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Industrial Location at the Intra-metropolitan Level: A Negative Binomial Approach

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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. Following the literature, we consider that agglomeration economies are related to the concentration of an industry (location economies) and/or to the size of the city itself (urbanisation economies). 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. Our results confirm these sectoral differences and show some interesting location patterns for manufacturing firms. Taking into account the renewed interest in the influence of geography and distance in the location of economic activity, we introduce in our estimation the effect of the area's central city as a determinant for the location of new firms in the rest of the metropolitan area. This allows us to determine whether a suburbanisation effect exists and whether this effect remains the same regardless of the industry involved. Our main statistical source is the REI (Spanish Industrial Establishments Register), which provides plant-level microdata for the creation and location of new industrial firms.

Keywords: industrial location, cities, metropolitan areas, agglomeration economies

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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 first three biggest provinces accounted for 37% of total employment and for 41% of industrial employment (Arauzo and Viladecans, 2004 and Viladecans, 2005). 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 the percentages rise to 57% and 55% respectively. The entry of new firms also shows high geographical concentration since, between 1993 and 1996, 44% of new industrial firms were located in the 13 biggest Spanish metropolitan areas.

The economic literature identifies several factors that may contribute to explain the location patterns of new manufacturing activities: the cost of productive factors, the availability of raw materials, the existence of infrastructures, local tax level, 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 on this decision. There is a substantial body of empirical literature on the nature and the extent of agglomeration economies (see Rosenthal and Strange (2003) 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 also 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 a dispersion in the location of new industrial firms towards the periphery of the metropolitan areas. So it is also worth analysing the location of new firms for a variety of industries, in order to test for differences in suburbanisation patterns.

This paper follows the line of research into the location of new firms in Spanish cities started in Costa et al (2004), but focuses specifically 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 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 they locate near the centre. In fact, our hypothesis is that in the recent years some new firms have started to operate in the suburbs of big cities but, in all cases, inside the metropolitan areas. So what we see is that these firms enjoy the advantages of proximity to the big city, especially communications 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 and introduce the process of suburbanisation as a possible new tendency in the intra-metropolitan location of these activities. In the third section we present the 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, which 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. It should be possible that empirical applications may apply one or more of these three approaches at the same time.

First, the industrial scope refers to the degree to which agglomeration economies extend across industries. There are two possibilities: first, when agglomeration economies are related to the concentration of a particular industry (location economies), and second when they are related to the economic size of the area where the firms are located (urbanisation economies). This is the approach for which there is most empirical evidence. Second, the geographic scope takes into account the importance of distance in the influence of agglomeration economies on firms' behaviour. That is to say, empirical analyses that use this approach try to determine whether the effect of these economies attenuates with distance from the area where the agglomeration is stronger (that is, the central city). Recently, a growing number of papers have analysed this geographic scope. Finally, the empirical analyses that study the temporal dimension of agglomeration economies assess whether the scope of these economies is static or dynamic. In this paper we analyse the sectoral scope of agglomeration economies at the intra-metropolitan level.

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, their employment growth, and their wages. 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. Figueiredo et al (2002a and b), Guimarães et al (2000), Holl (2004a and b) 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. 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 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 local level: Alañón and Myro (2005), Alañón et al (2005), Arauzo (2005 and 2006), Arauzo and Manjón (2004), Costa et al (2004), Holl (2004a) and Viladecans and Jofre (2006). All these papers have in common the 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 of the 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 it also 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 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, 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 locational factors in specific areas 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 new industrial firms towards the periphery of the metropolitan areas.

Some authors, however, believe that certain specific traits make the suburbanisation process less acute in Europe – especially in Spain – than in the US. For example, 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 than in the rural regions. There is a high presence of well-qualified young people and more new firms are created than in the rest of the area (though the exit rate of these new firms is also high, Arauzo, 2005). Big cities are suitable settings for the learning process of young people and also for the foundation of high technology firms. However, in recent years the increasing costs of congestion, the deterioration of the amenities and the soaring wage levels has led to a growing migration from the centres of the

metropolitan areas towards the periphery. These sprawl movements affect not only the population but 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 tries 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 mean to test whether the process of suburbanisation also affects high-tech activities which make less use of land and have less need for inputs from big urban agglomerations. To this end we will analyse the location of new firms in several industries in order to identify any differences in the suburbanisation patterns.

