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INDUSTRIAL LOCATION AT THE INTRA-METROPOLITAN LEVEL: THE ROLE OF AGGLOMERATION ECONOMIES

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CENTRE DE RECERCA EN FEDERALISME FISCAL I ECONOMIA REGIONAL

INDUSTRIAL LOCATION AT THE INTRA-METROPOLITAN LEVEL: THE ROLE OF AGGLOMERATION ECONOMIES[a,b]

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ABSTRACT: The objective of this paper is to analyse the influence of agglomeration economies on location decisions taken by new firms inside metropolitan areas. As we assume that these economies differ according to firms' level of technology, our sample comprises new firms from high, intermediate and low technology industries. We are particularly interested in analysing the effects of agglomeration economies that are felt over very short distances (inside the metropolitan areas. We introduce in our estimation the effect of the central city as a determinant for the location of new firms in the rest of the metropolitan area.

Keywords: Industrial location, cities, metropolitan areas, agglomeration economies.
JEL codes: L60, R12, R30.

RESUMEN: El objetivo del trabajo es analizar la influencia de las economías de aglomeración en las decisiones de localización de las nuevas empresas dentro de las áreas metropolitanas. Dado que se asume que estas economías difieren en función del nivel tecnológico de cada empresa, se clasifican las nuevas empresas en tecnología avanzada, intermedia y tradicional. El interés se centra particularmente en analizar los efectos de las economías de aglomeración que tienen lugar en distancias muy cortas (dentro de las áreas metropolitanas). En la estimación se introduce el efecto de la ciudad central del área metropolitana como determinante de la localización de las nuevas empresas en el resto del área metropolitana.

Palabras clave: Localización industrial, ciudades, áreas metropolitanas, economías de aglomeración.
Clasificación JEL: L60, R12, R30.

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1. Introduction

The geographical concentration of production and employment is an established fact, both in the United States and in the European Union. Spain is no exception: at the end of the nineties the three biggest provinces[1] accounted for 37% of total employment and for 41% of industrial employment (VILADECANS, 2004). When the analysis is carried out for a single manufacturing sector, this unequal geographical distribution becomes even greater: in the case of the Paper and the Chemical Products industries these employment percentages rise to 57% and 55% respectively. The entry of new firms also shows high geographical concentration since, between 1992 and 1996, 44% of new industrial firms were located in the 13 biggest Spanish metropolitan areas[2]. The geographic concentration of an economic activity can be analysed with various indexes and methodologies. In the case of Spain, a number of articles have analysed the concentration of its manufacturing activities using different databases and methodologies (see, for example, ALONSO et al. 2004 and PALUZIE et al. 2004). Both these analyses conclude that the level of concentration is very high and that this level differs considerably between industries.

The economic literature identifies several factors that may contribute to an explanation of the localization patterns of new manufacturing activities: input costs, availability of raw materials, infrastructure stock, local tax level, and the incentives offered by industrial and regional policies, and even, for some activities, the weather. Though many factors influence different aspects of the location decision of industrial firms, in this paper we will concentrate on the influence of agglomeration economies. There is a substantial body of empirical literature on the nature and the extent of agglomeration economies (see ROSENTHAL and STRANGE, 2004, for a survey). Most papers analyse the effects of agglomeration economies at the regional or metropolitan level. The reason for this approach is probably data availability, but it entails several methodological problems. These problems can be mitigated by focusing on intra-metropolitan location, assuming that some of the factors that influence the location of new firms are common to all the alternative locations inside a given metropolitan area. Another reason for the interest in the intra-metropolitan location patterns is the need to establish whether higher production costs in central cities produce dispersion in the location of new industrial firms towards the periphery of the metropolitan areas or, alternatively, whether the economic

[1] In Spain, the smallest political and administrative units are the cities, understood as municipalities. There are more than 9,000 municipalities of very differing sizes. The next level up in political terms is that of the provinces (of which there are 50 in the Spanish case) and this level is equivalent to the NUTS III.

[2] In section 3.1 we provide a detailed description of the characteristics of the Spanish metropolitan areas used in this paper.

environment of the central city, including the costs, can still attract certain specific firms. So it is also worth analysing the location of new firms for a variety of industries, in order to test for differences in suburbanization patterns. In fact, one of the main contributions of our analysis is not that we are analysing why a metropolitan area with more agglomeration economies receives more new firms than another with fewer such economies, but rather what actually happens inside each metropolitan area. Empirically, our methodology involves the introduction of dummies for each metropolitan area, which allows us to control for all the common factors inside the area, some of which are not easily measured.

This paper follows the line of research into the location of new firms in Spanish cities started in ARAUZO (2005), ARAUZO and MANJÓN (2004) and COSTA *et al.* (2004), but focuses above all on the location patterns of new manufacturing firms inside the 13 biggest Spanish metropolitan areas. This approach represents an improvement, because we study the micro-empirics of agglomeration economies at this geographical level. We also aim to establish whether the location of new manufacturing firms has undergone a process of suburbanisation and whether these new firms locate in the surrounding areas of big cities or, alternatively, whether they locate near the centre. In fact, our hypothesis is that by the mid-eighties some new firms had started to operate in the suburbs of big cities but, without exception, still within the metropolitan areas. So what we see is that these firms enjoy the advantages of proximity to the big city, especially communication infrastructures, and also pay less than before. For the empirical analysis we use a database of the new firms in six different manufacturing activities in the 13 biggest Spanish metropolitan areas for the period 1992-1996.

The paper is organised as follows: in the second section we present an overview of the influence of agglomeration economies on firm location at the intra-metropolitan level and introduce the process of suburbanisation and the role of the central city as a possible new tendency in the intra-metropolitan location of these activities. In the third section we present our empirical analysis, first describing the database, then discussing the evidence for the location of these firms and finally performing the econometric specification. The fourth section presents the results, and the fifth section concludes.

