Departament d'Economia Aplicada

DOCUMENT DE TREBALL

Employment descentralisation: polycentric compaction or sprawl? The case of the Barcelona Metropolitan Region 1986-1996

Miguel Ángel García López
Ivan Muñiz

05.11

Universitat Autònoma de Barcelona
Facultat de Ciències Econòmiques i Empresarials

Aquest document pertany al Departament d'Economia Aplicada.

Data de publicació : **Juny 2005**

Departament d'Economia Aplicada
Edifici B
Campus de Bellaterra
08193 Bellaterra

Telèfon: (93) 581 1680
Fax:(93) 581 2292
E-mail: d.econ.aplicada@uab.es
http://www.ecap.uab.es

EMPLOYMENT DECENTRALISATION: POLYCENTRIC COMPACTION OR SPRAWL? THE CASE OF THE BARCELONA METROPOLITAN REGION 1986-1996

Miguel Ángel García*

Ivan Muñiz

Departament d'Economia Aplicada, Universitat Autònoma de Barcelona,

Edifici B, Facultat de Ciències Econòmiques, 08193 Bellaterra, Espanya

miguelangel.garcia@uab.es

ivan.muniz@uab.es

Abstract: The Barcelona Metropolitan Region (BMR) has been repeatedly characterised as a polycentric-type urban system. The aim of this study is to corroborate this affirmation by making use of a methodology that enables the identifying of employment subcentres and valuing of the degree of polycentrism of the BMR in 1986 and 1996. The results obtained in the two years confirm the existence and extension of the polycentrism.

JEL: R12, R14

Keywords: Employment subcentres, identification, descentralisation, sprawl, compaction, polycentrism.

* We are grateful to Daniel P. McMillen, José Luis Roig and Anna Matas for helpful suggestions.

1 INTRODUCTION

The study of polycentric urban areas has been one of the research areas of urban economics that has advanced most in the last two decades. The evolving of cities towards polycentric-type structures has been so evident that the theories that seem firmly established have been obliged to introduce significant changes with the aim of being able to better understand said phenomenon. To do so, two parallel routes have been followed without there having been significant crossovers. The first of these is situated within the framework of the Monocentric City Model (Alonso, 1964; Muth, 1969). Starting out from the formal simplicity and elegance that characterises this central component of theoretical urban economics, the suppositions with which it starts out have been extended with the aim of capturing equilibrium solutions that are compatible with polycentrism. Thus, for instance, references have been included to congestion, the mechanism for fixing equilibrium wages, the spatial impact of agglomeration economics, or to the relationship between the costs of product transport and of commuting. This has been the theoretical framework from which the polycentrism of North American cities has been focused (Fujita and Ogawa, 1982; Sullivan, 1986; Wieand, 1987; White, 1990; Henderson and Slade, 1993; Anas and Kim, 1994) [1].

In the case of Europe, polycentrism has been presented mainly as the result of the evolving of pre-existing hierarchic urban systems, where the different centres have been functionally integrated due to the reduction of transport costs. Relationships that in the past were of a vertical nature (between centres of a different order) are being increasingly replaced by horizontal relationships (between centres of the same order), which has led to the role played by the different centres making up the system no longer being explained exclusively by the specificity of the services they offer, but rather also by the activity sectors in which they specialise. The metaphor of the hierarchic tree characteristic of the Central Place Theory (Christaller, 1933; Lösch, 1940) has been replaced by that of the network (Camagni and Salone, 1993; Dematteis, 1990; Capello, 2000).

In some sense, the reference theoretical framework has been adapted to the conditions in each place. In the North American case, the creation of subcentres is in general a relatively recent phenomenon linked to the decentralising trends of population and employment (Alperovich, 1983; Lahiri and Numrich, 1983; Heikkila et al., 1989; Small and Song, 1994).

[1] For an exhaustive review of this type of model, consult Anas et al. (1998) and White (1999).

At the other extreme, the subcentres of European polycentric systems tend to be medium sized cities with a long history (Hohenberg and Lees, 1985; Holmes, 1992; Batty, 2001). The problem is that the reality is usually situated somewhere between the two extremes. Not all the subcentres of North American cities are a result of recent employment decentralisation, nor do all the subcentres of European urban systems have their origin in a remote past. To be able to deal with the shades of grey that suggests the need for a detailed examination of the reality of the situation, it would be desirable to integrate both theoretical approaches, but this unfortunately has not occurred.

One of the effects deriving from the disconnection produced between the two theoretical approaches is that they have generated clearly separate applied research strategies. In the North American instance, the emphasis has been placed on the need to find some methodology that enables subcentres to be identified in a thorough and objective way. A special emphasis has also been placed on the impact of subcentres on ground rent and the intensity of land use (McDonald, 1987; McMillen and McDonald, 1998; McMillen, 2003). In the European case, research has been mainly directed towards the change of economic base of the systems' centres, as well as towards all that referring to the relationship between centres, whether they belong to the same or different hierarchical order (Camagni and Salone, 1993; Capello, 2000). There have been few studies that have, for instance, looked at the effects of a local urban system on land rent and population and employment density[2]. Neither are we aware of any occasion in which subcentres have been identified using sector employment data, which would enable the presence of specialised subcentres in a certain sector to be related to the spatial distribution of the employment in that same sector. This type of exercise where different theoretical and empirical traditions are mixed are not, regrettably, particularly common, which means renouncing elements that could contribute to and strengthen the analysis framework.

In the case of the Barcelona Metropolitan Region, a European and polycentric urban region, there exists a certain tradition in the analysis of urban structures on the basis of relationships of commuting (ATM, 1998; Burns et al., 2001). Recently some studies have gone beyond mere description, and have analysed the change of a hierarchical structure to a reticular type, by studying the functional relationships produced between the system's centres, as well as the specificity of services offered in them (Boix, 2004). There therefore

[2] An exception worth mentioning is the interesting study by Papageorgiou and Pines (1999).

exists a research strategy in tune with that carried out in other European metropolises. Although this manner of tackling Barcelona's polycentrism is clearly useful, we also believe it necessary to use a framework of analysis compatible with the theoretical models of the New Urban Economics, with the aim of focusing the analysis on questions that have up until now been neglected, such as the identification of subcentres using alternative techniques to mobility flows, or the analysis of their impact on the spatial structure of employment.