3. The empirical analysis

3.1 The territorial unit of analysis

As explained in the paragraphs above, the main objective of this paper is to analyse the location decisions of new firms at 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-San Sebastián, Madrid, Málaga, Murcia, Gijón, Sevilla, Valencia, 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 level¹. 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

¹ See Mompó and Monfort (1989) for further information about the REI.

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.

During the period analysed (from 1992 to 1996) 5,569 new manufacturing establishments began their activity in the 13 metropolitan areas under consideration. 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.

Table 1: Location of new establishments inside metropolitan areas (1992-1996)

Metropolitan Area	High		Intermediate		Low		Total	
	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-San Sebastián	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. This suggests that the higher the technology level of the new firm, the higher the preference for location inside one of the 13 biggest Spanish metropolitan areas.

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. Table 2 shows that the mean distance of new entrants from the central city in their metropolitan area increases as the technological level of the firm decreases.

Table 2
Mean distance (km) of new entrants from the central city of each metropolitan area (1992-1996)

	R&D machinery	Machinery and equipment	Chemical products	Food and beverages	Textiles	Leather
Mean distance	8.75	10.64	12.35	11.64	19.82	25.86

Source: our own calculations, using data from the REI.

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.

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 3) 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 3
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.

Like Table 2, Table 3 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 and not by the periphery.

3.3 The econometric specification

Following the Bartik (1985) approach, we analyse the location decision as a random profit maximisation process. Hence, when a firm i locates at city j , it reaches a profit level π_{ij} , which includes a deterministic term (βX_j) and a stochastic term (ε_{ij}). Formally:

$$\pi_{ij} = \beta X_j + \varepsilon_{ij} \quad (1)$$

Where X_j are locational attributes of the city j and ε_{ij} is an error drawing (specifically, ε_{ij} are some unobservable factors). In this model, firm i will choose location j if:

$$\pi_{ij} > \pi_{ik}, \quad \forall k, k \neq j \quad (2)$$

That is, firm i will choose the location in which profits are maximum or, in other words, in which the location has the greatest utility for the firm. This approach is usually modelled by using a discrete choice analysis framework. Among those models, McFadden's conditional logit model (1974) is the most commonly used. In this model, the probability that an

establishment will choose a location depends on the characteristics of the site and on a stochastic component. But the McFadden model involves a restrictive axiom (the “independence of irrelevant alternatives”: IIA) which means that the relative odds of choosing between two alternatives remain unchanged when there is a variation in the characteristics of a third alternative. Usually researchers introduce dummy variables in order to absorb the correlation between alternatives, but there are other estimation methods that can deal with this problem, such as Poisson models or Negative Binomial models.

Table 4
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	1000	1.138	1000	411	1000	2.566	1000	449	1000	555	1000

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.

Of the 330 municipalities in the areas analysed, 321 were chosen as a site by one or more industrial establishments³. This means we are analysing location decisions that affect 97% of municipalities. The situation in which a large number of territories (municipalities) receive no industrial establishments 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 4).

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

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.

The possible bias caused by ignoring the municipalities that received no industrial establishment during the period analysed disappears partially when we use a Poisson model. This count model⁴ shows how many times each location (municipality) is chosen by an establishment. The number of alternatives in a conditional logit model equals the number of observations in a Poisson model. This implies that increasing alternative locations when we analyse the phenomenon at a local level is not a major problem⁵. Another advantage of Poisson models over conditional logit models is that nil observations do not imply modelling problems. 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 entrants⁶.