2. An overview of the literature

2.1. Agglomeration economies and the creation of new firms

The empirical literature that analyses the influence of agglomeration economies on industrial activity already has a long tradition. Several approaches have been applied to analyse the effect of these economies on the behaviour of firms. ROSENTHAL and STRANGE (2004) classify agglomeration economies in three groups, depending on their scope: industrial, geographic and temporal. Apart from these three different but complementary approaches, in the empirical analysis, there are different ways to test the influence of agglomeration economies on firms' behaviour: the effect on their productivity, on their employment growth, and on their wages (see ROSENTHAL and STRANGE, 2003, WHEATON and LEWIS, 2002 and the seminal works of GLAESER *et al.*, 1992 and HENDERSON *et al.* 1995, as good examples of these different approaches). Finally, some empirical studies have analysed the influence of agglomeration economies on the location of employment or firms, in general, and on the location of new plants in particular. This latter approach is the one in which we are interested for our analysis. FIGUEIREDO *et al.* (2002), GUIMARÃES *et al.* (2004 and 2000), HOLL (2004a and 2004b) and ROSENTHAL and STRANGE (2003 and 2004) are good examples of analyses of the location of new firms, and COUGHLIN and SEGEV (2000), LIST (2001), and WOODWARD (1992) are good examples of analyses of location determinants of multinational firms. We should stress that in most of the references we mention, the empirical analysis has been performed with microdata (new firms locating in different geographical areas). This is a considerable advantage with regard to an aggregated analysis (one that uses the whole employment of an area, for example) because when we use individual data the problem of the endogenous agglomeration economy variables disappears. Though the empirical analyses in these papers are applied to different countries and use different databases, most of them analyse the location of firms at the local level and introduce as explanatory variables the characteristics of the economic environment used as proxies of agglomeration economies. They conclude that, to different degrees, these variables have a clear implication in the geographical distribution of new industrial activities. In the Spanish case, some recent papers have also analysed the determinants of new firm location at the local level: ALAÑÓN *et al.* (2007), ARAUZO (2005 and 2007), ARAUZO and MANJÓN (2004), COSTA *et al.* (2004) and HOLL (2004a). All these papers have in common their use of local data, Spanish municipalities, and the use of the economic environment of the firm as an explanatory variable, in some cases specifically called "agglomeration economies".

2.2. Agglomeration economies and the intra-metropolitan location of firms

Most papers analyse the effect of agglomeration economies on firm location at the regional or metropolitan level. The reason for this approach is probably data availability, but this approach entails several problems. First, with the exception of some countries like the US, the number of regions or metropolitan areas tends to be quite small, which means that the geographical variation in locational factors may be also quite limited. And second, the pure effect of agglomeration economies may be difficult to identify in inter-metropolitan analyses because there are so many locational factors which may influence inter-metropolitan location (and are sometimes very difficult to quantify) and which may be correlated with agglomeration economies. This problem can be mitigated by focusing on intra-metropolitan location and assuming that some of these factors are common to all the alternative locations/municipalities inside a given metropolitan area.

There is a long tradition of analysing intra-metropolitan industrial location in the United States. The works of ERICKSON and WASYLENKO (1980), CARLINO and MILLS (1987), BOARNET (1994), DEITZ (1998), OUWERSLOOT and RIETVELD (2000) and ROSENTHAL and STRANGE (2005) are good examples. The last of these papers specifically analyses the influence of agglomeration economies at this geographical scale. More recently, and since more disaggregated data have become available, other papers have been published with the same objective but performing the empirical application in metropolitan areas in other countries (BAUDEWYNS (1999) in Belgium, WU (1999) in China, MAOH *et al.* (2005) in Canada and CHAKRAVORTY *et al.* (2005) in India or VAN SOEST *et al.* (2006) in Holland, for example). These papers, however, analyse the location of firms inside a single metropolitan area. The only paper analysing intra-metropolitan location with a database covering several metropolitan areas is ROSENTHAL and STRANGE (2003). With many different metropolitan areas to draw on, these authors are able to control for location factors in a specific metropolitan area by including fixed effects in the estimated equation.

It should be noted that the demographic and economic structure of a metropolitan area is not homogeneous. In fact, the analysis applied to the intra-metropolitan level normally separates the central city from the periphery (comprising the rest of the municipalities of the metropolitan area). This is another reason for the interest in intra-metropolitan location patterns: to establish whether higher production costs in central cities (due to land costs, wages, congestion, transport costs, among others) could produce dispersion or suburbanisation in the location of some new industrial firms towards the periphery of the metropolitan areas or, alternatively, whether the economic environment of the central cities can still attract specific activities.

Some authors believe that certain specific traits make the suburbanisation process less acute in Europe – especially in Spain – than in the US. This, however, is not strictly true because suburbanisation is an ongoing process in metropolitan areas in Spain: in terms of economic activity it started in the mid-eighties, just after the economic/industrial crisis, and in terms of population in the nineties. In fact, the intensity of urban sprawl has accelerated in the last two decades, possibly as a consequence of rising personal incomes and the changing economic structure. Therefore, although the starting points are different, the fundamental problems of metropolitan areas in the US, Europe and Spain in particular are similar. The analysis we perform here may also have interesting implications for scenarios outside Spain. In spite of this interest, few studies have analysed the interdependencies between central cities and their suburbs in the Spanish (or European) case (SOLÉ and VILADECANS, 2004, is one).