The aim of this study is to satisfy three objectives. The first of these consists of identifying the employment subcentres of the Barcelona Metropolitan Region for the total number of jobs, using a methodology inspired by the new contributions to the field of applied urban economics, for Manufacturing and Services separately, and for eight manufacturing and eight service two-digit sectors. The second objective is to contrast the hypothesis of polycentrism and to investigate the impact of the centre and the subcentres on the spatial distribution of employment by means of an exponential density function with a double gradient, one for the distance to the centre and the other for the distance to the nearest subcentre. The third aim consists in analysing the evolution of the polycentrism over the period 1986-1996.

The study we are presenting is therefore innovative with regard to at least three aspects. First of all, in the case of the Barcelona Metropolitan Region there was a considerable vacuum with regard to the use of identifying techniques, contrasting of the hypothesis of polycentrism and the impact of the subcentres on the location of employment. Secondly, a sector-based approach has been used here that is not limited to the characterisation of previously identified subcentres[3], but is rather implemented from the identification phase itself. Thirdly, neither are we aware that employment decentralisation has been studied at a two digit sector level using comparative analysis of the density gradients estimated from each industry employment density functions.

[3] This type of sector focus has been used in studies such as McMillen and McDonald (1998) or Giuliano and Small (1991)

2 EMPLOYMENT DECENTRALISATION IN THE BARCELONA METROPOLITAN REGION

2.1 Characterisation of the study area

The Barcelona Metropolitan Region contains 163 municipalities, occupying almost 4,000 km^2 within an approximate radius of 55 km. In addition to its polycentric nature, the BMR has also been defined as a discontinuous, partially disperse, complex and diverse urban region (Font et al., 1999). The BMR contains a primary city of over a million and a half inhabitants – the municipality of Barcelona. This is followed by a first, extremely dense and urbanised metropolitan ring with housing estates, and a second ring that combines residential uses – with density levels that are markedly lower than those in the first ring – and industrial ones. Beyond the second ring, there appears a group of medium-sized cities in the form of an arch and a number of metropolitan corridors where rural and urban uses are mixed (ATM, 1998, Muñiz et al., 2003a). The BMR is structured on a markedly radial transport network, where the main agglomerations and corridors are connected to the centre of the city by various railway lines and the network of metropolitan roads. It should be pointed out that transport infrastructures have had an important influence on the pattern of urbanisation (Miralles, 1997; Muñiz et al., 2003a).

2.2 Employment in the Barcelona Metropolitan Region, 1986-1996

Before discussing the employment data, the period being analysed should be put into context. In 1986 Spain joined the European Economic Community, coinciding with the beginning of a phase of strong economic growth which would last until the end of 1992, although from 1991 onwards this was flagging noticeably. Between 1992 and 1993 a deep economic recession was produced, with worldwide effects, which for the Spanish economy meant "(…) the most intense recession since 1960, with a rapid destruction of occupation and a net fall in the value of production (…)" (Trullén, p. 41, 1998). 1994 onwards saw the beginning of the recovery, finally consolidated by the end of 1996. The ten years being considered in this study therefore contain a complete economic cycle, in which the

production sectors together had 38.4% more jobs; an increase of 10.95% for Manufacturing, and a significant 54.45% for Services (Table 1) [4].

TABLE 1. BMR employment data, 1986-1996

	Employment BMR		*% Total BMR*		*% Employment Growth*
	1986	*1996*	*1986*	*1996*	
Total	1,063,283	1,471,630	100.00%	100.00%	38.40%
Manufacture	421,363	467,515	39.63%	31.77%	10.95%
Services	591,556	913,683	55.63%	62.09%	54.45%

2.3 The decentralisation of employment

During this period a substantial redistribution of the activity in the metropolitan environment took place, loosing importance in the centre and gaining it at the periphery. The indicator used to measure the *decentralisation* of the activity is the variation of the average distance of each municipality with respect to the centre weighted by the percentage of jobs in each municipality.

$$DCBD = \frac{1}{n}\sum_{i=1}^{n}\left(d_{CBD,i}\,\frac{E_i}{E_{RMB}} \right)$$

where n is the number of municipalities, E_i is the employment in the municipality i and $d_{CBD,i}$ is the distance that separates the municipality i from the centre of the city.

The calculation of the DCBD indicator for the year 1986 shows that the manufacturing sectors were more decentralised than the services (Table 2). The development between 1986 and 1996 indicates that the speed at which the activity is decentralised is an average of 1% per annum; i.e. in the ten years considered, the average weighted distance increased by 10%, both in the manufacturing and service sectors[5].

[4] At two-digit sectors level (see Tables A.1 and A.2 in the Appendix), the most dynamic sectors in terms of generation of employment are Health, Financial Institutions and Firm Services, the Food industry, Hotels and Restaurants and Public Administration. In contrast, three sectors present negative employment growth rates, Other Services, Timber and Furniture Industry, and Textile Industry, with the fall in the Textile industry being the most important, as it is a traditional sector that concentrates a high proportion of manufacture employment.

[5] The results by sector offer significant differences. The Food and Textile sectors stand out among the most decentralised manufacture sectors in 1986, while the least decentralised were Transport Material, Paper and Graphic Arts. In addition, the two industrial sectors that have been most decentralised are Transport Material and Furniture As regards the service sector, the least decentralised was Transport and Financial Activities and the most decentralised Trade and Hotels, while the sectors that have decentralised most are Transport and Public Administration.

TABLE 2. Weighted average distance to CBD, 1986 - 1996

	DCBD (Km.)	
	1986	*1996*
Total	9.82	10.50
Manufacture	12.23	13.32
Services	7.79	8.79
Chemical Industry	10.06	11.91
Metallurgy, Electrical Equipment	11.34	12.88
Production of Transport Material	5.83	12.61
Food Industry	13.91	13.08
Textile, Leather, and Dressmaking	17.79	17.98
Timber and Furniture	13.75	16.12
Paper, Graphic Arts and Edition	7.22	8.82
Rubber and Plastic	12.22	13.84
Trade and Repair	9.75	10.09
Hotel and Restaurant Services	10.68	11.81
Transport and Comunication	5.48	8.26
Financial Institutions and Firm Services	5.08	6.88
Public Administration	6.29	8.62
Education and Research	8.54	9.35
Health and Social Services	7.89	8.27
Other Services	8.17	8.05

Having confirmed the employment decentralisation trend, questions need to be asked about the role played by the employment subcentres in this process: Has the decentralisation been accompanied by a dispersed activity location model? In the event of the degree of polycentrism having increased, is it due to the growth of pre-existing subcentres or to the emergence of new subcentres? In the following sections we shall attempt to respond to these questions.