Like many recent studies of industrial location (see Arauzo, 2005, Arauzo and Manjón, 2004, Guimarães et al, 2000, Papke, 1991 and Wu, 1999), in this paper we model the number of new firm locations in each municipality as a Poisson-distributed random variable. Specifically, we consider that the probability that a municipality will attract a firm depends on the specific attributes of the site (municipality):

$$\text{Prob}(y_i) = f(x_i) \quad (3)$$

⁴ In those models the dependent variable is a count variable (here, the number of times that an industrial establishment locates in a municipality).

⁵ Obviously, working at a local level involves more observations than at regional or national level.

⁶ 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 y_i denotes the number of new industrial establishments created in site (municipality) i between 1992 and 1996, and x_i denotes municipality attributes that affect profit functions of firms and act as a location determinant.

As we know (Greene, 1998), each Y_i is a random variable with Poisson distribution and with λ_i parameter (related to regressors x_i):

$$\text{Prob}(Y = y_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!} \quad y_i = 0, 1, 2, \dots \quad (4)$$

in which the most common representation of λ_i is:

$$\ln \lambda_i = \beta' x_i \quad (5)$$

where β is the parameter vector to be estimated and x_i is a vector municipality with attributes that affect profit functions of firms.

The main advantage of Poisson models is that they deal with the “zero” problem. However, they make two important assumptions that need to be taken into account. The first is that the mean and the variance should be equal, but this restriction is often violated when they 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. The probability distribution of the negative binomial model is:

$$\text{Prob}(Y = y_i | u) = \frac{\exp(-\lambda_i \exp(u_i)) \lambda_i^{y_i}}{y_i!} \quad (6)$$

where $\exp(u)$ has a gamma distribution with mean 1 and variance α .

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.

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; indeed the empirical analysis is conditioned by the availability of information at the local level. Furthermore, these factors are closely related to each other and it is normally difficult to attribute an effect to one factor in particular: for example, it is not easy to separate the effect of agglomeration economies from that of human capital availability, or the cluster effect from that of the existence of a pole of providers located in the same area. So the empirical approach may face the problem of correlation between variables, which has to be corrected.

As we stressed above, we aim to analyse the sectoral scope of agglomeration economies (urbanisation economies and location economies) 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 Population⁷ or Population density. Both variables are 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". Another variable that measures the agglomeration economies in terms of the economic activity of each geographical area could be the area's market share (Annual Spanish Economic Report, Banesto-La Caixa, which provides information at the city level). This variable is calculated as a function of several economic activity indicators (e.g. number of phones, number of bank branches and number of commercial facilities). There is a high correlation between the GDP and the market share at regional level (0.99 every year) so we consider this variable to be a good proxy of the GDP of each municipality. 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 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

⁷ As a proxy of urbanisation economies we also estimated the model using the entries of all manufacturing firms during previous years. However, we believe that population provides a fuller reflection of the benefits obtained by the agents when they are pooled together in the same place.

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.

So, after the selection of variables, the negative binomial model described above is implemented here using a linear specification of the profit function. Hence, from equation (1) we have:

$$\pi_{ij} = \beta_1 DEN_j + \beta_2 POP_j + \beta_3 ECO_j + \beta_4 PE_j + \beta_5 DIST_j + \beta_6 HC - IL_j + \beta_7 HC - UL_j + \varepsilon_{ij} \quad (7)$$

where DEN_j is population density in each municipality; POP_j is population in each municipality; ECO_j is the economic activity 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; $HC-IL_j$ is the stock of intermediate-level human capital in each municipality; $HC-UL_j$ is the stock of university-level human capital in each municipality, and ε_i is an error term.

4. Results

The results of the estimation of the model are presented in Table 5. As our aim was to identify the specific location patterns of industries with different technological levels, we perform econometric regressions for each of the six industries previously selected for the municipalities in our 13 metropolitan areas. All the estimations have a good explanatory capacity and the goodness of fit seems high. The α value, which indicates whether a Poisson or a Negative Binomial estimation is more appropriate, favours the latter.

Our results (see Table 5) show that there are some specific industry location patterns that can be analysed according to specific industrial characteristics and territorial requirements. For the variables used to quantify the effect of urbanisation economies on the location of new firms (Population density, Population and Economic Activity), the evidence is very mixed.

