human capital, transportation infrastructures, employment levels and external economies[9]. The role of space,

[6]See the special issue of *Regional Studies* (1994) entitled *Cross-national Comparisons of the Variation in New Firm Formation Rates*.

[7]See ARAUZO ET AL. (2010) for a review of these contributions.

[8]There is a semantic aspect that should be considered when dealing with spatial variables determining entries, since in the literature analysing those factors entries are named *locations* rather than *entries*, although the underlying phenomenon might be the same.

[9]The contributions by GLAESER ET AL. (1992) and HENDERSON ET AL. (1995), in which external economies were accurately defined and classified, triggered the study of these external economies as key determinants of industrial location.

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however, is broader and deeper, since new establishments may consider not only the characteristics of particular geographical sites they want to settle in, but also the characteristics of a the areas nearby. This spatial interaction between geographical areas causes spatial effects, i.e. spatial dependence and spatial heterogeneity, which are important both from a conceptual and a methodological point of view. In this sense, the effects that new establishments cause on the economy are not only confined to the precise geographic spot where they are located, because they might contribute to the demand of labour and capital in a broader geographical area and also might stimulate the economic activity in different sectors, for example, via suppliers and distributors of inputs and outputs. The other fundamental dimension is *time*, because one basic feature of industrial markets is their dynamic nature[10]. Focusing strictly on the dynamic demand for productive factors, the effects of establishment entries are multiple and take place both in the short and the long term. At the moment of the entry, new establishments demand a certain amount of factors in order to start their economic activity. On average, this amount is not high, since the average size of new establishments when entering the market is small (GEROSKI 1995). However, those establishments that survive grow in size as time goes by and thus the demand for productive factors increases. However, as new establishments keep coming on, some establishments (both recent newcomers and incumbents) exit the market, which has a negative effect on the stock of factors. All in all, as time goes by some establishments enter the markets while some others exit out of it, some others expanding and shrinking continuously in size, being one of the results a countinuous effect on the demand for labour and capital factors.

As stated earlier, the aim of this thesis is to analyse the framework depicted in Figure 1.1 for the Spanish and Catalan economy. First, the effect of territorial characteristics on establishment locations is analysed for the Catalan manufacturing sectors at the municipality level. At such desaggregated level, the spatial effects between municipalities can be studied precisely and accurately[11]. In order to study this relationship taking into account the spatial dimension, new methodological proposals are made and used in this thesis. Second, with respect to the effects of establishment entries on the demand for labour and capital, they are analysed for

[10] See next Section 1.2 for a detailed review on industry dyamics.

[11] For a discussion about the effects of differents levels of aggregation on industrial location, see ARAUZO AND MANJÓN (2004) and ARAUZO (2008).

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the Spanish manufacturing sectors at the regional and sectoral levels. By estimating dynamic models the short-term and long-term effects of establishment entries upon (a) the demand of labour and (b) the joint demand for labour and capital are studied. Finally, conclusions are drawn and several proposals for further research are made.

1.2 How Space and Time Changed the Economy

1.2.1 The Origins

It is clear that space and time are two fundamental dimensions in many natural sciences, such as physics, geology, etc. One could think that these dimensions are only restricted to natural sciences, having social sciences nothing to do with such dimensions. However, considering the economy as the branch of social anthropology that studies the allocation of limited resources with alternative uses among economic agents with illimited needs, it is clear that this allocation process takes place in a physical space and evolves as time goes by. Despite how clear this fact might be, the economic analysis has neglected these two fundamental dimensions for a long time, focusing on static equilibriums applied to a whole economy, no matter how the economic activity might be distributed over space. Fortunately, the last decades have witnessed different and heterogeneous waves of contributions which incorporated, in different and alternative ways, space and time into economic analysis. If one is to look for the original seed of such contributions to economic science, it dates back to the end of the XIXth century, to the insightful work MARSHALL (1890), named *Principles of Economics*[12]. This extense work contained many ideas, and with respect to time and space his contributions can be summarised as follows:

a) **Space:** apart from those economies that are internal to the firm, that is, economies of scale of production, Marshall defined and developed the concept of *external economies*, that is, positive externalities external to the firm stemming from being located next to other producers and economic activity in general. The author named these concentrations of activity *industrial districts*, and classified these external economies into three types, i.e. (1) economies resulting from access to a common labor market and shared public goods, such

[12]Despite the consequences and importance of Marshall's contributions, the German location theorists started their contributions at the beginning of the XIXth century already (see Subsection 1.2.2 for a review).

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as infrastructure or educational institutions; (2) economies from saved transportation and transaction costs due to the regional proximity of firms along the supply chain, this is, suppliers and customers; and (3) economies from spillovers that result from industry knowledge being readily discerned due to physical proximity. Later on, the idea of external economies was developed, widened, updated and sophisticated by many authors (HOOVER 1936; BECATTINI 1979; KRUGMAN 1991; GLAESER ET AL. 1992), but Marshall's contributions remain as the pioneering work on the topic.

b) **Time:** Marshall stressed the importance of the dynamic nature of industrial activities in his contribution *Principles of Economics*. Following his arguments, modern economies are characterised by different sectors, each of which following different paths, that is, some sectors being more successful than others in terms of expansion and growth. Some years later, PETER SCHUMPETER (1939,1942) highlighted throughout his contributions the role of entrepreneurs in the dynamic process of technological change. This author coined and poularised the term *creative destruction*, used to describe the process of transformation caused by the entry of entrepreneurs that led to sustained long-term economic growth by destroying the value of established companies that enjoyed some degree of monopoly power.

1.2.2 Industrial Location: from Geometric Models to New Economic Geography

1.2.2.1 Economics and Geography: a Journey through the Dark

As stated earlier, the matter of the location of economic activity has been neglected by the mainstream economics for a long time. Many of the main contributors to the general equilibrium theory (HICKS 1939; MOSAK 1944; SAMUELSON 1947, to name a few) neglected the role of space in the economy, assuming that the economy was formed by factors, producers, commodities and consumers that were congregated at one abstract point in space. Even MARSHALL (1890), when discussing the role of time and space in economics, argued that the influence of time was more fundamental than that of space. However, CHAMBERLAIN (1933) treated the space more carefully and thoroughly in his contribution *The Theory of Monopolistic Competition*. Specifically, he contributed to the fields of competition theory and consumer

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choice, and also their connection to prices, coining the term *product differentiation* to describe how a supplier may be able to charge a greater amount for a product than perfect competition would allow. From his analysis emerges explicitly the need for applying the techniques of monopolistic competition in order to handle with the spatial dimension of the economy. In fact, his theory was later to be used by some developers of economic geography theory, such as KRUGMAN (1991).

1.2.2.2 The German School

Apart from the mainstream economic theories being developed at the beginning of the XXth century[13], there were many attempts to construct location theories, coming mainly from German authors who have been named *The German School* some years later. The first contribution was VON THÜNEN (1826), which is an analytical developement of a model for agricultural location and stands for the first serious treatment of spatial economics, connecting it with the theory of the rent. This study is far ahead of its time, and von Thünen is considered to be the father of location theorists. Later on, LAUNHARDT (1882) contributed to the location theory by studying industrial location and market areas with a mathematical formalisation. However, it was Alfred Weber the first scholar who tried to develop a general location theory (WEBER 1909). Adopting an evolutionary approach, he tried to develop a theory of the transformation of locational structures. Specifically, he developed the Least Cost Theory, which tried to explain and predict the locational pattern of the industry at an aggregated level, being input and output transportation costs as well as labour costs the main location determinants[14]. CHRISTALLER (1933) went a step further and proposed the Central Place Theory, which explains the number, size and location of human settlements in an urban system. According to this theory, settlements would tend to form in a triangular/hexagonal lattice surrounding the central places, and then these could serve smaller settlements efficiently without any over-

[13] ISARD (1956) names this stream of contributions the "Anglo-Saxon tradition". Besides, he defined the "Anglo-Saxon bias" as the rejection of the space in their analysis, compressing everything within the economy to a point, so that all spatial resistance disappears.

[14] The fact that Weber wanted to study industrial location from a general economic perspective can be noticed in that he criticised classical theories for the way they where treating the space-economy. As an example, in WEBER (1911) he pointed out that classical trade theory entirely ignored transport costs, thus overlooking a large proportion of internationally distributed industry which is transport-oriented.

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lap. Another monumental contribution was due to LÖSCH (1940), which, going beyond simple partial analyses considering spatial interrelations, developed a simplified static model of a space-economy operating under conditions of monopolistic competition. His model predicts the division of space into hexagons and the spatial concentration of spatial activities. The contributions of the German School were overlooked by those economists belonging to the so-called Anglo-saxon tradition[15] for a long time, until ISARD (1956) translated, made known and popularised the main contributions from the German School, thus settling the grounds of regional science[16]. This discipline then grew and gained supporters, who were dissatisfied with the low level of regional economic analysis in the mainstream research in economics. However, the discipline was thought of as an interdisciplinary field which went beyond the scope of economists, thus incorporating natural scientists, psychologists, anthropologists, lawyers, sociologists, political scientists, planners and geographers.

1.2.2.3 The Development of the Economic Geography

The second half of the XXth century has been characterised by the emergence of a variety of contributions on the relationship between economics and geography. These contributions have been, and still are, so heterogeneous that it is impossible to label them under a common definition. Usually, economic geography is regarded as a subfield of the discipline of geography, although some economists have claimed that economic geography is a field on its own[17]. The evolution of the discipline in the second half of the XXth century is very diverse and heterogeneous, and some of the main developments can be grouped into these categories:

a) **Quantitative revolution:** this revolution occurred during the 1950s and 1960s and was intended to overcome the simplistic descriptive nature of geography.

[15]It has been argued that one reason why the contributions of German scholars were mainly ignored by the mainstream of English-speaking economists was the disdain with which they regarded texts written in other languages.

[16]The efforts by Walter Isard and other economists to promote a scientific analysis of industrial location and urban development translated into the creation of the Regional Science Association, which was founded in 1954.

[17]This discussion is related to the crisis that geography as an academic field suffered during the 1950s. One of the reasons was the continuing division between physical and human geography, being economic geography included in the latter category.

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Many scholars had then the aim of bringing the scientific methodology into geography, so that this would become a nomothetic discipline[18]. This revolution consisted mainly of the introduction of mathematical, statistical and econometric techniques which tried to improve the simple descriptive methods being used so far. Then, apart from borrowing quantitative methodologies being used so far in other disciplines, there was a wave of new methodological developements for the treatment and analysis of georeferenced data[19]. This revolution was parallel to the development of computers and software, thus allowing researchers to assess more and more complex models with the help of GIS techniques[20].

b) **Critical geography:** this denomination includes several schools of thought that emerged in the 1970s as a response of the quantitative revolution, criticising its methods. The first school of thought is the *behavioural geography*, whose followers argued that quantitative methods are a limited tool to analyse the perception that people have of places and how location decisions are made, thus being an alternative approach for studying the behavioural scope of location decisions. Another school of thought is the *radical* or *marxist geography*, which emerged in the 1970s with the seminal contribution of HARVEY (1973). This school of thought argued that purely quantitative research was positivist instead of normative[21], so that it did not deal with problems such as social justice or poverty caused by capitalism and therefore did not propose any solution to these problems. Radical geographers used theories and philosophy of Marxism to examine the spatial relations of human geography, and with their research they intended to alleviate poverty and exploitation in capitalist societies. The third school of thought is the *humanistic geography*, which frontally refuses the use of quantitative methods. Its followers argue that the

[18]That is, a discipline where the researcher can make laws from empirical observations and evidence.

[19]CRESSIE (1993) stands for a complete methodological textbook on statistics for spatial data, and ANSELIN (1988) is a seminal contribution on the introduction of spatial effects in econometrics, thus giving birth to spatial econometrics.

[20]GIS stands for *Geographic Information System*, describing those information systems devoted to the analysis of geographical information.

[21]A positive statement deals with what is and not is and contains no indication of approval or disapproval, while a normative statement expresses a judgment about whether a situation is desirable or undesirable.

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focus of humanistic geography is on people and their condition, and therefore research should be carried out by using qualitative analyses and literature to get into the mind of the subjects.

c) **New economic geography:** this discipline can be defined as the study of economic geography, i.e. the study of where economic activity occurs and why, in a general theoretical framework that includes recent developments in the fields of industrial organisation, international trade, technological change and economic growth[22]. Specifically, the defining issue of the new economic geography is to explain the formation of a large variety and typology of economic agglomeration patterns at different geographical levels, such as industrial districs, shopping centers and cities. The starting point of this discipline was the seminal contribution by KRUGMAN (1991), which started a stream of contributions sharing several key features, i.e. the general equilibrium modelling of an entire spatial economy, increasing returns and indivisibilities at the level of individual producers which lead to market structures characterised by imperfect competition, transportation costs and locational movement of productive factors and consumers[23].

1.2.3 Industrial Organisation: from the Static Analysis to Firm Demography

1.2.3.1 First Contributions

The first contributions to the field of industrial economics were mainly static. These were aiming at the study of entry barriers and their effect on firm turnover,

[22]To name a few insighful contributions, DIXIT AND STIGLITZ (1977) introduced in the field of industrial economics an analytical model of an economy with monopolistic competition and increasing returns to scale, which had power in explaining the concentration of economic activity; HELPMAN AND KRUGMAN (1985) revised the theory of trade, assessing that countries with similar levels of income have been shown to trade more because they trade in differentiated goods due their similarities, and GROSSMAN AND HELPMAN (1991) contributed to the endogenous theory of economic growth with a model in which innovation is viewed as a deliberate outgrowth of investments in industrial research by forward-looking, profit-seeking agents, these innovations generating externalities which are introduced in the final goods sector and ultimately causing increases in productivity and economic growth.

[23]A broad discussion of these topics and the current state of the new economic geography can be found in FUJITA AND KRUGMAN (2004).

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that is, the entry and exit of firms. A seminal study that analysed barriers to entry in industrial markets was BAIN (1956), which studied to what extent entry barriers are important factors shaping the structure of industries[24]. Following his analysis, those markets with high entry barriers would be characterised by having a reduced number of incumbents, which are likely to have a large market share and to establish a mark-up so that prices are above the competitive equilibrium. One common feature of the first contributions in this field, besides its static nature, was the notion of *average firm*, thus dismissing to some extent the effect of firm's heterogeneity in the markets[25].

1.2.3.2 Introducing Dynamic Markets and Heterogeneous Firms

In the 1970s a new wave of contributions to the field of industrial economics emerged. One basic difference with the previous wave was its mainly theoretical nature, introducing developments from the noncooperative game theory. Furthermore, it made serious progress in two crucial areas: dynamics and assymmetric information (TIROLE 1988). Yet there remained several questions to be answered. What is the effect of new firms on the market's structure? Which factors determine the individual growth of firms? Why do so heterogeneous firms coexist in the markets? A pioneering study aiming at answering such questions was MANSFIELD (1962), which tried to answer some of these. The author presented a simple model of entry and exit determinants, and then studied the post-entry behaviour and performance of firms. Among the main results are the facts that (a) contrary to Gibrat's law, smaller firms have relatively higher death rates and more variable growth rates than larger firms, (b) successful and innovative firms grow twice as much as other firms and (c) the amount of mobility in an industry depends significantly on its market structure. This contribution was relevant in the sense

[24] BAIN (1956) defined an entry barrier as the set of technology or product conditions that allow incumbent firms to earn economic profits in the long term. Bain identified three sets of conditions: economies of scale, product differentiation, and absolute cost advantages of established firms. Later on, STIGLER (1968) criticised this approach, especially the idea of scale economies as a barrier to entry. Instead, he defined entry barriers as the cost of producing which must be borne by an entrant but not by an incumbent.

[25] This first wave of empirical contributions, associated with the names of Joe Bain and Edward Mason, is often called the "Harvard tradition". For a detailed review of its main contributions, see TIROLE (1988).

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that, while earlier studies just focused on available technologies, costs and demand changes as factors determining firms' behaviour, this contribution and the wave of studies on market dynamics highlighted the role of entry and exit of firms as the main engine driving to the evolution of markets and technological change. With respect to firm heterogeneity, the paradigm of the *representative/average firm* was being left behind in favour of a more realistic vision according to which firms are essentially different from each other. Evidence shows that firms are different in many aspects, that is, they have different characteristics, behaviour and results, apart from having different age, size, growth rate, productivity, innovative rate, etc.

From a theoretical point of view, some studies aimed at studying the evolution of industries under the assumption that such evolution was driven by heterogeneous firms. A pioneering work was JOVANOVIC (1982), which assumed that the industry was composed by heterogeneous firms, each of which had an unknown learning path, only to be discovered by the firm only once it has entered the market and checked out its efficiency level. This passive view of the learning process is changed by ERICSON AND PAKES (1995), which assume an active learning process by linking gains in efficiency to investments in research and development. These theoretical contributions found an empirical confirmation, since several empirical evidence showed a clear path dependence in firms' behaviour which determined their path and evolution in the market. This way, DOSI ET AL. (1997) analysed from an evolutionary perspective the persistence of firm heterogeneity over time, and KLEPPER (1997) related firm heterogeneity to the product life cycle.

1.2.3.3 Different Views of Firm Entry and Exit

Going back to the first contributions in the field of industrial economics, firm entry was then understood just as a correction mechanism, in the sense that an excessive level of profitability in the long-term equilibrium induces new firms to enter the industry. This way, entries are conceived as a mechanism through which markets return to equilibrium levels of prices and profits. In the words of GEROSKI (1991, P. 65):

> *"If we think of entry as an error-correction mechanism which is attracted by and serves to bid away excess profits, it is natural to suppose that entry will occur whenever profits differ from their long-run levels. Given this mantained*

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> *hypothesis, observations of actual entry rates and current (or expected post-entry) profits can be used to make inferences about the unobservable of interest—long-run profits. In particular, entry in an industry is hypothesized to occur whenever expected post-entry profits exceed the level of profits protected in the long term".*

Such conception of entry has a theoretical origin in BAIN (1956) and was first empirically tested by ORR (1974), who found only a weak effect of industry profitability on entries. However, KHEMANI AND SHAPIRO (1986) and GEROSKI AND SCHWALBACH (1991) found a positive link between industry profitability and entry[26].

However, as new empirical contributions on firm entry emerged, it was progressively clear that the static simple model used to capture the phenomenon of entries was not suitable for the empirical evidence. NEUMANN (1993) pointed out that the fundamental problem lied in the fact that a simple static model was intended to capture a dynamic process. According to his opinion, adopting a static framework was misleading, since the slight effect that entry had on the performance of incumbents and the high rates of exit associated with entry was nor explained nor predicted by a static model. In fact, the idea that new entrepreneurs entering the markets might have a role other than a simple error-correction mechanism dates back to SCHUMPETER (1934) and his idea of *creative destruction*. This dynamic conception of entering firms met with an increasing availability of new data sets and the development of new econometric tools, which favoured an increase in the number of contributions that relate market entry and a large number of economic variables, such as dynamic of prices and margins, barriers to entry, technical progress and industry evolution. Although the empirical literature on firm entry is vast and very heterogeneous, many contributions have measured them by constructing entry and exit rates, that is, the number of entering and exiting firms divided by a denominator which can be the number of existing firms, the workforce or the population[27].

[26] AUDRETSCH (1995) reviews comprehensively the different views and conceptions of entry both from a theoretical and empirical point of view.

[27] See Appendix A.1 for details.

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Over the last decades, the empirical evidence on the nature and the effect of firm entry upon the economy has shown that it depends on many factors and can be very diverse, and thus it is not easy to make a statement regarding the effect of new firms upon variables such as productivity, labour demand, output growth, etc. One first reason is that new firms or establishments are very heterogeneous. Some of them can be innovative, in the sense that they bring new products or processes to the market, while other firms may just use the same standard technology common in the sector they are entering. VIVARELLI (2007) puts it the following way:

> *"(...) far from being solely the entrepreneurial creative destruction proposed by Schumpeterian advocates, the entry of new firms is a rather heterogeneous aggregate where innovative entrepreneurs are to be found together with passive followers, over-optimist gamblers and even escapers from unemployment."*

Even in the event that firms have such characteristics their importance should not be dismissed, since they can play a valuable role in creating incentives to innovate and behave efficiently. In this respect, GEROSKI (1989A) finds that industries which experience rapid changes in technology and have a high rate of turbulence (entries and exits) are likely to be those in which incumbents are under pressure to perform well, thus playing competition a significant role in stimulating productivity. In another study, CAMPBELL (1998) found that new entries which do not produce innovations themselves but just buy and use it might be the vehicle through which new innovations enter the markets.

However diverse and heterogeneous the empirical evidence might be, several contributions have gathered the main empirical regularities and stylised facts found in several studies. In this regard, GEROSKI (1995) reviewed the empirical evidence on firm entry, summarising both stylised facts and results whit a basis of support in the empirical literature. His analysis highlighted the fact that firm entry and exit are common in most markets, being penetration and survival rates low. This fact points out that there exists a process by which a large part of the entrants exit the market in the short term, and only the most efficient firms survive and grow, exerting a displacement effect on the less efficient firms (both incumbents and new firms)[28]. Besides, evidence was found to contradict the early

[28]See, among others, DUNNE ET AL. (1988), EVANS (1987), HALL (1987) and WAGNER (1994).

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developments in industrial economics, since entry rates were hard to explain using conventional measures of profitability and entry barriers, thus reacting slowly to high profits. A relationship between industry dynamics and dynamic changes was also emphasised, since high rates of entry were found to be associated with high rates of innovation and increases in efficiency, entries playing also a role in shaping industry structure in certain phases of the product life cycle. In a similar work, CAVES (1998) reported new findings on the turnover and mobility of firms, finding that mean growth rates of firms decrease with their initial sizes, gross entry is much larger than net entry, and successful entrants grow rapidly. Besides, the study finds that industry concentration levels depend on cumulative effects of past mobility rates, and that traditional structural entry barriers affect both the number of entries and the entrant's survival rate. Regarding the analysis of markets' efficiency, the study concludes that productivity growth for an industry as a whole depends on the redistribution of shares toward the more productive units and not just on the growth of the unit's individual productivity. This latter result is confirmed by a survey study on empirical contributions using micro data (AHN 2001), which finds that firm dynamics contribute to constantly reallocate inputs and outputs from less efficient productive units to those which are more productive. Besides, this survey shows that firm dynamics represent a important factor driving industry aggregate productivity growth, and this influence is more pronounced for total productivity growth than for labour productivity growth. Another relevant result stemming from this survey study shows that, while within-firm productivity growth drives overall fluctuations in aggregate productivity growth, during cyclical downturns the exit of low-productivity units gains importance.

AUDRETSCH (1995) brought up the concept of *conical revolving door effect*, which implies that the turnover of entries and exits is much higher for smaller firms than for larger ones. In fact, most of the research on the survival of firms shows that the revolving door effect prevails over the displacement effect (CALLEJÓN AND SEGARRA 1999). This means that the size of entering firms is smaller than the industry average, that many of these firms exit during the first few years, and that those that survive can grow faster than the incumbent firms. Several contributions have analysed the relationship between the initial size of the firm and the likelihood of survival (AUDRETSCH 1995; AUDRETSCH AND MAHMOOD 1995; DUNNE AND HUGHES 1994; MATA AND PORTUGAL 1995, 1999). Moreover, ESTEVE-PÉREZ

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ET AL. (2000) found that, for small and medium enterprises (SMEs), exporting firms face a lower probability of failure than non-exporters. Lastly, the empirical evidence shows that there is a positive relationship between size at start-up and the likelihood of survival. SEGARRA AND CALLEJÓN (2002) show that the survival patterns of new Spanish manufacturing firms are similar to those of other countries. However, there are some empirical studies suggesting that, if the firm is to survive, smaller firms should grow at a higher rate than their larger counterparts. Thus, AUDRETSCH ET AL. (1999) point out that post-entry growth rates of surviving firms are observed to be negatively related to firm size. AGARWAL AND AUDRETSCH (2001) also find a negative relationship for the mature life-cycle stage.

1.3 Determinants of Firm Location

1.3.1 Theoretical Approaches

One of the crucial questions that arise when a new economic activity is created is where to locate it. The decision can be made considering two points of view, i.e. the characteristics of the economic activity and the characteristics of the sites where it might locate. On the one hand, firm characteristics as size or industry clearly matter and, therefore, location decisions will vary according to those characteristics, since not all possible sites are equally suitable for bigger or smaller activities or for capital or service oriented activities. On the other hand, site characteristics[29] are also a key part of the analysis, since they are thoroughly taken into account by new production units when they are choosing a location, as plenty of empirical evidence shows.

Location decisions of manufacturing firms have been analysed by a wide range of scholars departing from different theoretical approaches. Nevertheless, and following HAYTER (1997), most of those contributions can be grouped into three main approaches: a neoclassical approach, a behavioural approach and an institutional approach.

[29] There is a wide range of site types, from functional ones (travel to work areas, etc.) to administrative ones (municipalities, counties, provinces, regions, etc.) or both (metropolitan areas).

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a) Neoclassical approach: this approach is mainly related to classical location theory and considers that the economic agents that choose the final location are rational and have perfect information, and therefore they choose the optimal location guided by profit maximisation and cost-minimising strategies. Following the reasoning behind this approach, neoclassical location determinants are quantitative profit- or cost-driving factors such as agglomeration economies, transport infrastructures, technology and human capital. This approach has the advantage that location determinants are quantifiable variables that can often be obtained for empirical analysis.

b) Behavioural approach: this approach extends the neoclassical framework by including situations of imperfect information and uncertainty, and by emphasising the role that individual preferences have on location decisions. Unlike neoclassical location determinants, behavioural factors are internal to the firm: size, age, residence, previous experience, social and familiar environment of the entrepreneur, his/her locational preferences, etc. The main drawback of this approach is that it needs detailed entrepreneur's information that is not usually available to researchers.

c) Institutional approach: this approach explicitly considers the network of economic agents that interact with the entrepreneur as a location factor. Some of these factors are the characteristics of suppliers and customers, firm networks, public policies and trade union's strategies. This approach also needs a huge amount of information that is not easy to obtain and is qualitative, so that they need to be transformed into categorical variables in order to be included in the analysis.

Given the scarcity of information, scholars usually follow the first approach and use those types of quantitative variables in order to analyse location decisions. However, in the context of the empirical location analysis the distinction between neoclassical, institutional and behavioural factors is blurry and not clear. For instance, factors such as wages and pollution can be attributed both to the neoclassical and the institutional approach. In short, such approaches must not be regarded as closed and mutually exclusive, but as a useful framework for descriptive purposes.

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1.3.2 Location Determinants

The empirical literature on industrial location is wide and diverse. So far, many methodologies have been used, and also a wide array of variables and their effect on location have been analysed. In order to summarise and review the main variables and results considered in the literature in a clear way, this subsection presents them grouped into six wide groups, i.e. agglomeration economies, public infrastructures, human capital, public policies, technological factors and factors internal to the firm.

1.3.2.1 Agglomeration Economies

Agglomeration economies are regarded as one of the main determinants of industrial location. The origin of this concept goes back to MARSHALL (1890), who has been acknowledged as the first scholar to establish their existence in the form of external economies (as opposed to those economies which are internal to the firm), that is to say, benefits derived from the concentration of jobs and firms in an area. Specifically, Alfred Marshall classified those external economies as a specialised labour market, supplier's availability and knowledge spillovers. Later, HOOVER (1936) and OHLIN (1933) made attempts to develop a taxonomy of the motivation and the different forces that explain the spatial concentration of economic activity. Under the concept of *agglomeration economies*, two categories were proposed:

a) Localisation economies: they are economies external to the firm but internal to the industry, that is, they arise from the size of the local industry or, in other words, the concentration of similar economic activities. These economies take place when firms belonging to a certain industry take advantage of being located near firms of the same industry. Basically, the local proximity allows the direct communication and the interchange of knowledge as well as the sharing of a specialised pool of labour.

b) Urbanisation economies: they are economies external both to the firm and to the industry, which stem from the size of the local economy, that is, these economies derive from the concentration of economic activity as a whole. Such economies emerge when the benefits come from being located in an urban area, where firms from several industries have access to infrastructures, labour markets, etc.

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After this classification has been done, it has become very popular among scholars, and many authors have proposed both theoretical and empirical contributions based on such classification. However, external economies have been given alternative definitions in the literature. On the one hand, localisation economies have been defined as *Marshall-Arrow-Romer (MAR)* externalities or external economies. MAR externalities were put forward by MARSHALL (1890), ARROW (1962), and ROMER (1986), to be later formalised by GLAESER ET AL. (1992) and HENDERSON ET AL. (1995), and they intended to extend the concept of *Marshallian externalities* to a dynamic context. Specifically, these authors tested whether these dynamic externalities are more important, and thus whether local sectoral growth is higher the higher the concentration of the sector in the city, an effect they called MAR externalities. They found that dynamic local externalities induce spatial agglomeration of firms and employment, thus favouring localised growth in the long term, especially of cities. On crucial explanation of why such MAR externalities foster growth is that regions with production structures specialised towards a particular industry tend to be more innovative in that particular industry, as it allows for knowledge to spill over among similar firms. On the other hand, urbanisation economies have been defined as Jacobian externalities due to the contribution of JACOBS (1969). She argued that knowledge may spill over between complementary rather than similar industries, thus favouring the emergence of increasing returns when the productive structure is diversified. Therefore, a diversified local production structure causes urbanisation economies to emerge. With respect to the competition of firms, both concepts of externality have different assumptions. On the one side, *MAR externalities* assume that local monopoly is more favourable to innovation and growth than local competition because intensive competition reduces the appropriability of returns on investment. On the other side, *Jacobian externalities* assume that local competition favours innovation and therefore local growth, since competition acts as an incentive to engage in innovation. However, JACOBS (1969) understood local competition as competition for new ideas instead of the common definition of competition within product markets.

A stream of the literature has focused on the empirical identification and measurement of agglomeration economies[30]. In a pioneering study, HENDERSON

[30] An extensive review of several classifications regarding agglomeration economies can be found in PARR (2002), and a complete explanation of the different proxies for agglomeration economies

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(1986) proxied localisation and urbanisation economies by including in the regression the spatial density of the indsutry-specific and the overall labour level respectively. GLAESER ET AL. (1992) measured the specialisation of cities as the city's share of employment in an industry relative to the share of that industry in the whole economy, and its diversity (a characteristic of urbanisation economies) is measured by the fraction of employment belonging to the city's five largest industries. HENDERSON ET AL. (1995), in a similar study, introduced as a measure of urbanisation economies the Hirschmann-Herfindahl index, which measures the lack of diversity in a territory, and CICCONE AND HALL (1996) also assumed labour density as a proxy for localisation economies.

Although agglomeration economies play in principle a positive role in the development of cities and territories, and excessive agglomeration can lead to the opposite effect. TOWNROE (1969) wrote a seminal article on the subject, and introduced the idea that an excessive concentration of economic activity generates negative effects that can overcome the benefits derived from urbanisation economies. This later assumption implies that there are some limits to agglomeration and, therefore, growing and increasing economic activity ad infinitum in an area is not always the best solution. Highly concentrated areas must face some problems like environmental pollution, traffic congestion, excess commuting, higher wages and high land prices. QUIGLEY (1998) focused on the effects that the segregation caused by high concentration had in terms of increased poverty, and GLAESER (1998) highlighted the higher returns to crime in cities, perhaps due to scale economies in stolen goods or a greater market of potential victims. In addition, HENDERSON (1997) showed how highly agglomerated areas led to a raise of the cost of living, which in turn made necessary the existence of a wage premium in those areas.

In the light of the studies showing both the positive and the negative effects of the agglomeration of economic activity, a straightforward implication is the existence of a trade-off between agglomeration economies and diseconomies. Therefore, as BASILE (2004, P.8) points out:

> *"Admittedly, agglomeration economies tend to reach limit values and*

used in the empirical analysis is provided by KEILBACH (2000).

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> *agglomeration diseconomies eventually emerge. Indeed, firms operating on markets with a relatively large number of firms face stronger competition in product and labour markets. This acts as a centrifugal force, which tends to make activities dispersed in space. Once the centrifugal forces surpass the effects of the agglomeration economies in a region, firms will look for locations in contiguous regions where production costs are lower, while at the same time taking advantage of some degree of external economies, given the short distances involved".*

In practice, this trade-off can be seen in the evolution of some urban areas. TOLLEY (1974) argues that the welfare in cities attracts population and make the city grow until the benefits of agglomeration are overwhelmed by the costs of congestion. Empirically, this process has been analysed by BRUECKNER (2000) and MIESZKOWSKI AND MILLS (1993), among others. GLAESER (1998) for the US and LE JEANNIC (1997) for France have found for some cities a decline in urbanisation.

In the framework of the industrial location literature, agglomeration economies are probably one of the most studied determinants of industrial location[31]. However, the fact that it is a very broad concept makes it difficult to compare results across studies, since many different variables proxying for agglomeration economies have been used. However, spatial density variables such as the density of jobs, people and firms have been mainly used. Following the literature on agglomeration economies, two questions regarding their effect on industrial location have been raised:

a) Which type of external economies (localisation or urbanisation) are more suitable for attracting industrial locations?

b) Is there a threshold between agglomeration economies and diseconomies beyond which new locations are no longer attracted?

The first question is a key issue, because it refers to whether firms prefer to be surrounded by firms of the same industry or they just prefer to be in a site with economic activity regardless of its type. Supportive evidence of the existence of

[31] For an exhaustive review on location determinants, see ARAUZO ET AL. (2010).

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both urbanisation and localisation economies can be found in e.g. HANSEN (1987), HEAD ET AL. (1995), FIGUEIREDO ET AL. (2002), GUIMARÃES ET AL. (2004) and ARAUZO AND VILADECANS (2009). However, CIEŚLIK (2005B) and MANJÓN AND ARAUZO (2007) found evidence of a negative effect of urbanisation economies on industrial location. After all, these results depend on factors such as the studied economy and the data and variables that are being used, as well as whether the study has been made by using data referring to sectors or firms.

Regarding the second question, the identification and measurement of the threshold between agglomeration economies and diseconomies is not an easy task and, although agglomeration diseconomies seem to be of high importance, given that they contribute in a negative way to urban competitiveness, scholars have only used some rough measures of agglomeration diseconomies to analyse their effect on industrial location. In the empirical literature, the most common way to measure this negative phenomenon has been by using the square of the agglomeration measure as an additional regressor. By proceeding this way, BADE AND NERLINGER (2000), ARAUZO AND MANJÓN (2004) and ARAUZO (2005) found evidence of both urbanisation economies and diseconomies. In a similar way, VILADECANS (2004) found evidence of an effect of agglomeration diseconomies on industrial location[32] by using the squared population as a proxy.

1.3.2.2 Public Infrastructures

Public infrastructures are also very influential location determinants. Production units have transportation needs, since their activity involves movements of people, inputs and outputs. Therefore, being close to transport infrastructures has been hypothesised to have a positive impact on the location decisions of firms. However, the effects are not homogeneous for all economic activities, since accessibility requirements may differ with sector, input and output transportation needs, etc. For the case of transport infrastructures, COUGHLIN ET AL. (1991), FRIEDMAN ET AL. (1992), SMITH AND FLORIDA (1994), BAUDEWYNS ET AL. (2000), COUGHLIN AND SEGEV (2000), HOLL (2004AB), CIEŚLIK (2005AB) and STRAUSS-KAHN AND VIVES (2005) found that they had a positive effect on industrial location. These infrastruc-

[32]Although this contribution refers to industrial location, the dependent variable that they use is the number of new workers instead of new firms.

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tures include roads, highways and train, port and airport facilities, and they can be measured in different ways. One direct approach is a dummy variable of the existence of the infrastructure in a specific location. Another approach is the transport time or distance to certain infrastructures or facilities, such as highways, ports or airports (LUKER 1998; EGELN ET AL. 2004; GABE AND BELL 2004). After all, the choice of the proper variable proxying for the effects of infrastructures on industrial location largely depends on the data base available by the researcher.

1.3.2.3 Human Capital

Human Capital has also a predominant role in the attraction of industrial location. Intuitively, and especially for certain sectors, entrepreneurs will try to set up firms in those places where they can have access to a qualified workforce. However, for more mature sectors with routinised production processes firms will demand a different type of worker. Thus, the concept of Human Capital is very broad, and it encloses different elements. Some firms are attracted by large labour markets with available workforce for their activities, whilst some other firms just look for high-skilled workforce (engineers, economists, etc.), and then variables like education become important. In this regard, most studies tend to conclude that geographical areas that have a higher mean level of education in the working population are more attractive (COUGHLIN ET AL. 1991; WOODWARD 1992; SMITH AND FLORIDA 1994; COUGHLIN AND SEGEV 2000). In contrast, BARTIK (1985) and ARAUZO (2005) found evidence of the opposite effect. Another key variable related to Human Capital are wages. In principle, production units tend to avoid areas with higher wages, as it has been found by LUGER AND SHETTY (1985), COUGHLIN ET AL. (1991), PAPKE (1991), FRIEDMAN ET AL. (1992), HENDERSON AND KUNCORO (1996), LUKER (1998), LIST (2001), BARBOSA ET AL. (2004) and BASILE (2004). However, high wages can sometimes be a sign of the existence of high-skilled labour force, and therefore places with high wages may attract firms demanding employees, as it was found by SCHMENNER ET AL. (1987), SMITH AND FLORIDA (1994) and HEAD ET AL. (1999).

1.3.2.4 Public Policies

Many economic areas are interested in attracting new firms to the territory, since economic activitiy is a source of employment and wealth. Thus, policy-makers

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from many economic areas (cities, counties, regions, provinces, etc.) undertake policies supporting the location of new economic activities. Of course, public investments in transport infrastructures and facilities also have an attraction effect, but other specific policies exert a positive effect as well. In this regard, GABE (2003) and GABE AND BELL (2004) found positive effects of public investments on industrial location, and LUGER AND SHETTY (1985), FRIEDMAN ET AL. (1992), HEAD ET AL. (1999) and CHENG AND STOUGH (2006) showed how specific public policies as subsidies and incentives helped attracting investments in the form of new production units.

Some regions devote public funds to specific incentive programs aiming to attract new businesses, but the research has yielded only limited and ambiguous results so far. LEE (2008) studied the effect of such programs in the US, finding that they had only limited effects on relocation decisions. GUIMARÃES ET AL. (1998) found similar evidence for the case of the regional incentive policies of Puerto Rico in the early 1980s. Those policies aimed to promote industrial decentralisation and attract new activities to the less developed areas of the island, but no significant effect on manufacturing plants' location decisions was found. However, these programs have been proven crucial when it comes to FDI locations. In this regard, FRIEDMAN ET AL. (1992) and WOODWARD (1992) have found evidence supporting this positive effect.

There are some other institutional factors that affect locations, like the unionisation level of an area. In this sense, BARTIK (1985) and WOODWARD (1992) found evidence indicating that the level of unionisation has a negative effect on the likelihood that new business start-up activities locate in a particular location.

a) Taxation: taxation policies can be very complex and diverse, and their effect on location depends on many factors. In principle, firms tend to avoid high taxes, since they behave as profit-maximising agents. However, local governments that charge high taxes to firms are able to spend more resources in public services such as transport infrastructures and facilities. In this case, high-tax locations are likely to be on average more attractive to firms because of their provision of public goods and services. These two opposite effects constitute a trade-off between taxes and public investment, in that high-tax locations re-

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main attractive as long as they spend large sums of money in the provision of public goods and services (GABE AND BELL 2004). Therefore, empirical evidence of the effect of taxation is ambiguous (see e.g. LUGER AND SHETTY 1985). For instance, BARTIK (1985) found that taxation exerts a moderately negative effect on US states location, whereas CARLTON (1979, 1983) found a non-significant effect of tax levels on location decisions in the US. For the case of FDI locations, COUGHLIN ET AL. (1991), FRIEDMAN ET AL. (1992), WOODWARD (1992), DEVEREUX AND GRIFFITH (1998) and COUGHLIN AND SEGEV (2000) showed that taxes had a negative effect on the location of foreign firms.

b) Regulations: several local, regional and national governments have tried to limit the pollution caused mainly by industrial plants and facilities. The result is that this regulation, in the form of specific taxes to polluting units, has had an effect on location decisions. However, the measurement and effects of such regulations differ across studies. A country where many studies have been made is the US, where since 1970 the Clean Air Act and its Amendments have taken place (see JEPPESEN ET AL. 2002 for an overview). In this regard, BECKER AND HENDERSON (2000) studied Census of Manufacturers data on the location decisions of polluting plants between 1963 and 1992 and concluded that there had been a progressive migration of those firms from areas where the air-quality standards had not been attained to areas where these standards had been attained. The same effect was found by LIST AND MCHONE (2000) in a similar study. On the other side, BARTIK (1988), MCCONNELL AND SCHWAB (1990) and LEVINSON (1996) did not find any statistically significant effect of state environmental regulations on the location of new branch plants. For the specific case of FDI in California, LIST (2001) found similar results.

1.3.2.5 Technological Factors

For the case of technological sectors, there are additional specific factors that determine the final location decision of firms. One key factor are the external economies stemming from the agglomeration of establishments belonging to high-technology sectors, because of the knowledge spillovers that take place. In this respect, BADE AND NERLINGER (2000) find that German start-ups in technology intensive industries prefer to be located in large agglomerations with R&D facilities. Also for the

German case, EGELN ET AL. (2004) studied knowledge intensive spin-offs, finding that the share of employees in R&D sectors had a positive effect on spin-off's location decisions, and AUDRETSCH AND LEHMANN (2005) found that the number of knowledge-based start-ups clustered around German universities was positively influenced by the knowledge output of the respective university and the innovative capacity of the region. In France, agglomeration economies and knowledge spillovers have been found crucial for small and medium size biotech firms and large R&D labs (AUTANT-BERNARD 2006, AUTANT-BERNARD ET AL. 2006). More specifically, ARAUZO AND VILADECANS (2009) show that Spanish manufacturing establishments in high-tech industries prefer to be located as close as possible to the centre of the metropolitan area.

1.3.2.6 Factors Interal to the Firm

This group of factors has not been as much studied as other factors, since data on the personal circumstances of the entrepreneur and the characteristics of the firm are rather difficult to obtain. However, the scarce empirical evidence on the effect of these factors seems to indicate that they do matter. FIGUEIREDO ET AL. (2002) compared location alternatives inside and outside the entrepreneur's area of residence, finding that some investors are willing to pay higher labour costs to take advantage of the potential home-field advantages. In contrast, non-home location choices are strongly driven by neoclassical factors such as agglomeration economies and the proximity to major urban centres. Another key variable is the size of the firm/establishment that searches a location. In that regard, ARAUZO AND MANJÓN (2004) show that large and small firms follow different location patterns, this is, whereas large firms seem to be mostly guided by "objective" factors (e.g. markets' characteristics), small firms seem to be mostly guided by the entrepreneur's preferences (see also CARLTON 1983).

1.4 Effects of New Firms on the Economy

1.4.1 How New Firms Change the Economy and Make it Evolve

The role of new firms has changed drastically over the last half century. Perhaps, it is not just the role of new firms that changed, but also the perception that

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scholars and researchers have of it. Historically, industrial organisation economists have studied the role of entry and its determinants, concluding that entry was not very important (ACS AND AUDRETSCH 1990). In fact, the growing interest in firm entry can be related to a growing interest in the multidisciplinary field of entrepreneurship, which has come to be perceived as an engine of economic and social development throughout the world (ACS AND AUDRETSCH 2003). Entrepreneurship research is a growing field, and it includes disciplines as heterogeneous as economics, geography, management, finance, strategy, psychology and sociology[33]. This interdisciplinary nature allows the study of entrepreneurship from many different perspectives. The analysis presented in this chapter is carried out from the economics perspective, and although there exist many alternatives on how to measure entrepreneurship —specifically when it comes to its empirical measurement— (AUDRETSCH ET AL. 2006), a widely accepted way is to consider the entry of new firms or establishments in the market and, more specifically, the entry rates, that is, the number of new firms divided by the number of existing firms. Besides, the focus of this chapter in on the effect of new firms on the industry they are entering, and subjects such as financing, ownership and the background of the entrepreneur are not considered here.

There are many scholars who have come to the conclusion that entry plays a fundamental role in the evolution of markets and the development of the economy as a whole. One of the pioneering works is GEROSKI (1991), with which the author wanted to prove that entry could play a more significant role in the evolution of markets than the simple view of entry as an error correction mechanism suggested by static theories of industrial organisation. GEROSKI (1995) covered a broad range of aspects related to the entry of firms in markets, i.e. entry rates and patterns, market penetration, firm turnover and survival. Besides, the study covered many aspects of the effects of new firms on the market, such as entry barriers, prices, margins and the relationship with incumbents. Specifically, the author devoted a large part of his contribution to assess the effects of entry on productive efficiency and innovation in markets, concluding that it is difficult to convincingly state whether

[33] ACS AND AUDRETSCH (2003) stands for an interdisciplinary survey on entrepreneurship research, AUDRETSCH ET AL. (2006) gathers several topics regarding entrepreneurship and economic growth, and both AUDRETSCH (2006) and CARREE AND THURIK (2006) are collections of articles about the same topic.

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new firms have an important role in stimulating innovation, since the entry process is very selective and there are other factors coming into play, such as the stage of the industry life cycle, the competitive pressure of entrants, the existence of potential technological opportunities and, most important, the imitative or innovative nature of the entering firm. In fact, the increased importance of new firms can be contextualised in relation to the changes that many industrial markets have experienced during the last decades. According to ACS AND AUDRETSCH (2003), two systematic findings can be reported: (a) the industry structure is generally shifting towards an increased role for small firms and (b) the extent and timing of this shift is anything but identical across countries. The finding (a) has been straightforwardly related to the emergence of entrepreneurship, the role of which has been related to changes in the industry structure towards less concentration and centralisation. This statement is backed by empirical evidence that economic activity moved away from large to small firms in the 1970s and 1980s[34].

The next subsection reviews the main contributions on the effect of entries on different economic variables, i.e. economic growth, competition, innovation and productivity[35]. The number of such contributions has increased recently, mainly due to the increasing availability of new data sets and the development of new econometric tools. It is noteworthy that the discussion about the effect of entries on these economic variables has a common point, that is, to what extent new firms are responsible for the changes that the industry undergo. In the case of the introduction of innovations, the fact that only a fraction of entries are innovative casts doubt on the idea that they always serve as the vehicle for new ideas. On the other hand, it can be argued that, although innovative entry constitutes a small proportion of entries, these entrants are responsible for a major share of total innovative activity. The debate in the literature revolves very often around whether it is new entrants or rather established incumbents the agents responsible for major changes and improvements in the industry. The answer is anything but straightforward, since sur-

[34]The literature on entrepreneurship is broad and very diverse, and while some contributions highlight the fact that entrepreneurship is brought into being by means of *new firms*, other studies rather focus on the role of *small firms*. Although it seems quite obvious that both concepts are not quite the same, it is also true that a large part of new firms have a small size (GEROSKI 1995), which makes the distinction of both terms not always clear.

[35]The effects of entries on labour demand are reviewed extensively in Section 3.2 of this thesis.

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viving entrants become incumbents immediately after they are in the market and also a competitive environment somehow forces incumbents to behave efficiently and innovatively, a convincing reason why the importance of new firms should not be dismissed.