3 IDENTIFICATION OF SUBCENTRES IN THE BMR

Previous studies that have attempted to identify the subcentres of the BMR are few and far between. There are some studies where, without it being their main objective, some extremely simple criterion has been used, such as a threshold of population (Martori and Suriñac, 2002) or of employment (Asensio, 2000). Somewhat more sophisticated are the studies where subcentres are identified by analysing commuting flows, such as ATM (1998)

or Burns et al. (2001). Lastly, the study by Muñiz et al. (2003a) defines as a subcentre those municipalities that present a population density local maximum, whereas in Muñiz et al. (2003b) a double filter is used combining employment and density thresholds, to then examine the significativity of the gradient associated with the distance to each subcentre candidate in a function of population density (Table 3).

In the light of the few studies that have tackled the question, the forcefulness with which the polycentric nature of the BMR is normally affirmed is in a way surprising. The already long list of studies focussing on the identification of subcentres that have appeared in the last twenty years in the main specialist journals does not seem to have influenced the research applied to the BMR.

TABLE 3. Selected studies on BMR polycentricity

	Study	*Criteria*	*Year*	*Subcentres*
Thresholds	Martori and Suriñac (2002)	Population > 50000	1998	11
	Asensio (2000)	Employment > 20000	1996	5
Commuting	ATM (1998)	Net in-commuting in subregional predetermined zones	1996	7
	Burns et al. (2001)	Positive net in-commuting> 15 % Population > 10000	1996	11
Density Peaks	Muñiz et al. (2003a)	Local maximum in a population density cubic-spline function	1996	7
Theresholds + Density Peacks	Muñiz et al. (2003b)	(1) *a.* Dens > 4.5 Empl./ha	1996	15
		b. Density peak		11
		c. Positive residuals in a employment exponential density function, and Empl. > 10000		12
		(2) Candidates a+b+c positive effect on a polycentric exponential population density function		13

3.1. Methodologies for subcentres identification

The literature on the identification of subcentres has evolved over the years, gaining objectivity, thoroughness and replicability. The first studies that identified subcentres by making use of information provided by some official agency (Greene, 1980; Griffith, 1981), or by the fact of being historical areas (Baerwald, 1982; Erickson and Gentry, 1985; Bender and Hwang, 19885; Heikkila et al., 1989; Dowal and Treffeisen, 1991; and Shukla and Waddel, 1991, among others), gave way to studies where the identification was carried out

using more sophisticated criteria, but whose complexity impeded their replicability in other realities (Dunphy, 1982; Cervero, 1989). Although this group of studies provided interesting material, it can only be seen as a first step in the expansion of a literature whose aim is an interesting mixture of simplicity and objectivity. There follows a brief summary of these studies.

Beyond the first attempts at identification, the studies carried out to date can be grouped into five categories. The first method consists of using a reference threshold. The majority of studies that apply this method consider a double threshold, one for the number of jobs and another for employment density (Giuliano and Small, 1991; Song, 1994; Cervero and Wu, 1997; McMillen and McDonald, 1997, 1998; Bogart and Ferry, 1999; or Anderson and Bogart, 2001), although some studies add an additional threshold for the ratio of jobs per resident population (Shearmur and Coffey, 2002). The second method is based on the analysis of the data on mobility, either by means of net entry flows or trip generation density (Bourne, 1989; Gordon and Richardson, 1996). The third group of studies uses a criterion based on the identification of "peaks", i.e. a set of contiguous census sections that present a local maximum with respect to the area that surrounds them, whether it be employment density (Gordon et al., 1986; Craig and Ng, 2001), or the ratio of jobs per resident population (McDonald, 1987; McDonald and McMillen, 1990). The fourth method consists of identifying the positive residues estimated from an exponential employment density function (McDonald and Prather, 1994), or with a combination of non-parametric and semi-parametric methods (McMillen, 2001). Finally, there have recently appeared some studies where elements of spatial econometrics are used, such as the Moran index (Baumont et al., 2004; Guillain et al., 2004) (Table 4).

In a recent study, McMillen and Lester (2003) discuss the suitability of the different methods according to the objectives being pursued in each investigation. The authors point out that the most objective criteria based on econometric regressions are especially suitable when the intention is to carry out comparisons between different metropolitan regions, due to the adaptability of their statistical "thresholds" to local conditions. In contrast, when the aim of the research is focused on comparing the polycentrism of a particular city at different moments in time, methodologies based on thresholds, especially Giuliano and Small-type ones, function better.

TABLE 4. Methodologies for subcentre identification

	Study	*Criterium*	*City-Year*	*Subcenters*
Thresholds	Giuliano and Small (1991)	Density > 25 Empl./ha Empleo > 10000	Los Angeles, 1980	32
	Song (1994)	Density > 37 Empl./ha Empl. > 35000	Los Angeles, 1980	6
	Cervero and Wu (1997)	Density > 17 Empl./ha Empl. > 10000	San Francisco, 1990	22
	McMillen and McDonald (1997)	Density > 25 Empl./ha Empl. >10000 Negative subcentre density gradient	Chicago, 1980	20
	McMillen and McDonald (1998)	Density > 25 Empl./ha Empl. >10000 Negative subcentre density gradient	Chicago, 1990	20
	Bogart and Ferry (1999)	Density > 20 Empl./ha Empl. >10000	Cleveland, 1990	9
	Anderson and Bogart (2001)	Density > 20 Empl./ha Empl. >10000	Cleveland, 1990 Indianapolis, 1990 Portland, 1990 San Luis, 1990	9 11 11 11
	Shearmur and Coffey (2002)	Empl. >5000 Employment/Population > 1	Montreal, 1996 Toronto, 1996 Ottawa-Hull, 1996 Vancouver, 1996	16 17 7 13
Commuting	Bourne (1989)	Commuting flows	Calgary, 1981	0
	Gordon and Richardson (1996)	Density trip generation>0.8 standard deviation	Los Angeles, 1980	18
Density peaks	McDonald (1987)	Density or Empl./Pop.	Chicago, 1970	9
	McDonald and McMillen (1990)	Density or Empl./Pop.	Chicago, 1956 Chicago, 1970	8 9
	Gordon et al. (1986)	Density	Los Angeles, 1980	
	Craig and Ng (2001)	Density	Houston	7
Residues	McDonald and Prather (1994)	Exponential	Chicago, 1980	3
	McMillen (2001)	a) Locally Weighted Regression b) Flexible Fourier with subcentre distance	Chicago, 1990 Dallas, 1990 Houston, 1990 Los Angeles, 1990 New Orleans, 1990 San Francisco, 1990	33 28 25 19 2 22
Spatial econometrics	Baumont et al. (2004)	Global and local Moran I. (Employment density)	Dijon, 1999	2
	Guillain et al. (2004)	Global and local Moran I (Employment/Population)	Ile de France 1978 Ile de France 1997	3 7