First, the result for Population density is surprising. This variable has little impact on location decisions; the only industry in which it is significant is Food and beverages, in which it has a positive influence on the location of 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; Figueiredo et al, 2002a and b) and a mixed effect (Arauzo, 2005; 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)⁸.

Table 5: Location determinants of new entries (1992-1996)^a

Variables ^b	High technology	Intermediate technology		Low technology		
	R&D machinery	Machinery and equipment	Chemical products	Food and beverages	Textiles	Leather
Population density (x 10 ⁻⁰⁶)	40.600 (35.600)	-8.240 (32.00)	-38.400 (28.400)	51.700** (25.000)	30.900 (42.000)	34.500 (59.800)
Population (x 10 ⁻⁰⁶)	3.900*** (1.300)	-0.980 (1.050)	-0.348 (0.440)	0.286 (1.110)	3.420** (1.370)	4.530*** (1.700)
Economic activity	-0.536 (0.500)	-0.985** (0.419)	-0.705* (0.385)	-0.090 (0.255)	-0.232 (0.608)	0.124 (0.651)
Previous entries (own sector)	0.007 (0.010)	0.052*** (0.008)	0.092*** (0.011)	0.014*** (0.003)	0.035*** (0.008)	0.013* (0.007)
Distance from the central city	-0.024** (0.010)	-0.018*** (0.007)	-0.017** (0.007)	-0.013*** (0.005)	-0.001 (0.009)	0.013 (0.012)
Human Capital (intermediate-level)	0.084*** (0.031)	0.097*** (0.023)	0.085*** (0.021)	0.059*** (0.016)	0.116*** (0.036)	0.019 (0.048)
Human Capital (university-level)	-0.024 (0.033)	-0.081*** (0.026)	-0.042* (0.025)	-0.009 (0.017)	-0.121** (0.049)	-0.012 (0.055)
Constant	-2.180** (1.181)	-1.010 (0.851)	-1.728** (0.788)	-0.704 (0.591)	-3.778*** (1.325)	-3.128* (1.833)
Pseudo R ²	0.181	0.178	0.217	0.195	0.239	0.208
N	330	330	330	330	330	330
χ ²	160.83	252.36	210.21	368.20	187.24	139.64
Log-likelihood	-365.163	-581.924	-380.012	-758.67	-298.544	-265.59
α	1.346 (0.255)	0.873 (0.119)	0.441 (0.115)	0.613 (0.074)	1.528 (0.309)	2.762 (0.572)

(***) 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.

Second, the Population variable, which can be a proxy for market opportunities as well for labour availability, is significant and positive for R&D machinery, Textiles and Leather. Those results corroborate those obtained by Holl (2004a), also for the Spanish economy. Though the effect is the same, the reasons for the effect differ in high and low technology industries: high tech firms need an innovative environment, which is usually found inside

⁸ See Arauzo (2005) for a more detailed analysis.

bigger cities, whereas low tech firms are labour-intensive and need to be located inside bigger cities where larger amounts of labour are available.

Third, the Economic activity variable shows little effect on firm location decisions and is only significant (and negative) for Machinery and equipment and for Chemical products. This result may indicate a suburbanisation process, from more active (and costly) areas to smaller ones with lower congestion and lower land prices. According to this variable, the process is observed only for intermediate technology industries.

The estimation for the variable which is a proxy of the effect of location economies is positive and significant for all industries except for R&D machinery. This evidence is very common in this type of analysis (see Rosenthal and Strange, 2003, and Costa et al., 2004). The reasons for this result may be similar to the ones proposed for the previous variables. We suspect that the suburbanisation process is especially important for high technology firms. These firms move from bigger cities in higher metropolitan areas (their traditional location) to smaller cities which have improved accessibility due to transport infrastructure investment. Indeed, smaller cities seem to be the preferred locations for technology-intensive firms; they offer amenities that are highly valued by skilled individuals working in those industries (see Arauzo, 2006, for a more detailed analysis of the impact of amenities supply on individuals' location decisions).