1.4.2 Theoretical Framework

The theoretical framework of many empirical contributions on firm dynamics are the industrial dynamics models, which aim to model the long-term evolution of the industry. These theories assume that plants face ex-ante uncertainty about their underlying ability or efficiency once they entered in the market. Such underlying efficiency is not to be observed once the firm has entered, it is rather gradually learned over time through the process of production, and this information eventually determines which firms exit and which ones survive and grow. A pioneering contribution presenting such model is JOVANOVIC (1982), which was referred to as a passive learning model, that is, entering firms had nothing left but to discover whether or not they were efficient enough to remain in the market, regardless of potential proactive initiatives that they could undertake. An alternative theory was given by ERICSON AND PAKES (1989), which develop a firm and industry dynamics model that explains more thouroughly and accurately the phenomenon of high turnover rates of jobs and firms. Specifically, the Ericson-Pakes theory assumes that firms make investments whose outcome is stochastic and uncertain, and at the end the relative position of each firm relative to its competitors will determine the firm's expansion, contraction or even exit. Because this model entails elements of active learning and selection, it is considered to be an *active learning model*, which also helps explaining industry selection processses and heterogeneity. HOPENHAYN (1992) develops and analyses a dynamic stochastic model for a competitive industry which endogenously determines processes for entry and exit and for individual firms' output and employment. The presented model is based on the previous ones, and is intended to provide a simpler framework to address questions relating to the process of job and firm reallocation. Specifically, the model assumes a stationary equilibrium, and its analysis allows the understanding of how changes in structural characteristics of an industry (i.e. entry costs, fixed costs demand and firm shocks) affect turnover, firm growth, and the distribution of size, profits and value of firms. The knowledge of firm and industry dynamics was enriched and furthered by AUDRETSCH (1995),

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which expanded the passive learning approach into an evolutionary perspective, allowing for inter-industry differences in the likelihood of survival of new firms, whose survival likelihood as well as entry and exit are determined by industry-specific characteristics, such as scale economies and the endowment of innovative capabilities. Thus, only the most efficient among newborn firms will survive and grow, whereas the others are pushed out of the market.

1.4.3 Economic Growth

The lasting dismissal of entrepreneurship and market dynamics in economic growth theory parallels in some ways its lack of study in the field of industrial organisation. Neoclassical growth models have given new firms and activities no role in the growth process of an economy. A seminal work by SOLOW (1956) provided the most studied and referenced growth model, which focused on the role of the capital factor in relation to the output level[36]. An important characteristic of this growth model and neoclassical growth models in general is that technological improvements are exogenous and not related to individual initiatives such as new firms. This rather limited vision of economic growth was broadened by further contributions which have been labelled as endogenous growth models, which have as a common feature that technological change is assumed to be the result of the intentional actions of economic agents, such as research and development[37]. However, a large part of endogenous growth models does not take into account the role of entrepreneurs in fostering technological change and economic growth. A remarkable exception is AGHION AND HOWITT's (1992) model of creative destruction, which incorporates into growth theory the Schumpeterian idea of creative destruction. This model departs from existing models of endogenous growth in emphasising issues such as the obsolescence of old technologies induced by the

[36]Specifically, the growth of an economy, measured as the output-labour ratio, was determined by the capital accumulation and exogenous technological process. Just because capital's decreasing returns to scale, the economies tend to a steady state. Solow considered that the output growth not due to accumulation of factors was explained by a variable called *Solow's residual*, an exogenous variable that grows at a constant rate. This model, despite its important limitations, has been considered by economists for a long time, and even at present there is a stream of literature whose theoretical model is based on Solow's model (MANKIW ET AL. 1992; BARRO 2001).

[37]For complete textbooks on endogenous growth theories, see AGHION AND HOWITT (1998) and BARRO AND SALA-I-MARTIN (2004).

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accumulation of knowledge and the resulting process or industrial innovations, the growth resulting from research and also the degree of market power available to the innovator. The Schumpeterian entrepreneur plays a crucial role in this model, since he is to enjoy temporary monopoly power in case he successfully patents an innovation that renders previous products or processes obsolete. However, this model has a main drawback: it assumes that monopoly rent is what induces firms to innovate and thereby makes the economy grow, and thus following this argument product market competition can only be detrimental to growth. However, this assumption is contradicted by empirical evidence pointing out that there exists a positive relationship between market competition and productivity growth (BLUNDELL ET AL. 1995; NICKELL 1996). Such evidence points out that market competition fosters growth because it forces firms to innovate in order to survive.

The empirical evidence on the effect of entrepreneurship on economic growth is characterised for being very heterogeneous and yielding dissimilar results among studies and economies[38]. One source of heterogeneity is the level of analysis, which ranges from cities to counties, regions and countries, making it hard to compare among different studies. However, in this subsection only those contributions analysing explicitly output growth are considered. Besides, economic growth is a very broad concept, and empirical contributions have used a wide array of measures to proxy it, such as output growth, employment growth and both labour and total productivity growth[39]. REYNOLDS (1999) analysed the relationship between creative destruction and economic growth, finding that these phenomena occured together but that there is not a causal relationship between them. Besides, the author emphasises that creative destruction is a very broad concept, and that it is not clear which features of creative destruction (i.e. new firm births, small firm expansions) are central to enhancing economic growth. In this respect, CARREE AND THURIK (1998) pointed out that economic activity in manufacturing industries moved away from large firms toward small firms in many OECD countries,

[38]The studies included in this review refer only to the effect of new firm entry on economic growth, although there are many other measures that have been studied, such as the size distribution of firms, the number of firms or the number of self employed. For a complete review, see ACS AND AUDRETSCH (2003).

[39]In that respect, ACS (1992) distinguishes four consequences of the importance of small firms: a vehicle for entrepreneurship, routes of innovation, industry dynamics and job generation.

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this transformation process varying across countries. The authors tested it for the European economies, finding that the employment share of large firms in 1990 has a negative effect on output growth in the subsequent four-year period. ACS AND ARMINGTON (2003) emphasise the role of local externalities as opposed to scale economies as the primary engine in generating growth in cities and surrounding areas. The authors examined the impact of these externalities on regional growth from an entrepreneurial perspective by examining the relationship of local economic growth to local entrepreneurial activity for the US economy, concluding that higher rates of entrepreneurial activity were strongly associated with faster growth of local economies. A different conclusion was reached by AUDRETSCH AND FRITSCH (1996) for the German economy during the 1980s, finding that regional high rates of turbulence tended to lead to lower rates of growth. The explanation the authors gave was that German new firms might not have been agents of change through innovative activity, unlike other countries such as US. After all, these dissimilar results showed that the link between new firms and economic growth was not straightforward and a theoretical background as well as further evidence were needed. AUDRETSCH AND FRITSCH (2002) came up with an explanation of the role of new firms on economic growth. These authors coined the term *growth regime*, which is derived from the concept *technological regime* proposed by NELSON AND WINTER (1982)[40]. They extended the concept of technological regimes to regions, asserting that each region could have a different growth pattern, depending on whether it was caused by new entrants or by incumbent firms. They tested this hypothesis for the German economy, identifying four types of regimes: (a) entrepreneurial regime, under which new start-ups and a turbulent enterprise structure are the main sources of growth; (b) revolving door regime, which applies when a region shows high rates of firm entry but no growth; (c) routinised regime, happening when the source of growth is the innovative activity and job creation provided by established firms; and (d) downsizing regime, which is characteristic of those regions showing neither

[40]This contribution aimed at reconciliating the a priori contradictory Schumpeterian assumptions about the nature of creative destruction. That is, while SCHUMPETER (1934) argued that new firm entry and the displacement of incumbents fostered innovation and growth, SCHUMPETER (1942) contradicted himself by stating that large corporations were more conductive to innovation and growth. NELSON AND WINTER (1982) combined and reconciled these approaches, in that each industry could operate under either an *entrepreneurial regime* or a *routinised regime*. The former regime is favourable to innovative entry, while the latter is favourable to innovative incumbents. The regime that each industry has is to be determined by the underlying knowledge conditions.

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high entry rates nor economic growth and development. Also for the German case, AUDRETSCH AND KEILBACH (2004AB) study the link between entrepreneurship and economic growth at the regional level. They adopt a different approach, and consider entrepreneurship as a part of the social capital that can be included into a regional production function. They proxied entrepreneurship by the startup activity and estimated its contribution to a Cobb-Douglas production function whose output is per-capita income growth, finding a positive relationship between these variables. This approach is sophisticated in AUDRETSCH AND KEILBACH (2005), confirming the previous finding but adding new evidence, i.e. entrepreneurship capital is stronger in urban areas and is spatially correlated, and the results holding only for risk-oriented measures of entrepreneurship capital and for densely populated regions.

1.4.4 Competition

The study of the role of new firms at the level of industry competition dates back to the first contributions in the field of industrial organisation. Insightful and cornerstone contributions like CHAMBERLAIN (1933) and ROBINSON (1933), the parents of the modern study of imperfect competition, triggered the study of different market structures. Since then, theoretical models of imperfect competition based on these seminal contributions have made diverse predictions about the competitive effects of entry. On the one side, contestable market theories (BAUMOL ET AL. 1982) are based on the fact that low barriers to entry and exit represent a constant entry threat for incumbents, which keeps market power low and the competitive effect is reached without the direct inclusion of new firms. On the other side, entry barrier models assign a limited role to potential entrants, and the deterring effect of entry barriers actually sets incumbents free from competition pressure and thus enables them to enjoy market power[41]. Having these models as a theoretical framework, many contributions have tried to assess the prevalence and consequences of entry with respect to market competition. BRESNAHAN AND REISS (1990) estimate structural econometric models of entry in monopoly markets for the automobile retailing industry, and by means of the estimation of price-cost margins and entry barriers they obtain that barriers to entry are low in small markets and that it is compatible with the existence of market power. The study of entry in concentrated markets

[41] For a comprehensive exposition of these theories, see TIROLE (1988).

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is both theoretically and empirically analysed by BRESNAHAN AND REISS (1991), which propose an empirical framework for measuring the effects of entry on atomistically competitive markets and estimate it for US industries. This study deals with the relationship between the number of firms in a market, market size, and competition, obtaining that the competitive conduct changes quickly as the number of incumbents increases, i.e. in markets with five or fewer incumbents, almost all variation in competitive conduct occurs with the entry of the second or third firm, while once the market has between three and five firms, the next entrant has little effect on competitive conduct. The causal relationship between entry and profit margins is also studied by GEROSKI (1989B), which examines a dynamic feedback model of entry and profit margins for the UK economy. The interaction between these two variables is found to be weak, entries having no effect on margins and also varying over industry and time far more than margins do. This result was included in the literature survey GEROSKI (1995), where some stylised results are gathered and discussed. One of such results is the fact that entry reacts slow to high profits, a result that contradicts the theories predicting that entry levels depend on expected profits. This way, entries vary much within industry and over time, being expected profits much more stable and varying mainly between industries. As a result, empirical equations trying to explain variation in entry across industries and over time as a function of expected profits and entry barriers yield very poor fits. Analytically, the empirical equation takes que form

$$E_{it} = \beta\{\pi^e_{it} - F_{it}\} + \mu_{it}, \tag{1.1}$$

being i and t industry and time dimensions, π^e expected profits, F barriers to entry and μ a disturbance term. In the literature, a large part of the results have yielded very low estimates for β and a very poor fit, remaining the large part of entry variation in the disturbance term μ. This result implies that the determinants of entry are to be found in other variables that show more time-variation than π^e and F. Besides, this result somehow breaks the myth that entries are an error-correction process occurring when excess profits are high and reducing them to the level where they are in equilibrium with entry barriers. Therefore, in most cases entries only have a modest effect on mark-ups and profits (GEROSKI 1990)[42]. In a more recent

[42]However, this result is consistent with the fact that entry can have an important effect on prices as long as they force incumbents to cut their costs to an important extent.

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contribution, BERRY AND REISS (2007) review the multiple empirical models of entry and market structure, paying particular attention to equilibrium models that interpret cross-sectional variation in the number of firm turnover rates for different industries.

1.4.5 Innovation

The relationship between entrepreneurship and innovation has been also a source of both theoretical and empirical contributions, yielding often contradictory and dissimilar results. Before reviewing these, some clarification of a conceptual nuance is needed. As stated earlier, the discussion can be put in terms of small and big firms and also of new and established firms. In many cases the difference is not of great importance, due to the average small size of entrants and the bigger size of incumbent firms, but the difference is meaningful and its consequences should not be dismissed. Regarding the empirical analysis, contributions have mainly considered firm size to test whether large or small firms are the main driving forces of innovation. Next, the main contributions about the role of entrepreneurship and firm size in innovation generation are reviewed[43].

The field of innovation economics and specially the role of small firms in it is very novel. During the largest part of the XXth century, the common opinion of economists and scholars was that innovation and technological change lie in the domain of large enterprises and that small firms were not efficient enough and had not enough market power to undertake innovative activities and face their costs (SCHUMPETER 1942; GALBRAITH 1956)[44]. However, such beliefs have been shaken by a recent wave of contributions, which have shed light on the role that many different types of firms (not just according to size) play in (different) innovation generation processes[45]. In this regard, an interesting result is that, while larger

[43] The aim of next review is not to cover the whole field of economics of innovation but to explicitly focus on the mentioned relationships. For a complete review of this field, see ANTONELLI (2003).

[44] Some of the factors identified in the literature are that innovative activity requieres a high cost, a temporary market power has to be achieved, R&D investment is risky, scale economies in production are important and only large firms can obtain high profits from cost-reducing innovations (ACS AND AUDRETSCH 2003).

[45] The empirical literature on innovation has considered a wide array of measures proxying for firm innovation, i.e. patents, R&D investment, technical innovations and new products, to name

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firms tend to invest in R&D more than proportionally compared to small firms (SCHERER 1984,1991), these seem more prone to patent inventions (BOUND ET AL. 1984; SCHWALBACH AND ZIMMERMANN 1991). The latter result has been explained by arguing that small firms have less bureaucratic organisations, suffer less managerial restraints and often place innovative activity at the center of their competitive strategy. The trade-off between the suitability of either large and small firms for achieving technical advance was studied by COHEN AND KLEPPER (1992), which support both sides of the debate, i.e. while industries composed of many small firms tend to exhibit greater diversity in the approaches to innovation pursued, which is an advantage, industries composed of large firms will achieve a more rapid rate of technical advance due to the appropriability advantage, that is, the market power they can achieve. ACS AND AUDRETSCH (1988) introduced a new measure of innovative output[46] and considered it in the analysis of the market structure, finding that the number of innovations rose with increased industry R&D expenditures at a decreasing rate and that industry innovation tends to decrease as the level of concentration rises. In a similar study, ACS AND AUDRETSCH (1990) concluded that not only does market structure influence the total amount of innovative activity, but also the relative innovative advantage between large and small enterprises. Specifically, they found that the relative innovative advantage of large firms is higher in capital and advertising intensive industries, while small firms have an advantage in highly innovative industries that are mainly composed of large firms. Yet another approach to look at the subject is by considering the relationship between competition and innovation. Although competition does not necessarily mean that there are new firm entries taking place, the opposite is true, that is, those industries where new firms keep coming have a higher degree of competition. This approach is adopted by AGHION ET AL. (2006), which develop a Schumpeterian growth model and test it empirically, obtaining an inverted U relationship between product market competition and innovation.

The role of small firms in the innovation process can be also explained by two other sources. The first one is the existence of spin-offs, which occurs when an em-

some of them. Currently there exists in the literature a discussion about the suitability and reliability of different innovation measures.

[46]Specifically, they used the number of innovations in each four-digit SIC industry and related them to the size of firms in each sector.

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ployee of a large corporation generates knowledge and then creates his/her own firm to exploit it. The other source are the spillovers, which are those benefits obtained from R&D undertaken by other agents (mainly other firms, universities and research centers). In this respect, JAFFE (1989) and ACS ET AL. (1992) found that knowledge created in university laboratories spills over to contribute to the generation of commercial innovations by private firms, and ACS ET AL. (1994) found specifically that those spillovers contributed more to the innovative activity of small firms, in that these innovate through exploiting knowledge created by expenditures on research in universities and on R&D in large corporations. The question of the generation and transmission of knowledge spillovers has gained importance in the literature, since this knowledge is an important source for innovative small firms. One relevant aspect of knowledge transmission is its geographic range, that is, to what extent such knowledge spills over just at a cluster level, city level or a region level. ANSELIN ET AL. (1997) confirmed a positive and significant relationship between university research and innovative activity, both directly and indirectly through its impact on private sector R&D. Besides, they found that the spillovers of university research on innovation extended over a range of 50 miles from the innovating metropolitan areas. In a similar study, ANSELIN ET AL. (2000) found empirical evidence for the existence of both sectoral and regional differences in the innovative process, in that different mechanisms could be at work to generate externalities in connected as opposed to unconnected metropolitan areas. In fact, the existence of such spillovers are important not only for the innovative role of small firms and the production of innovations, but also it has effects on the location of firms and the geographic distribution of the industry. As AUDRETSCH AND FELDMAN (1996) show, the relative importance of new economic knowledge in each industry determines the extent to which the location of production units in such industry is geographically concentrated. This way, industries in which knowledge spillovers are more prevalent have a greater propensity for innovative activity to cluster than industries where knowledge externalities are less important. This fact is also explained in AUDRETSCH (1998), highlighting the fact that, since nowadays the innovative activity determines the comparative advantage of countries, and thus the value of knowledge-based economic activity has increased, which tends to be geographically clustered, then it has triggered a shift in public policy towards enabling policies at the regional and local levels. In addition, the importance of knowledge transmission between different agents has shifted the focus of the analysis of inno-

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vation determinants from the firm level to a broader dimension. In the words of AUDRETSCH AND FELDMAN (2004, P.2734):

> *"[t]he model of the knowledge production has been found to hold better for spatial units of observation than for enterprises in isolation of spatial context".*

These authors also point out future research directions:

> *"[w]hile research has determined that geographic space matters for innovation, it has yet to unravel how agglomerations are formed, where they come from, how they are either sustained and strengthen, or else deteriorate over time".*

1.4.6 Productivity

Again, new firm entry plays a key role in industry productivity gains. This relationship has been investigated and proven both by theoretical models and empirical estimations, and adopting very heterogeneous approaches, i.e. focusing on labour productivity and total factor productivity (henceforth TFP), considering different industries and also using different measures of firm entry, exit and turnover. Even after considering the specificities of different contributions, it must be accepted that there exists conclusive evidence that the dynamics of industries do have a role in productivity gains. One of the first contributions to this issue is GEROSKI (1989A), which studied correlations running from both entry and innovation to productivity growth rates in a sample of UK industries, finding that innovative activity accounted for a larger positive effect on TFP growth than domestic entry, and that foreign entry had a little effect on TFP growth. After this contribution, there have been many studies following different approaches, some of them being reviewed hereafter.

Firm entry can have many effects in the industry they enter, and one of these effects is that they force incumbents to behave more efficiently. This effect was studied by AGHION ET AL. (2004), which specifically studied the effect of entries on incumbent productivity growth, showing that more entry, measured by a higher share of industry employment in foreign firms, has led to faster TFP growth of domestic incumbent firms and thus to faster aggregate productivity growth in the UK. In a similar study, AGHION ET AL. (2006) introduce entry into a

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Schumpeterian growth model with multiple sectors which differ in their distance to the technological frontier, and then test it empirically for the UK economy, obtaining that entry threat has positive effects on incumbent innovation incentives and productivity growth in industries initially close to the technological frontier, but not in those industries that are initially further behind the frontier. A different and more complete approach to this phenomenon is to consider the effect that both entry and exit have on the overall industry productivity. OLLEY AND PAKES (1996) follow this approach and use plant-level data to study productivity dynamics in the telecommunications equipment industry for the US. They obtain that, after the industry was deregulated, there was an increase in firm entry and exit and a change of incumbents' size, with the overall result of productivity gains due to a reallocation of capital towards more productive establishments. A similar approach is taken by DISNEY ET AL. (2003), which study productivity growth in UK manufacturing due to both internal and external restructuring, the former consisting of new technology and organisational change among survivors and the latter being exit, entry and market share change. Their results indicate that much of the external restructuring effect comes from multi-establishment firms closing down inefficient plants and opening more productive ones, and also that external competition is an important determinant of internal restructuring. The relationship between productivity and the openness of the industry is covered by MELITZ (2003), in that his study introduces in the analysis the inter-industry effect of international trade and exporting activity. The author develops a model showing that the exposure to trade induces only the more productive firms to enter the export market, remaining some less productive firms producing for the domestic market and exiting the least productive firms. The overall result is that industry's exposure to trade lead to additional inter-firm reallocations towards more productive firms, with a result of aggregate industry productivity growth and welfare gains. A different approach is adopted by NICKELL (1996), in that his study considers as a productivity determinant the level of industry competition instead of firm entry. He studies for the UK economy the effect of industry competition —measured by increased numbers of competitors or by lower levels of rents— on corporate performance, finding that competition is associated with a significantly higher rate of TFP growth. FOSTER ET AL. (1998) analyse establishment-level data to examine the relationship between microeconomic productivity dynamics and aggregate productivity growth for the US, finding that

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the contribution of reallocation of outputs and inputs from less to more productive establishments plays a fundamental role in the aggregate productivity growth, having the contribution of net entry to aggregate productivity growth an increasing trend in the long term. This evidence confirms the existence of a creative destruction process by which old firms contribute negatively to the growth of labour productivity, and also that new firms replacing old ones bring about labour productivity gains because new jobs incorporate the most recent technological innovations.

There are several contributions for the Spanish case. MARTÍN AND JAUMANDREU (2004) study productivity growth in Spanish manufactures during the 1980s, a time period characterised by an intense competitive pressure derived from the EEC integration, which resulted in an extensive structural change through a process of creative destruction, reflected mostly in high and unbalanced gross rates of firm entry and exit. Their results indicate that there were efficiency and productivity gains strongly linked to competitive pressure and the restructuring of industries through two channels: incumbent firms sharply increasing efficiency to survive, and the replacement of less efficient firms by new competitive entrants. Following an alternative approach, FARIÑAS AND RUANO (2004) study the contribution of turnover and continuing firms to TFP growth in Spanish manufactures during the 1990s, and buy applying a non-parametric decomposition approach[47] they obtain insighful results, i.e. incumbent firms are the main factor contributing to the change in the productivity distribution, the replacement of exiting firms by entering ones has a positive effect on productivity, and net entry has a negative effect on productivity, this latter result explained by the fact that new entries have less productivity than incumbents at the moment of the entry, thus changing the relative weights of incumbents. CALLEJÓN AND SEGARRA (1999) bring along the interesting discussion about the innovative/imitative nature of entries. Although the fact that firm entries are a very heterogeneous phenomenon, in that each entry is unique in its nature, size, technological ability and competitiveness, some studies take for granted that entries are innovative in nature and hence they contribute to productivity and innovation. In countries like Spain, whose economy does not lie on the knowledge frontier and thus is more user than producer of technology, models of technological change based on embodied technology can contribute to better

[47]Specifically, this decomposition approach consists of the definition of counterfactual distribution functions in order to characterise the dynamics of productivity distributions.

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understand market dynamics. By using one of these models, their study tests the assumption that a significant part of new firms contribute to improve TFP by adopting modern technology embodied in the capital they use, and concludes that entry, exit and turnover contribute positively to TFP growth, although the positive impact changes both across regions and industries.

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Chapter 2

Firm Location: an Empirical Analysis focusing on Distributional Issues, Spatial Effects and Nonlinearities

2.1 Motivation

The location of economic activity has been a major topic of economic analysis since the seminal works of Alfred Marshall (external economies), Alfred Weber (the impact of transportation costs on the location decision), Johann Heinrich von Thünen (land use model), Walter Christaller (Central Place Theory) and William Alonso (Central Business District). However, in recent years the firm location literature has been attracting a growing interest from researchers, and hence both theoretical and empirical contributions have increased considerably. One key issue that helps explaining such interest is the existence of strong policy implications deriving from the economic phenomenon of firm location. Nowadays economic activity is being more mobile than before and this means that traditional sources of competitiveness are being modified. Therefore, it is important to know which the location determinants of those manufacturing firms are, and why some territories seem to be in a better position to receive new firms than others.

During the last decades, many significant breakthroughs were made in the analysis of firm location behaviour (McCann and Sheppard 2003). These studies have highlighted that there exists a new group of factors, such as the rise

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of economic integration processes and free trade areas, as well as the growth in new communication technologies, that have changed the patterns of firm location. This group of studies can be classified into a discipline called New Economic Geography, which was founded by Paul Krugman at the beginning of the 1990s and provides new approaches to study spatial economic phenomena[1]. Besides, new developments both in data availability and econometric analysis have triggered the interest in firm location and trade, an interest that has spanned a range of disciplines including economics, geography, management science, marketing and international business studies.

From an economic point of view, the location of new production units is a relevant issue, in which entrepreneurs, managers and policy makers are involved. For the entrepreneur, the location choice may probably determine the success or failure of a new production activity. Consequently, the public sector gives entrepreneurs advice on location decisions so that the probability of success of new units increases. Some of the initiatives the public sector undertakes to help new firms succeed are the *business incubators*, the improvement of infrastructures, financial support and tax reductions. Therefore, the location of new firms and establishments involve a continuous reallocation of an important amount of both public and private resources. However, the knowledge of the factors determining the specific geographical location of an economic activity is still relatively limited (HAYTER 1997).

The empirical analysis of firm location can be made following different approaches. On the one hand, the research can focus on the viewpoint of the agent that makes the choice, this is, which characteristics of both the entrepreneur and the firm determine the location decision. Methodologically, in order to empirically analyse these effects a Discrete Choice approach is adopted. On the other hand, the analysis can focus on the territory, studying the effect of territorial characteristics on the number of new units located in each spatial unit. This is empirically analysed

[1]New Economic Geography is a relatively new field of economic sciences which, in addition to the formalisation of older location and foreign trade theories, examines the modern causes that explain why economic activity tends to concentrate in some regions and tend to abandon others (see FUJITA ET AL. 1999).

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by estimating Count Data models[2]. In the contribution presented in this chapter the second approach is adopted. The reason for this choice is twofold: on the one side it responds to the nature of the available data, and on the other side it is suitable for the methodological proposals put forward in this chapter. Finally, some methodological proposals that can help both improving and enriching the empirical literature on firm location are made.

One key issue discussed in this chapter is the spatial dimension of firm location, and how it can be efficiently taken into account in the analysis. The empirical evidence suggests that the location of new units has to do with space, yet so far the study of this link is not generalised in the firm location literature. The location of productive units is unevenly scattered across the geography, and zones where almost no locations take place coexist with highly agglomerated zones. A consequence of this fact is the existence of a high spatial heterogeneity in the data as well as crossed effects between the different territories, which is called spatial dependence. Although several contributions trying to incorporate these effects in the context of firm location studies have been proposed, the exhaustive consideration of such effects and the use of new methodological quantitative tools allowing such analysis are still a pendent assignment. In this chapter, evidence on the presence of spatial heterogeneity and spatial dependence of firm entries is presented, and in order to deal with it spatial econometric techniques are used in the empirical model estimation.

The second key issue is the measurement of potential nonlinear effects between some territorial variables and the location of new productive units. An illustrative example of such nonlinearities is the existence of both economies and diseconomies of agglomeration, which shows how the same variable (in this case, a variable proxying for agglomeration effects) can exert both a positive and a negative effect on the dependent variable. So far, just parametric methods have been used to measure such nonlinearities. However, these potential nonlinearities could be more efficiently analysed by means of more flexible specifications and estimation methods. In order to do so, in the present analysis a more flexible semiparametric specification is used, which allows the effect of the regressors on the dependent

[2]See ARAUZO ET AL. (2010) for a discussion.

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variable to vary across the regressor's whole range, thus allowing the study of potential nonlinear relationships between different territorial variables and location processes.

A third issue is the explicit study of those territorial units that receive no entries at all. Theoretically, count data models, such as Poisson or Negative Binomial models, allow the existence of zero counts. But once the proportion of zero counts becomes larger, Poisson and Negative Binomial models cease to be efficient (CAMERON AND TRIVEDI 1998). A solution widely used in the literature has been the use of zero inflated models, such as the Zero Inflated Poisson and the Zero Inflated Negative Binomial models (GABE 2003; MANJÓN AND ARAUZO 2007; ARAUZO 2008). These models, although taking into account the zero counts by means of a discrete mixture of distributions, do not allow the modelling of zero and non-zero counts separately. In this chapter an alternative approach is proposed: instead of assuming the same effects for the zero and non-zero counts, such approach lies on the assumption that the set of regressors and their coefficients need not be the same in both cases. The model to be estimated is called Zero Augmented Inverse Gaussian (ZAIG), its remarkable characteristics being the different treatment of zero and non-zero counts and also the nonparametric analysis of nonlinearities, two issues which are important in the context of the firm location literature.

This chapter is structured as follows. Section 2 deals with the methodological issues, first by exposing technically the Count Data models used in the literature, and then by pointing out the main drawbacks and limitations of such methods in the context of the firm location analysis, that is, the presence of overdispersion and excess of zero counts. Specifically, the problems of spatial effects, the measurement of nonlinearities and the treatment and interpretation of zero counts are explained in detail. Section 3 presents and describes the data and variables used in the analysis, and both the description and the descriptive statistics of such variables are exposed. This statistical analysis takes into account both the existence of multiple zero counts and the sectoral division of entries. Section 4 provides the first part of the empirical analysis, which is an exploratory analysis that deals with the distributional characteristics of the dependent variable (establishment entries) and speficically focus on it spatial dimension, thus justifying the grounds of the need for an alternative approach. Section 5 provides the empirical confirmatory analysis by proposing and

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empirically estimating a Zero Augmented Inverse Gaussian (ZAIG) model. Such analysis is made both for the overall manufacturing sectors as well as for five sectoral aggregates, with the aim of obtaining insights into sectoral differences in the location patterns of firms. In section 6 the main conclusions are summarised.

2.2 Methodological Issues

2.2.1 Empirical Analysis of Firm Location

The empirical literature on firm location has experimented a rise in the recent years due to the higher availability of new data and estimation methods. Besides, the topic is of concern both to entrepreneurs and policy-makers, and therefore it is of great importance to empirically study the factors that shape this decision. Analytically, there are mainly two main methodologies suitable for the study of location determinants:

a) Discrete Choice Models (DCM): these models study specifically how a set of individuals (firms/plants) choose among a set of territorial alternatives (municipalities, counties, regions, etc.). In order to analyse this decision, both factors related to the agent taking the decision (e.g. entrepreneur, manager, etc.) and factors related to the set of territorial alternatives are accounted for. This way, both territorial and decision agent's characteristics explain why some territories are comparatively more attractive than others[3].

b) Count Data Models (CDM): this methodology focuses strictly on territorial charactersitics that determine the average number of new firm/plants that are located therein, so that the location of firms is studied from the point of view of the chosen geographical space. This way, as opposed to DCM, decision agent's characteristics are not taken into account, and those territories that get no entries are also considered for the analysis[4].

Both methodologies differ in the sense that the statistical information and the quantitative tools required are not the same (BRADLOW ET AL. 2005). However,

[3] For a review of the principal assumptions about DCM in the context of the firm location analysis, see CARLTON (1979) and MCFADDEN (1974).

[4] See CAMERON AND TRIVEDI (1998) for a complete analysis of CDM.

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from a conceptual point of view, both DCM and CDM are consistent with a profit maximisation framework in which the optimal location is chosen subject to certain restrictions. Besides, results from both methodologies can be interpreted as reduced-form results derived from a structural model of firm location decision (BECKER AND HENDERSON 2000; GUIMARÃES ET AL. 2004).

There are some pros and cons of using both models. On the one side, DCM account not only for territorial characteristics, but also for the agent's ones. However, when the number of location alternatives gets larger the computation of the likelihood function becomes problematic. On the other side, although CDM do not consider agent's characteristics, their computation is easier to carry out, and also they allow the inclusion of territories with no entries in the analysis. This is a relevant issue, since territorial characteristics also explain why some territories do not attract entries (MULLAHY 1997).

2.2.2 Count Data Models

2.2.2.1 Motivation

Most of recent research on location decisions is based on CDM, which are concerned with the modelisation and estimation of event counts. An even count is the realisation of a nonnegative integer-valued random variable, and the first distrubution that was used in this framework is due to POISSON (1837). The Poisson distribution has been and still is the cornerstone of the analysis of CDM. However, problems relative to the distribution of the data have led to many further developements, like the Negative Binomial distribution, which is a standard generalization of the Poisson distruibution controlling for unobserved heterogeneity (GREENWOOD AND YULE 1920). A crucial development of CDM was the emergence of Generalized Linear Models (CLM), first described by NELDER AND WEDDEBURN (1972) and detailed in MCCULLAGH AND NELDER (1989). GLM are an extension of classical linear models, in that they allow the distribution of the dependent variable to belong to a broad collection of dstributions. This collection is called the exponential family, and it comprises the Poisson and related distributions. In this sense, GLM are a framework in which several models can be fitted[5].

[5]The formal description and some concepts and definitions relative to GLM can be found in Section A.2.1 of the Appendix.

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2.2.2.2 Basic Assumptions

In the case of firm location, the counts are the number of new locations that take place in a certain period of time. BECKER AND HENDERSON (2000) expose the principal assumptions of CDM applied to the particular case of firm location. Specifically, they adapt the stock model in HENDERSON ET AL. (1995) in order to model the birth process in each county. The assumptions are as follows:

a) For each industry, at a point in time t, there is a supply of entrepreneurs who might enter this industry in spatial site i, for $i = 1, \ldots, N$. This supply function to a spatial site is stochastic, and is upward sloping in the number of new firm/plants created over a certain period of time (y_{it}), the "expected net present value (NPV) per plant", and also depends on location characteristics (x_{it}). As one moves up the supply curve, the higher the NPVs, the more local entrepreneurs will enter this industry, and the curve may shift outward, as the size of the spatial site increases (e.g. in terms of total employment or population).

b) In terms of the opportunities for new plants, there exists a stochastic demand function that depends also on the same factors as the supply function (y_{it} and x_{it}) as well as some other location characteristics not related to the supply function (i.e. $x_{it} \subseteq z_{it}$). The demand curve can be locally upward sloping (e.g. in the presence of external economies) or downward sloping (e.g. with competition in the local output markets).

c) The number of new firm/plants created over the period of time t in the spatial site i (y_{it}) is given by the intersection of the demand and supply functions. In equilibrium, y_{it} is given by a reduced-form equation:

$$y_{it} = f(z_{it}, \delta_i + \varepsilon_{it}), \tag{2.1}$$

where z_{it} are location characteristics, δ_i is a location fixed effect of unmeasured time-invariant features of the location affecting births in the industry (which is potentially related to the measured location characteristics, i.e. $Cov(z_{it}, \delta_i) \neq 0$), and ε_{it} is a contemporaneous i.i.d. error term.

These assumptions and the equation given in (2.1) allow an empirical framework in which the determinants of industrial location decisions can be analysed. Specif-

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ically, changes in location characteristics can affect, ceteris paribus, the conditional expectation of the number of firms/plants created in the geographical location i over a certain period of time. In more general terms than in equation (2.1), assuming the same notation for the variables and omitting the time dimension, the empirical framework can be defined as

$$E(y_i|z_i) = f(z_i, \theta), \tag{2.2}$$

where $E(y_i|z_i)$ is the conditional expectation (or conditional mean) of the dependent variable, $f(\cdot)$ is a certain function governing the relationship between the regressors and the conditional mean and θ is a parameter vector. At this point, it is crucial to correctly choose the model and the estimation method used to analyse the effects of the regressors on the dependent variable. Because of the count nature of the dependent variable ($y_i = 0, 1, 2, \ldots$), a linear model would not be appropriate, since the dependent variable (and therefore the error term) would not follow a normal distribution. Then, the natural candidate for the Count Data model is the Poisson distribution, from which the standard Poisson regression model derives. Such model assumes the following formal relationship:

$$y_i|x_i \sim Po(\mu_i), \tag{2.3}$$

where y_i is the dependent variable and x_i a set of regressors. This way, the Poisson regression model speficies that the distribution of y_i conditional on x_i (henceforth conditional distribution) follows a Poisson distribution[6]. In the firm location literature, the Poisson regression model has been widely used in many contributions. Some of them are SMITH AND FLORIDA (1994), WU (1999), LIST (2001), ARAUZO AND MANJÓN (2004), BARBOSA ET AL. (2004), GABE AND BELL (2004), ARAUZO (2005, 2008), AUTANT-BERNARD ET AL. (2006), ALAÑÓN ET AL. (2007) and ARAUZO AND VILADECANS (2009). Due to the specificities of the distribution of entries, Poisson model was the starting point of an important stream of empirical research on industrial location. However, as it is explained next, estimation problems related mainly to overdispersion and excess of zero counts made it necessary to use alternative and more sophisticated models.

[6]The basic assumptions and the technical details of such regression model are exposed in Section A.2.2 of the Appendix.

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2.2.2.3 Overdispersion and Excess of Zero Counts

In practice, Poisson regression model is restrictive and has several drawbacks. Specifically, Poisson regression model makes two assumptions which usually do not hold when working with empirical firm location data. These two assumptions are:

a) Overdispersion: the Poisson regression model has an assumption called mean variance equality, and it has been proven to be very restrictive. Such assumption imposes that the conditional mean and variance should be equal, but this assumption does not usually hold in the firm location literature because the data tends to be overdispersed, which makes the variance in the data exceed the variance assumed by the model, i.e. $V(y_i|x_i) > \mu_i$. Overdisperion may result from neglected or unobserved heterogeneity which is inadequately captured by the covariates in the conditional mean function, that is, the existence of overdisperion can be explained in terms of unobserved heterogeneity in the mean function. With regard to estimation and inference issues, the dismissal of overdispersion leads to a loss of efficiency and the invalidation of the posterior inference.

b) Excess of zeros: Poisson regression model can deal with situations in which there are a high number of observations with zero value, but some problems arise when this number is excessive and exceeds the number of zero counts expected by the model. The problem may arise from (a) the existence of unobserved heterogeneity and (b) a selectivity problem, which occurs when the observed outcomes are produced by two latent processes, i.e. a Count Data process and a selection process, generally independent from each other.

From a methodological point of view, several solutions have been implemented to tackle with these two problems. One of the most popular and widely considered alternatives has been the mixture Poisson model as a way to extend the basic Poisson regression model, which consists of the addition of some distributions to the underlying Poisson distribution, thus adding flexibility to the basic Poisson distribution by improving the fit of the resulting distribution to the observed data[7].

[7]Section A.2.3 of the Appendix offers a formal and detailed exposition of mixture models

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Such models can be grouped into continuous and finite mixture models, whose formal definitions are shown in Sections A.2.3.2 and A.2.3.3 of the Appendix, respectively. Continuous mixtures models control for the unobserved heterogeneity by including an unobserved heterogeneity term for each observation, extending the specified distribution from $(y_i|x_i)$ to $(y_i|x_i, \nu_i)$, being ν_i an i.d.d. term that denotes the unobserved heterogeneity and is independent of the covariates, which is regarded as a location-specific random effect in the firm location literature. A very popular and used mixture model is the Negative Binomial (NB) model[8], which arises as a mixture of a Poisson distribution for the dependent variable and a Gamma distribution for the unobserved heterogeneity term. Depending on the specific way of computing the variance, the NB model can be estimated following two similar approaches: NB1 and NB2. In the firm location literature, the NB1 model has been used by, for example, KOGUT AND CHANG (1991) in a FDI application, and the NB2 model is used by e.g. ARAUZO AND VILADECANS (2009); by WU (1999) and CIEŚLIK (2005B) in FDI applications; and by MANJÓN AND ARAUZO (2007) for relocations. Other studies that use the NB model but do not explicit the form of the conditional variance function include BADE AND NERLINGER (2000), EGELN ET AL. (2004), GABE AND BELL (2004), AUDRETSCH AND LEHMANN (2005), AUTANT-BERNARD ET AL.(2006), ALAÑÓN ET AL. (2007) and ARAUZO (2008), and for the FDI case, COUGHLIN AND SEGEV (2000) and CIEŚLIK (2005A).

The other alternative to the overdispersion and excess of zeros problem are the finite mixture models[9], which are specially suited for handling the excess of zeros. These models outperform continuous mixture models in some cases, because continuous mixtures, despite controlling for heterogeneity, may not properly account for the excess of zero counts. The reason lies in that, since the excess of zeros may stem from two sources, i.e. unobserved heterogeneity and an underlying selectivity process, continuous mixture models such as NB1 or NB2 are likely to account only for the excess of zeros stemming from the unobserved heterogeneity. Besides, sometimes data displays heterogeneity through an excess of zero counts, the number of which exceeds the number of zeros expected by the continuous mixture model. In the context of the firm location literature, a class of finite

[8]The complete derivation of this model is shown in Section A.2.3.2 of the Appendix.
[9]The complete derivation of this model is shown in Section A.2.3.2 of the Appendix.

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mixtures models called *with zeros* (WZ) models[10] has been used, which assume a discrete representation of the unobserved locational heterogeneity by modifying the probability of the zero outcome by a mixing parameter, which is parametrised using Logit or Probit models (see GREENE 1994 for details). Two specific WZ models have been used in the context of the firm location literature: Zero Inflated Poisson (ZIP) models and Zero Inflated Negative Binomial (ZINB) models[11]. ZIP models have been used by LIST (2001), GABE (2003), BASILE (2004) and MANJÓN AND ARAUZO (2007), whereas ZINB models were considered by MANJÓN AND ARAUZO (2007) and ARAUZO (2008).

An extension of the previous models is the introduction of a longitudinal dimension to the data, which allows a better and more accurate study of the unobserved individual heterogeneity. HAUSMAN ET AL. (1984) derived Count Data estimators for Poisson and other related distributions, which can be divided into fixed and random effects models[12]. The starting point of such models is the Poisson regression model with exponential mean and multiplicative individual specific term for two dimensions:

$$y_{it} \sim P[\mu_{it} = \xi_i \lambda_{it}] \tag{2.4}$$

$$\lambda_{it} = exp(x'_{it}\beta), \qquad i = 1, \ldots, N, \ \ t = 1, \ldots, T, \tag{2.5}$$

where ξ_i stands for an individual effect. The fixed effects estimation of the model assumes ξ_i to be an individual parameter, whereas the random effects estimator considers that ξ_i are i.i.d. random variables instead. Like the case of panel data linear models, if the covariates and the effects are correlated, fixed effects estimation is the proper choice, since random effects are not consistent, but in the absence of such correlation, random effects estimation is efficient (although fixed effects estimation does not cease to be consistent). It is worth noting that, in the presence of panel data, Poisson panel data models are preferred to NB1 and NB2 models for two reasons mainly. First, the advantage of NB models in terms

[10]The excess of zeros can be dealt with following two approaches in the context of finite mixture models: hurdle (or conditional) models, which are interpreted as two-parts models, and with zeros (or zero inflated models), which are models in which the heterogeneity is introduced in a binary form. See Section A.2.3.3 of the Appendix for details.

[11]A technical exposition of such models is shown in Section A.2.3.4 of the Appendix.

[12]For a review of panel data models, see BALTAGI (2001).

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of modelled heterogeneity with respect to the basic Poisson regression framewors vanishes in the panel data framework, since in such framework the heterogeneity is already accounted for; and second, NB1 and NB2 models for panel data face several computational difficulties.

In the firm location literature, location and relocation studies mostly use either fixed effects Poisson models (PAPKE 1991, BECKER AND HENDERSON 2000, LIST AND MCHONE 2000, HOLL 2004AC AND MANJÓN AND ARAUZO 2007) or fixed effects Negative Binomial models (HOLL 2004AB and MANJÓN AND ARAUZO 2007). On the other hand, FDI location studies seem to be efficiently studied under the assumptions of random effects models (BLONIGEN 1997, BLONIGEN AND FEENSTRA 1997 and BASILE 2004).

2.2.3 Problems to be Solved

So far, the motivation for the use of Count Data models has been introduced, starting with the basic Poisson regression model, and then introducing the problems of overdispersion and excess of zero counts, which motivated the development and use of alternative regression models. These improvements notwithstanding, there are still several methodological as well as conceptual issues that need to be taken care of. Next, three of these problems (spatial effects, measurement of nonlinearities and treatment and interpretation of zeros) as well as the proposed solutions, which are to be implemented in Section 2.5 of this chapter, are exposed[13].

2.2.3.1 Spatial Effects

One key feature of firm location studies is that the data are geo-referenced. That is, each observation from the sample is linked to a specific geographical area or location. The study of this kind of data implies that two types of spatial effects arise[14]:

a) Spatial heterogeneity: this concept is related to the lack of homogeneity of the data caused by its irregular distribution. This heterogeneity is likely to arise

[13] For an exhaustive anaysis of the state-of-the-art of the empirical literature on firm location, see ARAUZO ET AL. (2010).

[14] See ANSELIN (1988) and ANSELIN ET AL. (2004) for a complete review of these effects.

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when working with spatial data, and elements of the model such as parameters or even the functional form may vary in space. In principle, in order to deal with this kind of heterogeneity standard econometric techniques should suffice, but spatial econometric techniques are highly recommended, since the spatial heterogeneity may appear combined with spatial autocorrelation, being both effects impossible to tell from an observational point of view. In this case, classic heteroskedasticity tests are biased.

b) Spatial dependence: For a sample of $i = 1, \dots, n$ geo-referenced elements, spatial dependence arises when the observation from location i depends upon other elements j, $\forall j \neq i$, from the sample. In this case, the basic assumption of independence between sample observations does not apply, and this spatial relationship or dependence ought to be explicitly specified in the model in order for it not to suffer from misspecification.

In the study of location presented in this chapter it is reasonable to think that both problems may arise[15]. On the one hand, firm locations tend to take place in urban areas, which also tend to be close to each other, causing this fact spatial heterogeneity. On the other hand, it is reasonable to think that, when making the decision of where to locate, firms not only consider the characteristics of a single municipality, but the characteristics of other near municipalities as well. That is, for the municipality i, the value of the dependent variable y_i (number of located firms) might be determined or influenced not only by covariates from the same area (x_i), but also by x_j, for $i \neq j$ but being these two neighbours.

2.2.3.2 Measurement of Nonlinearities

A feature of the existing literature on firm location is that so far only purely parametric models have been considered. This approach is likely to suffer from a misspecification problem, especially when the relationship between the regressors and the dependent variable is not linear. This may be the case of the variables related to agglomeration economies and diseconomies. As stated before, the agglomeration of economic activity may boost the location of firms in a particular geographical area, because of the existence of positive externalities. Up to a point, however, these advantages may turn into disadvantages, because a too high level of agglomeration

[15]See next Section 2.4 for empirical evidence on that matter.

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may cause congestion and, hence, diseconomies. The common way of measuring this nonlinear relationship on the literature has been to include two regressors for agglomeration in a purely parametric model: one in levels and the other its squared value. By including these covariates, a parabolic relationship between agglomeration and location is being assumed. More formally, the possible nonlinearities in the relationship between the agglomeration covariates and the dependent variable have been dealt with parametrically, by specifying the index η in a purely additive parametric form, that is:

$$E(y_i|x_i) = h(\eta_i) \tag{2.6}$$

$$\eta_i = x_i'\beta = \sum_{k=1}^{K} \beta_k x_k. \tag{2.7}$$

This simple specification is likely to be inappropriate in the presence of complex covariate structures, that is, in the presence of nonlinear effects of the covariates on the index. That is, there are effects that are non-linear and cannot be measured parametrically. Specifically, let z_i be the covariate for agglomeration (population, industries, etc...). Many location studies have measured the effects of economies and diseconomies of agglomeration by including z_i in levels as well as its squared value, that is,

$$\eta_i = \beta_1 z_i + \beta_2 z_i^2 + ... \tag{2.8}$$

A regression result commonly obtained is $\hat{\beta}_1 > 0$ and $\hat{\beta}_2 < 0$, which confirms the existence of economies of agglomeration and, when the agglomeration is excessive, of diseconomies of agglomeration. Figure 2.1 plots z_i against $\hat{\beta}_1 z_i + \hat{\beta}_2 z_i^2$, which stands for the nonlinear relationship between location and agglomeration. However, the nature of those nonlinearities is likely to demand a more flexible way of measuring them. However, so far in the empirical literature on firm location just parametric methods have been used, in the form of two regressors (agglomeration variable in levels and its squared value) discussed before.