3.3 Identification of subcentres in the BMR, 1986-1996

Given that the aim of this study is not only the identification of subcentres, but also the evaluation of how the degree of polycentrism evolves over time, a methodology based on thresholds has been adopted, where instead of specifying equal and fixed numerical values

for each type of identification – the most usual technique when subcentres are identified using total employment data -, fixed statistical values have been defined which adapt numerically to the conditions in each sector aggregation.

After a number of trials, it was decided to define as subcentres those municipalities with an employment density[6] ($D_{i,s}$) higher or equal to the average for the BMR in 1986 ($\bar{D}_{RMB,s,1986}$) and with an employment level ($E_{i,s}$) equal or higher than 1% of the total for the BMR in 1986 ($E_{RMB,s,1986}$)[7]:

$$D_{i,s} \geq \bar{D}_{RMB,s,1986}$$
$$E_{i,s} \geq 1\% E_{RMB,s,1986}$$

where i and s refer to the municipality[8] and to the sector aggregation respectively. These values generate a reasonable number of subcentres in each sector aggregation and for each year considered.

Normally subcentre identification methodology has been applied for the total of employment. Few studies have used a sectorial approach[9]. This research goes somewhat further by carrying out an identification for different levels of industries aggregation. The main argument is that, just as the subcentres identified using the total number of jobs influence the spatial distribution of the total employment, a sector's employment distribution may also be conditioned by the presence of specialised subcentres in this same sector.

To calculate the minimum thresholds of gross employment density and of municipal employment we used the employment and surface area data obtained from the 1986 and 1996 population censuses. The identification was performed for the Total of employment, for employment in Manufacturing and Services together, and for a fragmentation of these

[6] In accordance with McDonald (1987), the employment density used is a gross density that takes in the number of jobs per hectare of the municipality surface area.

[7] Note that, unlike the studies by Giuliano and Small (1991) or McMillen and Lester (2003), we do not have more fragmented spatial units, rather we work with municipalities: highly aggregated spatial units that are administrative entities. For this reason, we do not consider the continuity or proximity between them in order to establish the employment threshold.

[8] Of the BMR's 162 municipalities in 1986, 12 municipalities that form the Barcelona spatial continuum are excluded. According to Hall et al. (1973) these municipalities cannot be considered subcentres but rather the periphery of a centre that goes beyond the administrative borders of the municipality of Barcelona.

[9] An example is that of McDonald (1987) where an identification of subcentres is also carried out for manufacture employment.

two major sectors into eight subsectors each[10]. The criterion used to identify subcentres means that their number varies on altering the number of sectors and subsectors being considered.

The results obtained (Table 5) reveal that the region's polycentrism has changed substantially over the period under consideration. In 1996 a significantly higher number of subcentres are identified than in 1986 for any level of sector aggregation. In addition, the "new subcentres", those identified in 1996 but not in 1986, are closer to the centre of the region. These are therefore subcentres arising from the recent employment decentralisation from the centre towards the nearest periphery. The maps clearly show how the new industrial subcentres have tended to concentrate in a triangle whose apexes are Montcada, Granollers and Terrassa, while the new service subcentres are distributed in a more disperse way throughout the territory (Figure 1).

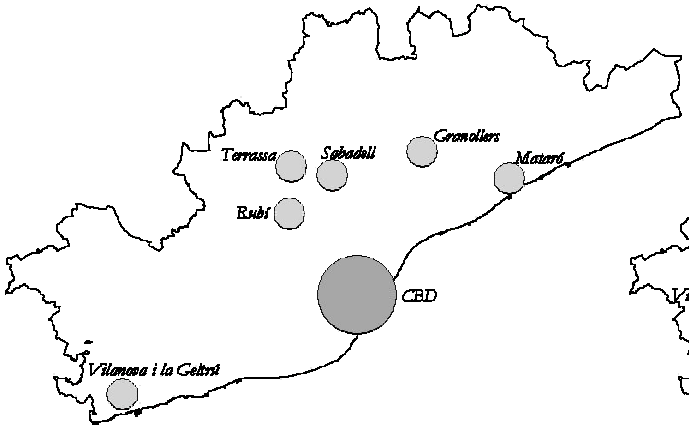
[10] The minimum level of aggregation has become conditioned by the fact that in 1986 the 1974 National Classification of Economic Activities was in force (CNAE74). For 1996 the CNAE93 provided correspondence with the CNAE74.