The empirical data show that traditionally the concentration of high-tech activities is higher in the centre of the metropolitan area. There is a high presence of well-qualified young people and more new high-tech firms are created than in the rest of the area (though the exit rate of these new firms is also high, ARAUZO, 2005). Central cities are suitable settings for the learning process of young people and also for the location of high technology firms. However, in recent years the increasing costs of congestion, the deterioration of the amenities and the soaring wage levels have led to a growing migration from the centres of the metropolitan areas towards the periphery. These sprawl movements affect not only the population but certain manufacturing firms and even some services activities as well (BODENMAN, 2000). The suburbanisation of traditional manufacturing activities, which use large surface areas, is a widely accepted process.

This paper seeks to go a step further and, in addition to the analysis of location patterns of new industrial firms at the intra-metropolitan level, analyses whether these firms tend to locate in the centre of the metropolitan area or on the periphery. We also wish to test whether the process of suburbanisation affects high-tech activities which make less use of land and have less need for inputs from big urban agglomerations. To this end we analyse the location of new firms in several industries in order to identify any differences in their location patterns.

3. The empirical analysis

3.1. The territorial unit of analysis

As explained above, the main objective of this paper is to analyse the location decisions of new firms at the intra-metropolitan level: that is to say, to use the municipalities belonging to each of the metropolitan areas as geographical units. In Spain there is no formal administrative record of metropolitan areas and the jurisdictions belonging to them. In spite of this constraint, we define the metropolitan areas of 13 big Spanish cities on the basis of economic and geographical criteria. These areas are chosen because they represent most of the bigger metropolitan agglomerations in Spain and, as we will see, most entries of new firms.

The metropolitan area considered for each city covers the land within a 35 kilometre radius of the centre. This geographical criterion is also used in the Spanish Ministry of Public Administrations' report on big cities and the areas of urban influence published in 2001. Due to limitations of the statistical sources, jurisdictions with less than 3,000 inhabitants are not considered. Finally, we obtain a database of 13 central cities (Alacant, Palma de Mallorca, Barcelona, Córdoba, Donostia, Madrid, Málaga, Murcia, Gijón, Sevilla, València, Bilbao and Zaragoza). Adding the jurisdictions that belong to their metropolitan areas, the sample comprises 330 municipalities. The number of municipalities in each metropolitan area varies, depending on the urban structure and, above all, on the size of the central city.

3.2. The database

Our main database is the REI (Spanish Industrial Establishments Register), which provides plant-level microdata on the location of new industrial establishments at a local level. The basic unit for the REI is a business establishment, a single physical location where industrial operations are performed. Specifically, we know the municipality where each new industrial establishment starts its activity, the year of opening, the sector and the number of employees. Our database covers the period from 1992 to 1996.

Our point of departure is the fact that location patterns differ across sectors, since different industries require specific characteristics to perform their manufacturing activities successfully. To simplify our analysis, we use the OECD classification (OECD, 2001) to divide manufacturing activities according to their technological intensity. We thus identify high, intermediate and low technology sectors, and selected six specific 2-digit sectors belonging to previous technology groups (see Table A.1 in the Appendix for a more detailed explanation): 1) High technology sector: R&D machinery; 2) Intermediate technology sectors: Machinery and equipment and Chemical products; and 3) Low technology sectors: Food and beverages, Textiles and Leather[3]. These activities present differing productive characteristics (i.e., level of productivity, degree of innovation, labor skills and presence of foreign investment), while their patterns of geographical distribution in the territory also differ. The first of these manufacturing sectors can be considered high-tech, the second and the third as representing a medium level of technology, while the remaining three are traditional manufacturing activities. It is interesting to determine whether the influence of agglomeration economies on the respective location patterns differs in line with their technological levels. Previous studies suggest that different types of agglomeration economies have different effects. For example, most of the evidence indicates that localization economies are more important for traditional activities, whereas urbanization economies have a more pronounced impact on high-tech activities.

During the period analysed (from 1992 to 1996) 5,569 new manufacturing establishments began their activity in the 13 metropolitan areas under consideration (see Table 1). Most of them belonged to low technology sectors (3,570), followed by intermediate sectors (1,549) and, at some distance, by high sectors (450). Most of the entering firms were small, as almost 83% of entrants had ten employees or fewer (see Table A.2, in the Appendix). It seems to exist a relation between firm size and technological level: the high technology entrants had a mean of 11.5 employees, compared with 8.0 for intermediate technology firms and 7.6 for low technology firms. This evidence is not exclusive to entrants, but in fact it reflects the size distribution of all Spanish manufacturing firms.

[3] We expected to obtain different location patterns according to the broad characteristics of each industrial sector (measured in terms of technological level), so it was not necessary to use data from all manufacturing activities.

Table 1. Location of new establishments inside metropolitan areas (1992-1996)								
	High		Intermediate		Low		Total	
Metropolitan Area	N	%	N	%	N	%	N	%
Alacant	17	2.43	71	10.16	611	87.41	699	100
Palma de Mallorca	23	12.64	34	18.68	125	68.68	182	100
Barcelona	96	7.72	462	37.14	686	55.14	1,244	100
Córdoba	4	5.26	29	38.16	43	56.58	76	100
Donostia	25	14.97	64	38.32	78	46.71	167	100
Madrid	148	11.15	289	21.78	890	67.07	1,327	100
Málaga	12	3.55	75	22.19	251	74.26	338	100
Múrcia	10	2.49	120	29.93	271	67.58	401	100
Gijón	21	8.02	55	20.99	186	70.99	262	100
Sevilla	23	6.78	121	35.69	195	57.52	339	100
València	21	9.50	115	52.04	85	38.46	221	100
Bilbao	13	11.61	41	36.61	58	51.79	112	100
Zaragoza	37	18.41	73	36.32	91	45.27	201	100
Metropolitan areas considered	450	8.1	1,549	27.8	3,570	64.1	5,569	100
Rest of municipalities in Spain	244	3.4	1,638	22.7	5,335	73.9	7,217	100
All municipalities in Spain	694	5.4	3,187	24.9	8,905	69.6	12,786	100
Source: our own calculations using data from the REI.								