Among the scholars that have used this rough measure there are ARAUZO AND MANJÓN (2004) and ARAUZO (2005) analysing the case of Catalonia. They obtained a positive value for the coefficient of the agglomeration variable in levels and a negative value for the coefficient of the squared value of that variable. This result confirms that both economies and diseconomies of agglomeration appear,

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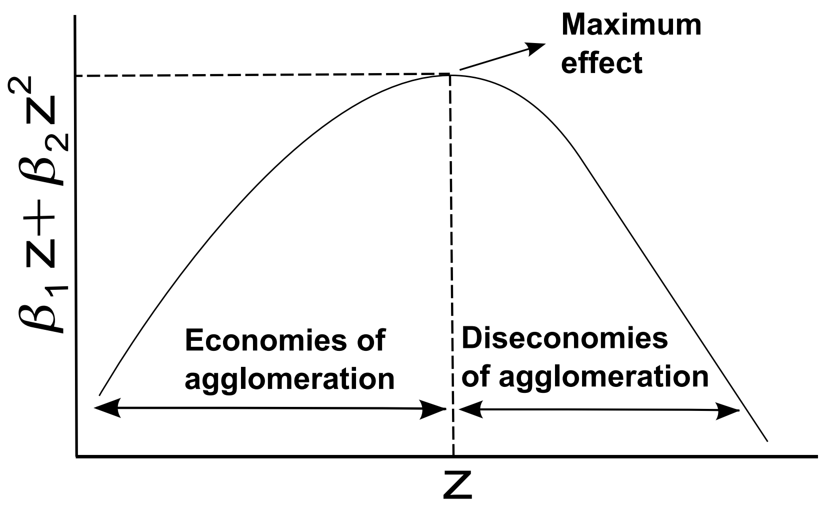

Figure 2.1: Parametric nonlinear relationship between location and agglomeration.

but even so the true nonlinear relationship among these variables may still remain veiled. VILADECANS (2004) used a similar measure, which is squared population, while BARRIOS ET AL. (2006) just used population to proxy land prizes and CARLINO (1978) also used the population variable. Other scholars used the square root of population density (KEEBLE AND WALKER 1994).

Even though the idea of agglomeration economies might seem so clear, there are some problems with its empirical estimation. There are some scholars that share this argument, and in this regard CARLINO (1979) acknowledged that, although agglomeration economies have been well articulated, they have been hard to measure, and most of the techniques used for this purpose have been indirect rather than direct, being therefore measurement problems not exclusive of agglomeration diseconomies but also present when measuring agglomeration economies. A possible solution consists of a semiparametric specification, by which the relationship between a covariate and the dependent variable is not restricted to a single parameter β, and instead it is a smooth function that depends on the covariate, that is, $g(x_i)$. In this regard, one of the most notorious developments of GLM are the Generalized Additive Models (GAM), which extend GLM by allowing the covariates be related to the dependent variable nonparametrically adopting a semiparametric additive

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structure:

$$E(y_i|x_i) = G\left(c + \sum_k g_k(x_{ik})\right), \tag{2.9}$$

where $g_k(\cdot)$ are nonparametric smooth functions. Another class of models are the Generalized Additive Partial Models (GAPM), which allow the modelling of part of the covariates parametrically and the rest nonparametrically[16]. Although this kind of specification has become very popular in empirical studies in the fields of medicine, biology and epidemiology, its use is not yet generalised in the specific field of firm location, although its application in the measurement of nonlinear effects of agglomeration seems intuitively suitable.

2.2.3.3 Treatment and Interpretation of Zeros

An important issue is the explicit study of those territorial units that receive no entries at all. As it has been explained in this chapter, Count Data models such as Poisson, Negative Binomial or Zero Inflated allow the existence of zero counts. These models, although taking into account the zero counts by means of a discrete mixture of distributions, do not allow the modelling of zero and non-zero counts separately. In fact, the problem of the excess of zeros might exceed the methodological dimension, and may become an issue with deeper conceptual implications. If one takes as an example the Catalan municipalities, one can find very heterogeneous types of geographical areas, being some of them large urbanised areas with a structured industrial composition where entries take place very often, and some other low-populated rural or mountain areas with a very small and concentrated productive structure where manufacturing entries seldom or never occur. In this case, intuition suggests that the determinants of the amount of entries in an industrialised area might be different from the determinants of the occurrence of any entry at all in a non-industrial area. Then, why not taking into account both issues in the analysis independently but within the same theoretical and methodological framework? The analysis proposed in this chapter deals with this issue this way: instead of assuming the same effects for the zero and non-zero counts, the suggested approach lies on the assumption that the set of regressors and their coefficients need not be the same in

[16]For a review on nonparametric and semiparametric modelling and estimation tecniques, see HÄRDLE ET AL. (2004).

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both cases and therefore are allowed to vary. The model to be estimated is called Zero Augmented Inverse Gaussian (ZAIG), and has two interesting features regarding the analysis of firm location: (a) zero and non-zero counts are treated differently, i.e. the existence or not of entries in a municipality is treated as a binary variable $(0, 1)$, and the amount of entries in a municipality provided that it is a positive integer (that is, at least one entry) is treated as a positive discrete/continuous variable; and (b) the existence of nonlinearities in the effect of regressors on the dependent variable can be studied nonparametrically.

2.3 Data and Variables

2.3.1 Data

The data used in this chapter refer to local units (municipalities) in Catalonia[17], and it consists of two datasets: data on firm entries and data on municipal characteristics. The database on entries is the REIC (Catalan Manufacturing Establishments Register), which has plant-level micro data on the creation and location of new manufacturing establishments. The REIC provides data on both new and relocated establishments, and since these may be attracted to the territory by the same variables, here they are used without distinction[18]. Also, only selected establishments with codes 12 to 36 (NACE-93 classification) are considered. Table 2.1 shows a description of this sectoral classification, and Table 2.2 shows the classification grouping the sectors in five categories: natural resources intensive sectors, labour intensive sectors, scale economies intensive sectors, sectors with differentiated products and R&D intensive sectors. All in all, the analysis includes the aggregated entries of manufacturing establishments in 941 municipalities between 2002 and 2004. With respect to the database on territorial characteristics, it comes from the TRULLÉN AND BOIX (2004) database on Catalan municipalities, the Catalan Statistical Institute (IDESCAT) and the Catalan Cartographical Institute (ICC). The

[17]Catalonia is an autonomous region of Spain with about 7 million inhabitants (15% of the Spanish population) and an area of $31,895$ km^2. It contributes 19% of Spanish GDP. The capital of Catalonia is the city of Barcelona.

[18]See MANJÓN AND ARAUZO (2007) and HOLL (2004A) for a detailed analysis of interrelations between locations and relocations.

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data cover almost all the Catalan municipalities[19], and they refer to the year 2001.

Table 2.1: NACE-93 Classification

Code	Industry
15	Manufacturing of food products and beverages
16	Manufacturing of tobacco products
17	Manufacturing of textiles
18	Manufacturing of leather clothes
19	Tanning and dressing of leather
20	Manufacturing of wood and of wood and cork products, except furniture, manufacturing of straw articles and plaiting materials
21	Manufacturing of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
24	Manufacturing of chemicals and chemical products
25	Manufacturing of rubber and plastic products
26	Manufacturing of other non-metallic mineral products
27	Manufacturing of basic metals
28	Manufacturing of fabricated metal products, except machinery and equipment
29	Manufacturing of machinery and equipment n.e.c.
30	Manufacturing of office machinery and computers
31	Manufacturing of electrical machinery and apparatus n.e.c.
32	Manufacturing of radio, television and communication equipment and apparatus
33	Manufacturing of medical, precision and optical instruments, watches and clocks
34	Manufacturing of motor vehicles, trailers and semi-trailers
35	Manufacturing of other transport equipment
36	Manufacturing of furniture; manufacturing n.e.c.

Source: INE (Spanish Statistical Institute).

[19] Data for five new municipalities (Gimenells i el Pla de la Font, Riu de Cerdanya, Sant Julià de Cerdanyola, Badia del Vallès and La Palma de Cervelló) have been left out due to lack of data.

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Table 2.2: NACE-93 Classification
according to the elements that influence their competitiveness (OECD)

Code	Industry
Natural resources intensive sectors	
15	Manufacturing of food products and beverages
16	Manufacturing of tobacco products
21	Manufacturing of pulp, paper and paper products
Labout intensive sectors	
17	Manufacturing of textiles
18	Manufacturing of leather clothes
19	Tanning and dressing of leather
20	Manufacturing of wood and of wood and cork products, except furniture, manufacturing of straw articles and plaiting materials
36	Manufacturing of furniture; manufacturing n.e.c.
Scale economies intensive sectors	
24	Manufacturing of chemicals and chemical products
25	Manufacturing of rubber and plastic products
34	Manufacturing of motor vehicles, trailers and semi-trailers
35	Manufacturing of other transport equipment
Sectors with differentiated products	
22	Publishing, printing and reproduction of recorded media
26	Manufacturing of other non-metallic mineral products
27	Manufacturing of basic metals
28	Manufacturing of fabricated metal products, except machinery and equipment
29	Manufacturing of machinery and equipment n.e.c.
31	Manufacturing of electrical machinery and apparatus n.e.c.
R&D intensive sectors	
30	Manufacturing of office machinery and computers
32	Manufacturing of radio, television and communication equipment and apparatus
33	Manufacturing of medical, precision and optical instruments, watches and clocks
Source: OECD.	

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2.3.2 Variables

2.3.2.1 Description

This subsection presents the territorial variables used in this chapter, which are the regressors included in the empirical analysis and are in line with the previous research made in the field of firm location. The variables used so far in the literature and the main results are extensively reviewed in Section 1.3.2 of this thesis. Specifically, the empirical study carried out in this chapter considers a subgroup of variables extensively used in the empirical literature on firm location: agglomeration economies and human capital. Besides, the variables belong also to the following categories: industrial mix, spatial effects and geographical position. All variables are shown in Table 2.3 and explained next.

Agglomeration economies

As it is stated before, agglomeration economies represent one of the main determinants of firm location, in the sense that firms consider the presence of population, other firms and economic activity in general when deciding where to locate. Because agglomeration economies is a multidimensional concept that cannot be reduced to a single variable, several variables to proxy it have been considered up to now in the literature. Specifically, agglomeration economies have been divided into two types: urbanisation economies and localisation economies. As explained in Section 1.3.2, urbanisation economies involve a city's population and employment levels and the diversity of its productive structure, whereas localisation economies involve a city's specialisation in a certain sector. There is no clear evidence on whether urbanisation or localisation economies are more important for the location of new firms, the empirical evidence being mixed and inconclusive [20]. Among the studies that have considered agglomeration economies as a firm location determinant, there are BADE AND NERLINGER (2000), LIST (2001), BASILE (2004), ALAÑÓN ET AL. (2007) and ARAUZO (2008).

Urbanisation economies are proxied using two variables. EMP stands for employment density, where the area of urbanised land in square kilometres is the denominator, and HHI is the inverse of the Hirschman-Herfindahl Index, which is

[20] COMBES (2000) provides a discussion on this topic.

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Table 2.3: Description of variables

Variable	Description	Source
Dependent Variable		
ENT	Number of entries (2002 - 2004)	REIC
Agglomeration Economies		
EMP	Employment Density	IDESCAT
HHI	Inverse of Hirschman-Herfindahl Index	IDESCAT
ESI	Entropy Specialisation Index	own
Human Capital		
EDU	Average Years of Schooling	IDESCAT
Industrial Mix		
SME	Share of Manufacturing Employment	IDESCAT
SSE	Share of Services Employment	IDESCAT
Spatial Effects		
W-EMP	Spatial Lag of EMP	own
W-HHI	Spatial Lag of HHI	own
W-ESI	Spatial Lag of ESI	own
W-EDU	Spatial Lag of EDU	own
W-SME	Spatial Lag of SME	own
W-SSE	Spatial Lag of SSE	own
Geographical Position		
TMC	Transport time to Main Cities	ICC
CC	County Capital	ICC
CL	Coast Location	ICC
MAB	Metropolitan Area of Barcelona	T & B
MAG	Metropolitan Area of Girona	T & B
MAT	Metropolitan Area of Tarragona	T & B
MAL	Metropolitan Area of Lleida	T & B
MAM	Metropolitan Area of Manresa	T & B

Sources: Catalan Manufacturing Establishments register (REIC), Catalan Statistical Institute (IDESCAT), Catalan Cartographical Institute (ICC) and Trullén and Boix (2004), (T & B).

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intended to reflect the diversity of the productive structure of each municipality and can therefore be regarded as a manufacturing diversification index. In the literature, urbanisation economies have been regarded as a location determinant in many studies. GUIMARÃES ET AL. (2004), ARAUZO (2005) and CIEŚLIK (2005B) have included specifically urbanisation economies in their studies. Besides, ARAUZO AND MANJÓN (2004), HOLL (2004A,B), ARAUZO (2005) and MANJÓN AND ARAUZO (2007) include a measure proxying for industrial/sectoral diversity; BADE AND NERLINGER (2000), LIST (2001), PAPKE (2001), EGELN ET EL. (2004) and ARAUZO AND VILADECANS (2009) consider as a covariate the population density; MANJÓN AND ARAUZO (2007) control for the density of the economic activity, and KOGUT AND CHANG (1991) include firm density as a regressor.

On the other hand, localisation economies are proxied using the Entropy Specialisation Index (ESI), whose choice is justified because such index has several advantages over other measures, one of them being that it has desirable decomposition properties, i.e. the index can be decomposed into changes in the individual industries and the aggregate change in the industry. By analogy, changes in individual territorial units can be added together to provide the overall change. Thus, both concentration and specialisation can be analysed with this measure. Analytically, the index can be calculated as the sum of the products of the shares and log shares of each sector in the municipality's aggregate manufacturing:

$$ESI_i = -\sum_{j=1}^{J} \left(\frac{E_{ij}}{E_i}\right) ln \left(\frac{E_{ij}}{E_i}\right), \tag{2.10}$$

where i stands for the municipality, for $i = 1, \ldots, N$, and j stands for sector, for $j = 1, ..., J$. E_{ij} stands for employment of sector j in municipality i, E_i represents total employment in municipality i, E_j is total employment of sector j, and E is total employment in the whole territory for all sectors. This is an inverse index of specialisation, i.e. high levels of the index mean low levels of specialisation. In the literature, localisation economies have been considered by SMITH AND FLORIDA (1994), ARAUZO AND MANJÓN (2004) and GUIMARÃES ET AL. (2004); and sectoral specialisation measures have been included in the analyses by HOLL (2004B) and ARAUZO (2008).

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Human Capital

Human capital is proxied by EDU, which stands for the average years of schooling of the population over 25 years old. This variable is not computed at the municipality level but at the labour market area level, which is a more aggregated division of the territory that enables to take into account the spatial mobility of labour, this is, the commuting between municipaities. In the literature, human capital measures have been considered by COUGHLIN AND SEGEV (2000), ARAUZO AND MANJÓN (2004), EGELN ET EL. (2004), HOLL (2004A,B), CIEŚLIK (2005A), ALAÑÓN ET AL. (2007) and ARAUZO AND VILADECANS (2009).

Industrial Mix

These variables are intended to reflect the industrial composition of each municipality. SME is the share of manufacturing employment over total employment and SSE is the share of services employment over total employment. These variables have been considered in the empirical literature by SMITH AND FLORIDA (1994), BLONIGEN (1997) and ARAUZO (2005).

Spatial Effects

These variables reflect the possible influence of certain variables of neighbouring municipalities on the number of locations in a municipality [21]. These variables are spatial lags computed by means of the product of a neighbourhood (or weights) matrix W with certain regressors, representing the average value of regressor values in neighbouring municipalities[22]. In this analysis we consider a distance matrix such that $w_{ij} = (1/d_{ij})$, where d_{ij} is the distance between municipalities i and j, reflecting the idea that the closer these two municipalities the stronger the relationship between them. The spatial lags considered correspond to the variables for agglomeration economies, human capital and industrial mix, i.e. W-EMP, W-ESI, W-EDU, W-SME and W-SSE.

[21] For a similar approach, see VILADECANS (2004).

[22] See Section A.3.1 of the Appendix for a formal definition of the construction and structure of W.

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Geographical Position

This set of variables controls for the geographical position of each municipality. TMC is the average transport time to the biggest cities[23], CC is a dummy variable with a value of one if the municipality is a county capital, CL is a dummy variable with a value of one if the municipality is coastal, and MAB, MAG, MAT, MAL, and MAM take a value one if the municipality belongs to one of the five biggest metropolitan areas in Catalonia (Barcelona, Girona, Lleida, Tarragona and Manresa).

2.3.2.2 Descriptive Statistics

This subsection is devoted to an univariate descriptive statistical analysis of the variables defined in the previous section. Table 2.4 shows the descriptive statistics of the variables used in the analysis, that is, mean, standard deviation, minimum and maximum values. A common characteristic for all the variables is the huge range between the minimum and maximum values, which is due to the enormous heterogeneity present in the data. This result is to be expected, since municipalities are very dissimilar to each other, ranging from small isolated villages in the mountains to huge and densely populated cities. It is also worth noticing that 23% of the municipalities belong to the metropolitan area of Barcelona, and also that 47% of the municipalities belong to a metropolitan area in general. Tables 2.5 and 2.6 show the descriptive statistics for the variables distinguishing between municipalities without (Table 2.5) and with entries (Table 2.6). A closer look at both tables allows to notice that for some variables their mean values differ considerably among municipalities depending on whether there are entries or not. This way, municipalities with entries show a much higher value of urbanisation economies (EMP), and a higher diversification of the productive structure (HHI and ESI). Moreover, the share of manufacturing employment is higher in those municipalities with entries, and on the contrary the share of services employment is higher where no manufacturing entries take place. With respect to the geographical variables, municipalities with no entries have a higher transportation time to main cities (TMC), and county capitals and coast locations tend to receive at least one entry (CC and CL). These trends can be seen more in detail in Table 2.7, where the mean value of the variables are presented for groups of municipalities according to their

[23] The criterion for a city to be considered big is to have at least 100.000 inhabitants.

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number of establishment entries. There is a increasing trend for the variables EMP, HHI and ESI, and a decreasing rate for DPC and TMC.

Table 2.4: Descriptive statistics of the variables

Variable	Mean	Std. Dev.	Min.	Max.
ENT	4.359	14.589	0	258
EMP	1.648	4.665	0.013	118.600
HHI	3.476	1.445	0	7.175
ESI	6.764	2.171	1.312	12.077
EDU	8.497	0.521	5.753	9.798
SME	0.222	0.116	0	0.609
SSE	0.473	0.258	0	1
W-EMP	1.664	0.237	1.288	4.144
W-HHI	3.503	0.227	2.892	4.291
W-SME	0.229	0.026	0.167	0.281
W-SSE	0.466	0.017	0.425	0.542
TMC	87.412	23.302	56	190
CC	0.043	0.204	0	1
CL	0.074	0.262	0	1
MAB	0.230	0.421	0	1
MAG	0.073	0.260	0	1
MAT	0.074	0.262	0	1
MAL	0.064	0.246	0	1
MAM	0.030	0.173	0	1

Source: own elaboration.

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Table 2.5: Descriptive statistics of the variables for the case of the 461 municipalities without entries between 2002 - 2004

Variable	Mean	Std. Dev.	Min.	Max.
ENT	0	0	0	0
EMP	1.084	1.932	0.013	17.600
HHI	2.748	1.142	0	6.024
ESI	6.122	2.157	1.312	12.077
EDU	8.457	0.486	6.874	9.798
SME	0.177	0.098	0	0.609
SSE	0.509	0.299	0	1
W-EMP	1.612	0.214	1.307	4.094
W-HHI	3.402	0.156	2.892	4.124
W-SME	0.220	0.023	0.167	0.276
W-SSE	0.470	0.018	0.433	0.542
TMC	95.236	24.383	57.000	190.000
CC	0.006	0.080	0	1
CL	0.023	0.152	0	1
MAB	0.141	0.348	0	1
MAG	0.078	0.268	0	1
MAT	0.093	0.291	0	1
MAL	0.071	0.258	0	1
MAM	0.017	0.130	0	1

Source: own elaboration.

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Table 2.6: Descriptive statistics of the variables for the case of the 480 municipalities with at least one entry between 2002 - 2004

Variable	Mean	Std. Dev.	Min.	Max.
ENT	8.546	19.541	1	258
EMP	2.190	6.207	0.042	118.600
HHI	4.176	1.357	1.053	7.175
ESI	7.381	2.000	2.431	11.937
EDU	8.536	0.550	5.753	9.798
SME	0.265	0.115	0.026	0.582
SSE	0.437	0.205	0.022	1
W-EMP	1.714	0.247	1.288	4.144
W-HHI	3.599	0.242	3.011	4.291
W-SME	0.238	0.026	0.178	0.281
W-SSE	0.462	0.015	0.425	0.534
TMC	79.897	19.471	56	186
CC	0.079	0.270	0	1
CL	0.122	0.328	0	1
MAB	0.316	0.465	0	1
MAG	0.068	0.253	0	1
MAT	0.056	0.230	0	1
MAL	0.058	0.234	0	1
MAM	0.043	0.204	0	1

Source: own elaboration.

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Table 2.7: Mean value of the variables per number of entries in municipalities

	Number of entries per municipality						
Variable	0	$(1-10)$	$(11-50)$	$(51-100)$	$(101-200)$	+200	Total
Total municip.	461	383	88	6	2	1	941
ENT	0.000	3.148	20.727	76.666	177.000	258.000	4.359
EMP	1.084	1.972	2.812	4.787	4.698	10.172	1.648
HHI	2.748	3.900	5.236	5.612	5.654	5.085	3.476
ESI	6.122	7.247	7.824	8.253	9.022	11.168	6.764
EDU	8.457	8.457	8.811	9.123	9.585	8.968	8.497
SME	0.177	0.255	0.306	0.312	0.305	0.172	0.222
SSE	0.509	0.425	0.475	0.565	0.612	0.798	0.473
W-EMP	1.612	1.680	1.834	2.027	1.808	2.041	1.664
W-HHI	3.402	3.541	3.808	4.056	3.890	4.022	3.503
W-SME	0.220	0.234	0.254	0.268	0.261	0.260	0.229
W-SSE	0.470	0.463	0.460	0.461	0.464	0.468	0.466
TMC	95.236	82.736	69.488	60.333	64.500	57.000	87.412
CC	0.006	0.031	0.250	0.333	0.500	1.000	0.043
CL	0.023	0.109	0.159	0.166	0.500	1.000	0.074
MAB	0.141	0.232	0.613	1.000	1.000	1.000	0.230
MAG	0.078	0.073	0.056	0.000	0.000	0.000	0.073
MAT	0.093	0.062	0.034	0.000	0.000	0.000	0.074
MAL	0.071	0.070	0.011	0.000	0.000	0.000	0.064
MAM	0.017	0.039	0.068	0.000	0.000	0.000	0.030

Source: own elaboration

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2.4 Exploratory Analysis

2.4.1 Motivation

The purpose of this section is to provide a complete and deep exploratory analysis of the dependent variable, that is, firm entries. The analysis starts with a study of the descriptive statistics and a cartographical representation of both aggregate entries and also entries for different sectors, it is then followed by a study of the spatial heterogeneity and dependence of entries and it concludes with a study of the presence of such effects in several Count Data estimation results. The conclusion of the analysis shows that zero counts and spatial effects are issues that really matter and ought to be accounted for in the context of a regression analysis.

2.4.2 Spatial Distribution of the Dependent Variable

The dependent variable of the analysis is the entry of establishments in Catalan municipalities for the period 2002 - 2004, whose basic statistics are shown in Table 2.8. As it can be seen, for each year the sum of zero counts outnumbers the counts where at least one entry takes place. The proportion of zero counts is somewhat lessened when entries are aggregated over the period 2002 - 2004, since there are some municipalities where entries do not take place every year. Besides, the percentile information shows that the distribution of entries is heavily skewed, that is, there is a small group of municipalities that receives the largest number of entries, while more than a half get no entries at all. These distributional features can be seen in Figure 2.2, where both the histogram and a kernel density estimation of the dependent variable are plotted.

Table 2.9 shows the number of establishment entries per aggregate sectors during the period 2002 - 2004. A result worth highlighting is that the proportion of new entries per sectors is quite stable in this period, being roughly half of the located firms manufacturers of differentiated products, a quarter of these firms intensive in labour, a 10% intensive in natural resources and also a 10% intensive in scale economies, and the smallest proportion belongs to firms which are intensive in R&D. The sectoral composition of entries is quite important, since location determinants are likely to differ across sectors. Table 2.10 gives the establishment entries grouped by aggregate sector and municipality according to ranges of

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entry. The main result coming from such analysis is that sectors with more entries (basically manufacturers of differentiated products and establishments intensive in labour) are distributed across a larger number of establishments, being the other extreme the 80 entries intensive in R&D, which took place in 44 municipalities. Such conclusion can be also drawn from Table 2.11.

Table 2.8: Descriptive statistics of establishment entries 2002 - 2004

	Years			
	2002	2003	2004	2002 – 2004
Mean	1.420	1.484	1.453	4.359
Std. Dev.	4.889	5.222	4.800	14.590
Zero counts	614	609	612	461
Positive counts	327	332	329	480
Sum.	1337	1397	1368	4102
Min.	0	0	0	0
Max.	87	91	80	258
5th percentile	0	0	0	0
10th percentile	0	0	0	0
25th percentile	0	0	0	0
50th percentile	0	0	0	1
75th percentile	1	1	1	3
90th percentile	4	4	4	11
95th percentile	7	7	7	20

Source: own elaboration.

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Table 2.9: Establishment entries per aggregate sector 2002 - 2004

	Years							
	2002		2003		2004		2002 - 2004	
Aggregate sector	Total	%	Total	%	Total	%	Total	%
Intensive in natural resources	98	8.81	92	8.03	116	10.66	306	9.15
Intensive in labour	303	27.25	291	25.39	263	24.17	857	25.61
Intensive in scale economies	113	10.16	126	10.99	121	11.12	360	10.76
Differentiated products	578	51.98	609	53.14	556	51.10	1743	52.09
Intensive in R&D	20	1.80	28	2.44	32	2.94	80	2.39
Total	1112	100	1146	100	1088	100	3346	100

Source: own elaboration.

Table 2.10: Establishment entries per number of entries in municipalities and aggregate sector 2002 - 2004

Aggregate sector	Number of entries per municipality						Total
	0	(1 – 10)	(11 – 50)	(51 – 100)	(101 – 200)	+200	
Intensive in natural resources							
Total	785	155	1	0	0	0	941
%	83.42	16.47	0.11	0.00	0.00	0.00	100
Intensive in labour							
Total	698	240	1	1	0	1	941
%	74.18	25.50	0.11	0.11	0.00	0.11	100
Intensive in scale economies							
Total	775	166	0	0	0	0	941
%	82.36	17.64	0.00	0.00	0.00	0.00	100
Differentiated products							
Total	630	301	7	2	1	0	941
%	66.95	31.99	0.74	0.21	0.11	0.00	100
Intensive in R & D							
Total	897	44	0	0	0	0	941
%	95.32	4.68	0.00	0.00	0.00	0.00	100

Source: own elaboration.

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Table 2.11: Descriptive statistics of establishment entries per aggregate sector 2002 - 2004

	Years			
	2002	2003	2004	2002 − 2004
Intensive in natural resources				
Mean	0.104	0.097	0.123	0.325
Std. Dev.	0.523	0.429	0.648	1.344
Zero counts	875	872	865	785
Positive counts	66	69	76	156
Sum.	98	92	116	306
Min.	0	0	0	0
Max.	11	6	12	27
Intensive in labour				
Mean	0.321	0.309	0.279	0.910
Std. Dev.	1.858	2.000	1.388	5.037
Zero counts	806	811	821	698
Positive counts	135	130	120	243
Sum.	303	291	263	857
Min.	0	0	0	0
Max.	45	54	26	125
Intensive in scale economies				
Mean	0.120	0.133	0.128	0.382
Std. Dev.	0.474	0.556	0.543	1.239
Zero counts	860	860	863	775
Positive counts	81	81	78	166
Sum.	113	126	121	360
Min.	0	0	0	0
Max.	5	8	8	18
Differentiated products				
Mean	0.614	0.647	0.590	1.852
Std. Dev.	2.079	2.129	1.948	5.855
Zero counts	743	737	738	630
Positive counts	198	204	203	311
Sum.	578	609	556	1743
Min.	0	0	0	0
Max.	30	30	27	87
Intensive in R & D				
Mean	0.021	0.029	0.034	0.085
Std. Dev.	0.171	0.263	0.274	0.595
Zero counts	924	923	919	897
Positive counts	17	18	22	44
Sum.	20	28	32	80
Min.	0	0	0	0
Max.	3	5	6	14

Source: own elaboration.

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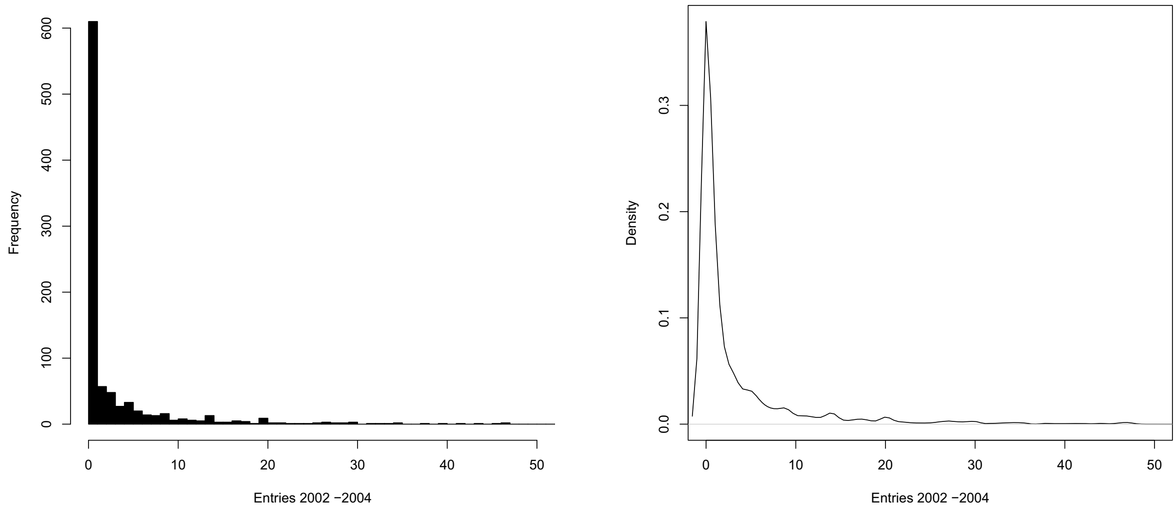

Figure 2.2: Establishment entries 2002 - 2004: histogram (left) and kernel density estimation (right).

Although the distribution of the dependent variable is a crucial issue, specially regarding estimation and inference, the geographical distribution of this variable is not a less important matter. The fact that zero counts or the higher counts are evenly distributed across the space or on the contrary show specific spatial patterns ought to be taken into account, since it may be a sign either of spatial dependence or spatial heterogeneity. Figure 2.3 shows a map of Catalonia displaying the municipalities where are least one entry took place, and Figure 2.4 shows a more detailed cartographic representation of entries in intervals. Both figures show how entries tend to be grouped, specially along the Catalan coast, and there are territories on the country part of the region where entries seldom take place. Figures 2.5 to 2.9 show the distribution of entries across municipalities per different aggregated sectors. It is noticeable that, for all sectors, entries tend to be concentrated in the metropolitan area of Barcelona and, to a lesser extent, in regions close to the coast and belonging to urban areas.

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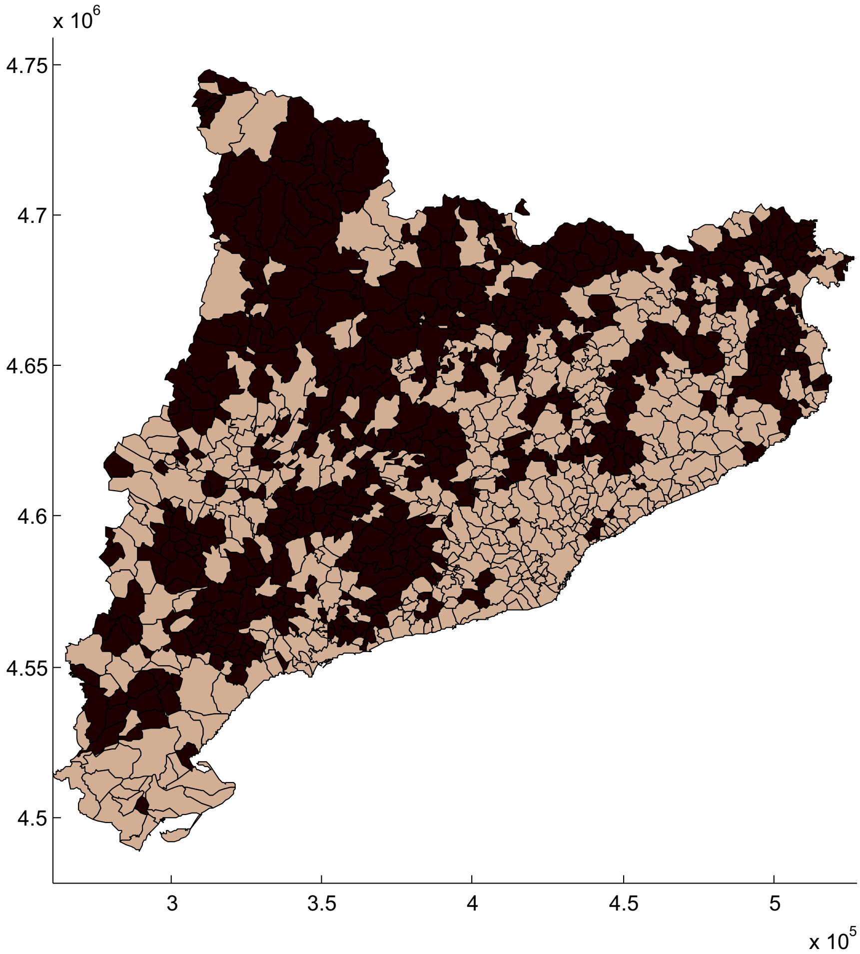

Figure 2.3: Establishment entries 2002 - 2004: map representation municipalities where no entries took place appear in black.

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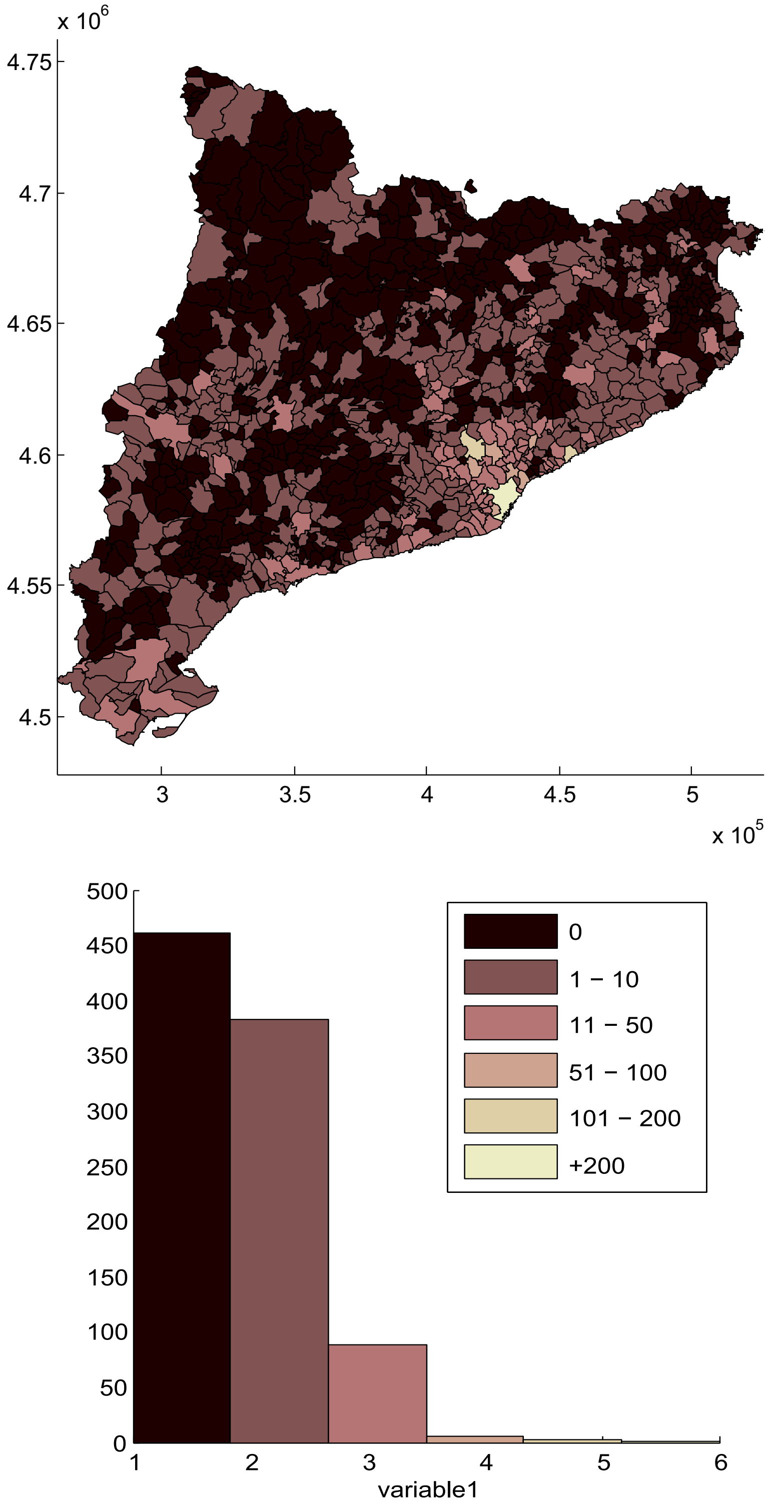

Figure 2.4: Establishment entries 2002 - 2004: map representation with entries in intervals.

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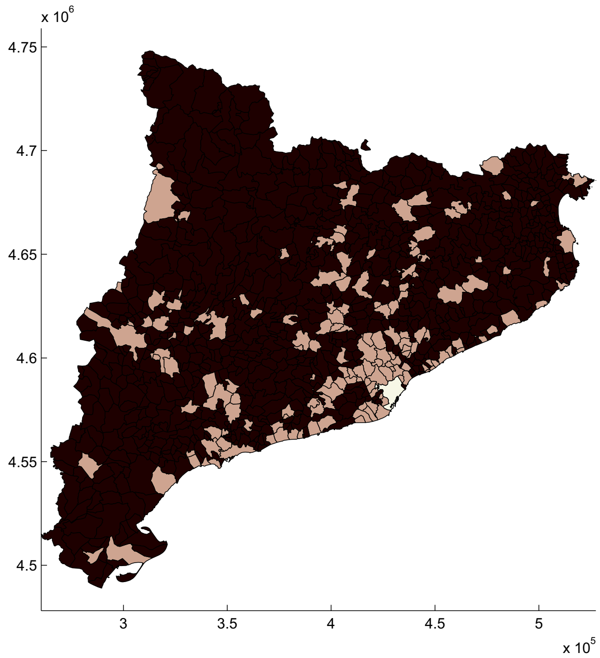

Figure 2.5: Establishment entries in natural resources intensive sectors (2002 - 2004): brighter areas show a higher number of entries.

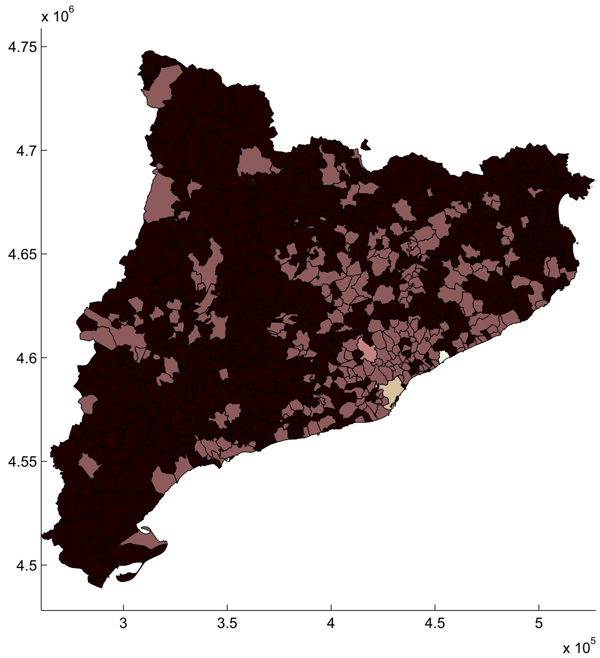

Figure 2.6: Establishment entries in intensive in labour sectors (2002 - 2004): brighter areas show a higher number of entries.

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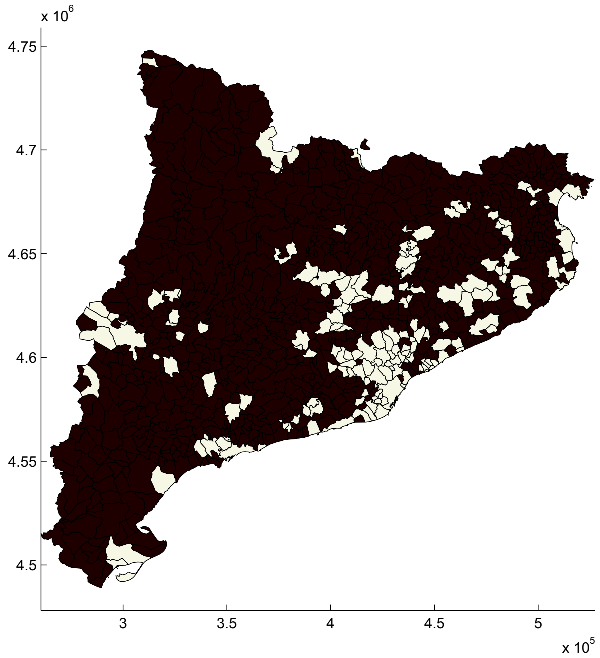

Figure 2.7: Establishment entries in intensive in scale economies sectors (2002 - 2004): brighter areas show a higher number of entries.

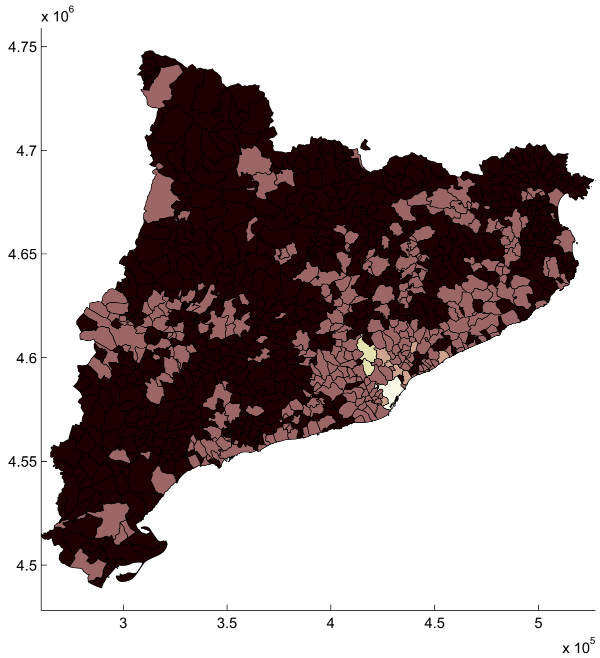

Figure 2.8: Establishment entries in sectors with differentiated products (2002 - 2004): brighter areas show a higher number of entries.

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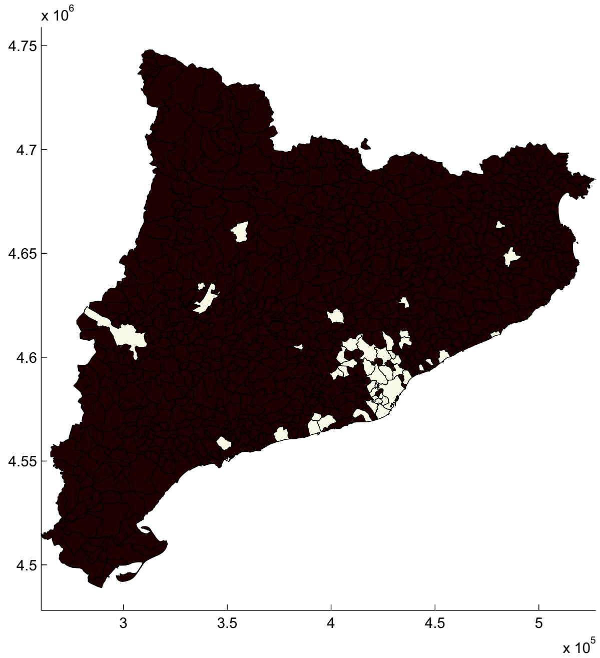

Figure 2.9: Establishment entries in the intensive in R&D sectors (2002 - 2004): brighter areas show a higher number of entries.

In order to analyse possible spatial patterns of the dependent variable, here a spatial analysis is carried out. Specifically, spatial autocorrelation patterns under several definitions of neighbourhood are studied[24]. In this analysis, we consider three neighbourhood criteria, i.e. nearest neighbours, distance neighbours and contiguous neighbours[25]. The nearest neighbours criterion considers as neighbours the $k-$nearest spatial units, whereas the distance neighbours criterion includes those territorial units within a circle whose radius is previously specified. Contiguous neighbours criterion only considers as neighbours those units with which the unit share a border[26]. Once the neighbourhood criterion has been defined, the spatial correlation is estimated by using the Moran's I statistic (MORAN 1948,1950), which has been computed under randomisation of the analysed variable, since it is not

[24]The used software has been the R programming environment (http://www.r-project.org). A detailed description of the analysis of spatial correlation by using R and an empirical application to urban clusters formation is provided by BIVAND AND PORTNOV (2004).

[25]The definition of the W matrix according to each criterion can be found in Section A.3.1 of the Appendix.

[26]GRIFFITH (1996) and BRETT AND PINKSE (1997) review the use of different weights matrices and note differences in inference stemming from different neighbourhood and distance choices.

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distributed normally. The results of the Moran's I statistic of the dependent variable under several neighbourhood criteria are shown in table 2.12.

From these results several conclusions can be made. The statistic is significant in all the cases, which is a sign of clear spatial correlation under several neighbourhood criteria. In the case of the $k-$nearest neighbours, the strongest correlation is found with $k = 10$, and then the statistic value decreases as k increases. The same result is found when the criterion is the distance, according to which the strongest correlation is found when the neighbours lie within 10 km. Like the previous criterion, the distance neighbourhood also shows a decrease in spatial correlation as the distance increases. Lastly, when the neighbourhood criterion is contiguity, spatial correlation is also positive and significant. These results as a whole lead to the conclusion that, from a spatial point of view, entries are a positively correlated variable.

Once the exploratory analysis has been carried out, and thus the existence of spatial effects has been proved, the next step is the confirmatory analysis. This implies including in the model and the estimation the spatial effects, i.e. spatial dependence and spatial heterogeneity. In the context of the firm location literature using Count Data models, these effects have only been considered seldom, since many of the spatial methodological contributions are not still extended to the Count Data framework. Count Data models allow for the inclusion of spatial lags of the covariates, and in theory the spatial heterogeneity can be controlled for by standard methods, which means that the dispersion parameter of the NB model might suffice for the control of spatial heterogeneity. However, since conventional models do not explicitly model the spatial structure of the data, the estimation of the variance might not be efficient (ANSELIN 1988).