TABLE 5. BMR employment subcentres, 1986-1996

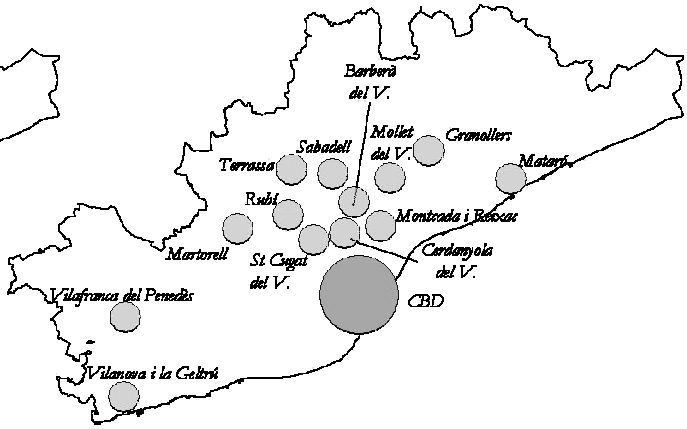
	Subcentres		*DCBD*		
	1986	*1996*	*1986*	*1996*	*New Subcentres 1996*
Total	6	13	23.93	21.32	16.76
Manufacture	8	12	23.36	20.46	16.32
Services	4	13	23.21	21.34	19.23
Chemical Industry	11	16	19.58	19.56	19.88
Metallurgy, Electrical Equipment	10	18	21.04	19.21	16.04
Production of Transport Material	3	14	19.14	20.42	21.27
Food Industry	12	21	24.08	21.99	20.84
Textile, Leather, and Dressmaking	8	7	24.46	24.70	13.94
Timber and Furniture	7	5	24.38	22.20	21.68
Paper, Graphic Arts and Edition	8	13	18.74	18.41	16.92
Rubber and Plastic	13	23	22.55	20.26	21.07
Trade and Repair	6	13	25.74	21.89	14.33
Hotel and Restaurant Services	9	18	31.51	27.73	25.08
Transport and Comunication	4	11	23.05	21.00	18.56
Financial Institutions and Firm Services	4	14	22.82	20.86	18.63
Public Administration	4	12	23.11	22.23	20.79
Education and Research	6	9	19.32	19.76	25.75
Health and Social Services	4	20	23.29	22.19	21.24
Other Services	4	0	23.21	---	---

FIGURE 1. BMR employment subcentres, 1986-1996

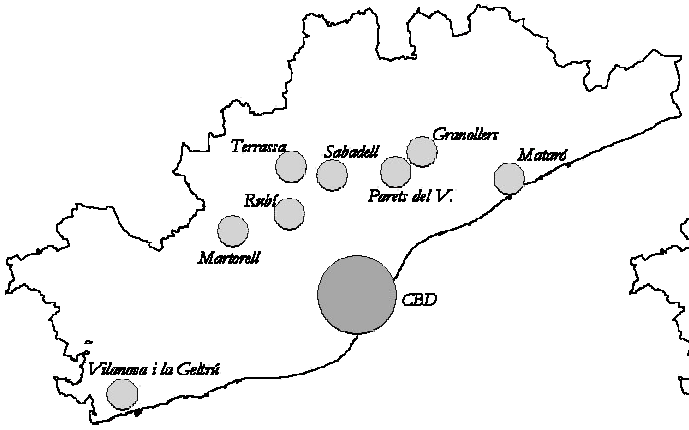
Total 1986



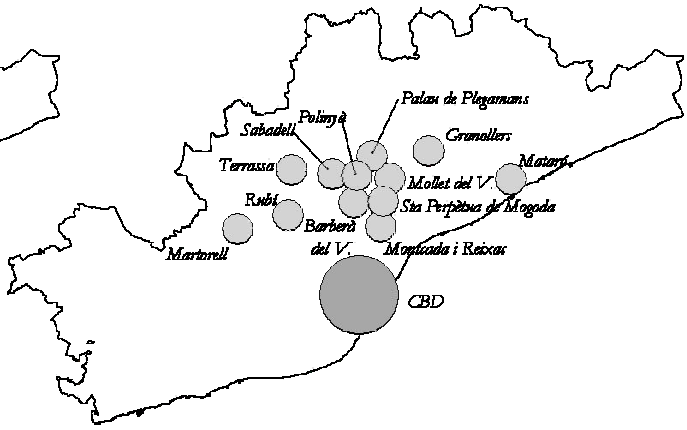
Total 1996



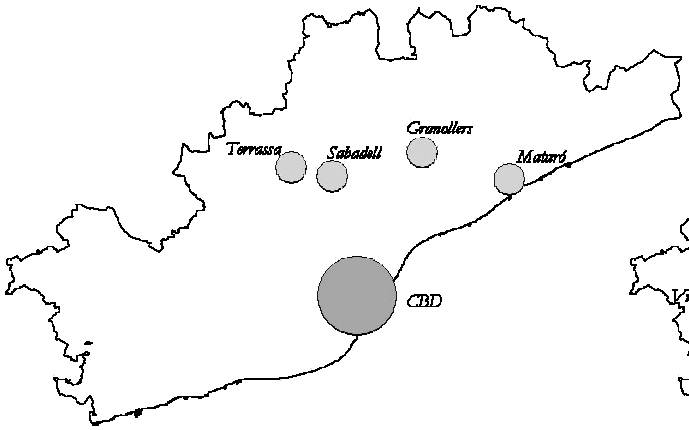
Manufacture 1986



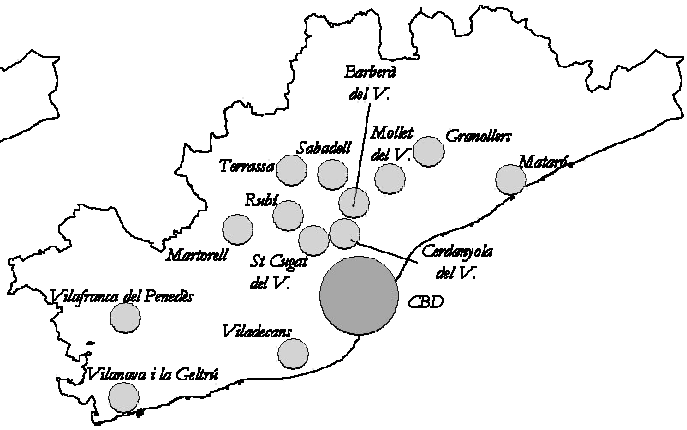
Manufacture 1996



Services 1986



Services 1996



4 POLYCENTRISM: CONTRAST OF HYPOTHESIS AND INCIDENCE OF SUBCENTRES ON THE LOCATION OF EMPLOYMENT

In order to meet the aims of this section, we started off with an employment density function typical of a monocentric spatial structure:

$$D\left(d_{CBD}\right) = D_0 e^{-\gamma d_{CBD} + \varepsilon} \tag{1}$$

where $D\left(d_{CBD}\right)$ is the gross employment density at a distance d_{CBD} from the CBD; D_0 is estimated gross employment density in the CBD; γ is the density gradient associated with the distance to the CBD[11]; ε is the error term with the usual properties.