Comparing the sectoral distribution of new firms in the municipalities of our 13 metropolitan areas with the rest of Spanish municipalities, our municipalities are specialised in high and intermediate technology sectors, while in the rest of municipalities low technological sectors predominate.

Before using econometric tools to analyse firms' location patterns, we will consider some descriptive statistics on the geographical location of these new establishments at the intra-metropolitan level. The mean distance of new entrants from the central city in their metropolitan area increases as the technological level of the firm decreases. On average, then, new R&D and machinery firms locate 8.75 km from the central city, new Machinery and equipment firms 10.64 km away, and new Chemical products firms 12.35 km away. In the low technology sectors, the distances were 11.64 km for new firms in Food and beverages, 19.82 km for Textiles, and 25.86 km for Leather. This evidence points to the fact that new high-tech manufacturing firms seem to prefer to locate their productive establishments close to the central city in their metropolitan area. This finding is in line with reports elsewhere that suggest that the central city has specific inputs related to the most advanced activities and which make them more attractive.

These location patterns can also be studied by establishing the distribution of new firms between the central city in the area and the periphery (i.e. the rest of municipalities in the metropolitan area). Our data (displayed in Table 2) show that new firms in high technology sectors are more concentrated in the central city of the metropolitan area (where 47.3% of new entrants locate), while new firms in intermediate and low technology sectors are more spread out: 68.1% of new entrants in intermediate technology sectors are in the periphery and 69.8% of new firms in low technology sectors.

Table 2. Distribution of new entrants between the central city and the periphery of each metropolitan area according to technological level (1992-1996)

Area	High	Intermediate	Low	Total
Central city (%)	47.3	31.9	30.2	32.1
Periphery (%)	52.7	68.1	69.8	67.9
Total (%)	100.0	100.0	100.0	100.0

Source: our own calculations with data from REI.

Table 2 shows that the higher the technological level of new entrants, the higher their concentration at the core of the metropolitan area. This specific location pattern emerges because high technology firms seem to require the kind of environment offered by central cities more than that offered by the periphery. On the basis of this, our hypothesis is that new firms in the most advanced manufacturing sectors will prefer to locate their activities in, or very close to, the city centre itself.

3.3. The econometric specification

When conducting location analyses, there are various methodological issues concerning the data that must be taken into consideration. One of these is the so-called "zero problem". Specifically, our data shows that of the 330 municipalities in the areas analysed, 321 were chosen as a site by one or more industrial establishments[4]. This means we are analysing location decisions that affect 97% of municipalities, but this situation changes when we shift our analysis and examine each industry separately. The situation in which a large number of territories (municipalities) receive no industrial establishments (zero entries) is reasonable if we are working at a very disaggregated geographical level like the municipality, or at a disaggregated industry level. Specifically, if we take into account the sectoral differences of those entrants, some specific patterns arise (see Table 3). While for high technological sectors only 33.9% of the municipalities received new firms, in Food products and beverages 73.9% of the municipalities were chosen by at least one firm. So, our industry-level data present the "zero problem".

[4] The nine municipalities that did not receive new industrial firms were: San Juan Bautista, Tiana, Cañete de las Torres, Espejo, Hoyo de Manzanares, Teverga, Gorliz, Lekeitio and Plentzia. These are small municipalities with a mean population of 3,759 inhabitants.

Table 3. Distribution of new entrants between municipalities that received at least one industrial establishment and the rest of municipalities according to technological level (1992-1996)

Municipalities	R&D machinery		Machinery and equipment		Chemical products		Food and beverages		Textiles		Leather	
	N	%	N	%	N	%	N	%	N	%	N	%
No entries[a]	218	66.1	143	43.3	185	56.1	86	26.1	238	72.1	260	78.8
One or more entries[a]	112	33.9	187	56.7	145	43.9	244	73.9	92	27.9	70	21.2
Municipalities	330		330		330		330		330		330	
Number of entries[b]	450	100.0	1.138	100.0	411	100.0	2.566	100.0	449	100.0	555	100.0

a Distribution of municipalities between those that received at least one industrial establishment and those that received none.
b Total number of entries of industrial establishments
Source: our own calculations, using data from the REI.

The Poisson model can deal with this "zero problem”. This count model[5] shows how many times each location (municipality) is chosen by an establishment. This implies that increasing alternative locations when we analyse the phenomenon at a local level does not constitute a major problem[6] as it does with other models like the conditional logit, for instance (in our case, highly disaggregated data means having more zeros). Hence, municipalities in which y=0 (i.e. municipalities where no establishment is located) are relevant because values of independent variables in these locations explain why they have not been chosen by new entrants[7].

Like many studies of industrial location (see ARAUZO, 2005; CIEŚLIK, 2005; ARAUZO and MANJÓN, 2004; HOLL, 2004a and 2004b; LIST, 2001; and WU, 1999), in this paper we model the number of new firm locations in each municipality (between 1992 and 1996) as a Poisson-distributed random variable in which the parameter λ_i is related to the regressors vector x_i that measures local characteristics. Specifically, we consider that the probability that a municipality will attract a firm depends on the specific attributes of the municipality (CIEŚLIK, 2005):

$$\Pr(y_i|x_i) = \frac{e^{-\lambda_i}\lambda^{y_i}}{y_i!}, \quad y_i = 0,1,2,...,n \tag{1}$$

[5] In those models the dependent variable is a count variable (here, the number of times that an industrial establishment locates in a municipality).