So far, the majority of empirical contributions in firm location using Count Data models have not explicitly taken into account spatial effects. However, as it is shown in this section, such effects are present in location data, and its study is fully justified. Then, why is its study not yet generalised in this literature? A reason may be that the introduction of spatial econometric methodologies in the context of Count Data models is not as prominent as in other econometric models. Nevertheless, spatial effects are still present. In order to show it, five classic Count

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Table 2.12: Spatial correlation of establishment entries 2002 - 2004

Statistic: Moran's I under randomisation		
Criterion	Statistic	Std. Dev.
k−nearest neighbours		
$k = 1$	0.179^{***}	4.753
$k = 2$	0.184^{***}	6.666
$k = 3$	0.219^{***}	9.611
$k = 4$	0.204^{***}	10.257
$k = 5$	0.214^{***}	11.991
$k = 6$	0.225^{***}	13.804
$k = 7$	0.222^{***}	14.635
$k = 8$	0.231^{***}	16.238
$k = 9$	0.229^{***}	17.059
$k = 10$	0.231^{***}	18.144
$k = 25$	0.194^{***}	24.248
$k = 50$	0.186^{***}	33.393
$k = 100$	0.161^{***}	42.402
$k = 200$	0.103^{***}	41.923
$k = 400$	0.041^{***}	29.565
Distance in km.		
5 km.	0.163^{***}	4.485
10 km.	0.235^{***}	15.578
15 km.	0.195^{***}	19.580
20 km.	0.183^{***}	24.723
25 km.	0.172^{***}	28.799
30 km.	0.160^{***}	31.723
35 km.	0.143^{***}	32.907
40 km.	0.126^{***}	33.353
45 km.	0.110^{***}	32.767
50 km.	0.099^{***}	32.931
Contiguity	0.296^{***}	16.337

Source: own elaboration.

***, ** and * indicate significance at the 99%, 95% and 90% levels.

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Data models typically used in the location literature are estimated next with the variables described in Section 2.3: Poisson, Negative Binomial type I and II and Zero Inflated Poisson type I and II. For each model, the spatial correlation of the residuals is analysed by computing Moran's I statistic in order to check out whether such model is controlling for the spatial effects or not. Then, if the residuals still show a spatial pattern, spatial heterogeneity has not been properly accounted for[27]. The results are shown in Table 2.13 and plotted in Figures 2.10 - 2.14. According to these results, only for the case of the NB1 estimation spatial correlation is rejected.

Table 2.13: Spatial correlation of several model's residuals

Statistic: Moran's I
Neighbourhood criterion: inverse distance

Model	Statistic	Std. Dev.
Poisson	0.114***	3.542
Negative Binomial I	0.007	0.256
Negative Binomial II	0.087***	2.707
Zero Inflated Poisson I	0.118***	3.637
Zero Inflated Poisson II	0.133***	4.098

Source: own elaboration.

***, ** and * indicate significance at the 99%, 95% and 90% levels.

The inverse distance neighbourhood criterion assumes that the intensity of the relationship between i and j is inversely proportional to the distance between them (d_{ij}), that is, $c_{ij} = 1/d_{ij}$.

[27] HENDERSON (1997) looked at this question in some detail for employment growth for some capital goods manufacturing industries. In 10 of 11 industry years, controlling for fixed effects, he could not reject the hypothesis that industry-county contemporaneous error terms were uncorrelated within the same metro area.

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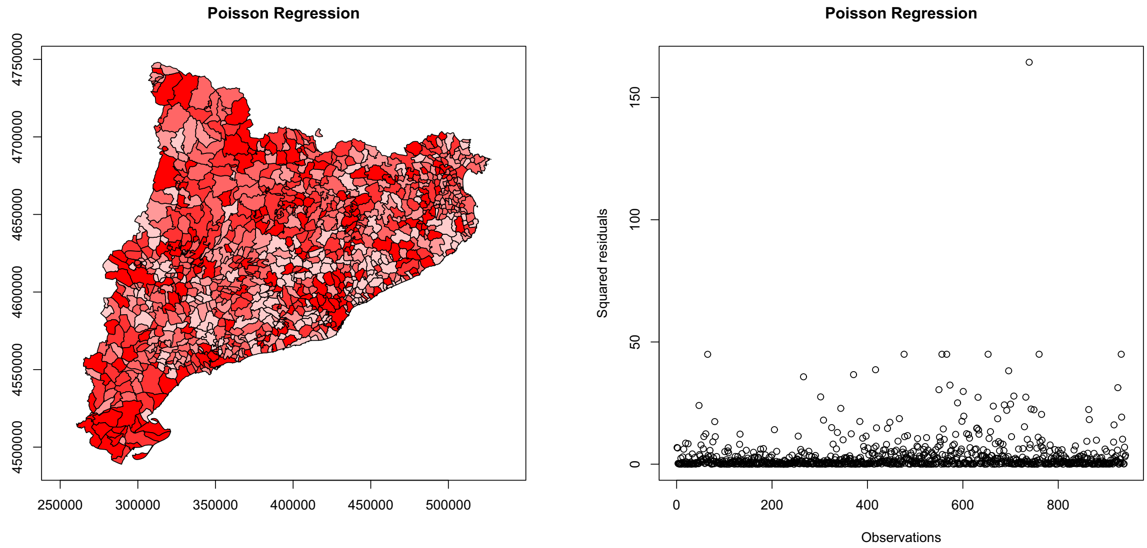

Figure 2.10: Residuals of a Poisson regression

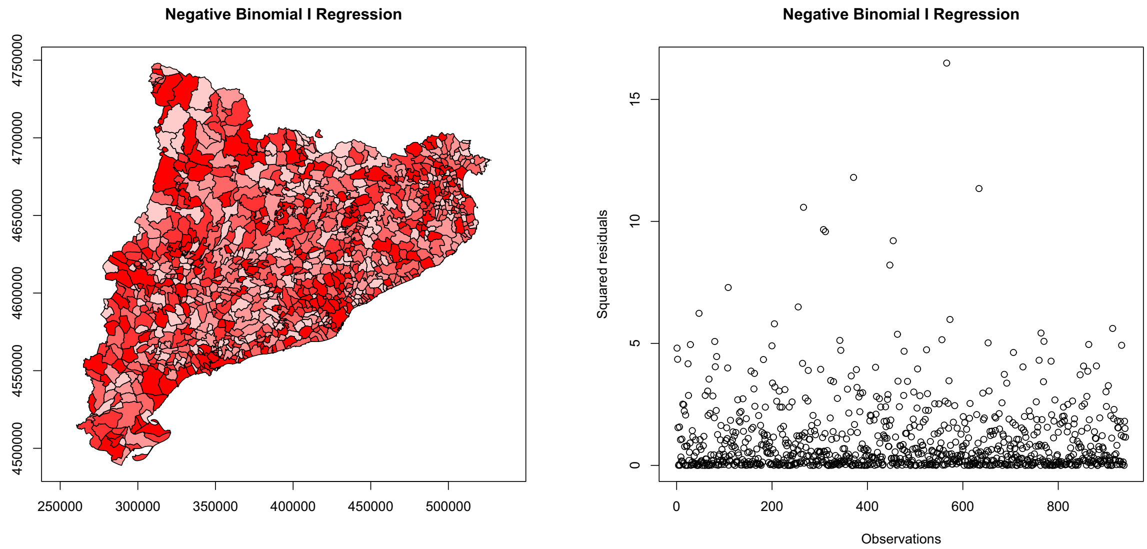

Figure 2.11: Residuals of a Negative Binomial type I regression.

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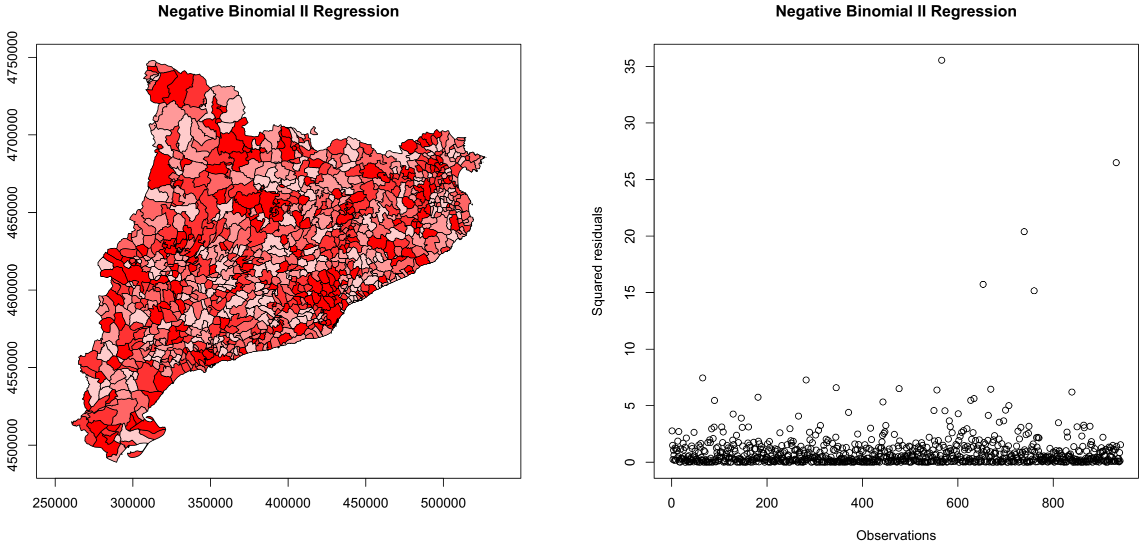

Figure 2.12: Residuals of a Negative Binomial type II regression.

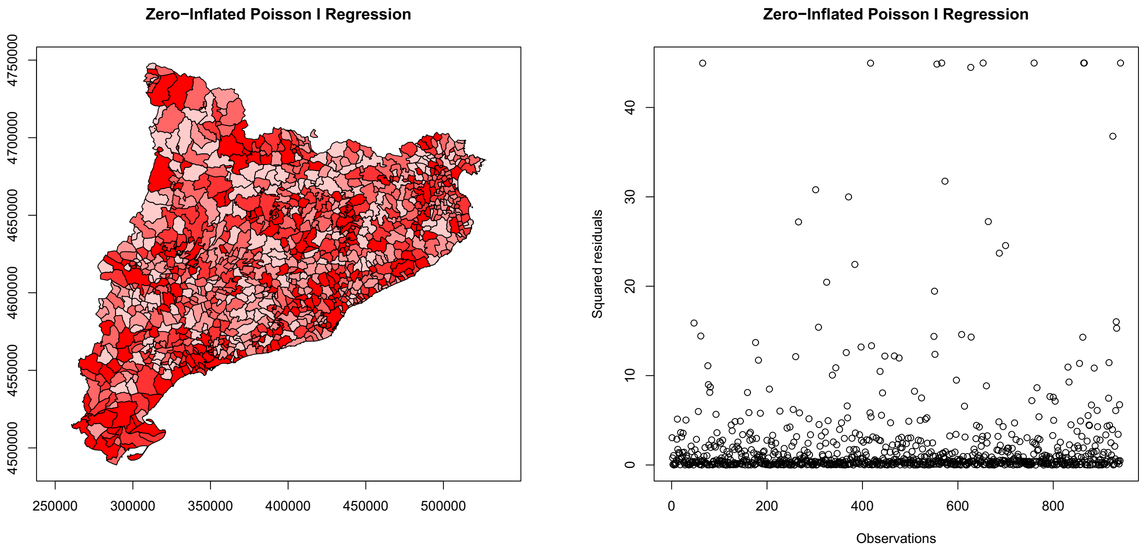

Figure 2.13: Residuals of a Zero Inflated Poisson type I regression.

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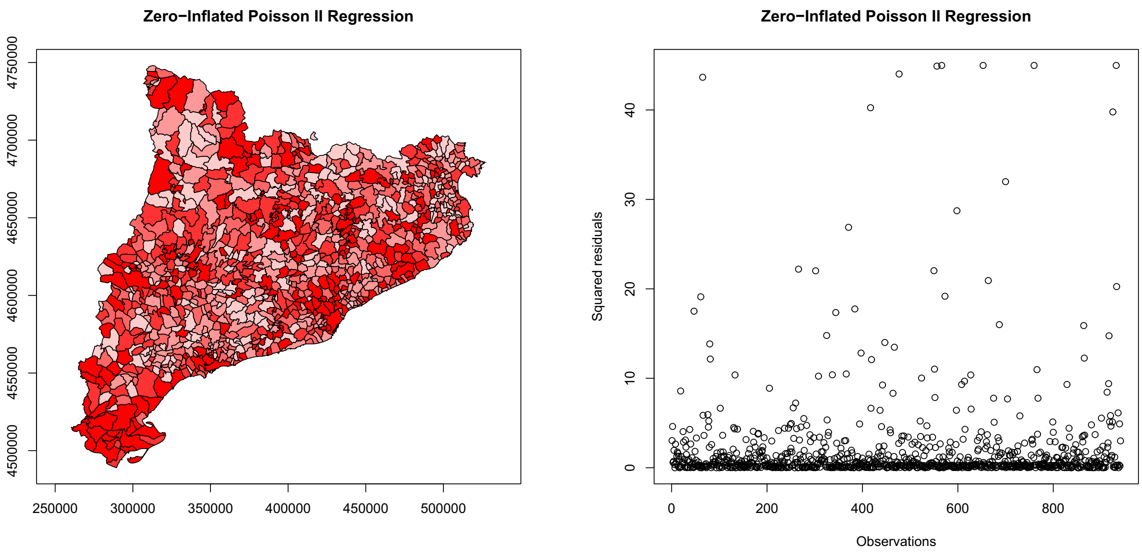

Figure 2.14: Residuals of a Zero Inflated Poisson type II regression.

2.5 Firm Location Analysis: a Zero Augmented Inverse Gaussian Model

2.5.1 Motivation

This section is devoted to the estimation of an empirical econometric model in order to study location determinants in Catalonia. In order to do so, a Zero Augmented Inverse Gaussian model is proposed and estimated, and the results are explained and discussed in the context of the evidence found in the literature. One important assumption of this analysis is the different nature of the zero and non-zero counts. The analysis of the distribution of the dependent variable has shown that it has two important features: (i) a high right-skewness and (ii) a very high percentage of zeros. Besides, a closer examination of the dependent variable has shown that there are several municipalities where there are no entries on a regular basis. That is, for the period 2002 - 2004, only the 51% of municipalities received at least one entry. In the light of this fact, it seems reasonable to think that the variables determining whether or not there are any entries on a municipality may differ from those determining the amount of entries in municipalities receiving a high number of them. Even if these variables are the same, their effects in both cases are likely to differ. Under these circumstances, in order to model new establishment entries

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a mixed discrete-continuous model has been chosen. This model has a probability mass at zero and an Inverse Gaussian continuous component. The Inverse Gaussian distribution is suitable because it accommodates the right- skewness of the entries distribution. This mixed model is called Zero Augmented Inverse Gaussian (ZAIG) model, and it allows to explicitly specify a logit-linear model for the occurrence of at least one establishment entry, and a log-linear model for the mean number of entries, given that at least one entry has occurred.

The model proposed in this paper belongs to a type of statistical models for an univariate response variable which is called Generalize Additive Models for Location, Scale and Shape (GAMLSS), proposed by RIGBY AND STASINOPOULOS (2005)[28]. This type of statistical models is a development of the Generalized Linear Models (GLM) and the Generalized Additive Models (GAM). GAMLSS introduce several improvements on GLM and GAM models. In these models the mean μ_i of the dependent variable y_i is modelled as a function of explanatory variables, depending the variance of y_i on the mean (μ_i) as well as on a constant dispersion parameter (ϕ), i e. $V(Y) = \phi v(\mu_i)$. Other characteristics of the distribution of y_i, as the skewness or the kurtosis, are not modelled explicitly in term of the covariates, but implicitly through their dependence on η_i. This problem is accounted for in GAMLSS, which moreover relaxes the exponential family assumption and replaces it by a wider general distribution family.

2.5.2 Specification

Let y_i be the average number of entries on the municipality i during the period 2002 - 2004, for $i = 1, \ldots, N$, being N the total number of municipalities. We assume that y_i follows a mixed ZAIG distribution, so that $y_i \sim ZAIG(\mu_i, \sigma_i, p_i)$, with $E(y_i) = p_i\mu_i$ and $Var(y_i) = p_i\mu_i^2(1 - p_i + \mu_i\sigma_i^2)$.

The ZAIG model assumes that the distribution of y_i can be written as a mixed discrete-continuous probability function, so that two processes generating the zeros and the positives are assumed. Thus, the density function of y_i presents the following composite form:

[28] A detailed analysis of GAMLSS can be found in Section A.2.4 of the Appendix.

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$$f(y_i) = \begin{cases} 1 - p_i & \Leftrightarrow \quad y_i = 0 \\ p_i \, g(y_i) & \Leftrightarrow \quad y_i > 0, \end{cases} \tag{2.11}$$

where p_i is the probability of having at least one firm located for a certain municipality i, and $g(y_i)$ is the inverse gaussian density of the positive values of y_i:

$$g(y_i) = \frac{1}{\sqrt{2\pi y_i^3}\sigma_i} \exp\left[-\frac{1}{2y_i} \left(\frac{y_i - \mu_i}{y_i \sigma_i} \right)^2 \right]. \tag{2.12}$$

The idea behind the model presented here is this: the binary variable of whether a count variable has a zero or a positive realisation is governed by a Bernoulli distribution, and for positive realisations the conditional distribution of those positive values is modelled by the Inverse Gaussian distribution.

This mixed distribution allows to model two different phenomena separately by means of different specifications: (i) the fact that a municipality has new firms located in it, and (ii) the amount of new firms located in a municipality. This is due to the fact that the ZAIG model allows the explicit modelling in terms of explanatory variables of its three distribution parameters: the mean μ_i, the standard deviation σ_i and the shape parameter ν_i, which is equal to $1 - p_i$. Therefore, this model consists of three different equations to be estimated:

$$log(\mu_i) = m_1(X_i) \tag{2.13}$$

$$log(\sigma_i) = m_2(X_i) \tag{2.14}$$

$$log\left(\frac{p_i}{1 - p_i}\right) = m_3(X_i), \tag{2.15}$$

being $m_r(\cdot)$ a flexible function of the subset of covariates r, for $r = 1, 2, 3$. This function stands for an additive regression structure, where the regressors may be related to the independent variable either parametrically or through a nonparametric smooth function. It is worth noting that in equation (2.15) covariates are incorporated through the logit link function on p_i.

2.5.3 Estimation and Results

The econometric software used in this analysis has been MATLAB and R. Specifically, the ZAIG regression model is incorporated into the gamlss package in R

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(STASINOPOULOS AND RIGBY 2007). The estimation method is the maximum penalised likelihood, and the penalised log likelihood functions have been maximized iteratively using the RS and CG algorithms of RIGBY AND STASINOPOULOS (2005). These algorithms use a backfitting algorithm to perform each step of the Fisher scoring procedure[29].

The empirical analysis of this section consists of the estimation of several models, each one containing the estimation of equations (2.13), (2.14) and (2.15). For the sake of simplicity, we consider the same subset of covariates for the μ-parameter equation (2.13) and ν-parameter equation (2.15). The subset of regressors that enter in the variance equation (2.14) has been chosen by performing a stepwise model selection using a Generalized Akaike Information Criterion. For all models, although consisting of three different estimated equations, one for each distributional parameter (μ, σ and ν), only the equations with an economic interpretation are shown: (a) the binary response ν-parameter equation with the logit link function (henceforth the logit equation), which explains the existence or not of new located firms in a municipality and is shown in the left column of the table, and (b) the μ-parameter equation with the log link function for the positive counts (henceforth the log equation), which explains the amount of new firms located in a municipality conditional on the fact that at least one new firm has been located there, its results being shown in the right column.

On the one side, Models I and II are estimated for the overall aggregate manufacturing sectors: in Model I (Table 2.14), all covariates enter the equations parametrically, and in Model II (Table 2.15) some regressors, those which are likely to have a nonlinear relationship with the dependent variable, enter the equations nonparametrically by means of Penalized splines[30], which are piecewise polynomials that stand for smooth nonlinear functions linking the covariates to the dependent variable. On the other hand, Models III-VI are partial estimations for four sectoral groupings: sectors intensive in natural resources (Model III, Table 2.16), sectors intensive in labour (Model IV, Table 2.17), sectors intensive in scale

[29]For a technical explanation of the Fischer scoring and the backfitting method, see HASTIE AND TIBSHIRANI (1990) and HÄRDLE ET AL. (2004).

[30]For a technical explanation of Penalized splines as well as other smoothers, see HASTIE AND TIBSHIRANI (1990) and HÄRDLE ET AL. (2004).

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economies (Model V, Table 2.18) and sectors with differentiated sectors (Model VI, Table 2.19). The partial estimation for the fifth sectoral group (sectors intensive in R&D activites) could not be carried out, since the overwhelming excess of zeros made it impossible for the model to reach convergence. Indeed, further research should tackle the issue of the efficient estimation of models where the proportion of positive counts to zero counts is minimum, as it is the case.

Table 2.14 shows the results for the Model I (overall aggregated sectors). As it can be noticed, the estimates of both equations are not very different from each other, although the magnitude and significance of certain estimates vary. With respect to agglomeration economies, we obtain that the EMP coefficient is positive and significant for the log equation, as usual in the location literature. For instance, the studies by BECKER AND HENDERSON (2000), LIST (2001), GABE AND BELL (2004) and ARAUZO (2005), among others, have provided evidence on a clear and positive effect of agglomeration economies on location. The estimated coefficients of variables that measure the industrial structure (HHI) is positive and significant for both equations, while the estimation of the Entropy Specialisation Index (ESI) is not significant for any of the equations. These results seem to show that (a) agglomeration economies do exist and (b) urbanisation economies are more appealing than localisation economies, since firms seem to have a preference for diversified environments. This is, firms prefer environments characterised by a high diversity of economic activities rather than a concentration of establishments belonging to a reduced group of sectors. In this regard, the evidence found in the literature is mixed, finding ARAUZO AND MANJÓN (2004) and HOLL (2004A,B) evidence that urbanisation economies and a high sectoral diversity favour firm location, and GUIMARÃES ET AL. (2004) finding evidence of both types of economies. Besides, according to the positive estimated coefficient of the share of manufacturing employment (SME), environments composed of mainly manufacturing sectors attract new establishments, as was found by BECKER AND HENDERSON (2000), ARAUZO (2005) and MANJÓN AND ARAUZO (2007). These results are also also confirmed by the estimates of the spatial effects. Regarding the composition of the productive structure, the variable SME displays a positive and significant value for both equations, which means that firms do value the presence of other manufacturing firms in the specific municipality where they locate.

With respect to the spatial lags, the W-EMP coefficient is just significant for the μ-parameter equation and it is negative, which might be a sign for the presence of diseconomies of agglomeration, that is, firms tend to avoid big areas when the level of agglomeration surpasses a certain threshold. These results confirm the idea that new establishments not only consider urbanisation economies (in the form of employees per km^2 and manufacturing diversity) in the municipality where they locate, but also in the surrounding area. This fact is also confirmed by the positive sign of the W-HHI estimate, which indicates that establishments not only prefer a diversified particular location, but also a diversified surrounding area. All in all, both local and surrounding economic characteristics are taken into account by new establishments. Interestingly, the coefficient for the spatial lag of the Share of Service Employment (W-SSE) is significant for the logit equation, and this result points out that, in order for a municipality to receive a positive number of entries, it is important to have a surrounding area with the presence of service firms. Regarding the education variable EDU, it is positive, but significant just for the log equation. This result reveals that the workforce education is not a key variable for receiving a positive number of entries, but it is crucial for receiving a high number of entries. This result is compatible with the fact that, for many municipalities receiving a few number of firms, such firms have a low technological intensity, and therefore they do not need a qualified workforce, being a low-skilled labour force just what new establishments mainly demand. By contrast, for more agglomerated areas, where firms with a higher technological intensity tend to locate (see Figure 2.9), EDU is likely to play a more active role in attracting firms. In the literature, the empirical evidence of skill level of the population over firm location decisions is usually contradictory. Sometimes it influences in a positive way entrant's decision (WOODWARD 1992; SMITH AND FLORIDA 1994; COUGHLIN ET AL. 2000), while some other studies have found evidence of the opposite (ARAUZO AND MANJÓN 2004; BARTIK 1985) and some studies have found no significant influence at all.

The results for the geographical position variables also shed light on some interesting facts. The sign of the Time to Main Cities (TMC) variable coefficient is negative and only significant for the logit equation, which means that the most isolated municipalities are likely to receive no firms at all. This result is likely to indicate that there are certain industrial areas being developed outside the province capitals but, nevertheless, they do need to maintain a good accessibility to them.

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These results have been found in the literature but the evidence is not conclusive. On the one side, some studies have found a negative relationship between distance to capitals or big cities and location (ARAUZO 2005; ALAÑÓN ET AL. 2007), which differs from the results obtained here, but on the other side the evidence in the literature regarding the effect of road accessibility and transport time to main cities is clear, i.e. those locations with access to main transportation ways and lower time transportation to big cities attract more firms (SMITH AND FLORIDA 1994; BLONIGEN 1997; COUGHLIN AND SEGEV 2000; BASILE 2004; GABE AND BELL 2004; HOLL 2004A,B,C; CIEŚLIK 2005A,B). The dummy variable for the county capital (CC) is positive and significant for both equations, and the dummy variable for the coast location (CL) is positive and significant for the logit equation. These results show that new establishments are also influenced by non-economical variables as the natural amenities available at the sea side (CL) and the public, cultural and leisure facilities available at county capitals (CC). With respect to the metropolitan areas, it is noticeable that only the coefficient for Lleida (MAL) is positive. This result might be due to the fact that Lleida is the most rural area of Catalonia and has plenty of available and cheaper land for manufacturing activities.

An interesting fact of the estimation of Model I is the lack of spatial correlation of its residuals. The value of the Moran's I statistic for the residuals yields a value of $I = 0.03$, which is not statistically significant. Besides, this results can be seen in Figure 2.15, where the residuals are plotted in the map and in a graph. This result indicate that, although the spatial heterogeneity of the dependent variable has not been explicitly accounted for, the GAMLSS estimation of the variance through a modelisation of $log(\sigma_i)$ using a set of covariates is efficient in this regard, since the spatial heterogeneity has been removed.

Table 2.15 and Figures 2.16 and 2.17 show the estimation of Model II. In this model, Penalized splines substitute classic linear parameters in those variables that are likely to have a nonlinear relationship with the dependent variable[31]. Penalized splines allow to decompose the effect of each regressor into two parts: a nonvariant constant and a smooth function. The first part of this estimation is shown in Table 2.15, and the smooth partial functions showing the remaining nonlinear effect

[31]Although this decision may seem somewhat subjective, the variables that remain in its original parametric form are either dummies or their nonlinearity has been already dismissed.

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are shown in Figure 2.16 for the ν-parameter equation and in Figure 2.17 for the μ-parameter equation. With respect to the nonvariant part of the estimation shown in Table 2.15, its results are quite similar to the previous fully parametric estimation. A close interpretation of the smooth functions in Figure 2.16 (ν-parameter equation) allows to shed some light on the nonlinearities existing among agglomeration economies and new establishments. Particularly, the shape of the HHI and SME functions (standing for the manufacturing diversity and the share of manufacturing employment of a municipality) is slightly down-sloping, especially for the medium values of each variable rank. This result might show that the level of diversification (HHI) has a smaller effect on entries as it gets larger. Similarly, a very high share of manufacturing employment (SME) might indicate a certain level of congestion, which puts a brake on the location of new manufactures. With respect to the μ-parameter equation (Figure 2.17), the partial effect of EMP seems to be greater for low values of the variable, and as it gets larger, its partial effect vanishes (although it is largely due to the broadening of the confidence intervals). This shape might indicate the existence to some extent of diseconomies of agglomeration. A similar shape can be found for the variable W-EMP although the wide confidence intervals for high values of the variable do not allow its interpretation, since it is not significant. With respect to the HHI and SME variables, the behaviour of their associated splines seem to differ from the previous estimation, this time showing a slightly positive slope, which might mean that, provided that there are entries in a municipality, the higher the levels of diversification and manufacturing employment share (up to a point, though), the larger the number of new entries is going to be. This different result for both equations seems to confirm that the same variables might have a different role in both processes, i.e. the existence or not of new locations and the number of new locations provided that at least one exists.

Tables 2.16 to 2.19 show the results of the ZAIG model estimations for the four sectoral groupings: sectors intensive in natural resources (S1), sectors intensive in labour (S2), sectors intensive in scale economies (S3) and sectors with differentiated products (S4). The EMP coefficient is positive and significant for the logit equation in S1 and for the log equation in S2 and S4. By contrast, this variable seems to have no effect in S3, i.e. firms belonging to sectors intensive in scale economies do not regard employment density as a locational factor as much as firms belonging to other sectors do. Besides, the coefficient of HHI is positive for all sectors but for

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S2 is negative, which indicates that firms intensive in labour do prefer specialised rather than diversified productive environments. Moreover, this result can be linked to the coefficient of EDU, which is positive in S1, S3, S4 and negative in S2 as well. The straightforward implication of these results is that firms intensive in labour do prefer locating in environments with similar firms and also environments characterised by a low-skilled average workforce. A similar phenomenon happens with the variable SME, which is positive and significant in S1, S3 and S4 and negative and significant in S2 (for the logit equation). This result shows that, for those firms intensive in labour, the locations with a high share of manufacturing employment tend to be avioded for the logit equation, and the opposite case applied for the other three sectors (S1, S3 and S4), for which a high share of manufacturing employment is preferred. The variable SSE (share of service employment) is only significant and positive in S2 for the log equation, which implies that firms intensive in labour have a preference for environments with a high presence of service firms. The results for the spatial lags show a high level of heterogeneity. As before, it is noticeable that W-EMP (for the log equation) and W-HHI (for the logit equation) are negative in S2, which again is consistent with the fact that firms intensive in labour do prefer locating in specialised productive areas. Regarding the geographical position variables, the transport time to main cities (TMC) appears negative for all sector groupings, which is consistent with the result from the general estimation of the model. Moreover, for the logit equation, sector groupings S1, S3 and S4 show positive coefficients for the county capital (CC) and coast locatoin (CL), while these coefficients show negative values for S2, which undoubtedly show that firms intensive in labour have to some extent different geographical patterns from the other manufacturing firms.

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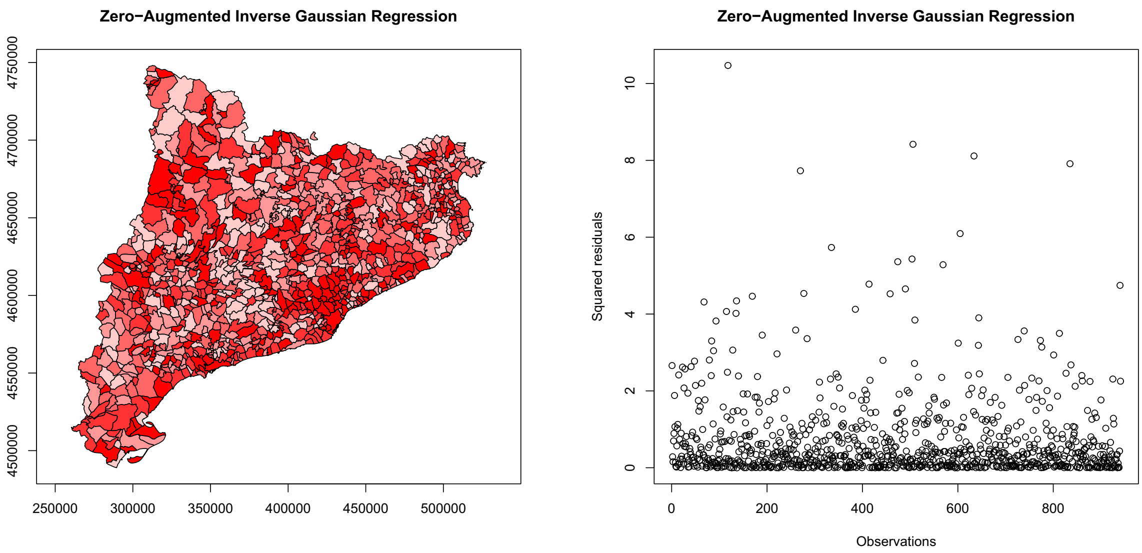

Figure 2.15: Residuals of a Zero Augmented Inverse Gaussian regression.

2.6 Summary

This chapter has dealt with the analysis of firm location processes. Section 2 first presents a methodological review of the empirical Count Data models used in the context of firm location, pointing out how common problems such as heterogeneity and the excess of zeros invalidate the basic Poisson regression model and make it necessary to estimate developments of the Poisson regression model (mixture models), such as the Negative Binomial and Zero Inflated models. Second, three important issues that are not being considered in the mainstream firm location literature are presented: the analysis of spatial effects, the measurement of potential nonlinearities and the specific treatment of zero counts.

Section 3 consists of the introduction of the data and variables used in the empirical analysis of firm location in Catalonia, the descriptive statistics of the data being provided. The dependent variable is the sum of firm locations over the years 2002 and 2004, and the covariates are grouped into the following categories: agglomeration economies, human capital, industrial mix, spatial effects and geographical position. Specifically, the importance of considering several measures of agglomeration is highlighted, since they are a very complex phenomenon that has multiples dimensions as well as ways of being measured. Besides, the spatial effects consist of spatial lags accounting for the spatial dependence of the variables,

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that is, spatial effects between municipalities. In that regard, the spatial lags of agglomeration, industrial mix and human capital variables have been included as regressors.

Section 4 offers an exploratory distributional analysis of establishment entries, showing that the variable has an important proportion of zeros and its variance depends largely on space. Besides, Moran's I statistic under several neighbourhood criteria is computed for the entries, with the result that the variable is unequivocally spatially correlated. Then, several Count Data models which are common to the firm location literature are estimated for the Catalan case, showing that (with the sole exception of a Negative Binomial (NB) model) they fail to take into account the spatial heterogeneity of the data, since their residuals are spatially correlated. In Section 5 the empirical model is dealt with by especifying and estimating a Zero Augmented Inverse Gaussian (ZAIG) model, thus allowing the estimation of two specifications (a binary variable showing the existence or not of new locations and a continuous variable for the strictly positive counts) both parametrically and nonparametrically. The ZAIG model belongs to a class of models called Generalized Additive Models for Location, Scale and Shape (GAMLSS). These models appear to be suitable for firm location analyses, both with respect to the modelling of the distribution of the dependent variable (which is a capital issue, considering the overdispersion and excess of zeros that location data often show) as well as regarding the modelling of the functional form of the regressors. Specifically, it has been assumed that the two processes in which firm location can be divided, i.e. the existence or not of new locations and the number of new locations provided that at least one exists, can be modelled as two related but different processes. In order to do so, and by means of a Zero Augmented Inverse Gaussian distribution, a logit-linear model for the occurrence of at least one establishment entry, and a log-linear model for the mean number of entries, given that at least one entry has occurred, are specified. Besides, the regressors have been specified as additive terms that enter the equation both parametrically and nonparametrically in the form of smooth functions, thus allowing for nonlinear effects among the variables.

The main results show that the variables regarding the level of agglomeration and the industrial structure of municipalities, both those related to the distinction between manufacturing and service activities and those indicating the extent to which the economic structure of a municipality is specialised or diversified, are relevant for the location of new establishments. Not only do they directly influence the location decisions in municipalities, but also determine the apparition of economies and diseconomies of agglomeration. Specifically, urbanisation economies seem to play a very important role in attracting new establishments. Besides, the percentage of manufacturing employment seems to foster new locations up to a point upon which the effect decreases. In that regard, the evidence obtained in this work seems to indicate that in moderately diversified economic environments economies of agglomeration work better and keep congestion effects from arising. Besides, the spatial heterogeneity is successfully accounted for in the estimated model, since residuals are shown to be free of spatial correlation according to the value of the Moran's I statistic. All in all, the model is successful when dealing with several sources of overdispersion that the data presents.

These conclusions notwithstanding, more work needs to be done in this area. The future research in this field should focus on issues like alternative definitions of agglomeration economies and a spatial econometric analysis of how the influence of those agglomeration economies varies across space. It is also important to take into account some specific industry effects that could shape the way in which agglomerations economies behave. Another element that would be important is the time dimension. The analysis carried out in this chapter considers cross-section data, which does not allow the analysis of the dynamic effects that might take place in the context of firm location. All in all, both the spatial and the temporal dimension are issues that are worth analysing, since they are an intrinsic part of the firm location phenomenon.

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Table 2.14: Model I: ZAIG estimation for the aggregated sectors

Estimation of the ν and μ equations with linear parametric terms.
Estimation method: penalized likelihood.
Dependent Variable: ENT

Variable	ν-parameter equation Link function: logit		μ-parameter equation Link function: log	
	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	−19.935	4.868***	−10.038	2.311***
EMP	0.016	0.023	0.174	0.061***
HHI	0.497	0.0792***	0.144	0.052***
ESI	0.074	0.055	−0.029	0.037
EDU	0.152	0.206	0.250	0.096***
SME	6.785	1.050***	1.579	0.600***
SSE	−0.582	0.410	0.209	0.255
W-EMP	−0.042	0.485	−0.324	0.098***
W-HHI	2.528	0.816***	1.639	0.472***
W-SSE	16.285	8.051**	4.246	4.013
TMC	−0.018	0.007***	−0.005	0.006
CC	2.636	0.737***	1.141	0.195***
CL	1.307	0.375***	0.141	0.161
MAB	−0.441	0.311	0.122	0.166
MAG	−0.058	0.328	−0.180	0.145
MAT	−0.650	0.409	−0.184	0.202
MAL	0.773	0.404*	0.038	0.172
MAM	−0.357	0.486	0.555	0.289*

Observations in the fit	941
Degrees of freedom for the fit	41
Residual degrees of freedom	900
Global Deviance (GD)	1901.41
Akaike Information Criterion (AIC)	1983.41
Schwarz Bayesian Information Criterion (SBC)	2182.14

The equation for the parameter σ has been not displayed for the sake of clarity. In such equation only significant terms are estimated, which are: HHI, CC, MAB, MAG and MAM.
***, ** and * indicate significance of the parameter at the 99%, 95% and 90% levels.

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Table 2.15: Model II: ZAIG estimation for the aggregated sectors

Estimation of the ν and μ equations with linear parametric and nonparametric terms.
Estimation method: penalized likelihood.
Dependent Variable: ENT

Variable	ν-parameter equation Link function: logit		μ-parameter equation Link function: log	
	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	−35.917	4.760***	−17.650	1.940***
EMP	1.493	0.044***	0.010	0.004**
HHI	0.922	0.085***	0.214	0.033***
ESI	0.211	0.057***	−0.060	0.024**
EDU	−0.001	0.002	0.001	0.001
SME	12.566	1.067***	2.090	0.433***
SSE	−0.108	0.405	0.412	0.181**
W-EMP	0.309	0.488	0.322	0.160**
W-HHI	4.192	0.825***	2.961	0.335***
W-SSE	33.582	7.534***	13.190	3.121***
TMC	−0.025	0.007***	−0.008	0.002***
CC	1.470	0.732**	1.018	0.267***
CL	1.750	0.426***	0.482	0.164***
MAB	−0.400	0.325	−0.041	0.141
MAG	−0.089	0.389	−0.100	0.150
MAT	−0.707	0.414*	−0.015	0.178
MAL	0.686	0.461	−0.133	0.174
MAM	−0.453	0.538	0.350	0.244
Observations in the fit				941
Degrees of freedom for the fit				89
Residual degrees of freedom				852
Global Deviance (GD)				2110.105
Akaike Information Criterion (AIC)				2288.106
Schwarz Bayesian Information Criterion (SBC)				2719.484

The equation for the parameter σ has been not displayed for the sake of clarity. In such equation only significant terms are estimated, which are: HHI, CC, MAB, MAG and MAM.
***, ** and * indicate significance of the parameter at the 99%, 95% and 90% levels.

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Table 2.16: Model III: ZAIG estimation for sectors intensive in natural resources

Estimation of the ν and μ equations with linear parametric terms.

Estimation method: penalized likelihood.

Dependent Variable: ENT

Variable	ν-parameter equation Link function: logit		μ-parameter equation Link function: log	
	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	−11.677	5.569**	−6.715	2.664**
EMP	0.035	0.021*	0.001	0.006
HHI	0.240	0.094**	0.011	0.045
ESI	0.094	0.074	−0.079	0.042*
EDU	0.209	0.284	0.233	0.121*
SME	4.383	1.421***	0.890	0.683
SSE	−0.047	0.623	0.417	0.318
W-EMP	0.028	0.714	0.218	0.400
W-HHI	1.506	1.023	0.299	0.482
W-SSE	5.190	10.471	6.233	5.202
TMC	−0.031	0.010***	−0.005	0.004
CC	2.787	0.503***	0.790	0.153***
CL	1.333	0.376***	0.145	0.139
MAB	−0.403	0.396	0.155	0.166
MAG	−1.610	0.710**	−0.489	0.263***
MAT	−0.373	0.530	0.055	0.212
MAL	0.027	0.690	0.034	0.269
MAM	0.437	0.480	−0.011	0.178
Observations in the fit				941
Degrees of freedom for the fit				37
Residual degrees of freedom				904
Global Deviance (GD)				564.125
Akaike Information Criterion (AIC)				638.125
Schwarz Bayesian Information Criterion (SBC)				817.46

The equation for the parameter σ has been not displayed for the sake of clarity. In such equation only significant terms are estimated, which are: HHI, CC, MAB, MAG and MAM.
***, ** and * indicate significance of the parameter at the 99%, 95% and 90% levels.

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Table 2.17: Model IV: ZAIG estimation for sectors intensive in labour

Estimation of the ν and μ equations with linear parametric terms.
Estimation method: penalized likelihood.
Dependent Variable: ENT

Variable	ν-parameter equation Link function: logit		μ-parameter equation Link function: log	
	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	18.378	4.859***	−3.132	1.953
EMP	0.003	0.019	0.193	0.059***
HHI	−0.359	0.081***	0.045	0.032
ESI	−0.066	0.062	−0.035	0.025
EDU	−0.444	0.232*	0.039	0.057
SME	−5.957	1.147***	0.620	0.481
SSE	0.569	0.519	0.918	0.160***
W-EMP	0.202	0.590	−0.205	0.042***
W-HHI	−2.360	0.864***	0.707	0.291**
W-SSE	−6.650	8.558	−1.368	2.960
TMC	0.008	0.008	−0.001	0.001***
CC	−1.659	0.433***	0.278	0.162*
CL	−0.645	0.345*	0.153	0.126
MAB	0.431	0.331	0.293	0.149**
MAG	0.600	0.376	−0.046	0.123
MAT	0.497	0.481	−0.244	0.096**
MAL	−0.425	0.510	0.037	0.109
MAM	−0.604	0.456	0.270	0.170

Observations in the fit	941
Degrees of freedom for the fit	41
Residual degrees of freedom	900
Global Deviance (GD)	950.97
Akaike Information Criterion (AIC)	1032.97
Schwarz Bayesian Information Criterion (SBC)	1231.70

The equation for the parameter σ has been not displayed for the sake of clarity. In such equation only significant terms are estimated, which are: HHI, CC, MAB, MAG and MAM.
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Table 2.18: Model V: ZAIG estimation for sectors intensive in scale economies

Estimation of the ν and μ equations with linear parametric terms.

Estimation method: penalized likelihood.

Dependent Variable: ENT

Variable	ν-parameter equation Link function: logit		μ-parameter equation Link function: log	
	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	−33.608	6.628***	−1.718	3.646
EMP	0.010	0.017	−0.014	0.018
HHI	0.415	0.095***	0.051	0.037
ESI	−0.031	0.074	−0.107	0.032***
EDU	0.864	0.295***	−0.011	0.096
SME	5.791	1.458***	1.328	0.680*
SSE	−0.025	0.647	1.012	0.299
W-EMP	−0.349	0.743	0.595	0.335*
W-HHI	3.888	1.092***	−0.063	0.485
W-SSE	18.420	11.035*	0.383	4.437
TMC	−0.002	0.010	−0.002	0.000***
CC	2.065	0.446***	0.249	0.117**
CL	0.875	0.378**	0.232	0.133*
MAB	−0.864	0.433**	0.370	0.240
MAG	0.291	0.391	0.129	0.158
MAT	−0.188	0.588	0.049	0.199
MAL	0.543	0.659	−0.005	0.219
MAM	1.051	0.471**	−0.169	0.132

Observations in the fit	941
Degrees of freedom for the fit	40
Residual degrees of freedom	901
Global Deviance (GD)	631.30
Akaike Information Criterion (AIC)	711.30
Schwarz Bayesian Information Criterion (SBC)	905.18

The equation for the parameter σ has been not displayed for the sake of clarity. In such equation only significant terms are estimated, which are: HHI, CC, MAB, MAG and MAM.

***, ** and * indicate significance of the parameter at the 99%, 95% and 90% levels.

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Table 2.19: Model VI: ZAIG estimation for sectors with differentiated products

Estimation of the ν and μ equations with linear parametric terms.
Estimation method: penalized likelihood.
Dependent Variable: ENT

Variable	ν-parameter equation Link function: logit		μ-parameter equation Link function: log	
	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	−19.950	5.368***	−9.658	2.432***
EMP	0.009	0.017	0.210	0.049***
HHI	0.732	0.089***	0.103	0.0430**
ESI	−0.102	0.063	0.006	0.0315
EDU	0.433	0.242*	0.314	0.124**
SME	5.427	1.151***	0.596	0.550
SSE	−0.759	0.529	0.117	0.279
W-EMP	−0.279	0.566	−0.216	0.170
W-HHI	3.167	0.911***	1.616	0.456***
W-SSE	7.477	9.202	2.492	4.237
TMC	−0.022	0.008***	−0.008	0.007
CC	3.062	0.642***	0.781	0.179***
CL	3.062	0.642***	0.065	0.202
MAB	1.018	0.388	−0.179	0.204
MAG	−0.289	0.345	−0.304	0.155**
MAT	−0.536	0.483	−0.230	0.238
MAL	1.127	0.450**	−0.233	0.164
MAM	−0.271	0.480	0.283	0.253

Observations in the fit	941
Degrees of freedom for the fit	42
Residual degrees of freedom	899
Global Deviance (GD)	1344.23
Akaike Information Criterion (AIC)	1428.23
Schwarz Bayesian Information Criterion (SBC)	1631.80

The equation for the parameter σ has been not displayed for the sake of clarity. In such equation only significant terms are estimated, which are: HHI, CC, MAB, MAG and MAM.
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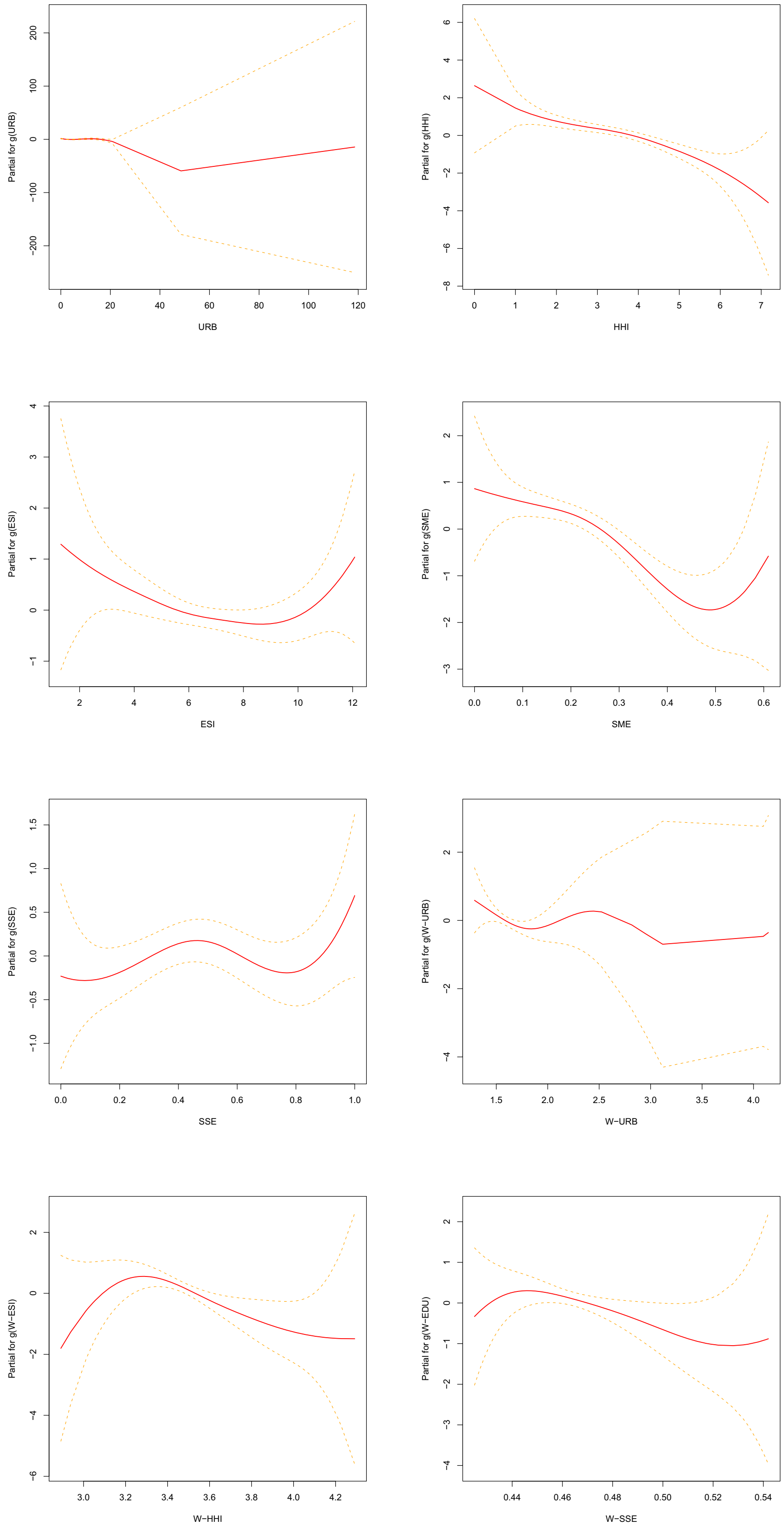

Figure 2.16: Nonparametric estimation of the Model II: Penalized Spline partial functions of the regressors from the ν-parameter equation. 95% pointwise confidence intervals are shown in dashed lines.