The results of the Distance from the central city are negative and significant for 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). These results suggest that, in the suburbanisation process, even though firms may prefer to move away from

the centre of the metropolitan areas, they must maintain fluid communications with the area's central city in order to benefit from the effects of agglomeration. The different results for Textiles and Leather show that these sectors need to be close to the core of the metropolitan areas, probably because these firms are labour-intensive and rely on high labour supply. This result suggests that distance from the major cities (the central cities of the metropolitan areas) deters new firm location, as Guimarães et al (2000) and in Arauzo (2005) report. From this evidence it seems clear that, in fact, as we hypothesised in the introduction, the process of suburbanisation affects all sectors, including the most technologically advanced.

Finally, the results for Human capital 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 activity⁹. But if look at more educated people (those with a university degree), some specific industry patterns emerge: a negative impact for 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.

5. Conclusions

The research reported here was undertaken after first demonstrating the high level of spatial concentration of new firms in the municipalities of the biggest Spanish metropolitan areas. We present empirical evidence on the location determinants of new firms using data from Spanish manufacturing firms for the period 1992-1996. The model devised basically analyses

⁹ Nevertheless, empirical work about incidence of labour force qualification usually shows ambiguous results. For example, Holl (2004b) find both a (mainly) positive and a negative effect over firm location depending on the industry analysed.

the effects of agglomeration economies on the location of new firms at the intra-metropolitan level. In line with recent research in economics and the latest empirical studies, this model incorporates two types of agglomeration economies, urbanisation economies (the influence of the city'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). We have been particularly careful to use the most appropriate geographic unit of analysis. The analysis was conducted using a database of local information of the economic structure of the municipalities in the selected metropolitan areas. In an intra-metropolitan approach, rather than a regional or an inter-metropolitan one, we can assume that some of the factors that influence new firm location are common to all the alternative locations inside a given metropolitan area. A second reason for our interest in the intra-metropolitan location patterns is the need to analyse the roles of the central city and the suburbs of the metropolitan area separately, in order to contrast the process of suburbanisation in these settings. As several authors point out, location determinants are not independent of the industry to which every single firm belongs. In fact, our data show that there are some specific industry characteristics that influence location patterns.

The results show that agglomeration economies are an important factor in determining the location of new manufacturing firms. The geographical distribution of most of the sectors is influenced to some extent by the productive environment. Yet the influence of agglomeration economies on the location of new firms differs clearly, depending on the type of industry. In the case of urbanisation economies, the evidence indicates that the results may differ depending on the variable used for measurement. For their part, the results of the location economies variable suggest that the industrial specialisation of a municipality in a particular industry will attract new firms belonging to the same sector. An interesting conclusion

deriving from the results of the distance variables is that all the industries are undergoing a process of suburbanisation from the central city towards surrounding municipalities, even new firms in the high technological sector. The point is that these firms still enjoy the advantages of being close to the central city, especially when communication infrastructures are good, but pay less than before.

These conclusions notwithstanding, further studies are required. Future research should focus on firm size. Obviously, the size of new firms may vary substantially and may condition their strategic decisions. At the moment we suspect that the determinants of location are not the same for large firms as they are for small firms.

From a policy point of view, given the differences in location patterns in manufacturing industries, promotional efforts to attract new firms should take into account the characteristics of the area. A key first step in any policy design process is the identification of industries that are likely to choose a specific area. Therefore, promotional efforts for particular areas should focus on the industries identified at the first stage.

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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	2308	361	327	4604
Entrants 10-50 L	102	186	70	226	86	225	895
Entrants > 50 L	13	12	8	32	2	3	70
Total entrants	450	1138	411	2566	449	555	5569
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 L
Entrants < 10 L	335	1273	2996	4604
Entrants 10-50 L	102	256	537	895
Entrants > 50 L	13	20	37	70
Total entrants	450	1549	3570	5569
Mean size of entrants	11.5	8.0	7.6	8.0

Source: our own calculations, using data from the REI