[6] Obviously, working at a local level involves more observations than at the regional or national levels. The “problem” is the inbuilt restrictions of the econometric software concerning the maximum number of alternatives that can be estimated using a conditional logit model. Therefore, having more observations constitutes a major “problem”.

[7] One problem with this argument is how to choose the samples. Because an undetermined number of firms were not able to locate, we did not count them. All of these are counted as zero.

where λ_i is dependent on the vector of explanatory variables (local characteristics):

$$\ln \lambda_i = \beta' x_i \tag{2}$$

and where β denotes a vector of coefficients of explanatory variables to be estimated. But the Poisson model assumes that conditional mean and variance functions equal λ_i:

$$E[y_i | x_i] = \mathrm{var}[y_i | x_i] = \lambda_i \tag{3}$$

There is a generalized version of the Poisson model (the Negative Binomial model) that introduces an individual unobserved effect into the conditional mean:

$$\ln \lambda_i = \beta' x_i + \varepsilon_i \tag{4}$$

where ε_i shows either a specification error or some cross-sectional heterogeneity with exp (ε_i) having a gamma distribution with mean 1.0 and variance α.

As mentioned, one of the advantages of Poisson models is that they deal with the "zero problem". However, in so doing they make two important assumptions that need to be taken into account. The first assumption is that the mean and the variance should be equal is often violated when Poisson models are used to model the industrial location phenomenon, given the concentration of industrial establishments in specific areas (this causes the variance to be greater than the mean, which is known as the "overdispersion problem"). This problem can be solved by using a negative binomial model, which allows the variance to exceed the mean. In the Negative Binomial model the variance equals:

$$\mathrm{var}[y_i | x_i] = E[y_i | x_i]\{1 + \alpha E[y_i | x_i]\} \tag{5}$$

If α is zero, then the conditional variance is equal to the conditional mean and the Poisson and Negative Binomial models are the same.

The second assumption is the excess zero problem, that is, the existence of a large number of observations that take the value zero: for the phenomenon of industrial location, this occurs in the municipalities where no industrial establishments are located. Poisson models can deal with the existence of some observations with value zero, but not with an excessive number[8]. This second problem can also be overcome by using a negative binomial model.

The descriptive statistics of the entrants (Table 4) display signs of overdispersion for all the industries considered (CAMERON and TRIVEDI, 1998), and there is also an important "zero problem" for all industries. These results point to the possibility of using other count data models that can deal with these technical shortcomings.

Table 4. Descriptive statistics about entrants

Areas	Mean	Standard deviation	Min.	Max.	% of zeros
R&D machinery	1.364	5.077	0	71	66.1
Machinery and equipment	3.449	8.141	0	71	43.3
Chemical products	1.245	2.642	0	25	56.1
Food and beverages	7.776	24.310	0	348	26.1
Textiles	1.361	6.706	0	99	72.1
Leather	1.682	12.299	0	206	78.8

Source: own elaboration.

Even though we assume that the Poisson model is not the count data model that fits our data best, we still estimated this model (Table 5) so as to perform a Poisson goodness-of-fit test[9]. Our results showed a large chi-square value which confirms that the Poisson model is not a good choice.

Given the results of the previous test, we decided to estimate a Negative Binomial Model (Table 6). Nevertheless, so as to confirm the validity of this decision, we performed another test in order to choose between the Poisson or Negative Binomial models. We refer to the likelihood ratio test of alpha=0, which is a test of the overdispersion of the alpha parameter[10].

[8] See CAMERON and TRIVEDI (1998) for a detailed discussion as to how zero observations contribute to the likelihood function.

[9] The goodness-of-fit test divides the range of the data into intervals. Then, the number of points within each interval is compared to the expected number of points for that interval according to the hypothesized distribution of the data (here the hypothesis should have a Poisson distribution). Here we have used the deviance statistic (see CAMERON and TRIVEDI, 1998).

[10] Alpha determines the degree of dispersion. Specifically, if alpha=0, the Negative Binomial distribution is equivalent to a Poisson distribution (and there is no overdispersion).

Our results showed alpha to be significantly different from zero, which reinforces our initial assumption that the Poisson model was not the best choice. Thus, we decided to use this subsequent estimation for our empirical results.

3.4. Empirical model and variables

Now that the econometric method and its specification seem clear, we need to find the variables of the vectors of locations attributes. These attributes that, according to the economic literature, theoretically affect firm location have been fully described. But, in the empirical approach, and especially working at local level, it is not easy to find variables to quantify all the factors; our approach, which involves analysing the effect of agglomeration economies on the creation of new firms inside metropolitan areas, solves this problem because we use dummy variables for each metropolitan area to control for all the aspects that affect firm location and that are common within each of the metropolitan areas. The independent variables we introduce in the estimation are those that we consider to be different for each of the municipalities in the metropolitan area. This approach is in line with recent studies that seek to analyse the effect of agglomeration economies over very short distances. ROSENTHAL and STRANGE (2003) refer to this approach as the microgeography of agglomeration. In our case, we are working within a very small geographical area, i.e. a metropolitan area.