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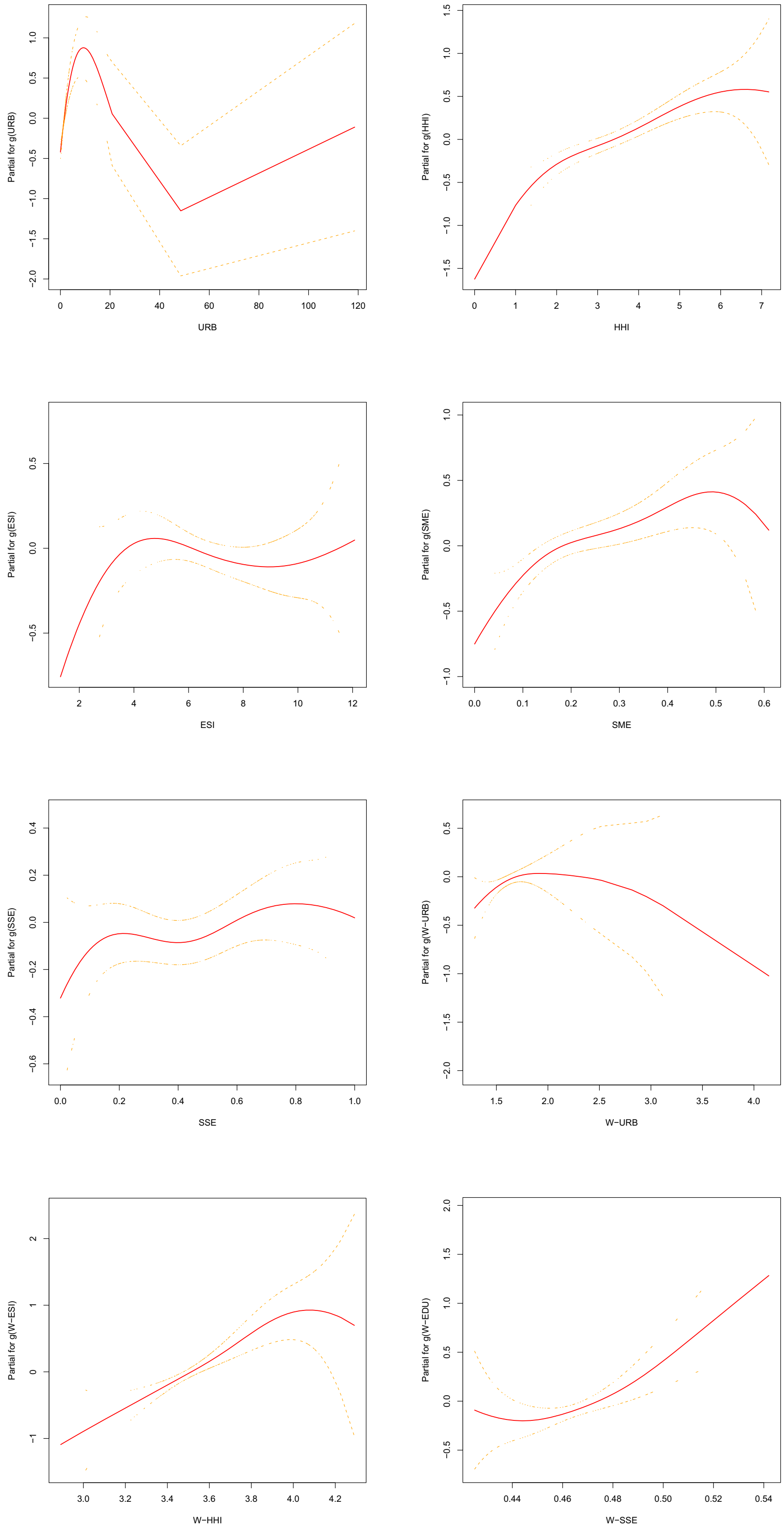

Figure 2.17: Nonparametric estimation of the Model II: Penalized Spline partial functions of the regressors from the μ-parameter equation. 95% pointwise confidence intervals are shown in dashed lines.

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Chapter 3

The Effects of Firm Entry on Factors' Demand: a Dynamic Analysis for Regions and Sectors

3.1 Motivation

In his very-well known contribution "What do we know about entry?", PAUL GEROSKI (1995) gave a brief, albeit insightful survey of empirical studies on market dynamics. His survey showed not only that there has been much empirical work undertaken in the field of industrial dynamics, but also that there was a vast, virgin field for future research, both from a theoretical and an empirical point of view. Indeed, if one takes a look at the evolution of economics as a science during the XXth century, one will realise that it is one of the fields where more discoveries and findings have been made. Besides, the field of industrial dynamics is especially relevant to economics for many reasons. One of them is its close bond to key variables such as employment, degree of competition, both productive and allocative efficiency, introduction of both process and product innovations and demand and substitution of productive factors, to name a few. Besides, industrial dynamics is a phenomenon closely linked to space and time. On the one hand, as it has been shown in the previous chapter, firm entries take place in a geographical spot, both conditioned and conditioning the local economic variables. Thus, the entry of firms is part of a broader and deeper cause and effect process by which firms enter the market induced by certain variables, and by

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doing it they change the local conditions that are to determine the future entry of firms. Then, it is in this continuous cause-effect process that the time dimension goes into action, because once firms have entered the markets they remain there for a certain period of time, during which both the firm and its environment change.

As it was pointed out in the introduction of this thesis, this dynamic and evolutionary conception of industrial markets is not a novelty. Thus, although the increasing interest in the dynamics of the industries nowadays, this field dates back to the time when MARSHALL (1890) highlighted the dynamism of industrial activities, and SCHUMPETER (1942) introduced the concept of *creative destruction*, which referred to the dynamic process of technological change. Indeed, the evolution of industrial markets during the second half of the XXth century, when several crises took place, has shown the true dynamism of small firms and the dynamic nature of industrial organisation. This way, economists and policy-makers gradually realised and came to the conclusion that the reality of industry changes over time had little to do with what old industrial organisation books foresaw about firm entry and exit. This fact, together with the increasing availability of data sets and the development of econometric and statistical methods, triggered the interest in this field and then the number of contributions never ceased to increase, opening new fronts just like a victorious army would do and leaving behind the trenches the static nature of the first contributions on industrial organisation.

Given the fact that it is firms that demand productive factors in order to undertake an economic activity whose result is an output, it is reasonable to think that the process of turnover that many industries experience has to do with this process. A related issue is the process of technological change and the role that new firms play in it. In this regard, as GEROSKI (1995) points out, it is a stylised fact stemming from the empirical literature on industrial dynamics that high rates of entry are often associated with high rates of innovation and increases in efficiency. From a theoretical perspective, technical change, productivity and factor demand can be considered as elements which are bound together by a more general economic phenomenon associated with technological change[1]. This way, the introduction of,

[1]The concepts *technical change* and *technological change* should not be mistaken. While the former refers to a change in the amount of output produced from the same inputs, the latter is used to describe the overall process of invention, innovation and diffusion of technology or processes

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say, a process innovation may trigger a technological change process by which both productivity and factor demand change. Following the example, it is straightforward to deduce that the role of new firms in the process of technological change will be greater as long as it is mainly new firms which introduce innovations or new technologies in the industry. In order to measure such role of new firms, empirical contributions have focused on the effect of these on a group of variables, among which there are labour and overall productivity and labour demand[2]. The results and conclusion of these contributions should not be read separatedly, because all these aspects represent a side of a broader and more general phenomenon, as stated earlier.

Given this framework of research, the motivation of this chapter is twofold: (a) to analyse the effects of firm entry on the dynamic demand of labour and (b) to study the relationship between firm entry and the dynamic demand and substitution of both capital and labour production factors. Both analyses are important and complementary. On the one hand, employment promotion represents a cornerstone of economic policy for both economists and policy-makes, since unemployment has a cost both for individuals (homelessness, malnutrition, depression, etc.) and for the whole economy, because it will not be using all of its resources and will be operating below its production possibility frontier. From this point of view, it is essential to study the effect of new firms on labour demand, i.e. employment generation, since the results will indicate to what extent new policies promoting new firms also have an effect on both short-term and long-term employment. The answer is not straightforward, since there is no consensus in the empirical literature on the fact whether it is new firms or rather long-established incumbents that generate the largest share of employment. However, employment growth does not represent the only remarkable improvement new firms can bring about. The process of turnover that many industries experience implies that new producers enter the markets and some others exit, and some of these entrants are likely to bring new technologies to the industry, that is, new processes of production which combine productive factors in a more efficient way. In this sense, it is possible that in some sectors some entrants provide the industry with a technology that allows to use less labour force

(SCHUMPETER 1942).

[2]Many contributions dealing with the effect of new firms on labour factor demand actually call it *employment change* and *employment growth*, although the concept is the same.

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(that is, a labour-saving process), with the result of an improvement in the efficiency of the production process. Given this case, it would be possible to observe that new firms are using less labour force than incumbent firms to produce the same output. Does this mean that the entry of new firms supposes a step backwards? That is not necessarily true. Then, the point (a) is important but it yields only a partial view of the whole story because firm entry is likely to have an effect both on the magnitude and on the proportion of the dynamic demand for several productive inputs, not just labour. This way, the analysis is completed with the study of the relationship between new firm formation and the dynamic demand and substitution of labour and capital factors, which is a process closely related to technological change. So far, most of the existing literature focusing on the relationship between industrial dynamics and technological change (GEROSKI 1991; BAILY ET AL. 1992; FOSTER ET AL. 1998) has considered productivity as a proxy for technological change, being productivity a measure of output per unit of input in the context of a production process[3]. The analysis undertaken in this thesis adopts an alternative approach by focusing on the demand and substitution of different inputs.

This chapter is structured as follows. Section 2 deals with the complex relationship between firm entry, labour demand and technology. First, some specific terms about factor demand are introduced, and the literature on the effect of firm entry on labour demand is reviewed, which includes both the main methodologies used by scholars and the results and evidence obtained so far. Second, the discussion about the relationship between technological change and employment is dealt with, starting with the introduction of a conceptual framework about the main definitions on the issue, and then continuing with a historical perspective on the matter and then discussing it in relation to the field of industrial dynamics and specifically with the role that new firms can play. Section 3 presents and describes the data and variables used in the analysis. Section 4 stands for an empirical descriptive analysis of regional, sectoral and temporal patterns of association of the variables analysed, and a contingency analysis, analysis of variance (ANOVA) and growth rates decomposition are performed. Section 5 is the first main empirical model of this chapter, providing the part of the empirical analysis that deals with the effect of new firms on dynamic labour demand. To do so, a dynamic distributed lag model is specified

[3] NADIRI AND PRUCHA (1999) discuss recent advances in modeling and estimating technical change, total factor productivity and dynamic factor demand.

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and straight on the estimation method and the results are shown. Section 6 is the second main empirical model presented in this chapter, which deals with the estimation of the effect of new firms on dynamic demand and substitution of labour and capital factors. The first part of this section presents a nonparametric analysis of the relationship between capital and labour factors, and then an econometric dynamic model analysing the dynamic demand of capital and labour factors as a function of both current and lagged values of the gross rate of entry is specified and estimated. Finally, the results are shown and interpreted. In section 7 the main conclusions are summarised.

3.2 Firm Entry, Labour Demand and Technology

3.2.1 Specifics and Importance of Factor Demand

At a microeconomic level, factor demand (that is, the demand for production inputs such as capital and labour) coming from productive units is a derived demand, since the demand for an input is derived from, or depends on, the demand for the output. If the output is more highly demanded, then the input used in production is also more highly demanded. In general, factors determining factor demand are heterogeneous, i.e. branch of activity, price and characteristics of the output, and also characteristics inherent to factors, such as substitutability, price and productivity (or marginal revenue product). Besides, a crucial factor that has generated many both theoretical and empirical contributions is the existence of adjustment costs. Such costs appear when a firm changes the proportion of productive factors used, and such costs then slow down the demand for such factors, that is, the process of adjustment of the quantity and proportion of productive factors as a response to changes in factor price and productivity is restrained[4]. However, static neoclassical theories for factor demand have not considered as determinants for factor demand dynamic changes in industry composition, that is, firm entry, exit, expansion and contraction. This section reviews theoretical models dealing with industry dynamics which, despite not considering explicitly the factor demand issue, give some hints on this issue.

[4] HAMERMESH AND PFANN (1996) analyse and analytically model these costs, both from a microeconometric and a macroeconometric point of view.

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So far, the literature focusing on the relationship between new firm entry and productive factor demand has focused mainly on the demand for the labour factor, that is, workers or working hours. One feature of the vast existing literature is the diversity of names given to this issue, i.e. employment growth, employment creation, job growth, demand for workers, etc. Despite this terminological mess, the underlying concept is the same and, henceforth, it will be referred to as labour demand. Another characteristic of the literature is the multiplicity of levels at which the phenomenon is studied. Early studies focused on the plant and industry level, that is, on labour demand changes caused by entering and exiting plants. This stream of the literature aims at determining whether it is plant entry and exit as opposed to plant expansions and contractions the main source of labour demand changes. This stream has been complemented lately by a regional economics approach, in that regional and local firm entry are considered to foster labour demand in certain geographical areas. This way, the target shifts from certain industries to regions, which has clear and important policy implications. All in all, the regional approach complements the results and conclusions obtained by studies focusing on certain industries, and the result is a great enrichment of the knowledge of the matter available for scholars and policy makers.

3.2.2 Evidence on Firm Entry and Labour Demand

Since the late 1970s there has been a stream of empirical contributions aiming at the study of the link between industry dynamics and labour demand. Such relationship is complex, since industry evolution encompasses firm entries, exits, expansions and contractions. Besides, the size at the moment of entry is dissimilar among firms and, moreover, firms follow different paths once they have entered, i.e. either they survive and grow or they fail and exit, just as the theoretical models reviewed in the previous section explain. All this complexity has a continuous effect on labour demand, whose different components are often difficult to identify and disentangle. The development of several data sets for several countries as well as the theoretical contributions providing a research framework triggered the study of this phenomenon. Generally speaking, such stream of contributions tried to decompose changes in labour demand into four component parts: (B) birth of new plants/firms, (G) growth of existing plants/firms, (D) death of existing plants/firms, and (C) contraction of existing plants/firms, each part indicating the

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percentage change in labour demand coming from that source. Analytically, this decomposition is represented by the identity

$$\Delta L^D \equiv B + G - D - C, \tag{3.1}$$

where ΔL^D stands for the net percentage change in labour demand in some aggregate[5].

In his empirical studies, BIRCH (1979,1981) was one of the first scholars to contribute some evidence to the matter, and he found that most of the net expansion of employment was due to the creation of new jobs through the birth of small establishments[6]. Evidence on the contrary was found by BALDWIN AND GORECKI (1988) by using plant level data. They found that net employment changes that occurred over a decade were due more to differences between growth and contraction in existing plants that to those between births and deaths of plants. Besides, they found that long-term gross additions to employment result as much from births as from growth, and long-term job losses result even more from deaths than from contractions. DUNNE ET AL. (1989A) examine the patterns of post-entry employment growth and failure for the US manufacturing sector at the plant level, finding that plant growth and failure were closely related to the plant's age and size, i.e. both the failure rate and the growth rate of nonfailing plants decline with age, and larger plants, if they survive, have lower failure rates and lower growth rates than smaller plants. Besides, they confirm the common result that small plants grow faster than large ones, if they survive, but that they are much less likely to survive. They also confirm the existence of an underlying plant turnover resulting in a continual loss and creation of employment, which is evidenced by the fact that gross employment flows resulting from plant turnover are substantially larger than the resulting net change in employment. All in all, they conclude that the continual entry and exit of the high failure probability plants generates employment turnover, while the high survival rate of low failure probability employers ensures that many employment opportunities are of long duration. In a similar study, DUNNE ET AL. (1989B) quantify the role of plant construction, expansion, contraction, and closing

[5] HAMERMESH (1993) reviews extensively and compares the empirical literature based on this relationship.

[6] His studies have been the object of some criticism, since small firms are oversampled in the used database and then the results are likely to be biased.

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in generating net and gross changes in US manufacturing employment. A novelty provided by this contribution is that it compares the plant-level with the industry and regional levels. First, they identify significant offsetting employment flows within industries and regions, with large numbers of jobs being created and lost within the same industry and region, which implies that turnover rates that are significantly higher than those indicated by employment shifts at the industry or regional level, thus revealing a substantial heterogeneity in employment patterns across plants within the same industry and region[7]. Second, their results point out that the rate of employment growth due to plant expansion is higher for young plants but this is offset by a higher rate of employment loss through plant closings. Besides, older plants have higher rates of job loss through plant contraction, particularly in those periods in which total manufacturing employment falls. DAVIS AND HALTIWANGER (1992) study the heterogeneity of establishment-level employment changes in the US manufacturing sector, focusing on the study of the gross creation and destruction of jobs and the rate at which they are reallocated across plants. Their result indicate that gross rates of job creation and destruction are remarkably large, and that there exists simultaneity of high rates of job creation and destruction among industries and groups of plants in terms of age, size and region. Besides, job reallocation is higher and more stable among young and small plants[8].

The introduction of the regional component in the analysis, which represented a whole different approach to the matter, is due to REYNOLDS (1994), who studied the relationship between the level of new business formation and regional employment change for the US. He found a positive effect of entry on employment growth, but conducting the analysis for different time periods revealed considerable variation in such relationship. For the British economy, ASHCROFT AND LOVE (1996) explore the relationship between regional firm formation and net employment change at the country level of Britain during the 1980s, and by means of the estimation of a factor-demand model they find that that firm formation is strongly associated with net employment change. For the Swedish economy FÖLSTER (2000) analyses a somewhat different but related topic, which is the question whether entrepreneurs

[7]Quantitatively, they obtained that over 70% of the turnover in employment opportunities occurs across plants within the same two-digit industry and geographical region.

[8]DAVIS ET AL. (1996) review the extense and compelling evidence on job creation and destruction at the level of individual plants in the US manufactirung sectors.

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create jobs, i.e. if there is a link between self-employment and overall employment. His results indicate that there is a positive relationship between these concepts, although it is not proven that all kinds of entrepreneurs have the same effect on employment growth. ACS AND ARMINGTON (2004) link employment growth to entrepreneurial activity at the city level in the US. By doing so, they also relate employment growth to agglomeration economies and human capital and thus analyse the question using terms and methodologies characteristic of the *New Economic Georaphy* literature. Their main conclusion is that new organisations play an important role in taking advantage of knowledge within a region and that, for the non-manufacturing sectors, new firms are more important than the stock of small firms in a region .

A novel approach to the issue of the effects of firm entry on labour demand was adopted by VAN STEL AND STOREY (2004) for UK and FRITSCH AND MUELLER (2004) for Western Germany, in that they used a different econometric approach in order to capture the dynamic effects of regional entries on aggregate labour demand changes. Therefore, this approach differs from other approaches in the sense that it captures both the spatial and temporal dimensions. The former is taken into account by analysing regional data and the latter is analysed by considering the effects of entries both in the short and the long term. The temporal sequence assumed by this approach is that firm entry has both an immediate and a long term effect in the industry. The short-term effect is a creation of employment, since new firms demand labour force to start their activities. However, as time goes by, some of those entering firms and some incumbent firms exit the industry, which causes employment destruction. Besides, those entrants that suceed and remain in the industry are likely to grow, which leads to employment creation. The approach proposed by these studies does not try to decompose labour demand changes according to the taxonomy shown in (3.1), i.e. births, deaths, expansions and contractions. Instead, the aim is to estimate the *net* labour demand change for each period after the entry has taken place for a certain region. Analytically, this dynamic relationship between labour demand change and firm entry suggests a time lag structure[9]. Econometrically the especification of such lag structure takes the form

[9] This way, for each period, the *net* labour demand change will be the result of employment creation by entering and growing firms and employment destruction by exiting and shrinking firms.

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$$\Delta L_{it}^{D} = \alpha + \beta_0 E_{it} + \beta_1 E_{it-1} + \ldots + \beta_s E_{it-s} + \varepsilon_{it}, \tag{3.2}$$

where i and t denote region and time period, ΔL^D are changes in labour demand and E is a measure of firm entry. The time span covered by the analysis is determined by the number of lags s, which denotes the number of periods during which the effect of entries on labour demand occurs. This way, the estimated parameter $\hat{\beta}_j$, $\forall j \in [0, s]$, represents the effect of E on L^D in the j^{th} period after the moment of entry, and thus the $s+1$ estimated parameters plus the intercept form the lag structure of the dynamic relationship between E and L^D. A severe econometric problem that the empirical estimation of (3.2) entails is the multicollinearity between the regressors, which invalidates the classic OLS estimation because it would not reflect the "true" lag structure. In order to solve this problem, VAN STEL AND STOREY (2004) and FRITSCH AND MUELLER (2004) applied the Almon polynomial lag procedure. This procedure attempts to approximate the lag structure by a polynomial function. In this type of analysis, an assumption has to be made about the order of the polynomial to be used for estimating the lag structure, this is, a value must be assigned to s. FRITSCH AND MUELLER (2004), by estimating a third and fourth order polynomial, found a "wave" pattern that has also been obtained in other similar studies for other economies. Such pattern is depicted in the Figure 3.1.

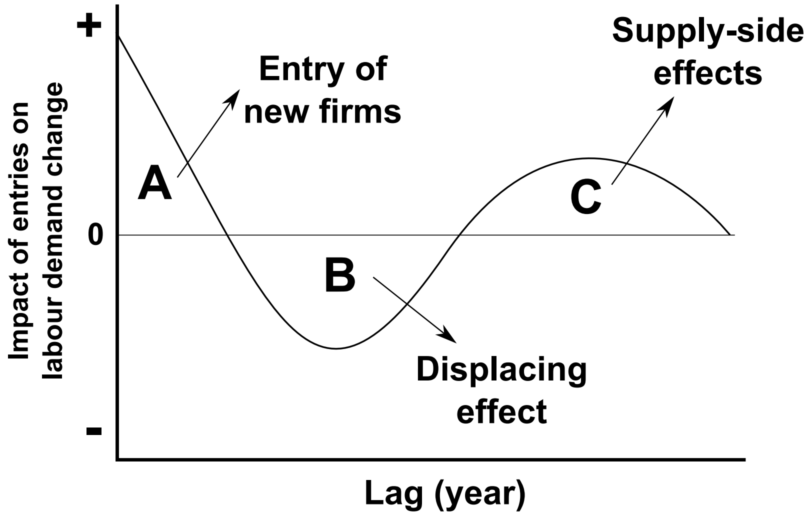

Figure 3.1: Dynamic effect of entries on labour demand change

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The smoothened distribution of the lags according to this pattern suggests the existence of three clear periods, represented by the areas A, B and C[10], which were given a name and explained by the authors as follows:

1. **Entry of new firms (area A):** the immediate, short-term positive direct effect of entries on labour demand changes stems from the labour force that new firms demand in order to enter in the market and start operating.

2. **Displacing effect (area B):** in the first period the market begins a firm selection process. Net job formation may therefore be positive or negative and will depend on how newcomers develop. Two types of exits derive from the entry of new firms. First, some new firms may have to leave the market after a certain time due to their lack of competitiveness. Second, some incumbents may be forced out of the market by new competitors. With a *survival-of-the-fittest* scenario, and if the overall market volume remains constant, a negative net job creation can be expected from the difference between the creation of employment by new firms and the destruction of employment by exiting firms (both newcomers and incumbents).

3. **Supply side effects (area C):** indirect supply-side effects derive from the entry of new firms and the more intense competition that this creates. These effects can help to increase the competitiveness of an economy and may stimulate economic growth. Among the indirect effects there are a greater efficiency of the incumbent firms due to stronger competition from real and potential entrants; a faster structural change, since the turnover of firms leads to the adoption of new technologies; greater innovation, since newcomers are more able than incumbents to introduce radical innovations and are more interested in exploiting the possibilities for potential profit; and innovative entry, which may lead to better-quality and more varied products and a greater probability of finding a better match for customer preferences. Supply-side effects do not depend on the success of new firms, since the greater supply can actually come from both new firms and incumbents. Then, after about nine or ten years, the impact of new business formation on regional employment has then faded away.

[10]The number of lags chosen by the authors was $s = 10$, although this number varies for other similar studies.

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This methodological approach and the conclusions derived from it aroused a great deal on interest among the scholars researching this topic, and some contributions for different countries using such methodology were presented at the workshop ”The Effects of New Businesses on Economic Development in the Short, Medium and Long Run” that took place at the Max Planck Institute of Economics in Jena (Germany) on July 11th and 12th, 2005. The aim of this workshop was to compare the empirical findings for different countries and to have a fruitful discussion on this topic. The result was an especial issue of the journal *Small Business Economics*[11] including the results of the analysis for sereval countries. FRITSCH AND MUELLER (2008) present evidence for the German economy, obtaining that the different phases of the effects of new business formation on regional development are relatively pronounced in agglomerations as well as in regions with a high-level of labour productivity, being the effect negative in those regions with lower productivity. Thus, for the German case the interregional differences indicate that regional factors play an important role. The study of the Dutch case is covered by VAN STEL AND SUDDLE (2008), the main results being that the maximum effect of new businesses on regional development is reached after about 6 years, the immediate employment effects are small and the employment impact of new firms is strongest both in manufacturing industries and in areas with a higher degree of urbanization. BAPTISTA ET AL. (2008) is the contribution for the Portuguese case, whose main result is that indirect effects of new firm births on subsequent employment growth are stronger than direct effects, indirect effects taking place about 8 years after firm entry, which might be due to a general pattern of results in which lags appear to be longer for Portugal. The study for the case of Great Britain is provided by MUELLER ET AL. (2008), being the main result the confirmation of the three discrete phases identified in similar studies. Besides, the authors show that employment impact of new firm formation is significantly positive in the high-enterprise counties of the country. ACS AND MUELLER (2008) adopt a somewhat different approach to study the impact of firm heterogeneity on employment effects for 320 US Metropolitan Statistical Areas (MSA), finding that only start-ups with a staff between 20 and 500 employees have persistent employment effects over time and only in large diversified metropolitan regions. Therefore, both the type of entry and the characteristics of the region are important for employment

[11] Volume 30, Number 1 / January, 2008.

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growth. ARAUZO ET AL. (2008) explore the incidence of new business formation on employment growth in the Spanish manufacturing industries, estimating a model with lags from t to $t-7$. Their results are similar to some other studies using the same model, obtaining a positive short-term effect, a negative medium-term effect and a positive long-term effect. Lastly, CARREE AND THURIK (2008) undertake the analysis of this phenomenon and extend it for 21 OECD countries. Their study is broader, in that they investigate the impact of changes in the number of business owners on three measures of economic performance, i.e., employment growth, GDP growth and labour productivity growth, the results confirming the evidence provided by similar studies: an initial direct positive effect, then a negative effect due to exiting capacities and finally a stage of positive supply-side effects.

In general, the main conclusion than can be drawn from these studies is that the initial wave pattern found by FRITSCH AND MUELLER (2004) has been roughly confirmed by the evidence for other economies. However, each study is unique, in the sense that it analyses a specific economy with certain characteristics and specificities, so that the exact wave pattern obtained by each study differs from the rest. All in all, the overall summarised evidence from all these contributions provides a highly rich and complete picture of the analysed phenomenon. This way, there are many specific elements that might influence and determine the exact relationship between new firm entry and employment change. The following enumeration summarises the key factors found by these contributions.

a) **Firm size:** the studies accounting for firm size have found that the effect of entries on employment growth differs with size. This way, when the prevailing entering firms are large (500 or more employees), the lag structure tends to be "u"-shaped, while for those cases where entrants are rather small (20 or less employees), the effect on employment is positive but continuously decreasing with time.

b) **Firm growth:** undoubtedly, the effect of entries on employment growth depends on to what extent such entering firms grow and hire employees. It has been proven that in those regions where there is a predominance of fast-growing firms (also called "gazelles") the effect of entries on employment growth is greater. The reason of such stronger effect is twofold, that is, on the

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one hand such gazelles tend to demand more labour force and, on the other hand, they are related to improvements in competition and overall efficiency in the long term, and it has also an effect on employment growth.

c) **Sector:** some studies have found that the effect of entries on employment differs with sector, and the results point out that those entries that take place in the manufacturing sectors have a greater effect than those entries belonging to the service or agricultural sectors.

d) **Region:** following a reasoning similar to the previous case, entries have a different effect according to the region where they take place. Evidence for different countries has shown that entries have a greater effect on employment when they take place in agglomerated and high-productive regions. On the contrary, in less agglomerated areas the effect is more limited and in some rural areas the effect has been found to be negative.

To sum up, apart from these specific elements that have an influence on the dynamic effect of entries on employment, it can be stated that the most important impact of entry is that it spurs competition and market selection. In the long term, employment growth may occur due to improved competitiveness of the regional economy that is induced by supply-side effects such as increased efficiency, more rapid structural change, amplified innovation and increased variety (FRITSCH 2007). It is remarkable that the greater effect occurs in the long term, and the short-term success and growth of entries themselves represent only a small part of the overall effect.

3.2.3 Technological Change vs. Employment Creation

3.2.3.1 What is Economic Development?

As it has been shown in the previous section, scholars trying to shed light on the effects of firm entry and turnover upon the economy have considered a wide array of measures to quantify it, i.e. increased competition, productivity, output growth, employment growth, and so on. Too often researchers identify the results of their estimations and analyses with the broad and general concepts of economic development, growth or performance by using very general terms. Table 3.1 gives an example of this.

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Table 3.1: Different terminology in the literature

Study	Definition used	Measured variable(s)
CARREE AND THURIK (2008)	economic performance	employment growth GDP growth labour productivity growth
AUDRETSCH AND KEILBACH (2004B)	economic performance	GDP growth
CARREE ET AL. (2002)	economic development	per capita GDP growth
FRITSCH AND MUELLER (2008)	economic development	employment growth
AUDRETSCH AND FRITSCH (2002)	economic growth	employment growth
CARREE AND THURIK (1998)	economic growth	output growth
REYNOLDS (1999)	economic growth	employment growth

Source: own elaboration.

The aim of this section is to introduce a discussion about the relationship between technological change, labour demand (a term that encompasses labour demand as well as capital demand) and factor substitution. The point to be made is that technological change and labour demand may be conductive to economic growth, but they are very different phenomena that are only compatible under certian circumstances. EDQUIST ET AL. (2001, P. *ix*) express this idea by stating that

> *"[w]hen politicians discuss remiedies for the unemployment problem, they often claim that more rapid growth is what would solve or mitigate it. Such a statement is unclear in the sense that it does not specify what kind of growth is meant. Is it, for example, economic growth (GDP) or productivity growth? Everyone talking about growth and employment should be specific on this issue, since the employment consequences of these two kinds of growth are very different!"*

Then, when it comes to the analysis of the effect of firm entry on the economy, more attention should be paid to the specific effect that these exert on different economic variables. Many contributions have highlighted the fact that entries are often agents that bring about technological change, and the theory says that such technological change can be labour saving, that is, that by means of certain advances the same level of output can be produced by using less labour force. This fact poses the following question: are new firms conductive to economic growth only as long

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as they create employment? What would happen if they demand less labour force as exiting firms did? Are these entrants still worth being promoted by policy makers? The empirical analysis carried out in this chapter aims at giving an asnwer to such questions. The rest of this section is intended to review the theoretical underpinnings on the relationship between technological change and factor demand and to give an historical overview of this phenomenon, reviewing the main results and stylised findings and to discuss the role of new firms in the matter.

3.2.3.2 Concepts about Technology and Labour Demand

The aim of this subsection is to introduce some terminology as well as concepts related to the issue of technological change and labour demand. First, the type of innovations and its relationship with labour demand is discussed, and second the different types of technological change are introduced in a formal way and several extensions are discussed.

A) Type of Innovation and Labour Demand

Technological change is a very complex and dynamic process, and it can take many forms and occur under very different circumstances. When it comes to the definition of an innovation, a possible way is to make a distinction between product and process innovations, since their short-term and long-term effects on employment differ. In fact, both theoretical and empirical contributions have pointed out at a rather complex relationship between innovation and employment, with *direct effects* of innovations on employment when these take place and also *indirect effects* in the long term that either accentuate, counterbalance or reverse the initial direct effects[12]. The main effects found in the literature are described and explained next.

A.1) Product Innovation

This concept refers to the creation or improvement of products and the satisfaction of needs in an innovative way, and is said to have an initial effect on em-

[12] BLECHINGER AND PFEIFER (1997) review the impact of both types of innovation on labour demand.

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ployment, because this kind of innovation generates production needs. However, several factors can act in the opposite way, and these factors are summarised as follows:

a) **Degree of substitutability:** if new products only replace old ones the direct positive effect might be offset by the loss of employment due to the replaced product.

b) **Technology of production:** the technology of production of the new product is important, specially compared to the technology with which the old replaced product was produced. In general, the overall effect on labour demand depends on the labour intensity of both technologies as well as the levels of production.

c) **Complementarities in demand:** if new products are complements to existing ones the overall effect on aggregate employment will be magnified, i.e. further employment will be created of destroyed as long as new products foster or hinder the production of complements.

A.2) Process Innovation

This kind of innovation occurs when the production process of a product is improved. If such innovation is labour saving, and provided that the output level remains unchanged, then the direct effect is a decrease in labour demand. Despite this initial effect, indirect effects in both directions may arise depending on the forthcoming variables.

a) **Elasticity of substitution:** This term refers to the degree to which production factors can be replaced between them. Provided that innovation renders a certain factor cheaper or more productive, a high elasticity of substitution will bring about a higher transfer from one factor to the other. This way, labour (capital) saving innovations will have an indirect positive (negative) effect on labour demand.

b) **Price elasticity of demand and competition:** process innovations are likely to have an effect on production costs, which in turn will eventually lead to a final product's price decrease. In this case, if the demand function is elastic enough,

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the demand for goods will increase, and so will production and labour demand. It is worth noting that this positive effect depends on the competition level of the market, since in markets characterised by a lack of competition cost reductions might not be fully transmitted to price reductions, then resulting in a lower effect on labour demand compared to the competitive case.

c) **Economies of scale:** in the presence of economies of scale, cost reductions due to innovation will lead to a larger output production, which combined with a high price elasticity of demand will bring about an increase in labour demand.

B) Technological Change Direction and Bias

The basic feature of technology is that it improves the efficiency of production factors. However, technological change can adopt many forms and take place under very different circumstances. For instance, it may improve the efficiency of a single factor, or just improve the manner in which different factors are combined in a production function. For the sake of simplicity, let K and L be capital and labour production factors, and Y the level of output produced by means of the aggregate production function $F(\cdot)$, so that $Y = F(K, L)$[13]. Then, the following types of technological change can take place:

a) **Hicks neutral/nonbiased technological change:** it is the case when the change increases the efficiency of each input proportionally, so that the production function can be written $Y = A\ F(K, L)$, where A stands for the state of technology. One feature of this type of change is that, for a given capital-labour ratio, the ratio of marginal productivities remains unchanged.

b) **Biased technological change:** this is the case when change increases the efficiency of productive factors asymmetrically. If the improvement makes it possible to obtain the same amount of Y with less labour (capital), then it is biased in favour of such factor, and is considered to be a labour (capital) saving/augmenting technological change. Both cases can be represented by adding efficiency indicators to each factor in the production funcion, that is, $F(A_L L, A_K K)$.

[13]Such function is assumed to be homogeneous of degree 1.

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These types of technological change are not mutually exclusive, and therefore they can appear simultaneously under the form of $A\ F(A_L L, A_K K)$. However, considering capital and labour factors as homogeneous is too simplistic, and it is necessary to consider them no only quantitatively, but also qualitatively. Regarding the capital factor, it is very common that new and improved equipments replace older installations. In this process, a distinction can be made between *embodied technological progress*, which increases only the productivity of new capital equipments, and *disembodied technological progress*, which increases the productivity of capital as a whole (CAHUC AND ZYLBERBERG 2004, P.567). This distinction is important and has consequences in terms of growth, since while the former affects growth only as long as new investments take place, the latter has an effect on growth independently of new capital investments. Heterogeneity in the labour factor has also been considered and studied, and the economic term *human capital* tries to capture those qualities of the labour force that improve its contribution to the production function[14]. In this respect, long-term historical empirical evidence from numerous developed countries points out that the number of skilled workers has grown over time, and this evidence has given birth to the "Skill Biased Technological Change" (SBTC) hypothesis, according to which the reason for such an increase in skills of the workforce is to be found in the non-neutrality of technological change that benefits skill labour more than other production functions (PIVA ET AL. 2005). Such an hypothesis assumes that technology is complementary to skills, and thus technological advances increase the demand for skilled labour. Besides, the diffusion of Information and Communication Technologies (ICT) have had an effect on the substitution of skilled workforce for the unskilled, since ICTs have raised the marginal productivity of skilled labour and therefore lowered its relative price[15].

[14]Since Adam Smith coined this term referring to the acquired and useful abilities of all the inhabitants or members of the society, much has been written and discussed about this type of capital. For a recent discussion about it, see KEELEY (2007).

[15]Despite the positive evidence on the SBTC hypothesis, the debate about it is open and many contributions are being made regarding in which sectors and factors such a phenomenon takes place, since the evidence on it is still inconclusive. For a comprehensive review of the literature, see SANDERS AND WEEL (2000) and PIVA AND VIVARELLI (2002), and for a discussion about alternative explanations for SBTC such as globalisation and organisational change, see LEE AND VIVARELLI (2004), PIVA AND VIVARELLI (2004) and PIVA ET AL. (2005).

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3.2.3.3 Historical Perspective

Lately, there has been considerable debate over whether technological change affects the labour market creating unemployment. This debate is not restricted to academic circles, and an example of that is the best-selling book by JEREMY RIFKIN (1995), in which he prophesied that worldwide unemployment would increase as information technology eliminates millions of jobs in the manufacturing, agricultural and service sectors. Specifically, he argued that while a small elite of economic agents appropriate the benefits of the high-tech global economy, the American middle class continues to shrink and suffer. Despite the success of this contribution, it has been criticised by many economists because his argumentation is based on the citation of individual cases and situations. In fact, this is not a new line of argument, and yet at the beginning of the XIXth century they were used in England during the luddite and Swing riots[16]. Interestingly, the luddite movement is the origin of an economic concept called *ludite fallacy*, which consists in the belief that labour-saving technologies increase unemployment by reducing demand for labour. Ever since, much has been written and studied about the effect of the introduction of labour-saving technologies upon labour demand, many authors concluding that the effect is not restricted to the short-term employment destruction. This broadened view is well reflected in SAUVY (1980), who admits that in the short term technological change can actually destroy employment, in that unskilled workers can be replaced by machines. However, he also argues that technological progress also creates jobs the long term, in a process by which productivity gains emerging from technological advances will allow to cut prices, increase wages or increase profits and thus raise the consumption of other products or services. Then, the result will be a generation of jobs of different nature than those first destroyed and in other sectors, an employment transfer taking place from industry to services. In fact, those arguments favouring a long-term positive link between technological change and employment have been gathered in the *compensation theory*, which is an aggregate of different market compensation mechanisms which are set off by technological change and

[16]The Luddites were a social movement of British textile artisans who protested against the changes produced by the Industrial Revolution by destroying machinery, since they thought that it was leaving them without work. A similar phenomenon was the Swing Riots, a widespread uprising by English rural workers who wanted to put a stop to the fall of their wages and to the introduction of the new threshing machines that threatened their jobs.

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which can offset the initial job losses caused by it[17]. VIVARELLI (2007) scrutinises such theory and identifies the following compensation mechanisms:

a) **New machines:** labour-saving innovations that replace labour with capital also generate labour demand in the capital sectors where the machines are produced.

b) **Decrease in prices:** labour-saving innovations may lead to production costs reductions and these in turn are translated into decreasing prices, which stimulate a new demand for products that pushes production and employment up.

c) **New investments:** the reducion in production costs explained in the previous mechanism is likely to provide innovative entrepreneurs with extra-profits that, when invested, generate production and employment.

d) **Decrease in wages:** assuming a neoclassical interpretation of the labour market, unemployment caused by technological change implies a decrease in wages, which will lead to the development of more labour-intensive technologies[18].

e) **Increase in incomes:** the benefits of technological innovation can lead to higher income and hence higher consumption, which represents an increase in demand which in turn leads to employment generation.

f) **New products:** when technological change takes the form of product innovations, its impact on employment is positive, since it implies either the creation of new economic branches or the development of existing ones.

The relationship between technological change and employment has been a target of both theoretical and empirical contributions for a long time. DOBBS ET AL. (1987) analyse analytically the impact of technical change on employment by dividing such total impact into two stages: (a) technical change at the firm level and its diffusion through the industry and (b) the adaptation of the industry,

[17] VIVARELLI (1995) offers an extensive analysis on this topic, and VIVARELLI (2007) provides a detailed survey of the theoretical and empirical literature on the subject as well as a critique of the theory.

[18] In fact, the idea behind this mechanism supports the vision of ACEMOGLU (2002), which states that the development and use of technology respond to profit incentives.

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with entry/exit of firms and changes in market structure. Their analysis allows technical change to have different effects on industries both in the short and the long term depending upon various factors, i.e. final demand elasticities, elasticities of substitution, number of firms, economies of scale and openness of the market. CABALLERO AND HAMMOUR (1998) introduce the embodiment of technology in capital and its relationship with capital-labour substitutability. The authors argue that, since technological embodiment makes capital supply much less elastic in the short than in the long term, it is therefore more exposed to appropriability[19], and thus technology choice implies that an attempt at appropriating capital will induce a substitution away from labour in the long term.

Indeed, this problem can be tackled by another perspective, that is, not by focusing on the quantity of employment, but on its quality. This alternative focus could be put forth by asking the following question: *what kind of jobs are created or destroyed by technical change?* This line of research has taken two main directions, i.e. changes in the composition of skills (SBTC) and changes in the wage structure (wage polarisation). This line of research is adopted by ACEMOGLU (2002), which specifically tackles the link between technical change and skill and wage differences in the labour market. Such essay put forth the idea that, while technical change was skill-replacing during the XIXth century, it was skill-biased during the XXth century in the US and during the past decades the skill bias accelerated[20]. The author argues further that the increased supply of unskilled workers in the XIXth century in England rendered skill-replacing technologies profitable, while for the US case in the XXth century the opposite situation applied, i.e. the increasing supply of skilled workers induced the development of skill-complementary technologies.

All in all, it is not possible to give a unique and unequivocal answer to the question posed in this section. There are many different elements to be taken into account, depending on which the result will vary for each type of sector, technological advance, economy and many other specificities. In a recent attempt to give a taxonomy on this issue, PIANTA (2005) examined the relationship between innova-

[19]Appropriability is the quality of being imitable or reproducible, or alternatively the conditions surrounding an invention that enables the capture of the value of an innovation.

[20]The skill-replacing technical change replaces skilled workers by capital units, while skill-biased technical change replaces unskilled workers for capital units.

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tion and employment and reviewed a large empirical literature addressing a variety of research questions at different levels of analysis. The result is list of stylised facts emerging from the empirical evidence, whose main elements are exposed next:

a) When economic growth, structural change and demand dynamics take place together, in the long term the employment loss due to labour-saving technological change is recovered in other sectors of the economy. However, there is also evidence that current technological change may be a cause of unemployment, which then is labelled as *technological unemployment*.

b) As a matter of fact, the type of innovation matters. For instance, product innovations are labour-demanding, while process innovations are labour-replacing, and organisational innovations may lead to firm restructuring and downsizing, having a negative effect on labour demand.

c) In general, innovations being generated in the last decades tend to be skill-biased, i.e. unskilled jobs are either declining or slowly growing, while skilled jobs are created at a faster pace. This fact is one of the phenomena responsible for the growing wage polarisation and income inequalities, being other causes the evolution of labour markets, employment forms, social relations and national policies.

d) Aggregate demand, macroeconomic conditions, trade openness, national innovation systems and labour market conditions and institutions are breeding grounds for a positive impact of technological change on employment, income and distribution.

So, according to PIANTA (2005), the subject is so complex that no single approach can account for the direct and indirect consequences of technological change on labour demand, and both theoretical and empirical research have to proceed simultaneously and interacting with each other.

3.2.3.4 The Role of New Firms

At this stage, a straightforward question emerges: what is the role of new firm in this process? So far, the broad and multidisciplinar literature reviewed in this chapter has provided these facts:

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a) Firm entry is a fundamental part of a complex mechanism by which industries evolve over time, other important elements being firm growth, contraction and exit.

b) Firm entry and turnover have been reported to have an effect on multiple variables, i.e. output growth, factor demand, innovations, technical change, productivity and competition.

c) Firm entry is very heterogeneous, and its aggregate effect on the economy depends upon many variables, i.e. life cycle of the industry, innovative attitude of entrants and demand conditions, to name a few.

d) Under certain circumstances, technological change is labour-saving, which has a negative effect on labour demand.