In the case of a polycentric spatial structure, McDonald and Prather (1994) show different examples of density functions. In our case, we adopted the most commonly used one:

$$D\left(d_{CBD}\right) = D_0 e^{-\gamma d_{CBD} + \delta d_{SUB}^{-1} + \varepsilon} \tag{2}$$

where d_{SUB}^{-1} is the inverse of the distance to the nearest subcentre[12]; and δ its corresponding density gradient[13]. While the interpretation of the coefficient of the distance to the CBD can be done directly, the reading of the estimated coefficient for the inverse of the distance to the nearest subcentre is the opposite, i.e. a positive (negative) coefficient indicates that the employment density growth is less (greater) as we move away from the employment subcentre under consideration.

Applying neperian logarithms to (2) we obtain:

$$\ln D\left(d_{CBD}\right) = \ln D_0 - \gamma d_{CBD} + \delta d_{SUB}^{-1} + \varepsilon \tag{3}$$

---

[11] The density gradient expresses the density's percentage variation in the event of a marginal increase of the distance to the centre. In an exponential function, the gradient is constant for any distance.

$$\gamma = \frac{\frac{\partial D}{D}}{\partial d_{CBD}}$$

[12] The use of an inverted distance enables multicolineality problems to be eliminated (McDonald and Prather, 1994). For the same reason, and following the example of studies like those of McMillen and McDonald (1998), McDonald and McMillen (2000), McMillen and Lester (2003) and McMillen (2004), among others, we used a single variable that adopts the distance to the nearest subcentre.

[13] . Note that working with a direct distance for the case of the CBD (Barcelona) and an inverted distance for the case of the nearest subcentre means recognising that the CBD's influence is greater than that of the subcentres for long distances.

The equation (3) is estimated by Ordinary Least Squares. In order to correct possible problems of heterocedasticity in the *cross-section* sample, the standard errors and the covariance matrix have been calculated using the White method.

4.1 Contrasting the hypothesis of polycentrism

Following McDonald and Prather (1994), in order to verify the existence of a polycentric spatial structure, in each estimation of (3) the Wald test is carried out, with which both structures are compared:

$$F = \frac{\left(SSR^r - SSR^u\right)/q}{SSR^u/\left(n-k\right)}$$

where SSR^r and SSR^u are the sum of the squares of the restricted, monocentric and non-restricted model residues respectively; n is the size of the sample; k is the number of estimated parameters in the non-restricted model; and q is the number of restrictions[14]. The significativity of the value F obtained implies the rejection of the monocentric model in favour of the polycentric model.

Tables 6, 7 and 8 show the results obtained in 1986 and 1996, for each industry and for overall manufacture and services. The Wald Test confirms the existence of a polycentric spatial structure in both years[15].

4.2 Incidence of subcentres on the location of employment: a dynamic analysis.

The analysis of the changes produced between 1986 and 1996 in the estimated gradients of the equation (3) enable the identifying of three different patterns in the evolving of polycentric spatial structures.

Firstly, only the Textile subsector presents a clear trend towards concentration of employment in the centre and subcentres, which is reflected by the upturn of both density gradients.

[14] In our case, to go from the polycentric model (3) to the linearised version of the monocentric model (1) we simple established a restriction, $\delta = 0$, and thus, $q = 1$.

[15] The only exception is, for 1996, the Other Services subsector where, as seen earlier, there are no employment subcentres.

$$|\gamma_{1996}| > |\gamma_{1986}|$$
$$\delta_{1996} > \delta_{1986}$$

Secondly, for the overall Manufacturing and four two-digit industries[16], the existence of a process of spatial homogenising of employment density can be seen as the absolute value of both gradients diminishes.

$$|\gamma_{1996}| < |\gamma_{1986}|$$
$$\delta_{1996} < \delta_{1986}$$

Finally, the most common result is an increase in the absolute value of the gradient for the distance to the centre and a reduction in the density gradient of the subsector. This behaviour is reproduced for the Services[17] as a whole, as well as for 10 two-digit industries being considered.

$$|\gamma_{1996}| > |\gamma_{1986}|$$
$$\delta_{1996} < \delta_{1986}$$

TABLE 6. Estimated coefficients for equation (3)

	Total		*Manufacture*		*Services*	
	1986	*1996*	*1986*	*1996*	*1986*	*1996*
$\ln D_0$	1.432*** (4.29)	1.914*** (5.74)	0.603*** (1.68)	0.937*** (2.76)	0.504 (1.42)	1.148*** (3.12)
γ	-0.080*** (-7.14)	-0.081*** (-7.43)	-0.082*** (-6.96)	-0.080*** (-7.28)	-0.079*** (-6.61)	-0.082*** (-6.89)
δ	2.494*** (6.21)	1.988*** (5.95)	2.611*** (7.70)	2.247*** (8.12)	2.817*** (6.87)	2.108*** (5.80)
Adjusted R^2	0.3414	0.4279	0.3530	0.4297	0.3236	0.4212
Wald Test	38.61***	35.45***	59.30***	65.99***	47.18***	33.70***

***, **, *: significant at the 1%, 5% and 10%, respectively.

[16] Chemical Industry, Metallurgy, Trade and Public Administration.
[17] Transport Material, Food industry, Timber and Furniture, Paper and Graphic Arts, Rubber and Plastic, Hotels and Restaurants, Transport and Communication, Financial Institutions and Services Firms, Education and Research, and Health and Social Services.