As we stressed above, we aim to analyse the sectoral scope of agglomeration economies (urbanisation economies and location economies)[11] inside each of the metropolitan areas selected. For that reason we need to quantify the two types of agglomeration economies. Urbanisation economies can be measured with a range of variables that quantify the economic size of each municipality from different points of view. One very common option is to use the municipality's Population density. This variable is obtained from the Population Censuses compiled by the Spanish National Institute of Statistics. As AUDRETSCH and FRITSCH (2002, p. 120) note, "population density here represents all kinds of regional influences, such as availability of qualified labour, house prices, local demand and the level of knowledge spillovers. Including population density instead of indicators for these individual effects in the regression avoids the problem of multicollinearity caused by relatively high levels of correlation among these factors". For their part, location economies, which indicate the effect of a particular industrial sector's size in an area on the firms in that sector, can be measured by the

[11] Measuring urbanisation economies at a local level is very common in the empirical literature. See, among others, ARAUZO (2005), ARAUZO and MANJÓN (2004), BARRIOS *et al.* (2006), COUGHLIN and SEGEV (2000), DURANTON and PUGA (2000), FIGUEIREDO *et al.* (2002), GUIMARÃES *et al.* (2000) and VILADECANS (2004).

entries of firms of the same manufacturing sector in an earlier period, between 1980 and 1991 (REI database).

In this way we can proxy the dynamics of the productive structure. In order to analyse the suburbanisation process and the influence of the central city on new firms' location, we need a variable to measure the physical position of a city inside its metropolitan area. This variable is the distance of each municipality from the central city. To measure this distance, we use the radial distance from the geographical co-ordinates of each city obtained from the National Atlas of Spain (1994) (Spanish Ministry of Public Works, Transports and Environment).

Finally, we measure the stock of human capital available for firms, obtained from the Population Censuses compiled by the Spanish National Institute of Statistics. Here we choose two proxies of this variable: one is Human capital (university-level), which is the percentage of the population with a university degree, and the other is Human capital (intermediate-level), which is the percentage of the population who (at least) completed secondary school.

After selecting the variables, and in order to test how new manufacturing firms within the metropolitan areas have been attracted by their local characteristics, we estimated the following model of the number of new establishments opened in a municipality as a function of these specific local characteristics:

$$N_{jk} = \beta_1 DEN_j + \beta_2 PE_j + \beta_3 DIST_j + \beta_4 MED_j + \beta_5 UNI_j + \sum_k \beta_k MA_k \qquad (6)$$

where N_{jk} is the number of new plants[12] of a given industry that open in a municipality j in the metropolitan area k, DEN_j is population density in each municipality; PE_j is the previous entries for the same manufacturing sectors in each municipality; $DIST_j$ is the distance of each municipality from the central city in each metropolitan area; MED_j is the stock of intermediate-level human capital in each municipality; UNI_j is the stock of university-level human capital in each municipality and MA_k are the dummies for each metropolitan area.

4. Results

The results of the estimation of the model are presented in Table 6. As our aim was to identify the specific location patterns of industries with different technological levels, we performed

[12] N_{ij} is a count variable in which we have 0 and non negative values.

econometric regressions for each of the six industries previously selected. All the estimations have a good explanatory capacity and the likelihood ratio test of alpha, which indicates whether a Poisson or Negative Binomial estimation is more appropriate, favours the latter.

Table 5. Location determinants of new entries (1992-1996)[a]: Poisson Estimation

	High technology	Intermediate technology		Low technology		
Variables[b]	R&D machinery	Machinery and equipment	Chemical products	Food and beverages	Textiles	Leather
Population density[c] (DEN)	0.1017*** (0.0000)	0.0355*** (0.0000)	-0.0669*** (0.0000)	0.0708*** (0.0000)	0.0864*** (0.0000)	0.1603*** (0.0000)
Previous entries own sector (PE)	0.0063*** (0.0006)	0.0132*** (0.0007)	0.0502*** (0.0036)	0.0043*** (0.0001)	0.0230*** (0.0008)	0.0033*** (0.0001)
Distance from the central city (DIST)	-0.0515*** (0.0062)	-0.0296*** (0.0036)	-0.0219*** (0.0055)	-0.0296*** (0.0022)	-0.0052 (0.0050)	0.0193*** (0.0040)
Human Capital (intermediate-level) (MED)	0.0806*** (0.0145)	0.0882*** (0.0083)	0.0783*** (0.0125)	0.0660*** (0.0047)	0.0786*** (0.0180)	-0.0284* (0.0163)
Human Capital (university-level) (UNI)	0.0139 (0.0139)	-0.0647*** (0.0117)	-0.0632*** (0.0174)	0.0065 (0.0060)	-0.0338* (0.0198)	0.0524*** (0.0189)
Constant	-2.5500*** (0.5592)	-1.2494*** (0.3120)	-1.9048*** (0.4786)	-0.5683*** (0.1826)	-2.9996*** (0.6527)	-1.4097** (0.6276)
N	330	330	330	330	330	330
Pseudo R^2	0.5490	0.4970	0.3930	0.6803	0.6859	0.7185
LR chi2(17)	1090.43	1754.54	557.13	5435.03	1619.85	2601.03
Log-likelihood	-447.88529	-888.02153	-430.30704	-1276.8133	-370.94981	-509.47695
Goodness-of-fit chi2	589.0369	1205.198	483.4489	1739.126	493.0472	825.5188
Prob>chi2(312)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(***) Significance at 1%, (**) significance at 5% and (*) significance at 10%. Standard error in brackets.
[a] Dependent variable is the count of new plants.
[b] Metropolitan areas dummies are available upon request.
[c] Coefficients of the population density variable have been multiplied by 1,000.