So, what does the complete picture look like? Figure 3.2 represents a simple picture of the process[21]. Firm entries cause exits (both newcomers and incumbents), which imply a reduction in labour demand, characterised by D in the Figure 3.2. But what is the effect of new entries on employment? Figure 3.2 classifies entries into two broad categories, i.e. not innovative and innovative firms[22]. Non-innovative entries have a positive effect on labour demand denoted by A. Such non-innovative entries are assumed to have a production process similar to that of exiting firms, and then differences in labour demand are expected to stem only from size differences between newcomers and exiting firms. Innovative entries are in turn classified into two categories: those which introduce product innovations and those which provide the market with process innovations. Their effect on labour demand is denoted by B and C, respectively. In both cases, new firms demand labour, that is, $B, C > 0$, but the final net effect differs. In the former case, product innovations imply either a product differentiation or the creation of new industry branches, which has in principle a positive effect on labour demand because of the final product demand that it generates. However, when new products only replace old

[21]It is worth noting that Figure 3.2 only shows changes in labour demand stemming from firm entries and exits, and thus not considering labour demand changes coming from firm growth/contraction.

[22]Here the term ”innovative” is to be interpreted in a broad sense, that is, a new firm is considered to be innovative both if it actively undertakes innovation activities and also if it introduces capital-embodied new technology.

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ones no positive effect can be expected, and even a negative effect on employment is possible, if the new products are produced using more labour-saving production technologies. The latter case is likely to be a cause of employment destruction, since the new production process will use less labour force than the one used by exiting firms[23].

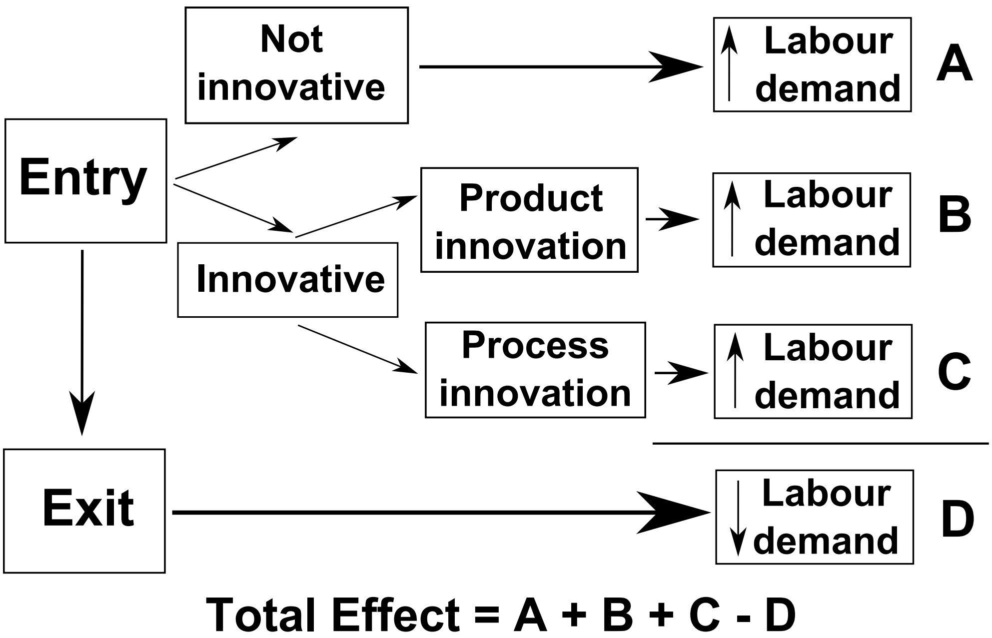

Figure 3.2: Entries, innovation and labour demand changes

All in all, the final outcome in terms of net labour demand will depend, on the one side, on the sum of A, B and C, which stands for the overall labour demand by entering firms, and on the other side, on the reduction of labour demand due to exiting firms (D). In the end, which effect will predominate? The net change in labour demand ($A+B+C-D$) will depend on many factors, which can be grouped into three categories:

a) The extent to which both product and process innovations are being generated either by incumbents or by entering firms. Depending on the case, labour

[23] This statement is made under the assumption that the process innovation introduced by entering firms is labour-saving.

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demand changes will come either via firm capacity expansion/contraction or via entry/exit of capacities.

b) The pace of firm turnover as well as the nature and characteristics of firm entries.

c) The extent to which compensation mechanisms take place, that is, factors derived from technological change benefits foster labour demand in the long term.

3.3 Data and Variables

3.3.1 Data

The data set used in this chapter is obtained from three statistical sources: the *Encuesta Industrial* (the Industrial Survey; EI), the *Registro de Establecimientos Industriales* (the Register of Manufacturing Establishments; REI) and the *Fundación BBVA*. The EI provides data on employment (measured as number of workers), Gross Value Added and number of existing establishments[24]. The number of new establishments comes from the REI, which is an administrative register[25], and the *Fundación BBVA* provides data on the stock of capital. The variables included in the data set are available for each pairing of industry and region[26] for each year between 1978 and 1996. The sectors and regions included are listed in Tables 3.2 and 3.3, respectively.

There are two features of the data worth mentioning and taking into account. First, the data shows a high level of aggregation, and thus individual establishments cannot be identified. This fact has implications both in terms of estimation and interpretation of the results, since an important part of the empirical studies in this

[24]The data on establishments include the set-up of several branches by the same firm, and besides there is not a minimum size of new establishments to be included.

[25]The REI provides information about all new manufacturing establishments while the EI focuses on those establishments with more than 10 employees (it also includes establishments with less than 10 employees, but only as a sample).

[26]Because of an excess of zero values, data on mineral extraction activities, as well as data on the Spanish region Extremadura, have been excluded. However, these exclusions do not affect the results of the analysis whatsoever.

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literature uses data at the firm/plant level. This fact should be borne in mind when comparing the results obtained in this chapter with other studies. Second, the data has multiple levels, i.e. region, sector and year. In the empirical analysis carried out in this chapter the dimensions will be denoted by subscripts, that is, the variable X_{ijt} will refer to region i, sector j and year t. The structure of the data is explained in Table 3.4 below.

Table 3.2: NACE-25 Classification

Sector
Mineral products
Chemical products
Metal products
Agricultural and industrial machinery
Electrical goods
Transport equipment
Food, beverage and tobacco
Textiles
Paper and printing
Rubber and Plastic
Other manufactures

Source: Register of Manufacturing Establishments (REI) and Industrial Survey (EI).

3.3.2 Variables

The variables used in the analyses carried out in this chapter stem from the databases REI, EI and *Fundación BBVA*, which are introduced and described in the previous subsection. The description of the variables is shown in Table 3.5.

3.3.3 Description

The variable GRE can be calculated following different criteria[27]. Under general conditions, the formula for GRE can be expressed as $GRE_t = 100 \times (ENT_t/D_{t-1})$, where D is a denominator that standardises the entries. There are three approached

[27]This variable stands for an indicator that can be analysed in relation to a wide class of industrial demography indices, which are explained in section A.1 of the Appendix.

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Table 3.3: Regional (NUTS-2) Classification

Region
Andalusia (AND)
Aragon (ARA)
Asturias (AST)
Balearic Islands (BAL)
Canary Islands (CAI)
Cantabria (CAN)
Castile-Leon (CLE)
Castile-La Mancha (CMA)
Catalonia (CAT)
Valencia (VAL)
Galicia (GAL)
Madrid (MAD)
Murcia (MUR)
Navarre (NAV)
Basque Country (BAS)
La Rioja (RIO)
Source: Instituto Nacional de Estadistica (INE).

to this: the first way is known as *labour market perspective*, where the employment level is used to standardise entries. The second way is called the *ecological perspective*, because the stock of establishments is used as the denominator. The third way of calculating the entry rate is the *population perspective*, where the population is used to standardise entries. In the analysis presented in this chapter the first two approaches will be used. A comparison of these two approaches is given by Table 3.6, where the aggregate GRE for the overall economy is shown. Although the magnitude of both approaches differ, they are not very different, since the correlation between them stands above 0.7.

3.4 Descriptive Analysis

3.4.1 Motivation

This section is devoted the descriptive analysis of the variables described in the previous section. The first part of the section depicts the economic situation of the

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Table 3.4: Data structure

Dimension	Subscript	Total
Region	i	$R = 16$
Sector	j	$S = 11$
Year	t	$T = 17$
Total sample: $N = R \times S \times T = 2992$		

Table 3.5: Description of variables

Variable	Description	Source
ENT_{ijt}	Flow of establishment entries	EI
EST_{ijt}	Stock of establishments	REI
GRE_{ijt}	Gross Rate of Entry	own
L_{ijt}	Number of workers	REI
K_{ijt}	Capital stock	BBVA
GVA_{ijt}	Gross Value Added	REI

Spanish and European economy for the analysed period (1980-1996) and relates it to basic descriptive statistics of the data. The second part of this section consists of three univariate analyses of the variables: a correspondence analysis, an analysis of variance (ANOVA) and a growth rate components analysis. The aim of such analyses is twofold: (a) to give an overview of the heterogeneity of the variables across regions, sectors and time and (b) to try to unveil certain patters of the variables across dimensions, that is, if the evolution of the distribution of the variables across sectors and regions over time can be considered as random or otherwise can be modeled explicitly. However, the purpose of this section is to provide a descriptive and univariate analysis, being the modelling of such a distribution and evolution far beyond the scope of this chaper.

3.4.2 Short Overview over the last 20 Years

In 1973, the world crisis also affected Spain, some sectors becoming obsolete, which demanded some policies to solve the problems associated with the situation. In this

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Table 3.6: Annual Gross Rate of Entries (GRE)

Year	GRE (labour market)	GRE (ecological)
1980	4.20	0.24
1981	3.68	0.24
1982	4.48	0.30
1983	6.04	0.41
1984	5.39	0.38
1985	6.38	0.45
1986	6.80	0.50
1987	8.47	0.62
1988	7.83	0.57
1989	8.05	0.57
1990	7.11	0.50
1991	6.99	0.49
1992	6.32	0.44
1993	5.35	0.37
1994	4.87	0.32
1995	5.13	0.35
1996	4.63	0.32

Source: own elaboration.

context, the Spanish government started a restructuring process, by which obsolete and exceeding capacities were closed down and those remaining industrial capacities had to adapt to the new technological and market cycle. Besides, between 1979 and 1982 the Spanish economy suffered the second energy crisis and stagnation in industrial production and investment, and as a response several economic, political and institutional reforms were implemented to restructure production. The middle 1980s were years of a recovery process, specially from 1986 on, when Spain entered the European Economic Community (EEC). From an industrial point of view, the membership of the EEC caused industrial firms to undergo a process of technical transformation and internationalisation that improved the quality of products and raised productivity. This event was crucial for the Spanish economy, since it implied that the markets were exposed to foreign competition, moreover receiving

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a higher amount of FDI and this way modernising the whole industry structure. In this respect, MARTÍN AND JAUMANDREU (2004) studied the role played by both competitive pressure and the industrial restructuration via entry and exit in manufactures' productivity growth during the 1980s, finding that the continuous process of creative destruction via entry and exit led to a structural change of manufacturing industries, besides firms were facing a higher competitive pressure from other economies, a fact that was reflected in the increased number of imports. According to their calculations, these changes accounted for 80% of productivity growth in manufacturing sectors. For the same time period, MYRO AND ÁLVAREZ (2003) analysed the inter-industry structure of Spanish manufactures during the 1980s and 1990s, paying attention to the effects of the entry into the EEC. Their main findings were that the inter-industry specialisation of Spanish manufacturing production diminished and got closer to the European average sectoral composition. Both the introduction of foreign competition and the introduction of Foreign Direct Inverstment (FDI) also contributed to change the Spanish production structure and stimulated the development of sectors intensive in technology. The development of such intensive technology sectors notwithstanding, the bulk of the manufacturing Spanish industry remained being traditional, with a weight of two thirds of the produced value added. This proportion was larger than in other European countries, but this fact need not be a drawback, since it offered growth possibilities both in terms of production and employment.

The period between 1989 and 1993 was characterised by the fact that many economies were sliding into the depths of a recession, which the Spanish manufacturing industry suffered to a great extent. There was an overall decrease in economic activity as well as in employment, and a continuous process by which old plants were closing down and new capacities were constantly entering the market was taking place[28]. From 1994 onwards, industrial production recovered from the crisis and experienced several years of growth. Anyhow, there are several issues that must be taken into account with respect to the evolution of manufacturing sectors compared to the rest of the economy. In the last decades there has been a constant reduction of manufacturing and agriculture employment share in favour

[28]There is a stream of literature analysing the dynamic relationship between firm entries and exits. For a preliminary study of the way in which the births and deaths of firms interact over time, see JOHNSON AND PARKER (1994).

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of service sectors. In fact, manufacturing employment share dropped from 27% to 19% in the period 1978-2002, whereas the service employment share increased from 42% to 62% in the same period. This negative evolution notwithstanding, the manufacturing industriy still plays an important role in the economy. Specifically, increases in labour productivity and the introduction of technical change in the manufacturing industry had a direct effect on economic growth and on the overall performance of the whole economy, new firms having played an important role in these improvements. FARIÑAS AND RUANO (2004) estimated the effects of incumbent firms and entry-exit turnover to total factor productivity (TFP) during the 1990s, obtaining that incumbent firms were the main factor contributing to productivity changes, although the replacement of existing firms by entering ones had a positive (but smaller) effect in the long term. The authors also found that changes in the relative weights of incumbent, entering and exiting firms had a negative effect on productivity growth, that is, in the short term, a positive net entry of firms during recovery periods decreased productivity, whereas a negative net entry during slumps improved productivity. This counter-cyclical movement in productivity was due to the fact that incumbent firms were on average more productive than newcomers. In another contribution, CALLEJÓN AND SEGARRA (1999) highlighted the fact that Spain was an economy more user than producer of technology, and thus many entrants were likely to introduce innovations into the markets by using the last vintage equipment. Their main results showed that, apart from being rates of entry and exit of establishments quite heterogeneous across industries, entry and exit rates impacted positively on total factor productivity, this effect having had, however, a different intensity across regions and sectors.

Figure 3.3 shows the evolution of the Gross Rate of Entries as well as the growth rates of establishments, employment and Gross Value Added (VAB) over time. Such graph shows that the creation of new establishments is closely linked to the evolution of macrovariables such as employment and VAB growth. This is, economic cycles that characterised production (VAB) are also present in employment growth. There is therefore a close link between economic growth (recession) and the creation (destruction) of employment. The whole result can be interpreted in the context of the cyclical evolution of the Spanish economy during the analysed period. Specifically, between 1978 and 1996, and taking into account the average growth, the three stages described earlier can be distinguished. The first stage covers the

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period of readjustment in manufacturing between 1978 and 1985. During this period, the Spanish economy suffered the second energy crisis (1979) and stagnation in industrial production and investment (19791982). Also, several economic, political and institutional reforms were implemented to restructure production (1982). One of these was a thorough industrial restructuring with important adjustments in employment. The second stage, which includes the country's integration into the EEC in 1986, covers a period of growth that ended in the late 1980s. The third stage covers a period of recession characterised by a decrease in economic activity and employment, followed by a slight recovery at the end of the period. This cyclical behaviour has had several implications for industrial labour and gross added value in the different Spanish regions, while the various manufacturing sectors have experienced repercussions of different intensities.

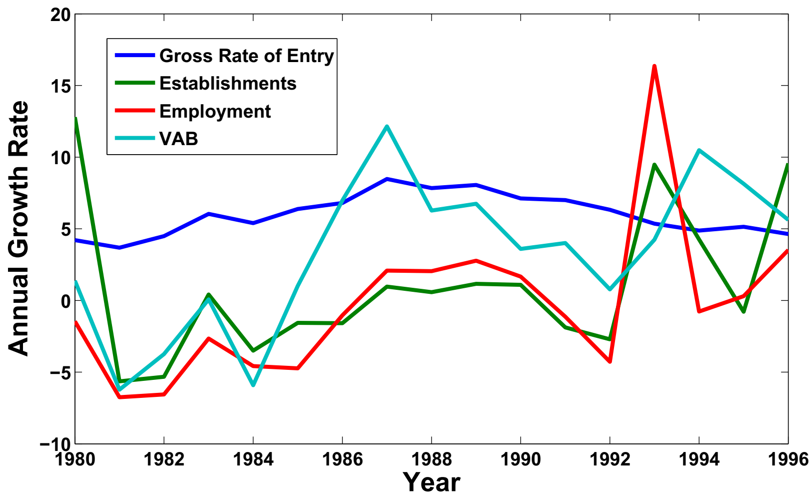

Figure 3.3: Evolution of GRE and the growth rates of employment, value added and number of establishments

Another important aspect worth highlighting is the process of capitalisation that the Spanish manufacturing industries underwent. Figure 3.4 shows the kernel density estimation[29] of the capital-labour ratio log, i.e. $log(K/L)$, for the years 1980 and 1992.

[29] A gaussian kernel and bandwidth following the Silverman's Rule of Thumb were applied to estimate the density of the variable. The MATLAB procedure used has been crated by the author of this article, and it is available upon request. For nonparametric estimation theory, see SILVERMAN (1986) and HÄRDLE ET AL. (2004).

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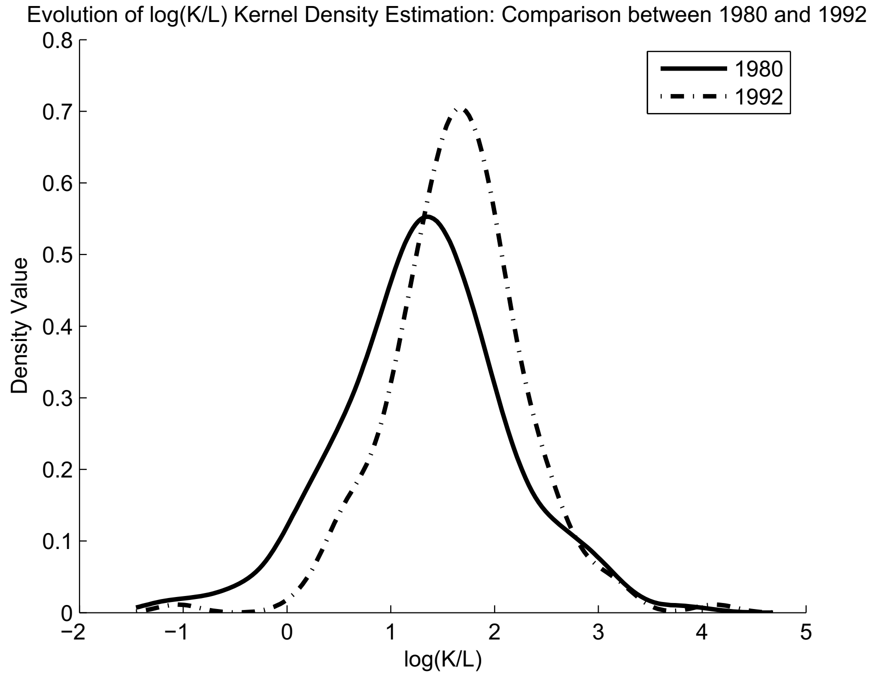

Figure 3.4: Kernel density estimation of $log(K/L)$ in the years 1980 and 1992.

The graph shows how the mean value of the ratio of capital to labour increased throughout the period considered. The increase of this ratio over time implies a rising degree of mechanisation of the Spanish manufacturing industry, which is a phenomenon closely related to the introduction of technological changes. Besides, the variance of the capital-labour ratio variable shrank over time, which could imply an increase in the convergence to the mean of this ratio among sectors over time. In that regard, SEGARRA (1997) found that this convergence did not take place among regions, arguing that only some industries succeeded in reducing territorial inequalities in the use of the capital factor. According to his study, regional industrial-mix and also endogenous regional factors help explain the high variation among different Spanish regions, and those differences are explained in terms of different productivities for different manufacturing sectors.

To conclude and summarise this subsection, it can be stated that the manufacturing output growth experienced by Spain during the last decades was mainly due to productivity improvements, the cause of which is very diverse. First, many new capacities have entered and many old and obsolete ones have exited the market, and as a consequence there has been a process of capitalisation of the capacities, im-

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provements in the workforce skills, changes in the sectoral specialisation of many manufactures and also there has been an introduction of technical change. These changes notwithstanding, the basis of the current Spanish economy remains traditional, and the average productivity of manufactures in the European Union (EU) has not been reached so far.

3.4.3 Correspondence Analysis

Correspondence analysis is a descriptive/exploratory technique designed to analyse simple two-way and multi-way tables containing some measure of correspondence between rows and columns. Such analysis develops simple indices that show relations between rows and columns of a contingency table, which is useful to describe the association between two variables in very general situations. This analysis is used in this analysis to assess whether there is any regional and/or sectoral pattern of the gross rate of entries (GRE_{ij}) over the years included in the analysis. The basic contingency table for a single year from which this analysis departs takes the following form:

Table 3.7: Contingency table's basic structure

sector/region	1	...	j	...	S	Total
1	GRE_{11}	...	GRE_{1j}	...	GRE_{1S}	$GRE_{1\bullet}$
$\vdots$	$\vdots$		$\vdots$		$\vdots$	$\vdots$
i	GRE_{i1}	...	GRE_{ij}	...	GRE_{iS}	$GRE_{i\bullet}$
$\vdots$	$\vdots$		$\vdots$		$\vdots$	$\vdots$
R	GRE_{R1}	...	GRE_{Rj}	...	GRE_{RS}	$GRE_{R\bullet}$
Total	$GRE_{\bullet 1}$	...	$GRE_{\bullet j}$	...	$GRE_{\bullet S}$	$GRE_{\bullet\bullet}$

Note 1: $GRE_{\bullet j}$ and $GRE_{i\bullet}$ are not actually row and column sums, but aggregate sectoral and regional gross rates of entry.

Note 2: GRE is calculated following the ecological approach.

The correspondence analysis is based on the interpretation of the relative position of points relative to the weights given by rows and columns, and then the independence of the two categories is tested. A standard analysis would proceed by calculating expected values for each pairing i, j and then make inference by compar-

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ing its distribution with the actual distribution of the observed values. Analytically, for a variable x_{ij} the expected value would be obtained by calculating the following formula: $x^*_{ij} = (x_{\bullet j} \times x_{i\bullet})/x_{\bullet\bullet}$. However, the data represented in Table 3.7 are not frequencies but ratios, and that imposes that rows and columns cannot be added up. In order to proceed with the analysis, an alternative approach to calculate the expected values was adopted. Provided that $GRE_{ijt} = 100 \times (ENT_{ijt}/EST_{ij,t-1})$, contingency tables were made both for ENT_{ijt} and $EST_{ij,t-1}$, for the time periods $t = 1, \ldots, T$. Then, once the expected values ENT^*_{ijt} and $EST^*_{ij,t-1}$ were calculated, it was straightforward to obtain GRE^*_{ijt}. The result of the inference derived from Table 3.7 for each year is summarised in Table 3.8. The first columns show the Pearson's chi-squared test statistic and the likelihood-ratio G-test statistic, while the three left columns give the result of three association tests: the phi-test, the contingency C and the Crámer's V. The two first statistics indicate that for the whole period the degree of association between region and sector is statistically different from zero and significant. Another way to see it is by thinking about the distribution function of GRE over regions and over sectors, being these two functions not independent. An important issue to take into account is the sectoral composition of the different regions. If GRE is larger in a certain sector, those regions having a greater share of such factor will enjoy a higher degree of entries. The three association statistics show, broadly speaking, a decreasing pattern. Such result seems to indicate that the strong link between sectoral and regional rates was registering a decrease during the analysed period, which is consistent with the fact that the sectoral composition of each region underwent a standardisation process due to the changes that the whole economy was undergoing.

3.4.4 Analysis of Variance (ANOVA)

The analysis of variance (ANOVA) is a collection of statistical methodologies consisting in partitioning the observed variance of a component into different components. Such methodology is useful in the research carried out in this chapter because of the multiple dimensions of the data. The analysis ANOVA allows to decompose the variance into sectoral and regional components, thus giving some insights into the intricacy of the variables' structure and variance. For the variable x_{ijt}, a two-way analysis of variance is given by the following expression:

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Table 3.8: Contingency analysis of GRE

Year	Pearson's χ^2		G likelihood ratio		Association coefficients		
	Statistic	P-value	Statistic	P-value	ϕ	C	V
1980	$1.21e+05$	0.00***	24427.0	0.00***	26.31	1.048	8.32
1981	945.0	0.00***	732.8	0.00***	2.31	0.962	0.73
1982	2231.9	0.00***	1219.4	0.00***	3.56	1.009	1.12
1983	5424.7	0.00***	2330.1	0.00***	5.55	1.032	1.75
1984	1583.4	0.00***	1149.0	0.00***	2.99	0.994	0.94
1985	1384.4	0.00***	844.4	0.00***	2.80	0.987	0.88
1986	2449.3	0.00***	1306.2	0.00***	3.73	1.013	1.17
1987	4948.1	0.00***	4008.0	0.00***	5.30	1.030	1.67
1988	1460.3	0.00***	1612.7	0.00***	2.88	0.990	0.91
1989	1506.1	0.00***	1351.8	0.00***	2.92	0.992	0.92
1990	937.9	0.00***	1069.3	0.00***	2.30	0.962	0.73
1991	894.1	0.00***	1013.6	0.00***	2.25	0.958	0.71
1992	563.7	0.00***	735.8	0.00***	1.78	0.915	0.56
1993	886.8	0.00***	1023.3	0.00***	2.24	0.958	0.70
1994	489.3	0.00***	543.1	0.00***	1.66	0.899	0.52
1995	336.4	0.00***	372.4	0.00***	1.38	0.849	0.43
1996	383.1	0.00***	457.8	0.00***	1.47	0.868	0.46

Source: own calculation.

$$x_{ijt} = \alpha + r_i + s_j + \varepsilon_{ijt}, \tag{3.3}$$

where α is a constant, r_i and s_j are regional and sectoral effects, and ε_{ijt} stands for a IID disturbance term. As in the case of panel data estimation, the effects can be regarded as fixed and random. While fixed effects (FE) are unknown parameters that can be estimated from the data, random effects (RE) are random variables whose study is based on the estimation of its distributional parameters such as the variance[30]. The empirical analysis undertaken in this subsection does not assume any specific condition of individual effects, and both FE and RE are estimated by using Maximum Likelihood (ML) and its results are shown in Table 3.9. The first two columns show the results for the FE estimation, consisting in the estimate for the constant α and the value of the F-statistics for the significance of the fixed effects. Next four columns are devoted to the RE estimation, which includes the

[30]For an extense discussion about fixed and random effects, see BALTAGI (2001).

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constant and the variance of both the random effects and the disturbance term. The last column shows the value of the P-value stemming from a bootstrapping methodology to test the significance of the random effects[31].

Table 3.9: ANOVA analysis of the main variables

	Fixed Effects (FE)			Random Effects (RE)				
Parametric Bootstrap Variable	$\hat{\alpha}$	$\hat{F}_r$	$\hat{F}_s$	$\hat{\alpha}$	$\hat{\sigma}_r$	$\hat{\sigma}_s$	$\hat{\sigma}_\varepsilon$	Bootstrap P-Value
GRE_{ijt}	10.14	17.00***	2.01	8.62	2.68	4.40	16.25	0.00***
ENT_{ijt}	36.05	3.98*	36.96***	46.03	43.84	33.89	45.08	0.00***
EST_{ijt}	645.31	2.90*	24.71***	782.90	709.02	706.80	720.48	0.00***
L_{ijt}	8788.59	22.64***	0.01	11124	11596.30	5109.20	8715.60	0.00***
GVA_{ijt}	42308.26	26.08***	17.10***	44122.00	48710.00	19438.00	38491.00	0.00***

Source: own calculation.

The analysis is carried out for the variables GRE, ENT, EST, L and GVA. With respect to the FE estimation, all fixed effects are significant except for the case of the sectoral effects of the employment level L, whose F-statistic points out that they are not significantly different from zero. With respect to the RE estimation, the bootstrap method indicates for all the variables that random effects are significant. In this case, and for all variables, the regional standard deviation outweighs the sectoral standard deviation.

3.4.5 Growth Rate Components

The analysis performed in this subsection deals specifically with the regional and sectoral components of the growth rate for the variables EST, L and GVA, and starts with the basic definition of growth rate between two consecutive time periods for the variable x_t:

$$r_t = \frac{x_t - x_{t-1}}{x_{t-1}} = \frac{x_t}{x_{t-1}} - 1, \qquad (3.4)$$

where r_t has the time subscript because it is allowed to change over time. The expression of r_t allows the expression of x_t as a geometric random walk depending

[31]This alternative testing method is convenient because the use of the ξ^2 approximation is not advisable when dealing with ML estimators (FARAWAY 2006, P. 158).

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on the initial value and the successive growth rates[32], i.e.

$$\begin{aligned} x_t &= (1+r_t)x_{t-1} && (3.5)\\ &= (1+r_t)\left[(1+r_{t-1})x_{t-2}\right] && (3.6)\\ &= x_0\prod_{h=0}^{t-1}(1+r_{t-h}). && (3.7)\end{aligned}$$

In order to empirically estimate equation (3.7), a disturbance term must be introduced. Following ALTINAY (2004), time-varying growth rates r_t can be modeled as $(1+r_t) = (1+\bar{r})\varepsilon_t$, and then the growth rate is expressed as the product of a constant deterministic growth $(1+\bar{r})$ and a disturbance term ε_t. With such a definition, equation (3.7) can be expressed and decomposed as follows:

$$\begin{aligned} x_t &= (1+\bar{r})x_{t-1}\varepsilon_t && (3.8)\\ &= (1+\bar{r})\left[(1+\bar{r})x_{t-2}\,\varepsilon_{t-1}\right]\varepsilon_t && (3.9)\\ &= x_0(1+\bar{r})^t\prod_{h=0}^{t-1}\varepsilon_{t-h}. && (3.10)\end{aligned}$$

Equation (3.10) can be transformed into a linear model by taking natural logs, i.e.

$$\begin{aligned} ln(x_t) &= ln(x_0) + ln(1+\bar{r})t + \sum_{h=0}^{t-1}\varepsilon_{t-h} && (3.11)\\ &= \alpha + \mu t + \nu_t. && (3.12)\end{aligned}$$

Equation (3.12) can be easily accommodated to include either a regional or a sectoral dimension, and this enables to link the growth of a variable to its region and sector, thus allowing a deeper investigation of the dimensions of growth. The extended equations including an effect to be estimated are defined as

$$\begin{aligned} ln(x_{it}) &= \alpha + \mu t + r_i + \nu_{it} && (3.13)\\ ln(x_{jt}) &= \alpha + \mu t + s_j + \nu_{jt}, && (3.14)\end{aligned}$$

[32] A condition for that to happen is that $(1+r_t)$ must be i.i.d. at all t over time, this is, the growth rate in one period must be independent of the previous growth rates.

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and the results of their estimations are shown in Table 3.10. As in the previous ANOVA estimation, no prior assumptions about the nature of the effects are made, the results of the pooled, FE and RE effects being reported.

Table 3.10: Sectoral and regional components of growth rates

	Pooled		Fixed Effects		Random Effects				LM Test
Variable	$\hat{\alpha}$	$\hat{\mu}$	$\hat{\mu}$	F-test	$\hat{\alpha}$	$\hat{\mu}$	$\hat{\sigma}^2_\nu$	$\hat{\sigma}^2_\varepsilon$	Stat.
Regional Effects									
EST_{rt}	8.37***	$6.2e-03$	$6.2e-03$***	971.63***	8.37***	$6.2e-03$***	13.92	13.94	45.79***
L_{rt}	11.26***	$1.9e-04$	$1.9e-04$	1496.54***	11.26***	$1.9e-04$	16.11	16.12	46.09***
GVA_{rt}	12.23***	0.04***	0.04***	1253.65***	12.23***	0.04***	17.66	17.67	45.98***
Sectoral Effects									
EST_{st}	8.86***	0.01	0.01***	529.05***	8.86***	0.01***	17.74	17.77	37.36***
L_{st}	11.97***	$2.4e-03$	$2.4e-03$	150.42***	11.97***	$2.4e-03$	3.11	3.13	34.39***
GVA_{st}	12.99***	0.04***	0.04***	124.43***	12.99***	0.04***	3.09	3.11	33.61***

Source: own calculation.

The results of the estimation show that both the F-test for the FE model and the LM test for the existence of RE support the existence of both regional and sectoral effects, having a role in the process of growth. But what is the specific effect of each region and sector on a variable's growth? This question can be addressed by estimating a variable coefficient model (VCM), which is based in the estimation of μ parameter for each individual, that is, μ_i for the case of regions and μ_j for the case of sectors. Since $\mu = ln(1+\bar{r})$, the growth rate can be easily obtained as $\bar{r} = exp(\mu) - 1$. Table 3.11 reports the result of the VCM estimation for regions and Table 3.12 does the same for sectors. Interestingly, the results point out that GVA displays a positive growth rate for all regions and sectors, and both EST and L show dissimilar results for regions and sectors, sometimes having the same sign and other times showing opposite signs.

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Table 3.11: VCM estimation of the growth model with regional components

	Growth rates in %		
Region	EST	LAB	GVA
Andalusia (AND)	−0.040	−0.041	2.796
Aragon (ARA)	−1.726	0.268	5.486
Asturias (AST)	−1.061	−1.019	2.233
Balearic Islands (BAL)	−2.354	−0.827	2.302
Canary Islands (CAI)	0.246	1.559	5.232
Cantabria (CAN)	−2.337	−2.194	2.135
Castile-Leon (CLE)	−3.505	−0.436	4.081
Castile-La Mancha (CMA)	−2.329	1.376	5.656
Catalonia (CAT)	1.213	0.273	4.568
Valencia (VAL)	1.442	1.236	4.696
Galicia (GAL)	−0.894	0.523	4.476
Madrid (MAD)	3.068	−0.116	4.112
Murcia (MUR)	0.372	1.511	4.219
Navarre (NAV)	−1.207	0.351	5.615
Basque Country (BAS)	0.273	−2.349	1.436
La Rioja (RIO)	−0.887	0.295	3.204
Average	−0.608	0.026	3.890

Source: own calculation.

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Table 3.12: VCM estimation of the growth model with sectoral components

Sector	Growth rates in %		
	EST	LAB	GVA
Mineral products	−0.980	−0.297	3.024
Chemical products	1.694	0.165	5.856
Metal products	−0.368	−0.895	1.958
Agricultural and industrial machinery	2.423	0.942	4.014
Electrical goods	2.945	−2.030	1.662
Transport equipment	4.943	−1.233	4.863
Food. beverage and tobacco	−3.294	0.204	4.044
Textiles	1.664	−1.333	1.871
Paper and printing	5.039	2.477	6.336
Rubber and Plastic	1.389	0.522	4.254
Other manufactures	1.183	4.342	7.357
Average	1.512	0.260	4.112

Source: own calculation.

3.5 New Firm Entry and Labour Demand: a Dynamic Approach

3.5.1 Motivation

This section is intended to provide the first part of the empirical analysis of this chapter. Section 3.4 has introduced the data and variables to be used, as well as a first exploratory analysis of such variables. The empirical model presented in this section aims at the analysis of the dynamic relationship between firm entry and labour demand changes, i.e. to what extent firm entries have an effect on the creation of employment when they enter the industry as well as in subsequent years. In order to do so, a dynamic distributed lag model is proposed and estimated, and then the results are shown and compared to similar studies for other economies.

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3.5.2 Empirical Model

The model considered to analyse the dynamic relationship between new firm entry and employment has been introduced in Subsection 3.2.2, and is the time lag structure first introduced by VAN STEL AND STOREY (2004) and FRITSCH AND MUELLER (2004). Econometrically, the especification of such lag structure takes the form

$$\Delta L_{it}^{D} = \alpha + \beta_0 GRE_{it} + \beta_1 GRE_{it-1} + \ldots + \beta_s GRE_{it-s} + \varepsilon_{it}. \tag{3.15}$$

The independent variable is the gross rate of entry (GRE) calculated accordig to the labour market approach, and the dependent variable is labour change, and it is computed as the growth rate of employment over 2 years, in order to avoid disturbances by short-term fluctuations, i.e.

$$\Delta L_{it}^{D} = \frac{L_{it} - L_{i,t-2}}{L_{i,t-2}}. \tag{3.16}$$

The data used to estimate equation (3.15) has two dimensions: region and time. This is so because the interest of this analysis is the effect of firm entries on the overall level of industrial employment of a region over all sectors, not just on a particular sector. This way, by aggregating all sectors and considering just regions and years, the intersectoral effects of entries are captured, that is, the employment that entries belonging to a certain sector may cause on other sectors. Therefore, each variable has two subscripts: i denotes region and t denotes year. Since the industrial mix varies between regions and the relative importance of new firms and incumbents varies between industries, a shift-share procedure is applied in order to obtain a sector-adjusted measure of new firm start-ups (AUDRETSCH AND FRITSCH 2002). The aim of such adjustment is to control for the effect that the composition of industries has on the number of start-ups, and it wipes off the estimation the potential bias of overestimating the level of entrepreneurship in regions with a high composition of industries where start-ups play an important role, and underestimating the role of new firm formation in regions with a high composition of industries where new-firm start-ups are relatively unimportant. Then, this procedure adjusts the data by imposing the same industrial mix on each region, and is explained in Section A.4 of the Appendix.

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3.5.3 Estimation and Results

Notice that, in principle, current and past values of the gross rate of entry affect labour change. Therefore, the number of lags (s) determines the number of periods during which the effect of the rate of entry on employment change occurs. To estimate the model (3.15) the parameter s must be given a value. Since the aim is to assess the long-term effect of entries on employment, a value $s = 7$ is set, i.e. a model with seven lags, in accordance with similar studies[33]. Table 3.13 shows the results of the estimation of (3.15) including the regressor in level as well as the seven first time lags. Because the correlation between the covariates is high, which means that there is a problem of multicollinearity[34], the impact of each regressor lag is also analysed separately. This way, model (1) includes all 7 lags, and models (2)-(9) include each a different time lag. The adopted estimation technique is Fixed Effects allowing for both regional and time effects, and the standard error estimates were obtained by using the cross-section White method. The results of the regression including all gross rates of entry and the separate regressions for each lag of the gross rate of entry are very similar, yielding a positive short-term effect the years t and $t-1$, a negative effect the year $t-2$, a positive effect the years $t-3$ and $t-4$ and lastly a negative effect for the year $t-5$. In the last years the effect of entries on employment change seems to vanish. The positive short-term effect reflects the direct creation on employment caused by the entry of new firms, whereas the negative medium-term effect is likely to be caused by the exit of firms as a result of the previous entry of new firms. The positive effect observed for the years $t-3$ and $t-4$ is likely to be related to indirect supply-side effects caused by entrants, i.e. improvements in efficiency, structural change and innovation (FRITSCH AND MUELLER 2004). These lag structures are shown in Figure 3.5. With regard to this negative effect in the short term, empirical papers on firm entry suggest that the average size of new firms is smaller than the average size of incumbent firms, that is, the size distribution of new cohorts is more skewed than market structure.

[33] A larger number of lags was also considered and studied, but the final choice is seven lags because the results are quite similar but the efficiency of the estimation decreases as the number of lags increases.

[34] In distributed lag models, the problem of multicollinearity is likely to become quite severe, which makes the interpretation of the estimated parameters unreliable.

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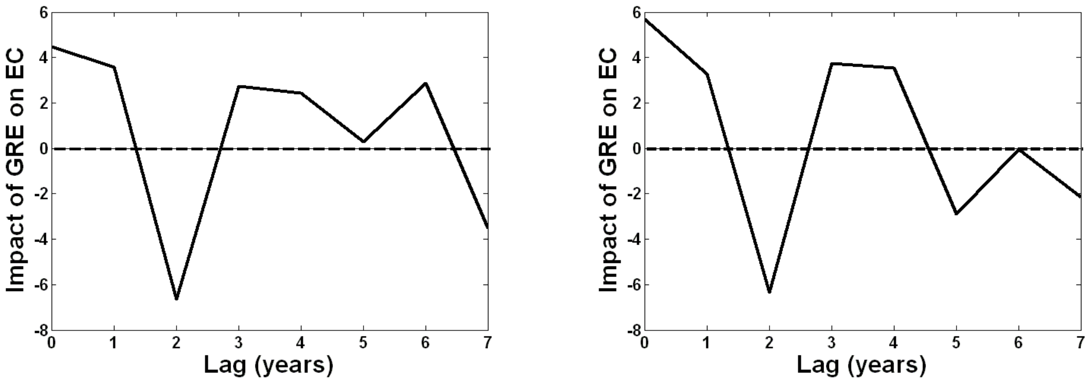

Figure 3.5: Lag structure of the impact of new business formation on regional employment growth resulting from the joint estimation (left) and from separate estimations (right).

Models that include several lags of the same variable as in (3.15) are likely to suffer from a multicollinearity problem, which makes the interpretation of the coefficients unreliable. To solve this problem, a structure on the lag distribution is imposed by applying the polynomial distributed lag model[35]. This method solves the problem of multicollinearity in distributed lag models by imposing a structure on the lag coefficients. It is assumed that the effects of entries on employment change are distributed over 7 years because the previous results show that in this period the effects have already vanished. Table 3.14 shows the results of the polynomial distributed lag estimation considering a second, third, fourth and fifth order of the polynomial. In such estimation both regional and time effects are accounted for, and the standard error estimates were obtained by using the cross-section White method, as in the previous estimation. Figure 3.6 shows the graphical lag structures resulting from the different polynomial orders considered.

The lag structure of the second order polynomial is approximately a "u"-shaped structure, whereas the lag structure of the remaining polynomial orders (third, fourth and fifth) is quite similar, showing a pattern also found in previous estimations. These results confirm the interpretation of the lag structure proposed before, i.e. the direct effect of entries on employment change is positive in the years t and $t-1$, then the effect becomes negative in the years $t-2$ and $t-3$, and is positive again between the years $t-4$ and $t-6$. The magnitude of the effect decreases

[35]This model is also known as the Almon lag model.

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Table 3.13: Fixed Effects Estimation

Dependent Variable: Employment Change (ΔL_{it}^{D})

	Model								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	-0.03	-0.03^{**}	-0.02^{**}	0.02^{**}	-0.03^{**}	-0.02^{**}	0.005	-0.005	0.002
	(0.04)	(0.007)	(0.008)	(0.007)	(0.008)	(0.004)	(0.007)	(0.011)	(0.012)
GRE_t	4.48^{**}	5.67^{**}							
	(2.22)	(1.74)							
GRE_{t-1}	3.56		3.26^{*}						
	(2.37)		(1.84)						
GRE_{t-2}	-6.64^{**}			-6.33^{**}					
	(2.54)			(1.59)					
GRE_{t-3}	2.75				3.73^{**}				
	(1.94)				(1.89)				
GRE_{t-4}	2.42					3.55^{**}			
	(1.93)					(0.99)			
GRE_{t-5}	0.28						-2.88^{*}		
	(2.18)						(1.67)		
GRE_{t-6}	2.86							-0.04	
	2.27							(2.55)	
GRE_{t-7}	-3.54								-2.16
	(2.68)								(2.82)
R-Squared	0.44	0.25	0.22	0.28	0.26	0.26	0.29	0.3	0.31
F-Statistic	3.24^{**}	2.57^{**}	2.08^{**}	2.74^{**}	2.43	2.35	2.58^{**}	2.47^{**}	2.44^{**}
N. of Obs.	160	272	256	240	224	208	192	176	160

Notes: Standard errors appear in brackets. ** and * mean that the estimated coefficients are significant at a 5% and 10% signification level, respectively.

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and is negative in the last included year ($t-7$). The F statistic is significant in all the estimations, and thus these results can be regarded as reliable. Such results seem to confirm the wave pattern first obtained by FRITSCH AND MUELLER (2004) and later by several other studies for different economies. For the case analysed here, and interpreting the third, fourth and fifth order polynomials, the first direct effect lasts just the first year after the moment of the entry, the displacing effect that follows lasts two periods and the indirect final supply side effects last three years. It is noticeable that these three effects take place in a time span of 7 years. Similar studies finding the same "s"-shaped wave pattern have analysed a longer time period and also found a longer effect. In this sense, CARREE AND THURIK (2008) find a "s"-shaped wave pattern that lasts 14 years, FRISCH AND MUELLER (2008) and MUELLER ET AL. (2008) the same result but for 10 years, and VAN STEL AND SUDDLE (2008) find a "s"-shaped effect lasting for 8 years. BAPTISTA ET AL. (2008) find an effect that lasts for 10 years, although the wave pattern that they obtain follows a "u"-shape. If the results for Spain are compared to those for other economies, a direct conclusion that can be drawn is that, for the latter, the indirect supply side effects are found to take place later in time and to last for a longer period of time. This result might derive from differences in the industrial structure of the countries, but differences in the aggregation and quality of data might have an influence as well. These studies also conclude that the indirect supply-side effects of entries contribute to employment growth more than the direct effects associated with jobs created by entrants.

The results obtained in this analysis are logical and can be expected, specially considering the time period for which the model is analysed. As it is stated in the previous part of this section, during the 1980s a modernisation and capitalisation process took place in the Spanish economy, especially after the entry in the EEC. With such a rapid and sudden change, it is reasonable to interpret that the displacement effects appear soon (in the first year after the entry) and only last 2 periods. The fact that supply side effects appear sooner in the Spanish case analysed here than in other economies might be due to the fact that, for the period studied, entries implied to a large extent modern facilities and means of production, while exits were in a high percentage old and obsolete plants. This difference between entering and exiting firms, and also the increase in final output demand that the Spanish economy underwent, can be an explanation for the fact that supply side effects appear

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Table 3.14: Polynomial Distributed Lag Estimation

Dependent Variable: Employment Change (ΔL_{it}^{D})	Order 2	Order 3	Order 4	Order 5
Constant	-0.04	-0.04	-0.04	-0.04
	(0.04)	(0.04)	(0.04)	(0.04)
GRE_t	3.70	6.59	6.59	6.29
GRE_{t-1}	2.33	0.41	-0.32	0.25
GRE_{t-2}	1.25	-1.40	-1.57	-2.00
GRE_{t-3}	0.47	-0.53	-0.09	-0.45
GRE_{t-4}	-0.01	1.42	1.83	2.26
GRE_{t-5}	-0.21	2.82	2.58	3.05
GRE_{t-6}	-0.11	2.01	1.19	0.62
GRE_{t-7}	0.27	-2.61	-2.65	-2.29
R-Squared	0.32	0.37	0.37	0.37
F-Statistic	2.40^{**}	2.75^{**}	2.65^{**}	2.58^{**}
N. of Obs.	160	160	160	160

Notes: Standard errors appear in brackets. ** and * mean that the estimated coefficients are significant at a 5% and 10% signification level, respectively.

that soon in time. However, these results should be contrasted with an analysis using a longer time span, and then it will become more clear whether the results obtained here are a constant of the Spanish manufacturing sectors over time or are rather limited to the specific time span considered here (1980-1996).