TABLE 7. Estimated coefficients for equation (3) – Manufacture subsectors

	Chemical Industry		*Metallurgy, Electrical Equip.*		*Transport Material*		*Food Industry*		*Textile, Leather and Dressmaking*		*Timber and Furniture*		*Paper, Graphic Arts and Edition*		*Rubber and Plastic*	
	1986	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*
$\ln D_0$	-2.145*** (-4.25)	-1.590*** (-3.73)	-0.638 (-1.53)	-0.217 (-0.55)	-2.918*** (-6.40)	-2.101*** (-5.74)	-2.276*** (-5.90)	-1.566*** (-4.41)	-2.009*** (-4.97)	-1.625*** (-4.96)	-2.444*** (-7.82)	-2.375*** (-9.01)	-2.275*** (-5.11)	-1.415*** (-3.91)	-2.716*** (6.04)	-1.938*** (-5.26)
γ	-0.090*** (-5.81)	-0.089*** (-6.43)	-0.098*** (-7.38)	-0.092*** (-7.60)	-0.088*** (-6.82)	-0.089*** (-7.85)	-0.068*** (-5.89)	-0.069*** (-6.40)	-0.061*** (-4.73)	-0.073*** (-6.54)	-0.070*** (-6.60)	-0.071*** (-7.45)	-0.097*** (-7.58)	-0.100*** (-9.33)	-0.083*** (-6.47)	-0.083*** (-7.50)
δ	3.282*** (8.43)	2.772*** (9.16)	2.957*** (8.09)	2.292*** (7.47)	3.533*** (3.82)	2.922*** (7.42)	2.717*** (7.41)	2.223*** (8.19	4.154*** (8.13)	4.313*** (7.35)	2.242*** (6.64)	2.008*** (5.88)	2.873*** (6.65)	2.331*** (7.73)	3.229*** (8.16)	2.516*** (9.36)
Adjusted R^2	0.4079	0.4737	0.4343	0.4768	0.3523	0.4718	0.3625	0.4313	0.2590	0.3560	0.3213	0.3530	0.4072	0.5243	0.4165	0.5288
Wald Test	71.07***	83.89***	65.44***	55.84***	14.61***	55.04***	54.90***	67.07***	66.16***	53.98***	44.04***	34.61***	44.26***	59.70***	66.67***	87.65***

***, **, *: significant at the 1%, 5% and 10%, respectively.

TABLE 8. Estimated coefficients for equation (3) – Services subsectors

	Trade and Repair		*Hotel and Restaurant*		*Transport and Comunication*		*Financial Institut. and Firm Services*		*Public Administration*		*Education and Research*		*Health and Social Services*		*Other Services*	
	1986	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*	*1986*	*1996*
$\ln D_0$	-0.551 (-1.54)	-0.129 (-0.34)	-2.146*** (-6.52)	-1.625*** (-5.05)	-1.820*** (-4.95)	-0.865*** (-2.36)	-2.120*** (-5.50)	-0.600 (1.52)	-1.675*** (-4.70)	-1.078*** (-3.07)	-1.441*** (-3.68)	-0.995*** (-2.86)	-2.913*** (-7.31)	-1.301*** (-3.15)	-1.962*** (-5.68)	-2.716*** (-10.75)
γ	-0.089*** (-6.95)	-0.087*** (-6.86)	-0.069*** (-6.28)	-0.070*** (-7.34)	-0.081*** (-6.76)	-0.091*** (-7.59)	-0.085*** (-6.59)	-0.092*** (-7.30)	-0.087*** (-7.39)	-0.082*** (-7.39)	-0.084*** (-6.75)	-0.088*** (-7.78)	-0.073*** (-5.79)	-0.084*** (-6.71)	-0.084*** (-7.17)	-0.079*** (-8.95)
δ	2.901*** (6.77)	2.263*** (6.38)	3.285*** (6.62)	2.800*** (6.64)	2.754*** (6.10)	2.347*** (6.53)	3.431*** (8.13)	2.288*** (5.84)	2.497*** (5.76)	2.051*** (5.19)	2.463*** (5.35)	2.304*** (5.87)	3.492*** (7.24)	2.685*** (6.70)	3.082*** (7.72)	---
Adjusted R^2	0.3188	0.4122	0.3296	0.4326	0.3218	0.4585	0.3246	0.4544	0.3483	0.4316	0.3485	0.4250	0.3011	0.4745	0.3448	0.3265
Wald Test	45.90***	40.68***	43.78***	44.10***	37.16***	42.71***	66.13***	34.11***	33.15***	26.95***	28.58***	34.45***	52.40***	44.94***	59.57***	---

***, **, *: significant at the 1%, 5% and 10%, respectively.

5 DESCENTRALISATION: POLYCENTRIC COMPACTION OR DISPERSION?

Although subject to certain controversy (Ewing, 1997), polycentrism can be interpreted as an alternative decentralisation model to dispersion[18]. In such a case, a compaction indicator that is useful for its extreme simplicity is the percentage of employment located in the centre and subcentres[19]. The remaining percentage can be used therefore as an indicator of dispersion. Calculating said indicator in 1986 for the total number of jobs, gave 64.8% of the employment concentrated in the centre, 14.77% in the subcentres, and the rest, i.e. 20.4% located in a relatively dispersed way in a high number of municipalities (Table 9). In contrast, the figures obtained in 1996 show the percentage of jobs located in the centre falling to 60.2%, while that of the subcentres rose to 20.6%.

The rest now represented somewhat less than in 1986, at 19.1%. These results allow us to maintain that, although very slightly, the degree of polycentrism in the region has increased, since the centre's loss of weight has been accompanied by an increasing in the weight of the subcentres in a slightly higher proportion. It should be noted that this increase in weight of the subcentres is not due to a greater concentration of employment in the subcentres identified in 1986, but rather to a significant increase in the number of new subcentres identified in 1996[20].

[18] The controversy focuses on the fact that there is no clear dividing line between a polycentric urban system and a discontinuously dispersed one.
[19] Other indicators that have been used to capture the relative concentration of employment or population in dense environments are the Gini index, that of Theil, or that of Relative Entropy (Malpezzi and Guo, 2001).
[20] The third column referring to subcentres in Table 9 indicates clearly how in general, the percentage of jobs concentrated in 1996 by the subcentres that had been identified in 1986 has reduced.