Our results (see Table 6) show that there are certain specific industry location patterns that can be analysed according to specific industrial characteristics and territorial requirements. First, the result for the variable used in quantifying the effect of urbanisation economies on the location of new firms (Population density) is mixed, since it has a positive influence on new entries for firms belonging to low and high technology groups, but has no impact on intermediate technology firms. The empirical results of other authors present a great dispersion of the population density with regard to the entry of new firms: a mainly positive effect (LIST, 2001; WOODWARD, 1992; GUIMARÃES *et al.*, 2000), a mainly negative effect (ARAUZO and MANJÓN, 2004; GUIMARÃES *et al.*, 2004; FIGUEIREDO *et al.*, 2002) and a mixed effect

(ARAUZO, 2005; COSTA *et al*., 2004; COUGHLIN and SEGEV, 2000). In the literature, this variable has been used as proxy for urbanisation economies and for land costs (COUGHLIN and SEGEV, 2000). If we proxy urbanisation economies we would expect a positive relationship between them and the location of new firms (given that entrants will be positively affected by the existence of urbanisation economies) and if we proxy land costs we would expect a negative relationship (given that entrants will avoid locating in costly areas)[13]. Though the effect on low technology and high technology industries is the same, the reasons for this might differ in these industries: high tech firms need an innovative environment, which is usually found in more densely populated cities, whereas low tech firms are labour-intensive and need to be located in more densely populated cities where larger amounts of labour are available.

Second, the effect of the variable which is a proxy of the effect of location economies (Previous entries: PE) is positive and significant for all industries. This evidence is very common in this type of analysis (see ROSENTHAL and STRANGE, 2003, and COSTA *et al.*, 2004). Except for the Leather and Food and beverages industries, the smallest coefficient is obtained by R&D Machinery, the most high tech activity of those analysed here. This result is not at all surprising since earlier studies of agglomeration economies point out that location economies are less intense in more urban areas (big cities) where the urbanisation economies, tend to be stronger because of their more diversified productive structure.

[13] See ARAUZO (2005) for a more detailed analysis.

Table 6. Location determinants of new entries (1992-1996)[a]: Negative Binomial Estimation

	High technology	Intermediate technology		Low technology		
Variables[b]	R&D machinery	Machinery and equipment	Chemical products	Food and beverages	Textiles	Leather
Population density[c] (DEN)	0.0709* (0.0000)	0.0085 (0.0000)	0.0416 (0.0000)	0.0543** (0.0000)	0.0747* (0.0000)	0.1171* (0.0001)
Previous entries own sector (PE)	0.0268** (0.0115)	0.0458*** (0.0056)	0.0867*** (0.0104)	0.0143*** (0.0020)	0.0459*** (0.0096)	0.0268*** (0.0084)
Distance from the central city (DIST)	-0.0309*** (0.0101)	-0.0188*** (0.0065)	-0.0179** (0.0076)	-0.0137*** (0.0046)	-0.0092 (0.0085)	0.0019 (0.0118)
Human Capital (intermediate-level) (MED)	0.0922*** (0.0324)	0.0869*** (0.0221)	0.0767*** (0.0214)	0.0579*** (0.0158)	0.1216*** (0.0368)	0.0261 (0.0501)
Human Capital (university-level) (UNI)	-0.0199 (0.0352)	-0.0882*** (0.0259)	-0.0466* (0.0253)	-0.0085 (0.0171)	-0.0922** (0.0452)	0.0503 (0.0558)
Constant	-3.2433*** (1.1649)	-1.5845** (0.7785)	-2.0896*** (0.7636)	-0.7581 (0.5675)	-4.3048*** (1.2700)	-3.1936* (1.8279)
N	330	330	330	330	330	330
Pseudo R^2	0.1671	0.1735	0.2127	0.1952	0.2290	0.1898
LR chi2 (17)	148.94	245.67	206.36	368.01	179.64	127.33
Log-likelihood	-371.10566	-528.27014	-381.93651	-758.76462	-302.33949	-271.75077
Ln alpha	0.3924 (0.1909)	-0.0963 (0.1346)	-0.6621 (0.2217)	-0.4873 (0.1210)	0.4481 (0.2064)	1.1781 (0.1981)
alpha	1.4805 (0.2826)	0.9082 (0.1222)	0.5158 (0.1144)	0.6143 (0.0743)	1.5653 (0.3230)	3.2481 (0.6434)
Likelihood ratio test of alpha=0	Chibar2(01)=153.56 Prob>=chibar2=0.000	Chibar2(01)=605.50 Prob>=chibar2=0.000	Chibar2(01)=96.74 Prob>=chibar2=0.000	Chibar2(01)=1036.10 Prob>=chibar2=0.000	Chibar2(01)=137.22 Prob>=chibar2=0.000	Chibar2(01)=475.45 Prob>=chibar2=0.000

(***) Significance at 1%, (**) significance at 5% and (*) significance at 10%. Standard error in brackets.
[a] Dependent variable is the count of new plants.
[b] Metropolitan areas dummies are available upon request.
[c] Coefficients of the population density variable have been multiplied by 1,000.

Third, the results of the Distance from the central city variable are negative, as we expected, and significant for all high and intermediate technology sectors (R&D Machinery, Machinery and equipment and Chemical products) and for one of the low technology industries (Food and beverages). It should also be noted that the higher the technological level of the industry, the higher the negative coefficient of the distance variable was found to be. This means that the most advanced activities prefer to locate their establishments within, or as close as possible to, the central city itself. Thus, there is a more marked effect for the more highly skilled activities which need to maintain good accessibility to the centre of the metropolitan areas. These results suggest that, even though a suburbanisation process exists and some firms may indeed move away from the centre of the metropolitan areas, they prefer to locate their activity close to the central city because it allows them to maintain fluid communications with the centre and so benefit from the greater advantages of agglomeration.