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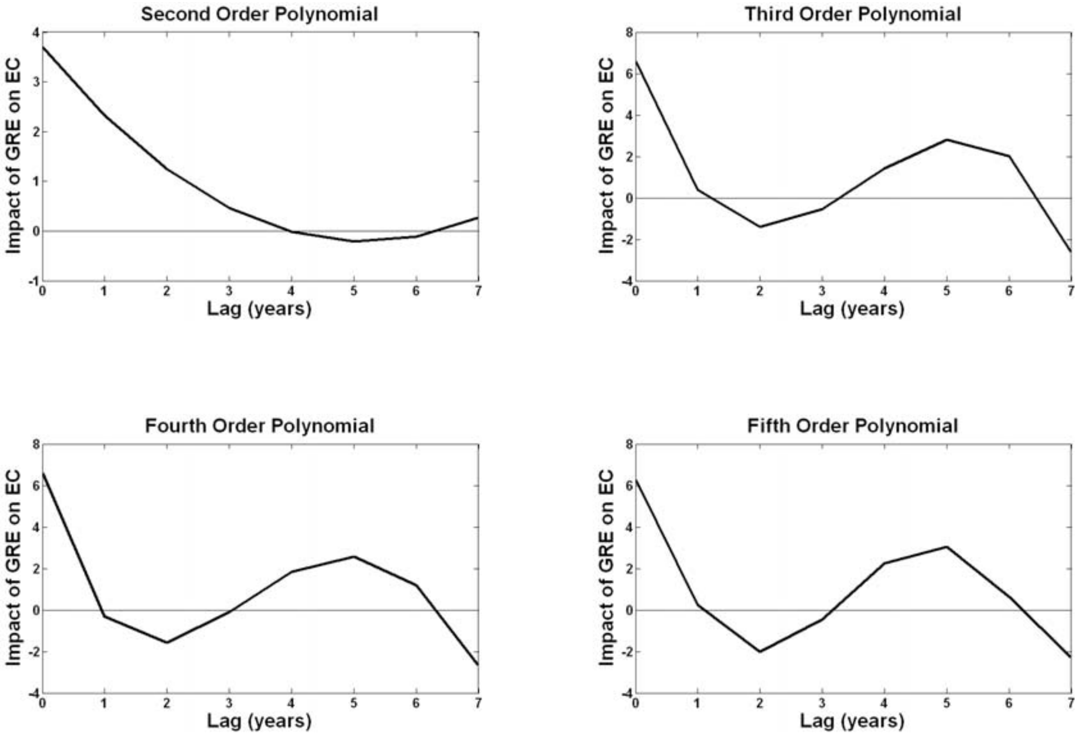

Figure 3.6: Lag structures of the impact of new business formation on regional employment growth resulting from the Almon lag model estimations.

3.6 Firm Entry and Dynamic Factor Demand and Substitution

3.6.1 Motivation

The aim of this section is to provide the second main empirical analysis of this chapter. Such analysis can be considered an extension of the previous empirical analysis carried out in Section 3.5. As stated earlier, such extension is based on the introduction of the capital factor, so that the short and long effect of establishment entries are related to the dynamic demand of both capital and labour factors. Interestingly, such analysis has not been carried away so far in the literature, so that it can be considered a pioneering contribution. This section has two parts: the first one is a bivariate nonparametric descriptive analysis that deals with the dynamic relationship between these two factors, and the second part is the specification and estimation of an econometric dynamic model that models the dynamic demand of these pro-

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duction factors as a function of both current and lagged values of the gross rate of entry.

3.6.2 Capital and Labour: some Descriptive Insights

This subsection offers a nonparametric descriptive analysis of the relationship between capital and labour factors by using a nonparametric kernel density estimation. The first analysis is aimed at the analysis of the evolution of the capital-labour ratio over time, and it will determine to what extent there has been a capitalisation process in the Spanish manufacturing industries, which will have taken place as long as the ratio $log(K/L)_{ijt}$ shows a growing pattern over time. However, this is not an easy analysis, because such variable has 3 dimensions (i, j and t). The nonparametric and visual analysis carried out consists of stacking together the estimated density function of $log(K/L)_{ijt}$ for each year in a 3-dimensional graph[36]. An element which should be taken care into account is the existence of both regional and sectoral individual effects, which could have a biasing influence in the final output, since for each year t the density is calculated over regions and sectors. If such effects are not properly accounted for, a significant change in $log(K/L)$ in a specific sector or region could bias the overall level of the variable. In order to prevent this to happen, a possible solution is to create a modified variable accounting for regional and sectoral effects. Such variable can be constructed by demeaning the original variable as follows:

$$\overline{log(K/L)}_{ijt} = log(K/L)_{ijt} - log(K/L)_{\bullet jt} - log(K/L)_{i\bullet t} + log(K/L)_{\bullet\bullet t}, \qquad (3.17)$$

where

$$log(K/L)_{\bullet jt} = \sum_i log(K/L)_{ijt}/R \qquad (3.18)$$

$$log(K/L)_{i\bullet t} = \sum_j log(K/L)_{ijt}/S \qquad (3.19)$$

$$log(K/L)_{\bullet\bullet t} = \sum_i \sum_j log(K/L)_{ijt}/RS, \qquad (3.20)$$

[36]A gaussian kernel and bandwidth following the Silverman's Rule of Thumb were applied to estimate the density of the variable by means of a MATLAB procedure (own elaboration). For nonparametric estimation theory, see SILVERMAN (1986) and HÄRDLE ET AL. (2004).

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being R and S the total number of regions and sectors, respectively.

The analysis of the evolution of the capital-labour ratio over time has been carried out by analysing these two variable: the capital-labour ratio in levels ($log(K/L)_{ijt}$), shown in Figure 3.7, and the same variable including sectoral and regional effects ($\overline{log(K/L)}_{ijt}$), shown in Figure 3.8. Both figures have two parts: the upper graph is the 3-dimensional density function, whereas the bottom part is the 2-dimensional surface of the density function. The dark colours correspond to the areas where the density is concentrated, and therefore the dispersion is more reduced.

Figure 3.7 shows how, due to the changes that the Spanish industry underwent throughout this period, the ratio of capital to labour (without including sectoral and regional effects) in the different sectors of the industry increased from the year 1980 to 1996. Besides, the variance of this variable shrank over time from 1980 to 1992, which could imply an increase in the convergence to the mean of this ratio among sectors over time[37]. However, to what extent is this growth common to all sectors and manufacturing regions? And, to what extent are few sectors and regions the sole agents of this growth process? To shed light on this issue, Figure 3.8 shows the evolution of the capital-labour ratio accounting for sectoral and regional effects, i.e. once regional and sectoral effects have been removed. The result is that, compared to Figure 3.7, (a) the upward trend of the capital-labour ratio disappears, being the distribution centered at zero during the whole period, and (b) the dispersion of the variable is much smaller and constant. The explanation of this result is that, once the specific effect of certain sectors and regions has been removed, there is not an underlying capitalisation process common to the whole manufacturing industry. In other words, it means that the growth in the capital-labour ratio was mainly driven by a subset of regions and sectors.

The second nonparametric analysis undertaken in this subsection is the study of the relationship between the degree of capitalisation and the evolution of the labour demand. Such relationship is important because it roughly reflects whether a process of capitalisation is necessarily accompanied by a net destruction of labour

[37]SEGARRA (1997) finds that this convergence did not take place among regions, arguing that only some industries succeeded in reducing the territorial inequalities in the use of the capital factor.

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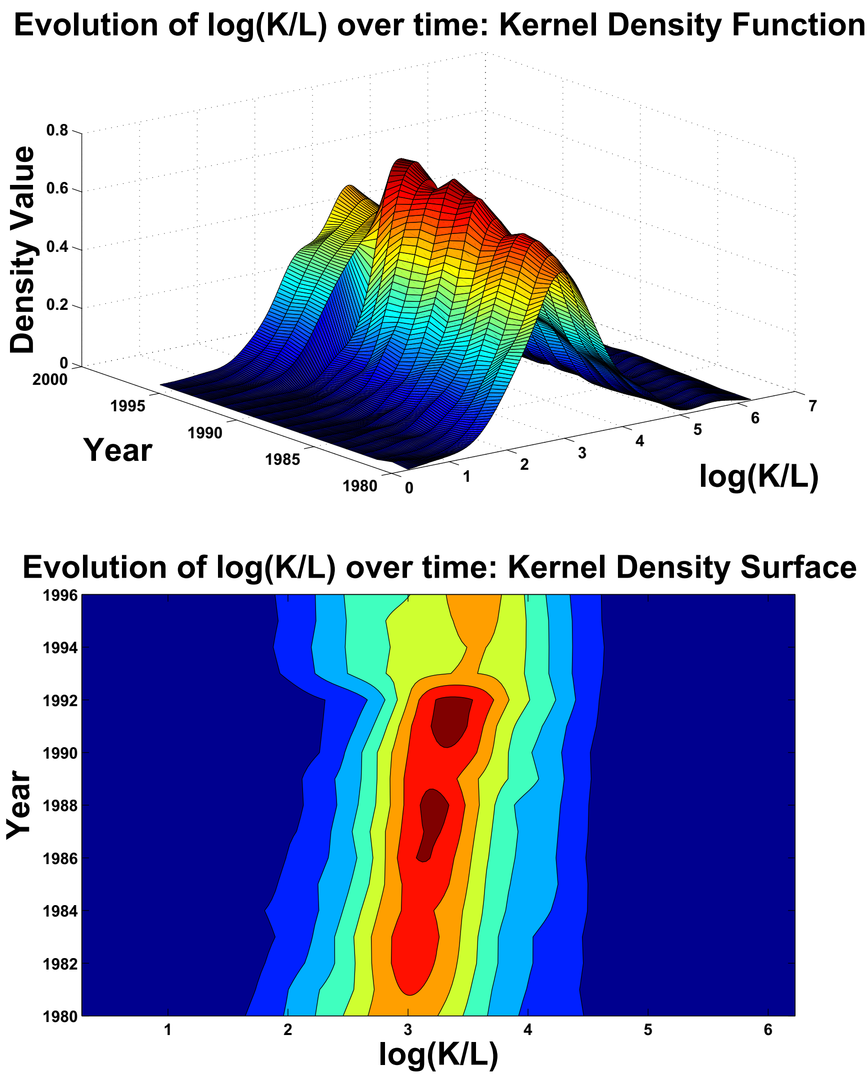

Figure 3.7: Kernel density estimation of $log(K/L)_{ijt}$ over time: variable in levels.

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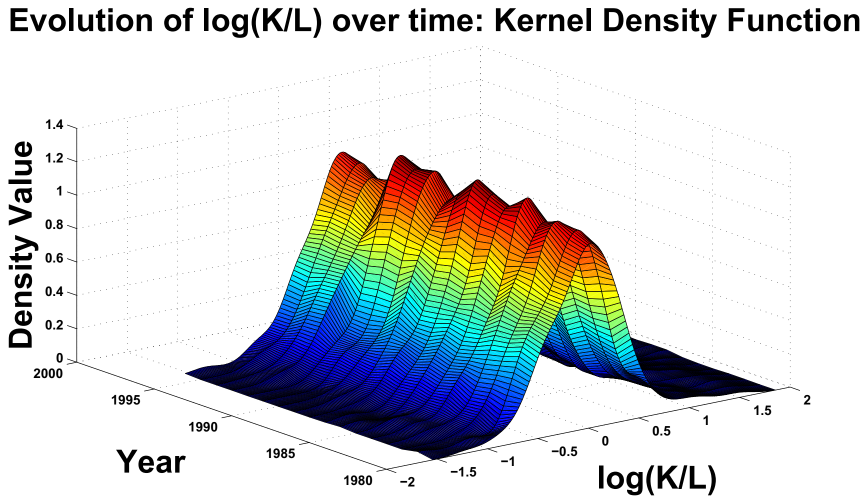

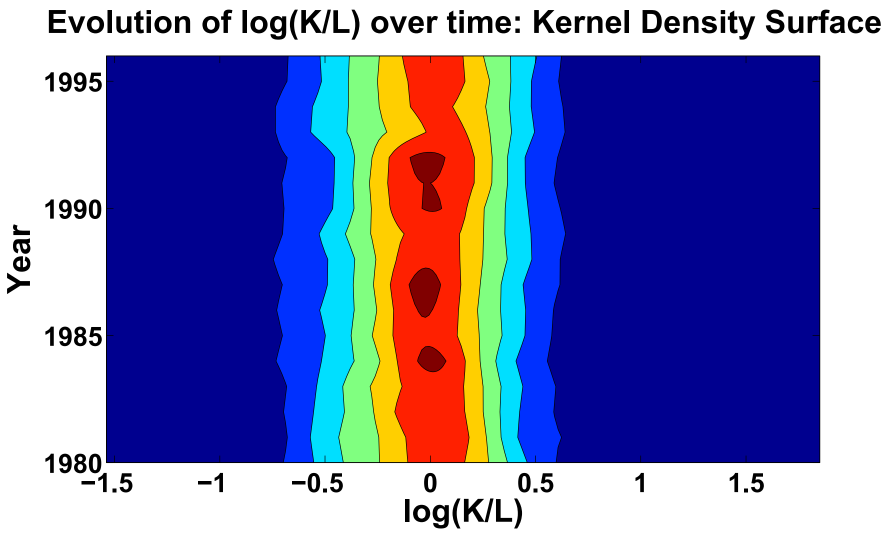

Figure 3.8: Kernel density estimation of $\overline{log(K/L)}_{ijt}$ over time: variable including fixed sectoral and regional effects.

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force. In order to analyse such relationship, two variables have been considered: the growth rate of the labour force ($\Delta L_t/L_{t-1}$) and the log of the labour force ($log(L)$). The methodology chosen for this analysis is a bivariate kernel density estimation, and the analysis is made by aggregating over data which are three-dimensional. Like in the previous case, individual effects are likely to distort the final outcome, and in order to overcome such problem the threefold individual effects are removed from the hypothetical variable x by using the following formula and using the same terminology as in the previous analysis:

$$\hat{x}_{ijt} = x_{ijt} - x_{i\bullet\bullet} - x_{\bullet j\bullet} - x_{\bullet\bullet t} + 2x_{\bullet\bullet\bullet}. \tag{3.21}$$

Figures 3.9 and 3.10 show the estimations of the Kernel bivariate density of $log(K/L)$ with $\Delta L_t/L_{t-1}$ and $log(L)$, respectively. Figure 3.9 shows that, for different values of $log(K/L)$, the growth rate of L is centered at zero. In other words, there is no positive relationship between these two variables, and for different levels of $log(K/L)$ the growth rate of L across sectors and regions are centered at zero (once sectoral and regional effects have been accounted for). On the other side, Figure 3.10 shows the estimates of the bivariate density of $log(K/L)$ and $log(L)$, and as in the previous case, the estimated density do not show any noticeable and remarkable association between the variables. In this case, the mean value of $log(K/L)$ is centered around 3, and the values of $log(L)$ roughly range from 6.5 to 11. In other words, the variance of $log(L)$ is greater than this of $log(K/L)$, and no positive relationship between these two distributions has been found. However, it should be borne in mind that this is a bivariate exploratory analysis, and, indeed, confirmatory research is needed in order to shed more light on this issue.

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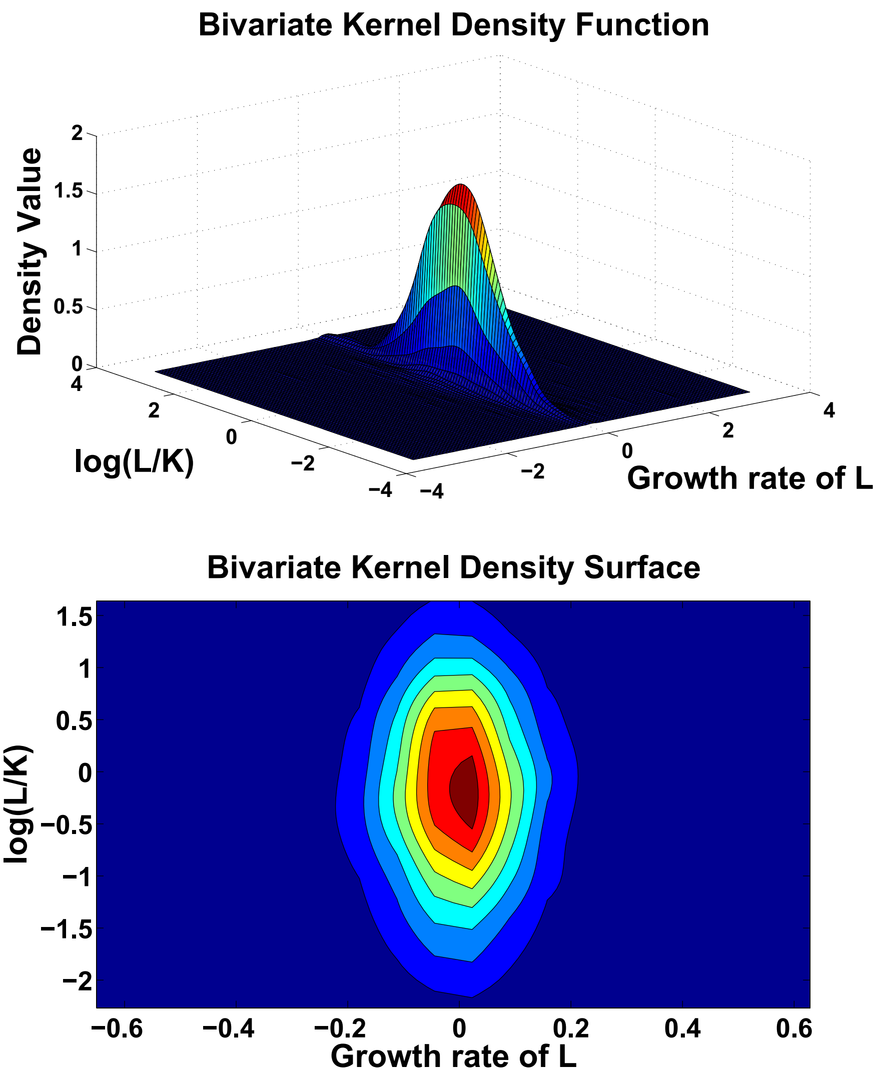

Figure 3.9: Kernel density estimation of $log(K/L)$ and $\Delta L_t/L_{t-1}$.

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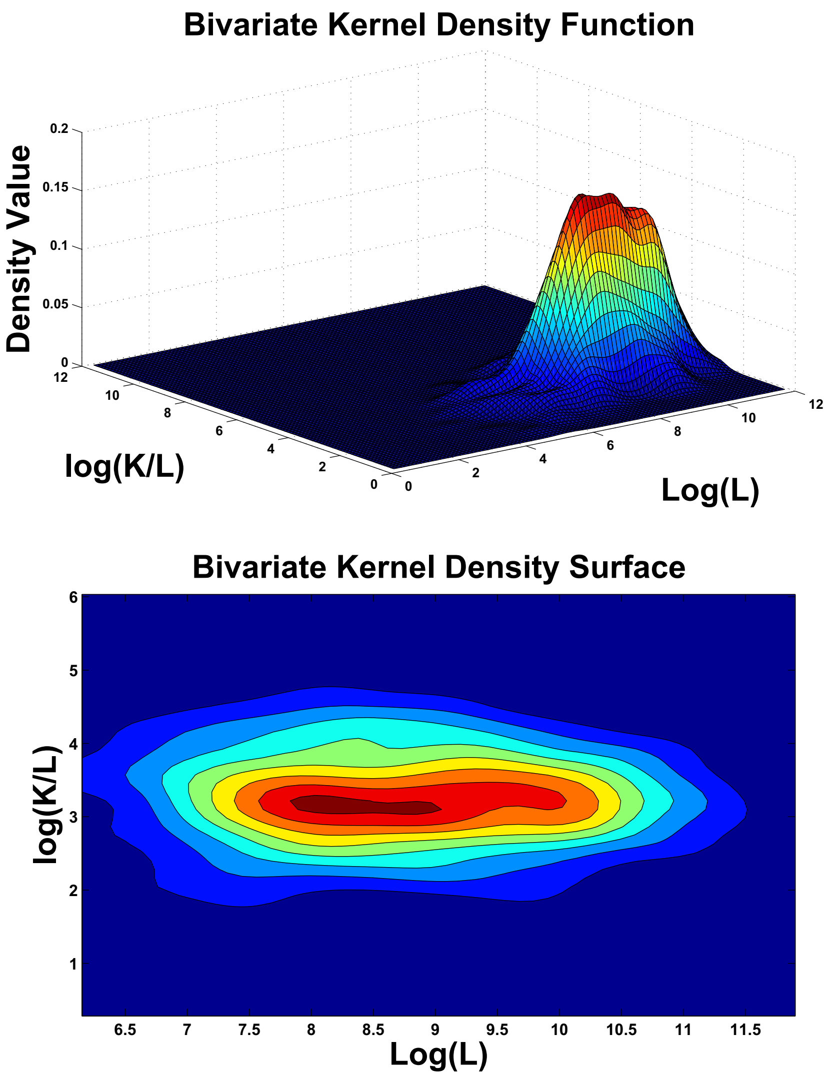

Figure 3.10: Kernel density estimation of $log(K/L)$ and $log(L)$.

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3.6.3 Empirical Framework

The aim of the econometric analysis presented here is to assess the role of new firm formation in capital and labour dynamic demand and substitution. The framework considered is the general adjustment model proposed by NADIRI AND ROSEN (1973), which takes the form[38]

$$Z_{it} = \lambda_{ii} Z_{i,t-1} + \sum_{k \neq i} \lambda_{ik} Z_{k,t-1} + \beta_i X_t, \qquad i = 1, ..., N, \tag{3.22}$$

where Z is a vector of productive factors, X is a matrix of explanatory variables, and N stands for the number of factors. Therefore, model (3.22) has as many equations as the number of factors N. λ_{ik} are adjustment parameters, and each β_i is a vector of parameters linking variables in the matrix X to the long-term equilibrium value of Z_i. The aim of the specification of (3.22) is twofold: (a) to determine whether two inputs i and k are dynamic p-complements or dynamic p-substitutes[39], and (b) to assess the effect of the explanatory variables X on the long-term equilibrium values of Z_i. There is a very important consideration that is worth mentioning, because in this section the data set used is aggregated at the sectoral, regional and temporal level, just like in the previous section. In this case, the estimation of (3.22) allows to infer aggregate and nonstructural relationships, because the data set contains information on factor levels of different industries, whose production functions surely do not share the same properties and therefore are very heterogeneous[40].

[38]For a thorough review of empirical studies using this model as framework, see HAMERMESH (1993).

[39]If two inputs are dynamic p-complements ($\lambda_{ik} > 0$), an increase in the speed of adjustment for the demand of one input speeds up the adjustment for the demand of the other. On the contrary, if two inputs are dynamic p-substitutes ($\lambda_{ik} < 0$), an increase in the speed of adjustment for the demand of one input slows the adjustment for the demand of the other.

[40]Studies of the properties of the production structure of firms require data at the firm level for an industry. For a study of the structure of the adjustment costs for heterogeneous labour inputs in Spanish manufacturing firms, see ALONSO-BORREGO (1998).

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3.6.4 Model Specification and Estimation

The empirical specification to be estimated departs from (3.22), and takes the form

$$L_{ijt} = \lambda_{LL} L_{ij,t-1} + \lambda_{LK} K_{ij,t-1} + \sum_{r=n}^{m} \beta_{Lr} GRE_{ij,t-r} + \eta_{Lj} + \mu_{Li} + \varepsilon_{L,ijt} \quad (3.23)$$

$$K_{ijt} = \lambda_{KK} K_{ij,t-1} + \lambda_{KL} L_{ij,t-1} + \sum_{r=n}^{m} \beta_{Kr} GRE_{ij,t-r} + \eta_{Kj} + \mu_{Ki} + \varepsilon_{K,ijt}, \quad (3.24)$$

where each variable has three subscripts: i stands for region, j stands for sector and t stands for year. L is the logarithm of the number of employees, K is the logarithm of the amount of capital[41], and GRE is the Gross Rate of Entry, measured as the ratio of new manufactures to the number of previously existing establishments. There are both sectoral (η_j) and regional (μ_i) individual effects, as well as disturbance terms in both equations, which are assumed to have the classical properties. Notice that a lag structure of $m - n$ lags is allowed for the GRE variable, which is an estimation strategy widely used in the studies considering this kind of models.

There is no prior reason to consider that $\varepsilon_{L,ijt}$ and $\varepsilon_{K,ijt}$ are correlated, because there are no dependent variables as regressors in other equations. Therefore, equations (3.23) and (3.24) do not constitute a classical system of equations, and they can be estimated independently. However, each equation is characterized by the presence of a lagged dependent variable among the regressors, which makes the equations suffer from two sources of persistence over time: (a) autocorrelation due to the presence of a lagged dependent variable among the regressors and (b) individual effects characterising the heterogeneity among the individuals. In this case, both OLS and Within estimators are likely to be biased and inconsistent (BALTAGI 2001). A solution widely used in the estimation of dynamic panel data models is the first-differenced GMM estimation proposed by ARELLANO AND BOND (1991), which estimates the equation in first differences to sweep out the individual effects and then utilizes the lagged values of the dependent variable as instruments[42]. However, as BLUNDELL AND BOND (1998) argue, the instruments

[41] In the literature related to the estimation of factor demand equations the use of logarithms of factors is very common (HAMERMESH 1993).

[42] More precisely, this GMM estimator utilizes the orthogonality conditions that exist between

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used in the first-differenced GMM estimator become less informative as the value of the AR(1) parameter increases toward unity, being the direct consequence a bias in the estimation of the AR(1) parameter. The problem of weak instruments is likely to happen in the analysis carried out in this chapter, because a previous OLS estimation of a simple AR(1) model $y_{ijt} = \alpha y_{ij,t-1} + u_{ijt}$ yields a value of $\hat{\alpha}$ close to unity, both for $y = L$ and $y = K$. Therefore, an initial solution proposed here is the estimator by BLUNDELL AND BOND (1998), which consists in the estimation of an extended system GMM estimator that uses lagged differences of the dependent variables as instruments for equations in levels, in addition to lagged levels of the dependent variable as instruments for equations in first differences. This system GMM estimator is shown to have dramatic efficiency gains as the AR(1) parameter tends to unity. Once this estimation has been performed, the obtained estimated coefficients are used as initial values in the Least Squares Dummy Variable estimation corrected for the finite-sample bias (LSDVC) proposed by BRUNO (2005), which extends the initial results obtained by KIVIET (1995), KIVIET (1999) and BUN AND KIVIET (2003). These contributions are based on the idea that dynamic AR(1) panel data models can be efficiently estimated by correcting the bias of a Least Squares Dummy Variables (LSDV) estimation. Such bias should not be dismissed, since the LSDV model with a lagged dependent variable generates biased estimates when the time dimension of the panel (T) is small, as it is the case in the analysis presented in this section. As a matter of fact, the bias-corrected LSDV estimation is an alternative to the GMM estimation techniques available for dynamic panels. In the analysis presented in this chapter, the low dimension of T tipped the balance in favour of the former[43]. The variance-covariance matrices of the models have been computed by means of a bootstrapping method assuming normality for errors, and the estimation of the models has been computed by means of the STATA procedures provided by ROODMAN (2005) for the Blundell and Bond GMM estimation and by BRUNO (2005) for the bias-corrected LSDV estimator.

The performed estimations are shown in Tables 3.15 to 3.26. The results for the capital equation estimation (3.23) are always shown in the upper part of the table, whereas the results for the labour equation estimation (3.24) are shown in

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lagged values of the dependent variable and the disturbance term.

[43] JUDSON AND OWEN (1999) analyse the suitability of different GMM and LSDV approaches to the estimation of dynamic panel data models by using a Monte Carlo approach.

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the lower part of the table. For each case, five models have been estimated, thus allowing for a different lag structure of the GRE variable, this is, including no value at all, the variable in levels, and the three first time lags. This multiple estimaton allows a better study of the lag structure of the model, and besides lags beyond the fourth year $(t-4)$ have been found not significant, so that only an estimation up to the third lag $(t-3)$ is reported. There are both theoretical and empirical reasons for considering these different lag structures. One the one hand, the theoretical framework given by (3.22) allows for the inclusion of explanatory variables in levels. Besides, another empirical approach considered to analyse dynamic relationships among variables considers VAR models, which include only lagged values of the variables as regressors[44].

3.6.5 Results

The analysis can be divided into two different parts. The first one is an overall estimation for regions (i), sectors (j) and years (t), so that each variables has three subscripts (ijt), the results being shown in Table 3.15. The second part of the analysis is a piecewise sectoral estimation, so that an independent estimation for each sector is yielded. In this case, the variables have only a regional (i) and time (t) dimension, and the results are shown in Tables 3.16 to 3.26.

Table 3.15 shows the results for the overall estimation, the results for both equations being considerably different. On the one hand, the capital equation (3.23) shows a value of $\hat{\lambda}_{KK}$ slightly above the unity, which indicates that the capital variable has a considerable persistence over time, and on the other hand the value of $\hat{\lambda}_{KL}$ is around -0.02, thus indicating that an increase in the level of labour factor has a slight negative effect on the value of capital. Interestingly, none of the GRE variables, neither the variable in levels nor its lagged valued, seem to have any effect on the dependent variable K_{ijt}, since the coefficient values are not statistically significant. The straightforward interpretation of this result is that the entry of new establishments has no effect on the dynamic demand of capital, neither in the short

[44]For a proposed estimation methodology for VAR models in a panel data framework, see HOLTZ-EAKIN ET AL. (1988). Also, HOLTZ-EAKIN AND KAO (2003) analyse the empirical relationship between new firm formation and productivity by specifying and estimating VAR models.

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nor in the long term. A plausible interpretation fully compatible with this result is that the dynamic process of capital demand takes place mainly within incumbent firms, thus new firm formation not affecting this process directly. As it has been found in many studies (GEROSKI 1995), the average size of new establishments is small, and therefore the entry of new capacities has not a direct and short-term effect on the dynamic demand of capital. In this regard, and in order to gather such a dynamic effect, a longer time span and data on the average size of both newcomers and incumbents would be necessary, such analysis being left for future research.

Regarding the labour equation (3.24), the results shown in the lower part of Table 3.15 are quite different. On average, the value of $\hat{\lambda}_{LL}$ yields a value around 0.8, whilst the value for $\hat{\lambda}_{LK}$ is on average close to 0.1. By virtue of these results, it can be inferred that labour factor shows persistence over time, but not as much as the capital factor does. This result is compatible with the fact that, during the analysed period, there were some years with job losses and labour destruction. Besides, the fact that the coefficient of $K_{ij,t-1}$ is around 0.1 seems to indicate that investments in capital further increases in the dynamic labour demand to a certain degree. Interestingly, the estimated parameters for $\hat{\lambda}_{KL}$ and $\hat{\lambda}_{LK}$ differ and have a different sign. This result reveals that the dynamic relationship between both factors is not symmetric, that is, the effects of the demand for each factor on the other one's demand are different. Moreover, the effect of GRE on the dynamic demand for labour is negative for the time periods t and $t-1$, positive in $t-2$ and negative in $t-3$. Such estimations point out that the initial effect of establishment entries on labour demand is negative at the moment of the entry and also in the subsequent year. This interpretation is compatible with the displacement effect, that is, new establishments expel old and less efficient incumbents out of the market, being the overall effect a destruction of labour force. Then, in the period $t-2$ the effect becomes positive, thus indicating that the net effect after two years becomes positive. However, this result should be taken cautiously, since the analysis does not include data on firm exit, and therefore the combined short-term and long-term effect of establishment entry and exit on labour demand remains unknown.

The second part of the estimation is carried out for each sector individually. For the capital equation (3.23), the value of $\hat{\lambda}_{KK}$ ranges from 0.95 to 1.1, which

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implies that the dynamic demand for the capital factor is highly persistent across all manufacturing sectors. With respect to the $\hat{\lambda}_{KL}$ values, in some sectors they show negative values, while in other sectors such coefficient is not statistically significant. Interestingly, the coefficient of the GRE_{it} variable is positive and significant for some sectors (mineral products, metal products, agricultural and industrial machinery, electrical goods, textiles, paper and printing, rubber and plastic and other manufactures) and not significant for the rest (chemical products; transport equipment; food, beverage and tobacco; textiles and paper and printing). This result seems to indicate that, for some sectors, the entry of new capacities does have a positive effect on dynamic labour demand when they take place. Most likely, this result has to do with the average size of the entering establishments, in that for some sectors the capital endowment needed to start a productive activity is greater than in other sectors. The estimation of the coefficient of $GRE_{i,t-1}$ yields a different result. For nearly half of the sectors the effect is not significant (mineral products; chemical products; metal products; transport equipment; food, beverage and tobacco and textiles), while for almost all the rest the effect is positive (electrical goods, paper and printing, rubber and plastic and other manufactures), and only for the agricultural and industrial machinery sectors the coefficient is negative. With respect to the effect of $GRE_{i,t-2}$ and $GRE_{i,t-3}$, it is not statistically significant for most of the sectors, being only positive for the agricultural and industrial machinery sector and negative for the electrical goods and rubber and plastic sectors.

The sectoral estimation of the labour equation (3.24), the value of the autoregressive parameter $\hat{\lambda}_{LL}$ yields an estimated coefficient between 0.65 and 0.85 for all sectors, thus confirming the fact that the labour factor is more volatile over time than capital. Moreover, the estimation of $\hat{\lambda}_{LK}$ is significant and positive for almost all sectors (with the exception of chemical products and transport equipment), and also it shows a great dispersion, ranging from 0.10 to 0.75. This result proves that, for almost all manufacturing sectors, investment in capital dynamically increases the demand for labour, this effect varying for different sectors. Regarding the effect of GRE on the dynamic demand for labour, in all sectors (with the sole exception of metal products) the effect in t is either not significant (mineral products; chemical products; food, beverage and tobacco and rubber and plastic) or negative (agricultural and industrial machinery, electrical goods, transport equipment, textiles,

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paper and printing and other manufactures). With respect to the effect on GRE in the periods $t-1$ to $t-3$, it is very heterogeneous and varies with sectors, some of them being positive, some negative, and some not statistically significant.

All in all, what are the general implications of these results? First, the relationship between establishment entry and dynamic factor demand and substitution has a dynamic nature and it is not easy to handle and analyse. The approach undertaken in this section has shown that dynamic capital demand is more persistent that dynamic labour demand, also that these factors have a non-symmetric effect on each other, and that the effect of establishment entries differs significantly between factors. Second, the separate estimation per aggregate sectors and individual sectors reveals that, although the results from the estimations of capital and labour equations share many similarities across sectors, each of them shows certain specificities. In the end, the prevailing effects will be those of the predominant manufacturing sectors in the economy. Third, these results do not allow to infer any direct conclusion regarding the relationship between establishment entry and productivity changes as it has been analysed in the literature so far. The implications that can be derived from this study regarding the effect of establishment entries is that, only for a subset of sectors, they contribute to the dynamic demand of capital and that, for most of the sectors, such entries have a negative effect on the dynamic demand of labour, presumably due to their limited size and the effect on establishment exits.

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Table 3.15: Dynamic factor demand estimation: all manufacturing sectors

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{ijt}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{ij,t-1}$	1.0454	1.045	1.0448	1.039	1.0293
	(0.0058)***	(0.0058)***	(0.0058)***	(0.0057)***	(0.0079)***
$L_{ij,t-1}$	−0.0209	−0.0197	−0.0193	−0.0154	−0.0061
	(0.0070)***	(0.0077)**	(0.0078)**	(0.0087)*	(0.0082)
GRE_{ijt}		0.0001	0.0001	0.0001	0.0001
		(0.0001)	(0.0001)	(0.0001)	(0.0001)
$GRE_{ij,t-1}$			0.0000	0.0000	0.0000
			(0.0001)	(0.0001)	(0.0001)
$GRE_{ij,t-2}$				0.0001	0.0001
				(0.0001)	(0.0001)
$GRE_{ij,t-3}$					0.0000
					(0.0001)
Obs.	2816	2816	2816	2640	2464

Dependent Variable: L_{ijt}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{ij,t-1}$	0.8240	0.8108	0.7964	0.8240	0.8512
	(0.0141)***	(0.0139)***	(0.0137)***	(0.0187)***	(0.0178)***
$K_{ij,t-1}$	0.1265	0.1298	0.1355	0.1245	0.0922
	(0.0151)***	(0.0149)***	(0.0147)***	(0.0198)***	(0.0179)***
GRE_{ijt}		−0.0010	−0.0009	−0.0006	−0.0005
		(0.0001)***	(0.0001)***	(0.0001)***	(0.0001)***
$GRE_{ij,t-1}$			−0.0009	−0.0013	−0.0013
			(0.0001)***	(0.0002)***	(0.0001)***
$GRE_{ij,t-2}$				0.0023	0.0023
				(0.0002)***	(0.0002)***
$GRE_{ij,t-3}$					−0.0004
					(0.0001)**
Obs.	2816	2816	2816	2640	2464

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.16: Dynamic factor demand estimation: mineral products

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0499	1.0381	1.0382	1.0320	1.0244
	(0.177)***	(0.0178)***	(0.0190)***	(0.0181)***	(0.0223)***
$L_{i,t-1}$	−0.0653	−0.0480	−0.0477	−0.0763	−0.0683
	(0.0277)**	(0.0313)	(0.0354)	(0.0320)**	(0.047)
GRE_{it}		0.0036	0.0036	0.0043	0.0052
		(0.0016)**	(0.0014)***	(0.0025)*	(0.0017)***
$GRE_{i,t-1}$			−0.0002	−0.0001	0.0005
			(0.0022)	(0.0018)	(0.0021)
$GRE_{i,t-2}$				0.0000	0.0003
				(0.0017)	(0.0025)
$GRE_{i,t-3}$					−0.0034
					(0.0021)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.7689	0.7718	0.7795	0.7550	0.7267
	(0.0321)***	(0.0383)***	(0.0466)***	(0.0520)***	(0.0482)***
$K_{i,t-1}$	0.1403	0.1348	0.1248	0.1059	0.1051
	(0.0319)***	(0.0322)***	(0.0324)***	(0.0360)***	(0.0456)**
GRE_{it}		0.0019	0.0010	0.0003	0.0001
		(0.0026)	(0.0022)	(0.0033)	(0.0026)
$GRE_{i,t-1}$			0.0035	0.0013	0.0009
			(0.0033)	(0.0030)	(0.0300)
$GRE_{i,t-2}$				0.0094	0.0089
				(0.0027)***	(0.0039)**
$GRE_{i,t-3}$					0.0004
					(0.0030)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.17: Dynamic factor demand estimation: chemical products

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	0.9540	0.9560	0.9570	0.9630	0.9654
	(0.0236)***	(0.0232)***	(0.0245)***	(0.0302)***	(0.0395)***
$L_{i,t-1}$	0.0208	0.0195	0.0188	0.0225	0.0318
	(0.0232)	(0.0229)	(0.0234)	(0.0167)	(0.0320)
GRE_{it}		0.0002	0.0003	0.0000	0.0000
		(0.0006)	(0.0006)	(0.0006)	(0.0007)
$GRE_{i,t-1}$			−0.0001	−0.0003	−0.0006
			(0.0006)	(0.0008)	(0.0009)
$GRE_{i,t-2}$				0.0010	0.0008
				(0.0007)	(0.0008)
$GRE_{i,t-3}$					0.0012
					(0.0007)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8552	0.8557	0.8565	0.8309	0.8866
	(0.0536)***	(0.0551)***	(0.0558)***	(0.0447)***	(0.0560)***
$K_{i,t-1}$	0.0060	0.0061	0.0064	0.0436	−0.0157
	(0.0675)	(0.0684)	(0.0064)	(0.0701)	(0.0709)
GRE_{it}		−0.0002	−0.0002	0.0002	−0.0001
		(0.0013)	(0.0013)	(0.0012)	(0.0014)
$GRE_{i,t-1}$			0.0001	0.0008	0.0002
			(0.0011)	(0.0015)	(0.0017)
$GRE_{i,t-2}$				0.0024	0.0014
				(0.0013)*	(0.0014)
$GRE_{i,t-3}$					0.0013
					(0.0013)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.18: Dynamic factor demand estimation: metal products

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	0.9980	1.0005	1.0010	1.0076	0.9970
	(0.0231)***	(0.0224)***	(0.0223)***	(0.0150)***	(0.0224)***
$L_{i,t-1}$	−0.0289	−0.0098	−0.0102	−0.0246	−0.0145
	(0.0256)	(0.0261)	(0.0260)	(0.0208)	(0.0332)
GRE_{it}		0.0050	0.0050	0.0066	0.0083
		(0.0015)***	(0.0015)***	(0.0017)***	(0.0021)***
$GRE_{i,t-1}$			−0.0002	−0.0010	−0.0018
			(0.0012)	(0.0016)	(0.0020)
$GRE_{i,t-2}$				0.0032	0.0035
				(0.0019)	(0.0019)*
$GRE_{i,t-3}$					−0.0021
					(0.0018)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8260	0.8468	0.8547	0.8191	0.8282
	(0.0450)***	(0.0466)***	(0.0474)***	(0.0474)***	(0.0509)***
$K_{i,t-1}$	0.1135	0.1175	0.1164	0.1163	0.0922
	(0.0385)***	(0.0383)***	(0.0382)***	(0.0306)***	(0.0416)**
GRE_{it}		0.0047	0.0036	0.0037	0.0037
		(0.0027)*	(0.0027)	(0.0030)	(0.0042)
$GRE_{i,t-1}$			0.0044	0.0068	0.0059
			(0.0023)*	(0.0031)**	(0.0039)
$GRE_{i,t-2}$				−0.0047	−0.0037
				(0.0038)	(0.0035)
$GRE_{i,t-3}$					−0.0056
					(0.0039)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.19: Dynamic factor demand estimation: agricultural and industrial machinery

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0687	1.0659	1.0694	1.0313	1.0083
	(0.0241)***	(0.0256)***	(0.0242)***	(0.0238)***	(0.0285)***
$L_{i,t-1}$	−0.0024	0.0119	0.0098	0.0280	0.0133
	(0.0241)	(0.0251)	(0.0260)	(0.0145)*	(0.0249)
GRE_{it}		0.0019	0.0021	0.0023	0.0024
		(0.0012)	(0.0015)	(0.001)**	(0.0013)*
$GRE_{i,t-1}$			−0.0005	−0.0023	−0.0027
			(0.0016)	(0.0011)**	(0.0013)**
$GRE_{i,t-2}$				0.0055	0.0041
				(0.0011)***	(0.0009)***
$GRE_{i,t-3}$					0.0033
					(0.0011)***
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.7674	0.6700	0.7147	0.7709	0.7488
	(0.0589)***	(0.0570)***	(0.0610)***	(0.0568)***	(0.0565)***
$K_{i,t-1}$	0.3356	0.3591	0.3306	0.2459	0.2442
	(0.3356)***	(0.0712)***	(0.0663)***	(0.0746)***	(0.0907)***
GRE_{it}		−0.0077	−0.0092	−0.0088	−0.0087
		(0.0025)***	(0.0032)***	(0.0020)***	(0.0028)***
$GRE_{i,t-1}$			0.0055	−0.0006	−0.0011
			(0.0038)	(0.0028)	(0.0030)
$GRE_{i,t-2}$				0.0182	0.0167
				(0.0027)***	(0.0019)***
$GRE_{i,t-3}$					0.0034
					(0.0030)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.20: Dynamic factor demand estimation: electrical goods

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0336	1.0366	1.0332	1.0305	1.0276
	(0.0187)***	(0.0182)***	(0.0186)***	(0.0192)***	(0.0208)***
$L_{i,t-1}$	−0.0354	−0.0297	−0.0225	−0.0169	−0.0100
	(0.0329)	(0.0328)	(0.0309)	(0.0311)	(0.0288)
GRE_{it}		0.0016	0.0013	0.0013	0.0013
		(0.0007)**	(0.0007)*	(0.0005)**	(0.0009)
$GRE_{i,t-1}$			0.0014	0.0015	0.0014
			(0.0006)**	(0.0004)***	(0.0007)*
$GRE_{i,t-2}$				0.0003	0.0006
				(0.0005)	(0.0008)
$GRE_{i,t-3}$					−0.0012
					(0.0007)*
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8000	0.7926	0.8077	0.7870	0.8336
	(0.0581)***	(0.0581)***	(0.0582)***	(0.0572)***	(0.0535)***
$K_{i,t-1}$	0.0525	0.0440	0.0411	0.0698	0.0136
	(0.0550)	(0.0549)	(0.0545)	(0.0354)**	(0.0451)
GRE_{it}		−0.0020	−0.0026	−0.0023	−0.0005
		(0.0013)	(0.0013)*	(0.0011)**	(0.0017)
$GRE_{i,t-1}$			0.0027	0.0029	0.0015
			(0.0013)**	(0.0010)***	(0.0014)
$GRE_{i,t-2}$				−0.0007	−0.0009
				(0.0011)	(0.0015)
$GRE_{i,t-3}$					−0.0009
					(0.0014)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.21: Dynamic factor demand estimation: transport equipment

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0239	1.0275	1.0293	1.0279	1.0452
	(0.0273)***	(0.0270)***	(0.0269)***	(0.0237)***	(0.0311)***
$L_{i,t-1}$	−0.0076	−0.0151	−0.0200	−0.0480	−0.0001
	(0.0281)	(0.0282)	(0.0296)	(0.0341)	(0.0360)
GRE_{it}		−0.0001	−0.0001	−0.0002	−0.0001
		(0.0001)	(0.0001)	(0.0001)	(0.0002)
$GRE_{i,t-1}$			−0.0001	−0.0001	0.0000
			(0.0001)	(0.0001)	(0.0001)
$GRE_{i,t-2}$				−0.0001	0.0000
				(0.0001)	(0.0002)
$GRE_{i,t-3}$					0.0000
					(0.0002)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8249	0.7791	0.6843	0.8619	0.8862
	(0.0486)***	(0.0500)***	(0.0450)***	(0.0402)***	(0.0426)***
$K_{i,t-1}$	−0.0636	−0.0406	−0.0075	−0.0730	−0.0720
	(0.0559)	(0.0562)	(0.0526)	(0.0491)	(0.0517)
GRE_{it}		−0.0007	−0.0006	−0.0001	−0.0001
		(0.0002)***	(0.0002)***	(0.0002)	(0.0002)
$GRE_{i,t-1}$			−0.0015	−0.0016	−0.0017
			(0.0002)***	(0.0002)***	(0.0001)***
$GRE_{i,t-2}$				0.0024	0.0025
				(0.0002)***	(0.0002)***
$GRE_{i,t-3}$					−0.0004
					(0.0002)**
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.22: Dynamic factor demand estimation: food, beverage and tobacco

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0961	1.0913	1.1043	1.1030	1.0873
	(0.0129)***	(0.0140)***	(0.0125)***	(0.0112)***	(0.0210)***
$L_{i,t-1}$	−0.0983	−0.0933	−0.0980	−0.1001	−0.0668
	(0.0284)***	(0.0293)***	(0.0293)***	(0.0389)***	(0.0429)
GRE_{it}		0.0005	0.0015	0.0014	0.0010
		(0.0011)	(0.0014)	(0.0018)	(0.0015)
$GRE_{i,t-1}$			−0.0030	−0.0036	−0.0038
			(0.0017)*	(0.0019)*	(0.0025)
$GRE_{i,t-2}$				0.0010	0.0011
				(0.0017)	(0.0014)
$GRE_{i,t-3}$					−0.0014
					(0.0020)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

Variable	Model (1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.7108	0.7160	0.7021	0.6882	0.6904
	(0.0500)***	(0.0481)***	(0.0476)***	(0.0593)***	(0.0659)***
$K_{i,t-1}$	0.1196	0.1152	0.1432	0.1453	0.1361
	(0.0332)***	(0.0360)***	(0.0364)***	(0.0341)***	(0.0415)***
GRE_{it}		0.0009	0.0025	0.0024	0.0029
		(0.0017)	(0.0021)	(0.0030)	(0.0026)
$GRE_{i,t-1}$			−0.0055	−0.0059	−0.0056
			(0.0030)*	(0.0030)**	(0.0041)
$GRE_{i,t-2}$				0.0014	0.0026
				(0.0028)	(0.0024)
$GRE_{i,t-3}$					−0.0036
					(0.0030)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.23: Dynamic factor demand estimation: textiles

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0074	1.0123	1.0083	0.9946	1.0071
	(0.0239)***	(0.0229)***	(0.0238)***	(0.0249)***	(0.0260)***
$L_{i,t-1}$	−0.0379	−0.0206	−0.0098	−0.0050	−0.0318
	(0.0258)	(0.0261)	(0.0263)	(0.0244)	(0.0299)
GRE_{it}		0.0028	0.0023	0.0021	0.0022
		(0.0014)*	(0.0014)	(0.0012)*	(0.0009)**
$GRE_{i,t-1}$			0.0016	0.0015	0.0015
			(0.0012)	(0.0013)	(0.0014)
$GRE_{i,t-2}$				0.0006	0.0006
				(0.0012)	(0.0006)
$GRE_{i,t-3}$					0.0001
					(0.0009)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8149	0.7748	0.8354	0.8518	0.8351
	(0.0368)***	(0.0366)***	(0.0387)***	(0.0450)***	(0.0478)***
$K_{i,t-1}$	0.1584	0.1264	0.0975	0.0533	0.0338
	(0.0748)**	(0.0725)*	(0.0696)	(0.0758)	(0.0814)
GRE_{it}		−0.0069	−0.0094	−0.0096	−0.0097
		(0.0027)**	(0.0026)***	(0.0021)***	(0.0020)***
$GRE_{i,t-1}$			0.0094	0.0096	0.0096
			(0.0023)***	(0.0023)***	(0.0029)***
$GRE_{i,t-2}$				−0.0118	−0.0009
				(0.0022)	(0.0015)
$GRE_{i,t-3}$					−0.0006
					(0.0021)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.24: Dynamic factor demand estimation: paper and printing

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0775	1.0677	1.0535	1.0409	1.0394
	(0.0182)***	(0.0174)***	(0.0180)***	(0.0171)***	(0.0247)***
$L_{i,t-1}$	−0.0478	−0.0112	0.0127	0.0278	0.0247
	(0.0327)	(0.0323)	(0.0330)	(0.0292)	(0.0357)***
GRE_{it}		0.0073	0.0064	0.0057	0.0059
		(0.0014)***	(0.0016)***	(0.0018)***	(0.0014)
$GRE_{i,t-1}$			0.0032	0.0033	0.0032
			(0.0019)*	(0.0018)*	(0.0022)
$GRE_{i,t-2}$				0.0011	0.0006
				(0.0013)	(0.0018)
$GRE_{i,t-3}$					−0.0007
					(0.0016)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8446	0.8126	0.8108	0.8151	0.7907
	(0.0500)***	(0.0490)***	(0.0535)***	(0.0363)***	(0.0444)***
$K_{i,t-1}$	0.1800	0.1891	0.1859	0.1613	0.1634
	(0.0376)***	(0.0357)***	(0.0384)***	(0.0285)***	(0.0377)***
GRE_{it}		−0.0060	−0.0060	−0.0059	−0.0072
		(0.0022)***	(0.0025)**	(0.0028)**	(0.0022)***
$GRE_{i,t-1}$			0.0003	0.0001	0.0009
			(0.0031)	(0.0029)	(0.0035)
$GRE_{i,t-2}$				0.0007	0.0003
				(0.0022)	(0.0030)
$GRE_{i,t-3}$					−0.0016
					(0.0027)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.25: Dynamic factor demand estimation: rubber and plastic

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0466	1.0563	1.0572	1.0444	1.0343
	(0.0158)***	(0.0150)***	(0.0147)***	(0.0161)***	(0.0239)***
$L_{i,t-1}$	0.0052	0.0145	0.0215	0.0362	0.0512
	(0.0263)	(0.0266)	(0.0262)	(0.0269)	(0.0382)
GRE_{it}		0.0021	0.0019	0.0021	0.0016
		(0.0006)***	(0.0006)***	(0.0008)**	(0.0005)***
$GRE_{i,t-1}$			0.0012	0.0013	0.0012
			(0.0007)*	(0.0005)**	(0.0007)
$GRE_{i,t-2}$				−0.0008	−0.0007
				(0.0008)	(0.0007)
$GRE_{i,t-3}$					−0.0011
					(0.0005)**
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.6428	0.6338	0.6397	0.6026	0.6369
	(0.0578)***	(0.0586)***	(0.0595)***	(0.0558)***	(0.0619)***
$K_{i,t-1}$	0.1744	0.1643	0.1658	0.1831	0.1598
	(0.0482)***	(0.0451)***	(0.0457)***	(0.0363)***	(0.0460)***
GRE_{it}		−0.0019	−0.0021	−0.0020	−0.0014
		(0.0013)	(0.0013)	(0.0019)	(0.0013)
$GRE_{i,t-1}$			0.0011	0.0009	0.0005
			(0.0017)	(0.0013)	(0.0018)
$GRE_{i,t-2}$				0.0019	0.0018
				(0.0020)	(0.0017)
$GRE_{i,t-3}$					−0.0020
					(0.0013)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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Table 3.26: Dynamic factor demand estimation: other manufactures

Estimation Method: LSDVC dynamic regression.