Fourth, the results for Human capital variables show that firms need access to the areas inhabited by people with an intermediate educational level, because this workforce is necessary in all kinds of activity[14]. But if we look at more educated people (those with a university degree), some specific industry patterns emerge: a negative impact for almost all industries, which is significant for the intermediate technology industries and for one of the low technology industries (Textiles). In previous work (see ARAUZO, 2005, and ARAUZO and MANJÓN, 2004, for instance) we concluded that firms prefer to avoid higher wages and that wages are higher where the population is more skilled. We should stress that human capital data refer to the municipalities in which these individuals live, and not to the municipalities in which they work. Thus, we must take into account the commuting pattern of individuals (even if it is not possible to include this factor in the econometric analysis). Here, it has been demonstrated that, in the Spanish case (CASADO, 2000), individuals with highly qualified occupations commute more. In line with this empirical evidence, we can assume that there is a spatial mismatch between the municipalities in which people live and those in which people work, and that this mismatch is greater for more highly qualified individuals. Additionally, we can also assume that these skilled workers (those holding a university degree) prefer a better environment (residential amenities), do not work in the same municipality as the one in which they live, and work (predominantly) in the high technology sectors. Therefore, it would be logical to find that the location of skilled workers has no influence on the location of high technology firms.

5. Conclusions

The objective of this paper was to analyse the influence of agglomeration economies on the location of new firms within the largest metropolitan areas of Spain, drawing on data for manufacturing firms for the period 1992-1996. In line with recent research and the latest empirical findings, the model incorporates two types of agglomeration economies: urbanisation economies (the influence of the area's economic activity) and localisation economies (the effects of specialisation in one sector on an area as a determining factor in the location of firms belonging to that sector). Some recent empirical analyses assume that the influence of these economies differs according to the industry being analysed. For this reason, we reproduce the analysis for six manufacturing industries that present different productive characteristics (i.e., level of productivity, degree of innovation, labour skills and presence of foreign investment) and different patterns of geographical distribution in the territory. Of these six, one can be

[14] Nevertheless, empirical work about the incidence of the qualifications of the labour force usually shows ambiguous results. For example, HOLL (2004b) finds both a (mainly) positive and a negative effect on firm location depending on the industry analysed.

considered a high-tech industry, two represent a medium level of technology, while the remaining three are traditional manufacturing activities.

We believe that one of the main contributions of this paper is the fact that the empirical analysis is undertaken at the intra-metropolitan level. This approach is in line with recent developments that suggest that what occurs over very short distances, i.e., between the municipalities of a metropolitan area, provides the key to understanding the impact of agglomeration economies. This approach has a further methodological advantage because it allows us to control for aspects that influence firm location and which are also common to all the municipalities belonging to the same metropolitan area. For this reason, we introduce a dummy for each of the metropolitan areas included in the econometric analysis.

Additionally, an analysis of intra-metropolitan location allows us to determine whether higher production costs in central cities lead to new industrial firms taking up dispersed locations in the periphery of metropolitan areas or, alternatively, whether the economic environment of the central city, even those that generate high costs, can still attract certain specific firms. Thus, it is also worth analysing the location of new firms operating in the six chosen sectors in order to test for differences in suburbanization patterns.

In line with recently reported evidence in the literature, our results indicate that agglomeration economies are an important factor in determining the location of new manufacturing firms. The location of newly established firms in most of the industries analysed was influenced to some extent by the productive environment. However, the influence of agglomeration economies on the location of new firms clearly differed according to the type of industry. First, our findings concerning the effect of urbanisation economies on the location of new firms are mixed, since this variable had a positive influence on new entries for firms belonging to the low and high technology groups, but was found to have no impact on intermediate technology firms. Second, in the case of localization economies, our results indicated that this variable had a positive and significant impact on all the industries analysed. This suggests that the specialisation of a municipality in a particular industry will always attract new firms in this sector. Third, the results we obtained for the distance from the central city variable were, as expected, negative and significant for all high and intermediate technology sectors and for one of the low technology industries. Interestingly, the higher the technological level of the industry became, the higher was the negative coefficient of the distance variable that we recorded. In line with our initial hypothesis, this means that the most advanced activities prefer to locate their establishments within, or as close as possible to, the central city itself. These results suggest that, even though a suburbanisation process exists and some firms may indeed move away from the centre of the metropolitan areas, they still prefer to locate their activity close to the central city because this allows them to maintain fluid communications with the central city and so benefit from the greater advantages of agglomeration. In terms of policy measures, and given these differences in the location patterns within the manufacturing industries, efforts to attract new firms should take into account the characteristics of the municipalities. The first step in any policy design process should clearly be the identification of industries that are likely to choose a specific area and subsequent promotional efforts should focus on the industries identified in this first stage.

Appendix

Table A.1
Classification of the manufacturing activities

CNAE	Technological level	Description
30, 32, 33	High	Manufacturing of office machinery and computers (30); Manufacturing of radio, television and communication equipment and apparatus (32); Manufacturing of medical, precision and optical instruments, watches and clocks (33)
29	Intermediate	Manufacturing of machinery and equipment n.e.c.
24	Intermediate	Manufacturing of chemicals and chemical products
15	Low	Manufacturing of food products and beverages
17	Low	Manufacturing of textiles
19	Low	Tanning and dressing of leather

Source: our own data.

Table A.2
Size characteristics of new entries (1992-1996)

Variable	R&D machinery	Machinery and equipment	Chemical products	Food and beverages	Textiles	Leather	TOTAL
Entrants < 10 L	335	940	333	2,308	361	327	4,604
Entrants 10-50 L	102	186	70	226	86	225	895
Entrants > 50 L	13	12	8	32	2	3	70
Total entrants	450	1,138	411	2,566	449	555	5,569
Mean size of entrants	11.5	7.2	10.0	7.1	6.8	10.5	8.0

	High technology	Intermediate technology	Low technology	TOTAL
Entrants < 10 L	335	1,273	2,996	4,604
Entrants 10-50 L	102	256	537	895
Entrants > 50 L	13	20	37	70
Total entrants	450	1,549	3,570	5,569
Mean size of entrants	11.5	8.0	7.6	8.0

Source: our own calculations, using data from the REI

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