Dependent Variable: K_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$K_{i,t-1}$	1.0982	1.0872	1.0765	1.0879	1.0872
	(0.0160)***	(0.0164)***	(0.0176)***	(0.0189)***	(0.0247)***
$L_{i,t-1}$	−0.0422	−0.0158	−0.0068	−0.0065	−0.0055
	(0.0135)***	(0.0149)	(0.0182)	(0.0083)	(0.0155)
GRE_{it}		0.0042	0.0037	0.0041	0.0041
		(0.0010)***	(0.0010)***	(0.0015)***	(0.0015)***
$GRE_{i,t-1}$			0.0017	0.0020	0.0022
			(0.0012)	(0.0010)*	(0.0013)
$GRE_{i,t-2}$				−0.0004	−0.0003
				(0.0011)	(0.0011)
$GRE_{i,t-3}$					−0.0008
					(0.0010)
Obs.	256	256	256	240	224

Dependent Variable: L_{it}

	Model				
Variable	(1)	(2)	(3)	(4)	(5)
$L_{i,t-1}$	0.8036	0.6606	0.7154	0.7011	0.6890
	(0.0540)***	(0.0485)***	(0.0566)***	(0.0481)***	(0.0543)***
$K_{i,t-1}$	0.7127	0.7563	0.6611	0.6374	0.6233
	(0.1015)***	(0.1063)***	(0.0982)***	(0.1185)***	(0.1897)***
GRE_{it}		−0.0206	−0.0240	−0.0256	−0.0268
		(0.0038)***	(0.0045)***	(0.0067)***	(0.0065)***
$GRE_{i,t-1}$			0.0113	0.0104	0.0099
			(0.0056)**	(0.0047)**	(0.0057)*
$GRE_{i,t-2}$				0.0029	0.0028
				(0.0050)	(0.0050)
$GRE_{i,t-3}$					−0.0018
					(0.0043)
Obs.	256	256	256	240	224

Note 1: LSDVC stands for Least Squares Dummy Variables estimator corrected for finite-sample bias. The initial estimator is the Blundell and Bond one-step system GMM and the bias correction is up to order $O(1/T)$.
Note 2: Standard errors appear in brackets, and have been computed by a bootstrapping method.
Note 3: ***, ** and * mean that the estimated coefficients are significant at a 1%, 5% and 10% signification level, respectively.

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3.7 Summary

This chapter has dealt with the analysis of the effect of firm entry on factor demand. The chapter starts with a motivation of the issue and an overview of the chapter's contents. Next, the relationship between firm entry, labour demand and technology is dealt with in Section 3.2, first by arguing that this is a relevant topic and that the research on it is totally justified, then by giving a broad literature review where the main approaches adopted by scholars so far, as well as the obtained results, are exposed, compared and discussed. Next, the complex mechanism linking technological change and employment creation is analysed. This study is made because the phenomenon of technological change is closely linked to that of factor demand and also linked to the emergence of new firms. Then, a conceptual framework is provided, by which basic definitions related to the type of innovation and the technological change direction and bias are given. The section continues with a historical perspective of how scholars have dealt with the effects of technology on factor demand, focusing the analysis upon the demand for labour force. Finally, the section concludes with a discussion about the role that new firms (or generally speaking industrial dynamics) have in labour demand, and how the innovative nature of the firm might tip the balance in favour of one specific factor (labour or capital) at the expense of the other.

Section 3.3 introduces the data and variables to be used in the two main empirical models of the chapter. Such data is related to the Spanish regions and manufacturing sectors for the period 1980-1996, and the resulting variables are related to productive factors and industry dynamics, i.e. firm entries, stock of establishments, gross rate of entry, labour and capital stock and Gross Value Added. Then, a descriptive analysis consisting of two parts is introduced. First, the economic situation of the Spanish and European economy for the considered period (1980-1996) is analysed and related to the basic descriptive statistics of the data. The second part of this section consists of three univariate analyses of the variables: a correspondence analysis, an analysis of variance (ANOVA) and a growth rate components analysis. The aim of such analyses is twofold: (a) to give an overview of the heterogeneity of the variables across regions, sectors and time and (b) to try to unveil certain patters of the variables across dimensions, that is, if the evolution of the distribution of the variables across sectors and regions over time can be

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considered as random or otherwise can be modeled explicitly. Such univariate analyses shed light on some interesting facts. On the one hand, the sectoral and regional gross rates of entry underwent a convergence process, that is, the strong link between sectoral and regional rates registered a decrease during the analysed period and tended to be more homogeneous both across sectors and regions over time. Besides, the ANOVA analysis reveals that, for the labour factor and the gross rate of entry, the regional dispersion is greater than the sectoral dispersion. This result is also confirmed by the growth components analysis, yielding the result that the growth of these variables has both a sectoral and regional component.

The last part of the chapter is devoted to the motivation, specification and estimation of two empirical models, and is divided into two sections. The first one is a dynamic model aimed at the estimation of the dynamic relationship between firm entry and employment change. Specifically, a distributed lag model has been specified, where both the gross rate of entry in levels and its time lags affect employment change. Such model has been estimated by including all the lags from t to $t-7$, both separately and simultaneously. For the latter case, a structure on the coefficients using the polynomial distributed lag model, which is also known as the Almon lag model, has been imposed. The results from the various estimations are quite similar: a positive short-term effect, a negative medium-term effect and a positive long-term effect. This result is similar to those of other studies that also estimate distributed lag models and confirm the existence of a three-stage wave pattern. Such pattern consists of three phases, i.e. a short-term positive effect on employment, a middle-term negative effect due to displacement of firms out of the market, and a long-term indirect supply side effect, which is related to dynamic gains in efficiency which in turn have a positive effect on employment growth.

The second empirical model is an original model that can be seen as a development of the first empirical model, and consists mainly on the introduction of the capital factor in the analysis. The model explicitly models the effect of new firm formation on the dynamic demand and substitution of capital and labour factors. A preliminary result indicates that the ratio of capital to labour has increased over the period considered, which corresponds to a process of capitalisation. Regarding the estimation of the empirical model, it has been performed for the overall manufacturing sectors as well as for each single sector. With respect to the overall estimation, the

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following conclusions can be drawn from the analysis: (a) both factors, capital and labour, present a high level of persistence over time, being this persistence higher for the capital factor; (b) the dynamic relationship between capital and labour is not symmetric, in that lagged values of capital foster the demand for labour, while the opposite does not apply; (c) at the aggregate level, current and lagged values seem to have no effect on the dynamic demand for capital, while this effect exists for the case of the dynamic demand for labour, being negative in the first two periods, positive in the third period and again negative in the fourth period. The individual estimation for each sector reveals that, although the different sectoral results tend to confirm the results obtained in the overall estimation to some extent, there are some specificities worth mentioning. Specifically, for the capital demand equation, in some sectors there seems to be a positive effect of the gross rate of entriy on the dynamic labour demand. This result is presumably due to the fact that the average size when entering the market is higher for these sectors, and hence the effect on the demand for capital is higher.

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Chapter 4

Summary and Conclusions

4.1 Summary of the Main Results

This thesis has emphasised the role of new firms in the economy, and such role has been studied here thoroughly from an empirical perspective by using quantitative methods, that is, statistic and econometric tools. This analysis is focused specifically on giving an answer to these two strongly interrelated aspects: (a) the determinants of new firms location and (b) the outcomes and effects of these new establishments in terms of factor demand. These two questions can be unified into a single general research framework (see Figure 1.1) which analyses, on the one side, both the creation and the location process, and on the other side, the outcome of such entry on the economy. The first question focuses on the effect that territorial characteristics exert on the location decision of firms, this is, on the number of new firms that will locate in different municipalities, given the characteristics of these municipalities. The second question deals with the outcome of firm entries in terms of dynamic factor demand. In this regard, the focus is on the effects on the labour and capital markets, that is, how new establishments demand productive factors (labour and capital) and how the stock of those factors vary over time. There are several isses regarding this framework that are worth noting. First, there exist two fundamental dimensions whose importance should be highlighted: space and time. Entries are a complex and multidimensional concept whose effects upon the economy spread over space and time, that is, their effect is not restricted to the specific spatial unit and sector where they take place, but to the whole economy, and this includes all territories and production sectors. Besides, entries exert also a dynamic effect on

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the economy, that is, they have both a short-term and a long-term effect, specifically in terms of technical change and efficiency improvements. Second, this framework regards new firms as the vehicle connecting territorial characteristics to economic outcomes such as economic growth, factor demand an technical change. All in all, firm location determinants and firm entry outcomes are parts of a complete and dynamic process, according to which different regions and territories are capable of attracting new firms through their own characteristics and strengths, and such entries in turn have a positive impact where they locate, in particular, and on the whole economy, in general, in that they demand productive factors, create value added and foster efficiency changes.

The first empirical analysis carried out in this thesis focuses on the relationship between territorial characteristics and firm location for the Catalan economy. The spatial unity considered has been the municipality, of which there are 941 in Catalonia. A previous descriptive analysis has shed light on many interesting and relevant characteristics of the spatial distribution of entries, and two important facts are worth noticing: (a) there exists a very high number of municipalities with zero entries whose distribution across the territory is not random, and (b) there exists a clear and statistically significant spatial correlation of entries. Therefore, zero counts and spatial effects are issues that really matter and are consequently accounted for in the context of the regression analysis. In this regard, the analysis shows that, if spatial correlation is not properly accounted for in the regression analysis, the estimated regression residuals show a statistically significant spatial correlation, and this fact is proven for the majority of models used in the empirical analysis of firm location. In order to take into account such issues as well as the potential presence of nonlinearities, a Zero Augmented Inverse Gaussian (ZAIG) model is specified and estimated, both for the overall sectors and for five sectoral groupings. The main results of these analyses shed light on the effect of certain variables on the amount of entries in Catalan municipalities, and can be listed as follows: (a) in general, the variables regarding the level of agglomeration and the industrial structure of municipalities are relevant for the location of new establishments; (b) urbanisation economies seem to outweigh localisation economies, that is, diversified productive environments are more attractive than specialised ones; (c) the percentage of manufacturing employment attracts new locations up to a point where this attraction decreases, which implies that moderately diversified

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productive environments are more likely to attract firm locations and to keep congestion effects from arising; (d) the spatial effects are significant, and they show that new establishments also consider territorial characteristics in the broader surrounding area when deciding to locate, and also that firms tend to avoid big areas when the level of agglomeration surpasses a certain threshold, which is likely to be a sign for the presence of diseconomies of agglomeration; (e) in order for a municipality to receive a positive number of entries, the presence of service firms in the surrounding area has been proven to be relevant; (f) the education level of the population has been found to exert a positive effect on the number of entries for those municipalities that usually receive a positive number of locations; and (g) for the sectoral estimations, firms belonging to sectors intensive in labour show somewhat different location patterns from the other sectors, in that they prefer locating in environments with similar firms and also environments characterised by a low-skilled average workforce, tend to avoid locations with a high share of manufacturing employment and have a preference for environments with a high presence of service firms.

The second empirical analysis presented here analyses the other link of the empirical framework, that is, the dynamic effects of firm entries on the dynamic demand for capital and labour for the Spanish regions and manufacturing sectors. A previous descriptive analysis provided evidence on some interesting facts: (a) sectoral and regional gross rates of entries underwent a convergence process, that is, sectoral and regional divergence tended to decrease over time, and (b) for the labour factor and the gross rate of entry, the regional dispersion was greater than the sectoral dispersion. The empirical analysis of this chapter is divided into two main models: a dynamic distributed lag model aimed at the estimation of the dynamic relationship between firm entry and labour demand changes, and a dynamic auto-regressive system that models the effect of new firm formation on the dynamic demand and substitution of capital and labour factors. The results stemming from such analyses can be summarised as follows: (a) the gross rates of entry exert a dynamic effect on labour demand changes that can be regarded as a three-stage wave pattern, that is, a short-term positive effect on employment, a middle-term negative effect due to displacement of firms out of the market, and a long-term indirect supply side effect, which is related to dynamic gains in efficiency which in turn have a positive effect on employment growth; (b) capital and labour

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factors present a high level of persistence over time, being the persistence of the capital factor higher; (c) current and lagged values of the rate of entry only have a positive effect on the demand for capital in some sectors, which presumably has to do with the average size of entry, in that only those firms with a minimum size when entering will have a significant effect on the demand for capital; and (d) current and lagged values of the rate of entry do have an effect on the dynamic demand for labour, being this effect negative in the first two periods, positive in the third period and again negative in the fourth period.

4.2 Discussion

The results obtained from the empirical work in this thesis permit drawing some conclusions and insights into the deep links depicted in Figure 1.1. To start the discussion, it should be noted that the results should be put into a broader perspective, that is, the life cicle of a firm, where many interesting stages take place. Beginning with the initial idea in the entrepreneur's head, then the decision of creating the firm comes, and immediately afterwards the decision of where to locate the firm must be made. Once the firm is located and start its activity, the firm begins its life cycle and interacts with the economy (demanding factors, providing an output to the market,...), and in the long term the overall economic change in terms of productivity, efficiency, employment and growth will be the long-term result of the actions and behaviour of many individual firms. Over this long time span, the analyses carried out in this thesis have focused on two specific aspects, which have shed light on several important issues. First of all, the creation of new firms is closely linked to the territory. As it has been shown in the empirical literature on firm location and also in this thesis, territorial characteristics are key factors determining how the emerging economic activity in the form of new firms is to be distributed across the geographical space. In this regard, the extent to which different territories have a specific production structure, offer certain transportation infrastructures and are located near big areas will determine to what extent firm choose them as potential locations. In this sense, it is advisable to consider in the discussion geographical areas bigger than single municipalities, since spatial effects among different municipalities have been proven to exist and to be relevant. Moreover, and regarding the

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second part of the analysis, the short-term and long-term overall effects of firm entries (labour and capital demand, efficiency and productivity changes, etc.) spread over the whole economy, but have a specific influence on the specific geographical area where firms locate. Then, in the long term, there is a sort of circle by which territorial conditions determine the location of firms which, in turn, have an effect on the whole economy that is particularly noticeable and effective in the geographical area where firms are active. Such an effect changes local and sectoral conditions in terms of employment, innovation, productivity and local markets which, in turn, have an influence on the future location of firms.

4.3 Future Research Directions

The results obtained in this thesis suggest some hints about how future research could continue this line of research. First, the issues tackled in this thesis could be studied in a unified methodological framework. As it has been argued before, the location of firms and the posterior effects on the economy are two sides of the same coin, being causes and consequences inextricably intertwined in a spatial dynamic process. Such framework is to gather the following steps: (a) the territorial determinants of firm location, (b) sectoral and territorial effects of such entries on economic conditions (productivity, efficiency, labour market,...), and (c) how these dynamic changes influence the location of firms in the long term. Regarding such dynamic framework, new methodological developments are very useful for this purpose. This thesis has provided some new approaches to deal with the spatial dimension of firm location, the excess of zeros in some geographical areas and the treatment of nonlinearities. In this regard, new developments in the methodological field of spatiotemporal econometrics are very appealing in this sense, since they allow the study of simultaneous spatial and temporal effects in a unified modelisation (LeSage and Pace 2004). However, more work should be done in this respect, and as new methodologies and databases are at the disposal of researchers, the proposed framework is going to be dealt with in alternative ways, so that more light will be shed on this matter. Besides, the issue of the data to be used is worth discussing. So far, the empirical literature reviewed in Chapter 1 shows to what extent the data used in different contributions is heterogeneous in terms of variables and spatial aggregation, which is not convenient in terms of

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comparison of different contributions across economies. The proposal made here is to use data at a local and disaggregated level, so that the spatial effects which are shown to be crucial can be completely and efficiently included in the analysis. Besides, the issue of the deep relationship between factor (specifically labour) demand and technological change should be studied further. As it has been shown in this thesis, because of the close bonds that these concepts share, it is advisable to study them from a unified perspective. Moreover, the issues discussed here have also very clear policy implications. Following the reasoning put forth in this section, since the themes analysed here can be dealt with in a unified framework, policies regarding firm location, innovation, employment growth and new firm promotion should be coordinated, since all these matters share deep bonds. However, the policy issues ought to be dealt with in further research, since they are beyond this thesis' reach.

As concluding remarks, it is worth noting that the topics analysed in this thesis are appealing and relevant because there are many agents interested in it: entrepreneurs, scholars and policy makers. Besides, as it is highlighted throughout this work, there are many areas where significant and insightful contributions can be made, both from a theoretical and a methodological point of view. If scholars keep researching on these issues, it is to expect that much more evidence will be provided in the next years, so that knowledge and understanding of the role of new firms in the economy will expand and grow.

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Appendix A

Methodological Appendix

A.1 Industrial Demography Main Indices

In this section of the Appendix, several measures related to the industrial demography considered in this study are presented. In this section, and following the previous one, i stands for territory, j stands for sector, and t is the time period.

A.1.1 Gross Rate of Entry (GRE)

The GRE is an indicatior of entrepreneurship, and relates the entries of firms or establishments in a year to the number of active firms or establishments at the beginning of that year.

$$GRE_{jit} = 100 \cdot (E_{jit}/N_{jit}), \tag{A.1}$$

where E_{jit} stands for entries and N_{jit} is the number of active firms or establishments at the beginning of the period.

A.1.2 Gross Rate of Exit (GRX)

GRX is an indicatior of the firms or establishments that leave the industry, and relates the exits of firms or establishments in a year to the number of active firms or establishments at the beginning of that year.

$$GRX_{jit} = 100 \cdot (X_{jit}/N_{jit}), \tag{A.2}$$

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where X_{jit} stands for exits and N_{jit} is the number of active firms or espablishments at the beginning of the period.

A.1.3 Turnover Rate (TR)

TR is an overall measure of firm or establishment entry and exit flows. It shows the degree to which an industry is dynamic and experiences a high degree of renewal.

$$TR_{jit} = 100 \cdot ((E_{jit} + X_{jit})/N_{jit}) = GRE_{jit} + GRX_{jit}. \tag{A.3}$$

As it is noticeable, it can be obtained by summing up the gross rates of enry and exit.

A.1.4 Net Rate of Entry (NRE)

NRE stands for the variation of active firms between two consecutive years, that is, it is positive if the entries outnumber the exits, and vice versa.

$$NRE_{jit} = 100 \cdot ((E_{jit} - X_{jit})/N_{jit}) = GRE_{jit} - GRX_{jit}. \tag{A.4}$$

It can be calculated as the difference between the gross rates of enry and exit as well.

A.1.5 Volatility Rate (VR)

This index has been proposed because the other indices cannot take into account the structural factors, such as technology, assets specificity and R+D investments, that might determine the barriers of entry and exit of an industry.

$$VR_{jit} = TR_{jit} - |NRE_{jit}|. \tag{A.5}$$

Those sectors with high VR will show weak barriers to the entry and exit of firms or establishments, and vice versa.

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A.2 Count Data Methodology

A.2.1 Generalised Linear Models (GLM)

GLM are a flexible generalisation of classical linear models. They were first described by NELDER AND WEDDEBURN (1972) and detailed in MCCULLAGH AND NELDER (1989), with the aim of unifying various other statistical models, including linear regression, logistic regression and Poisson regression, under a unified framework. This is achieved by allowing the dependent variable to belong to a broad collection of dstributions, called exponential family. Besides, a general algorithm for maximum likelihood estimation was also developed.

The simple regression model $y_i = E(y_i|x_i) + \varepsilon_i$, where $E(y_i|x_i) = x_i'\beta$, is extended by GLM in this way:

$$E(y_i|x_i) = h(x_i'\beta) \quad \Leftrightarrow \quad \mu_i = h(\eta_i) \;\; \text{and} \;\; g(\mu_i) = \eta_i, \tag{A.6}$$

where $\mu_i = E(y_i|x_i)$ is the conditional mean, $\eta_i = x_i'\beta$ is the index or linear predictor, $g(\cdot)$ the link function and $h(\cdot)$ the response function.

In equation (A.6), the link and the response functions relate the index with the conditional mean. Besides, the distribution of the dependent variable y_i is assumed to belong to the exponential family[1], and therefore its conditional density function has the structure:

$$f(y_i|\theta_i, \phi, \omega_i) = exp\left(\frac{y_i\theta_i - b(\theta_i)}{\phi}\omega_i + c(y_i, \phi, \omega_i)\right), \tag{A.7}$$

being θ_i a natural parameter of the exponential family, ϕ a scale or dispersion parameter, ω_i a prior weight for observation i and $b(\cdot)$ and $c(\cdot)$ functions depending on the specific exponential family.

The conditional mean and conditional variance are determined by the distributional assumption, and take the following forms:

[1] Some of the distributions included in the exponential family are the Bernoulli, Gaussian, Poisson and Gamma distributions, among others.

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$$E(y_i|x_i) = \mu_i = b'(\theta_i) = \frac{\partial b(\theta_i)}{\partial \theta} \quad \text{(A.8)}$$

$$V(y_i|x_i) = \sigma^2(\mu_i) = \frac{\phi \upsilon(\mu_i)}{\omega_i}, \quad \upsilon(\mu_i) = b''(\theta_i), \quad \text{(A.9)}$$

being $\upsilon(\mu_i)$ the variance function of the underlying exponential family.

A special case of the link function of particular interest is the *canonical link function*, which happens when

$$\eta_i = \theta_i. \quad \text{(A.10)}$$

One direct consequence of the canonical link function is that the density function (A.7) is evaluated at $x_i'\beta = \theta_i$, which has consequences in terms of the interpretation of the model.

A.2.2 Basic Poisson Regression Model

Let y_i be the dependent variable, and x_i a set of regressors. Then, the Poisson regression model speficies that the distribution of y_i conditional on x_i (henceforth conditional distribution) follows a Poisson distribution, i.e.

$$y_i|x_i \sim Po(\mu_i). \quad \text{(A.11)}$$

The conditional density of the dependent variable takes the form

$$f(y_i|x_i) = exp\{y_i ln(\mu_i) - \mu_i - ln(y_i!)\}, \quad \text{(A.12)}$$

the natural response function is given by the exponential[2]

$$h(\eta_i) = exp(\eta_i) = \mu_i \quad \text{(A.13)}$$

and the natural link function is the natural logarithm

$$g(\mu_i) = ln(\mu_i) = \eta_i. \quad \text{(A.14)}$$

[2]This function is also called *exponential mean function* in the literature.

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The scale parameter is fixed at $\phi = 1$, and the variance of the model is defined as $V(y_i|x_i) = (\phi/\omega_i)V(\mu_i) = \mu_i$. A strightforward result is that the conditional mean and variance are equal, property that is called equidispersion:

$$E(y_i|x_i) = V(y_i|x_i) = \mu_i. \tag{A.15}$$

In the statistics literature the Poisson regression model is also called a *log-linear model*, because the logarithm of the conditional mean is linear in the parameters, i.e. $lnE(y_i|x_i) = ln(\mu_i) = x_i'\beta$. Besides, the log link function is the caninical link function, since $b(\theta_i) = exp(\theta_i)$ implies $\mu_i = b'(\theta_i)$, so $\eta_i = ln(\mu_i) = ln(exp(\theta_i)) = \theta_i$.

A.2.3 Mixture Models

A.2.3.1 Definitions

In mathematics, the term mixture model refers to a model in which independent variables are fractions of a total. Specifically, in statistics many generalized count models have been generated by mixtures, which add flexibility to the basic Poisson distribution by improving the fit of the resulting distribution to the observed data.

With respect to count models, it is useful to distinguish between continuous and finite mixtures:

Definition. *Let $F(y|\theta)$ be a parametric distribution depending on θ, and let $\pi(\theta|\alpha)$ define a continuous mixing distribution. Then a **continuous mixture** is defined by*

$$F(y|\alpha) = \int_{-\infty}^{\infty} \pi(\theta|\alpha)F(y|\theta)d\theta. \tag{A.16}$$

where $0 \leq \pi(\theta|\alpha)$ and $\int_{-\infty}^{\infty} \pi(\theta|\alpha)\, d\theta = 1$. Estimation and inference involve the parameters (θ, α).

Definition. *Let $F_j(y|\theta_j),\ \ j = 1, 2, \ldots$ be a distribution function. Then, a $m-$**component finite mixture** is defined as*

$$F(y|\pi_i) = \sum_{j=1}^{m} \pi_j F_j(y|\theta_j), \tag{A.17}$$

where $\pi_j \in (0, 1)$ and $\sum_{j=1}^{m} \pi_i = 1$. Estimation and inference involve the parameters $(\pi_j, \theta_j;\ j = 1, \ldots, M)$.

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A necessary condition for estimation and inference is the **identifiability** of the mixture. A mixture is identifiable if there is a unique correspondence between the mixture and the mixing distribution.

A.2.3.2 Mixture Poisson Models

One of the most popular and widely considered alternatives has been the **mixture models** as a way to extend the basic Poisson regression model. In the count data literature they consist in the addition of some distributions to the underlying Poisson distribution, therefore being called mixture Poisson models. A special case are the **continuous mixtures**, which control for the unobserved heterogeneity by including an unobserved heterogeneity term for each observation. This way, the specified distribution is extended from $(y_i|x_i)$ to $(y_i|x_i, \nu_i)$, being ν_i an i.i.d. term that denotes the unobserved heterogeneity and is independent of the covariates. In industrial location literature, ν_i is regarded as a location-specific random effect. Although the specific link between y_i and (x_i, v_i) can take many forms, for mathematical and interpretation conveniences the multiplicative form is commonly used:

$$E(y_i|x_i, \nu_i) = \mu_i \nu_i = exp(x_i' \beta)\nu_i. \tag{A.18}$$

Mixture models based on multiplicative heterogeneity as shown in (A.18) have two crucial consequences. First, the conditional variance of the mixture exceeds the variance of the parent Poisson distribution conditional on both the regressors and the heterogeneity. Besides, the randomness of ν_i is distinguished from the intrinsic randomness of y_i. Second, the mixture model increases the proportion of zeros allowed by the Poisson model, so that mixture models are also valid in the presence of an excess of zeros. Ultimately, overdispersion and excess of zeros arise from the existence of unobserved heterogeneity in the conditional mean parameter[3] (MULLAHY 1997).

A very popular and used mixture model is the Negative Binomial (NB) model. This model has several derivations, and here the derivation and interpretation of the Negative Binomial model as a Poisson-Gamma (POGA) mixture[4] is adopted. An

[3]However, the proportion of zeros can be too large or there might exist a selection process, and in these cases other models are needed.

[4]The algebraic derivation of the NB model as a POGA model is an old result that can be derived

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initial assumption of the model is that the natural parameter has a random intercept term, that is,

$$\begin{aligned} \theta_i &= exp(x_i'\beta + \varepsilon_i) && \text{(A.19)} \\ &= e^{(x_i'\beta)} e^{(\varepsilon_i)} && \text{(A.20)} \\ &= \mu_i \nu_i. && \text{(A.21)} \end{aligned}$$

The model arises as a mixture of a Poisson distribution for the dependent variable and a Gamma distribution for the unobserved heterogeneity term, i.e.

$$\begin{aligned} y_i|\theta_i &\sim Po(\theta_i) && \text{(A.22)} \\ \nu_i|\delta,\phi &\sim G(\delta,\phi). && \text{(A.23)} \end{aligned}$$

On the one side, the density function of the dependent variable takes the form

$$f(y_i|\theta_i) = \frac{exp(-\theta_i)\theta_i^{y_i}}{y_i!}, \tag{A.24}$$

having its two first moments the same expression, i.e.

$$E(y_i|\theta_i) = Var(y_i|\theta_i) = \theta_i = \mu_i \nu_i. \tag{A.25}$$

On the other side, the ν_i parameter has the following density:

$$g(\nu_i|\delta,\phi) = \frac{\delta^{\phi}}{\Gamma(\delta)} \nu_i^{\delta-1} e^{-\nu_i \phi}, \tag{A.26}$$

with the corresponding two first moments:

$$\begin{aligned} E(\nu_i|\delta,\phi) &= \delta/\phi && \text{(A.27)} \\ Var(\nu_i|\delta,\phi) &= \delta/\phi^2. && \text{(A.28)} \end{aligned}$$

in several ways (GREENWOOD AND YULE 1920). Here, the NB model is derived from a POGA model by marginalising the distribution of the response variable with respect to the multiplicative random effects.

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However, because the intercept condition is $E(\nu_i) = 1$, which is obtained by setting $\delta = \phi$, a one-parameter Gamma family results, i.e. $\nu_i|\delta, \sim G(\delta, \delta)$, and the conditional variance of ν_i becomes $Var(\nu_i|\delta) = 1/\delta \equiv \alpha$.

By transforming from ν_i to θ_i using $\theta_1 = \mu_i \nu_i$ and being $(1/\mu)$ the Jacobian transformation term, $g(\nu_i|\delta)$ is transformed into $g(\theta_i|\mu_i, \delta_i)$. Then, the continuous mixture model is obtained by solving the following integral:

$$h(y_i|\mu_i, \delta) = \int f(y_i|\theta_i) g(\theta_i|\mu_i, \delta) d\theta_i, \tag{A.29}$$

which yields the final NB marginal distribution for y_i:

$$h(y_i|\mu_i, \delta) = \frac{\Gamma(y_i + \delta)}{\Gamma(y_i + 1)\Gamma(\delta)} \left(\frac{\mu_i}{\mu_i + \delta} \right)^{y_i} \left(\frac{\delta}{\mu_i + \delta} \right)^{\delta}. \tag{A.30}$$

After adopting the notation $1/\delta \equiv \alpha$, the first two moments of the distribution are defined as:

$$E(y_i|x_i) = \mu_i \tag{A.31}$$

$$Var(y_i|x_i) = \mu_i + \alpha \mu_i^2. \tag{A.32}$$

The variance shown in (A.32) corresponds to the so-called Negative Binomial type 2 (NB2) model, although there exists the alternative linear parametrisation $Var(y_i|x_i) = \mu_i + \alpha \mu_i$ corresponding to the Negative Binomial type 1 (NB1) model.

A.2.3.3 Finite Mixture Models

Although continuous mixtures control for heterogeneity, they may not properly account for the excess of zero counts. Since the excess of zeros may stem from two sources, i.e. unobserved heterogeneity and an underlying selectivity process, continuous mixture models such as NB1 or NB2 are likely to account only for the excess of zeros stemming from the unobserved heterogeneity. Besides, sometimes data display heterogeneity through an excess of zero counts, the number of which exceeds the number of zeros expected by the continuous mixture model. A solution to this problem consists of a discrete representation of the unobserved locational heterogeneity, instead of assuming a continuous distribution for it. This is the idea behind **finite mixture models**, which allow for the existence of an undetermined number

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of heterogeneous groups in the population of interest[5]. This way, the zero counts constitute an heterogeneous group which is explicitly taken into account. Here, two approaches for modeling the excess of zeros through discrete mixture models emerge, the adequacy of each depending ultimately on the interpretation of the zero counts.

a) Hurdle models: also known as conditional models, they have an interpretation as two-part models, the first part being a binary outcome model and the second part a truncated count model[6]. The idea underlying hurdle formulations is that a binomial probability model governs the binary outcome of whether a count variate has a zero or a positive realisation. If the realisation is positive, the hurdle is crossed, and the conditional distribution of the positives is governed by a truncated-at-zero count data model. Analytically, let Y be the dependent variable, which has a count data nature and an excess of zeros, and is distributed as a certain distribution function (DF) governed by the set of parameters θ, i.e. $Y \sim DF(\theta)$. Besides, let (π) be the probability of a zero count and $f(\cdot)$ the probability mass function associated with Y. Then, assuming that

$$Z = \begin{cases} 1 & \Leftrightarrow \quad Y = 0 \\ 0 & \Leftrightarrow \quad Y > 0 \end{cases}, \tag{A.33}$$

the hurdle model is defined by the following distributions:

$$Z \sim \pi)^Z (1-\pi)^(1-Z) \tag{A.34}$$

$$Y|Z = 0 \sim f_{trunc}(Y|\theta). \tag{A.35}$$

a) With Zeros (WZ) models: also known as zero-inflated models, these are finite mixture models in which the heterogeneity is introduced in a binary form, telling zero from non-zero counts. Specifically, and assuming as before that $Y \sim DF(\theta)$ and $Y = 0$ with probability π, the WZ mixture model consists of a mixture of a degenerate distribution with mass at zero and a non-degenerate distribution DF, such as the Poisson distribution:

$$Y \sim \pi I_\pi + (1-\pi) f(Y|\theta), \tag{A.36}$$

[5]See CAMERON AND TRIVEDI (1998) for details.

[6]See MULLAHY (1986) and HEILBRON (1994) for a discussion on these models.

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being I_π the degenerate distribution taking the value zero with probability one and $f(\cdot)$ the probability mass function associated with Y. One of the most used models was introduced by LAMBERT (1992) and called Zero Inflated Poisson (ZIP) model, in which the probability of zero counts is parametrised as a logistic function of the covariates. Zero Inflated Negative Binomial (ZINB) models stand as an alternative to ZIP models, since they account for overdispersion in a more efficient way by using an additional parameter in describing the variance of the count variable, although they can be hard to compute[7]. A formal description of such models is exposed next.

A.2.3.4 Zero Inflated Poisson (ZIP) and Zero Inflated Negative Binomial (ZINB) Models

In this subsection a formal expression for ZIP and ZINB models is provided. Let the response Y_i denote a count data variable, for $i = 1, \ldots, N$. The probability of an excess zero is denoted by $\pi_i \in (0, 1)$. Then, Following CHEUNG (2002), the random variable Y_i follows a ZIP distribution if

$$Pr(Y_i = y_i) = \begin{cases} \pi_i + (1-\pi_i)e^{-\mu_i} & \text{if} \quad y_i = 0 \\ (1-\pi_i)\frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!} & \text{if} \quad y_i > 0. \end{cases} \tag{A.37}$$

The mean and the variance are defined as $E(Y_i) = (1 - \pi_i)\mu_i$ and $Var(Y_i) = (1 - \pi_i)\mu_i(1 + \pi_i\mu_i)$.

If Yi follows a ZINB distribution, then

$$Pr(Y_i = y_i) = \begin{cases} \pi_i + (1-\pi_i)\left(\frac{1}{1+\kappa\mu_i}\right)^{\kappa^{-1}} & \text{if} \quad y_i = 0 \\ (1-\pi_i)\frac{\Gamma(\kappa^{-1}+y_i)}{\Gamma(\kappa^{-1})(y_i!)}\left(\frac{\kappa\mu_i}{1+\kappa\mu_i}\right)^{y_i}\left(\frac{1}{1+\kappa\mu_i}\right)^{\kappa^{-1}} & \text{if} \quad y_i > 0. \end{cases} \tag{A.38}$$

The mean and variance of the ZINB random variable are given by the expressions $E(Y_i) = (1 - \pi_i)\mu_i$ and $Var(Y_i) = (1 - \pi_i)\mu_i(1 + (\kappa + \pi_i)\mu_i)$, and κ stands for an overdispersion parameter. The ZINB model reduces to the ZIP model as $\kappa \to 0$.

[7] For a recent contribution on the computation of ZIP and ZINB models, see WILLIAMSON ET AL. (2007).

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A.2.4 Generalized Additive Models for Location, Scale and Shape (GAMLSS)

Generalized Additive Models for Location, Scale and Shape (GAMLSS) were introduced by RIGBY AND STASINOPOULOS (2001, 2005) and AKANTZILIOTOU ET AL. (2002) as a way of overcoming some of the limitations associated with Generalized Linear Models (GLM) and Generalized Additive Models (GAM) (NELDER AND WEDDERBURN 1972 and HASTIE AND TIBSHIRANI 1990, respectively).

GLM and GAM models assume that, given the response variable y_i, its mean μ_i is modeled as a function of a set of regressors and its variance, given by $Var(y) = \phi v(\mu)$, depends on a constant parameter ϕ as well as on the mean μ, through the variance function $v(\mu_i)$. This assumption implies that the skewness and kurtosis of y_i are functions of μ and ϕ, and thus not to be modeled explicitly in terms of the explanatory variables.

GAMLSS are a general class of univariate regression models which overcomes some of the shortcuts of GLM and GAM models. GAMLSS relaxes the distibution for the response variable y_i and replaces it by a very general family of distributions including highly skewed or kurtotic continuous and discrete distributions. Within this framework not only is the conditional mean modeled in terms of a set of regressors, but also any other distributional parameter is allowed to be modeled this way. Besides, the regressors can enter the model parametrically and/or as additive nonparametric smooth functions.

A basic formulation of a GAMLSS modes is described here. Let y_i be the response variable, for $i = 1, \ldots, N$, whose distribution is characterised by p parameters, each of which is related to the explanatory variables. Then, the conditional density function has the form $f(y_i|\theta^i)$ where $\theta^1 = (\theta_{i1}, \theta_{i2}, \ldots, \theta_{ip})$. The GAMLSS model assumes that the k^{th} parameter is related to the set of regressors by a semi-parametric additive model given by

$$g_k(\theta_k) = \eta_k = X_k\beta_k + \sum_{j=1}^{J_k} h_{jk}(x_{jk}). \tag{A.39}$$

In (A.39), θ_k is a particular distribution parameter, X_k is a subset of parameters

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related to the link function parametrically and h_{jk} a nonparametric additive function of the explanatory variable X_{jk} evaluated at x_{jk}.

In many practical situations at most $p = 4$ distribution parameters are required. They are usually written as $(\mu_i, \sigma_i, \nu_i, \tau_i)$, where the first two population parameters μ_i and σ_i are usually characterised as location and scale parameters, while the remaining parameters, if any, are characterised as shape parameters, although the model may be applied more generally to the parameters of any population distribution. Maximum (penalised) likelihood estimation methods are proposed to fit the models. Specifically, there are two algorithms, the CG and RS algorithms, which are discussed in detail in RIGBY AND STASINOPOULOS (2005).

A.3 Spatial Analysis Methodology

A.3.1 Generalized Weights Matrices

The weights matrix W has the information on the neighbouring relationship between the geographical units of which the sample is composed. Let N be the sample size. Then, the weights matrix has the form

$$W = \begin{bmatrix} 0 & w_{12} & \cdots & w_{1N} \\ w_{21} & 0 & \cdots & w_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ w_{N1} & w_{N2} & \cdots & 0 \end{bmatrix},$$

where w_{ij} represents the intensity of the interdependence between i and j, $\forall\, i, j = 1, ..., N$. When $i = j$, $w_{ij} = w_{ii} = 0$[8].

There are several ways of computing W, each depending on the neighbourhood criterion considered. Defining c_{ij} as the relationship between ith and jth spatial units, these criteria are used in the present thesis:

a) Contiguity: this is a simple and straightforward neighbourhood criterion:

[8] The reason of this result is that the proximity of a region with respect to itself is zero.

$$c_{ij} = \begin{cases} 1 & \text{if } i \text{ and } j \text{ share a border} \\ 0 & \text{otherwise} \end{cases} \tag{A.40}$$

b) $k-$nearest neighbours $(k - NN)$: according to this criterion, only the group of k closest units are regarded as neighbours:

$$c_{ij} = \begin{cases} 1 & \text{if } j \text{ is one of the } k\text{-nearest neighbours of } i \\ 0 & \text{otherwise} \end{cases} \tag{A.41}$$

c) Euclidean distance $C(d)$: this criterion considers as neighbours those units included in a circle around i, a circle whose radius is defined as the Euclidean distance d:

$$c_{ij} = \begin{cases} 1 & \text{if } hypot(i,j) \leq d, \; i \neq j \\ 0 & \text{otherwise} \end{cases} \tag{A.42}$$

$$hypot(i,j) = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}, \tag{A.43}$$

being (x, y) the cartographic coordinates of the spatial unit.

d) Inverse distance: following this criterion, the intensity of the relationship between i and j is inversely proportional to the distance between them (d_{ij}):

$$c_{ij} = 1/d_{ij}. \tag{A.44}$$

The weights matrices used in the present thesis have been standardised, that is, its elements have been standardised so that each row sums up to unity:

$$w_{ij} = \frac{c_{ij}}{\sum_{i=1}^{N} c_{ij}}. \tag{A.45}$$

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A.3.2 Moran's I Statistic

Moran's I is a measure of spatial autocorrelation due to MORAN (1948, 1950), which measures to what extent a variable is correlated in space. Let x_i be the variable of interest, for $i = 1, \ldots, N$. The neighbourhood between ith and jth element is given by the scalar w_{ij}, which is included in the weights matrix W. Then, Moran's I statistic is defined as

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}. \tag{A.46}$$

where $\bar{x} = \sum_i x_i / N$.

The expected value of Moran's I is

$$E(I) = \frac{-1}{N-1}, \tag{A.47}$$

and the variance takes the form

$$Var(I) = \frac{NS_4 - S_3 S_5}{(N-1)(N-2)(N-3)(\sum_i \sum_j w_{ij})^2}, \tag{A.48}$$

where

$$S_1 = \frac{1}{2} \sum_i \sum_j (w_{ij} + w_{ji})^2$$

$$S_2 = \frac{\sum_i (\sum_j w_{ij} + \sum_j w_{ji})^2}{1}$$

$$S_3 = \frac{N^{-1} \sum_i (x_i - \bar{x})^4}{(N^{-1} \sum_i (x_i - \bar{x})^2)^2}$$

$$S_4 = \frac{(N_2 - 3N + 3)S_1 - NS_2 + 3(\sum_i \sum_j w_{ij})^2}{1}$$

$$S_5 = S_1 - 2NS_1 = \frac{6(\sum_i \sum_j w_{ij})^2}{1}.$$

Positive values of the statistic mean positive spatial correlation, whereas negative values mean the opposite.

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A.4 Sectoral Adjustment of the Rate of Entry

In order to eliminate the effect of industry structure in a region on start-up activity, a shift-share structure procedure proposed by AUDRETSCH AND FRITSCH (2002) can be applied. Let i denote region and j denote sector. Moreover, assuming that E stands for entries and N stands for establishments, the *hypothetical number of establishments (HNN)* for each pairing of region and sector can be calculated as

$$HNN_{ij} = N_i S_j, \tag{A.49}$$

where $N_i = \sum_j N_{ij}$ and $S_j = N_j/N = \left(\sum_i N_{ij}/\sum_{ij} N_{ij}\right)$. Then, the *hypothetical number of entries (HNE)* per region can be calculated by multiplying HNN_{ij} with the entry rate GRE, i.e.

$$HNE_i = \sum_j HNN_{ij} GRE_j, \tag{A.50}$$

where $GRE_j = E_j/N_j = \sum_i E_{ij}/\sum_i N_{ij}$. The measure HNE is not influenced by deviations of the regional sectoral structure from the national average and other region-specific factors. Then, in order to estimate the impact of a deviation of a region's sectoral structure on the number of entries, the following operation is calculated:

$$HIE_i = \sum_j (N_{ij} - HNN_{ij}) GRE_j. \tag{A.51}$$

The resulting number is the hypothetical number of entries induced by differences between the industry structure of the respective region and the national average. Finally, the sector-adjusted number of entries (E_i^*) can be obtained by substracting this number from the observed number of entries, i.e.

$$E_i^* = E_i - HIE_i. \tag{A.52}$$

The resulting number is assumed to be independent of diverging sectoral structures in the regions.

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