TABLE 9. Empleyment spatial pattern, 1986-1996

	CBD (BCN+Conurbation)		*Subcentres*			*Other municipalities*	
	1986	*1996*	*1986*	*1996*	*Ident.86 1996*	*1986*	*1996*
Total	689,385 (64.84%)	885,958 (60.20%)	157,063 (14.77%)	303,657 (20.63%)	202,178 (13.74%)	216,835 (20.39%)	282,015 (19.16%)
Manufacture	231,636 (54.97%)	222,321 (47.55%)	87,676 (20.81%)	117,523 (25.14%)	92,918 (19.87%)	102,051 (24.22%)	127,671 (27.31%)
Servicios	431,088 (72.87%)	617,645 (67.60%)	61,921 (10.47%)	165,346 (18.10%)	94,105 (10.30%)	98,547 (16.66%)	130,692 (14.30%)
Chemical Industry	30,473 (62.92%)	28,199 (52.79%)	9,093 (18.77%)	15,100 (28.27%)	10,555 (19.76%)	8,867 (18.31%)	10,115 (18.94%)
Metallurgy, Electrical Equipment	69,747 (56.39%)	69,912 (46.89%)	27,868 (22.53%)	46,858 (31,42%)	32,189 (21.59%)	26,063 (21.07%)	32,341 (21.69%)
Transport Material	27,212 (77.13%)	19,013 (46.61%)	3,367 (9.54%)	14,912 (36.56%)	8,506 (20.85%)	4,703 (13.33%)	6,864 (16.83%)
Food Industry	17,214 (50.85%)	29,271 (51.22%)	8,307 (24.54%)	17,451 (30.54%)	11,085 (19.40%)	8,334 (24.62%)	10,426 (18.24%)
Textile, Leather and Dressmaking	35,430 (36.19%)	25,768 (35.13%)	38,958 (39.79%)	26,305 (35.87%)	26,703 (36.41%)	23,510 (24.01%)	21,269 (29.00%)
Timber and Furniture	9,602 (52.81%)	4,880 (40.18%)	2,671 (14.69%)	2,019 (16.62%)	1,402 (11.54%)	5,909 (32.50%)	5,246 (43.19%)
Paper, Graphic Arts and Ediction	27,154 (71.50%)	29,974 (63.44%)	5,102 (13.43%)	9,279 (19.64%)	6,780 (14.35%)	5,721 (15.06%)	7,995 (16.92%)
Tubber and Plastic	14,804 (56.81%)	15,304 (44.59%)	6,055 (23.24%)	12,299 (35.84%)	6,376 (18.58%)	5,199 (19.95%)	6,715 (19.57%)
Trade and Repair	104,497 (66.25%)	134,546 (62.91%)	24,263 (15.38%)	42,476 (19.86%)	29,104 (13.61%)	28,968 (18.37%)	36,834 (17.22%)
Hotel and Restaurant Services	30,175 (66.67%)	42,341 (60.42%)	6,744 (14.90%)	16,975 (24.22%)	11,384 (16.25%)	8,338 (18.42%)	10,757 (15.35%)
Transport and Comunication	67,277 (81.24%)	74,174 (69.61%)	6,007 (7.25%)	15,584 (14.63%)	8,790 (8.25%)	9,530 (11.51%)	16,794 (15.76%)
Financial Institutions and Firm Services	68,684 (81.33%)	149,987 (73.46%)	7,634 (9.04%)	35,363 (17.32%)	20,281 (9.93%)	8,137 (9.63%)	18,817 (9.22%)
Public Administration	49,371 (78.76%)	63,089 (68.70%)	4,480 (7.15%)	15,100 (16.44%)	8,451 (9.20%)	8,833 (14.09%)	13,648 (14.86%)
Education and Research	50,493 (68.39%)	53,988 (63.45%)	11,302 (15.31%)	16,763 (19.70%)	14,237 (16.73%)	12,039 (16.31%)	14,333 (16.85%)
Health and Social Services	29,069 (72.63%)	91,941 (70.17%)	6,263 (15.65%)	27,938 (21.32%)	14,852 (11.33%)	4,691 (11.72%)	11,153 (8.51%)
Other Services	31,522 (70.42%)	7,579 (68.39%)	5,857 (13.09%)	--- ---	1,111 (10.03%)	7,382 (16.49%)	3,503 (31.61%)

6 CONCLUSIONS

This study has set out three objectives: to identify subcentres, to contrast the hypothesis of polycentrism and to evaluate how the BMR's polycentrism evolved in the period 1986 – 1996. In order to fulfil the aims set out, a operational approach has been used which

distances itself from the extreme simplicity with which polycentrism has normally been studied in the case of Barcelona. The criterion used to identify subcentres was a double threshold with respect to the number and density of jobs. To contrast the hypothesis of polycentrism, a hypothesis contrast using the Wald test was carried out, where the restricted model is the monocentric one and the non-restricted model the polycentric one. Lastly, the way the degree of polycentrism evolved over time was evaluated by comparing the percentage of jobs located in previously identified subcentres, at the beginning and the end of the period. The results obtained can be synthesised in three points: firstly, the number of subcentres identified has increased significantly in the ten years under consideration; secondly, the Wald test confirms the polycentrism hypothesis; and thirdly, the degree of polycentrism has increased, not due to the growth of employment in the subcentres identified at the beginning of the period, but rather due to a substantial increase in the number of subcentres identified in 1996.

REFERENCES

ALONSO, W (1964) Location and Land Use: Towards a general theory of land rent. Cambridge, Mass., Harvard University Press.

ALPEROVICH, G. (1983) Determinants of Urban Population Density Functions, Regional Science and Urban Economics, 13, pp. 287-296.

ANAS, A. and I. KIM (1994) General Equilibrium Models of Polycentric Urban Land Use with Endogenous Congestion and Job Agglomeration, Journal of Urban Economics, 40, pp. 232-256.

ANAS, A. ARNOTT, R. and K..A. SMALL (1998) Urban Spatial Structure, Journal of Economic Literature, 36, pp. 1426-1464.

ANDERSON, N.B. and W.T. BOGART (2001) The Structure of Sprawl. Identifying and Characterizing Employment Centers in Polycentric Metropolitan Areas, American Journal of Economics and Sociology, 60, pp. 147-169.

ASENSIO, J. (2000) Cambios en la Forma Urbana y Demanda de Transporte, Tesis Doctoral, Departament d'Economia Aplicada, Universitat Autònoma de Barcelona.

AUTORITAT DEL TRANSPORT METROPOLITÀ (1998) Diagnosi del sistema i Directrius del Pla Director d'Infraestructures. Barcelona.

BAERWALD, T.J. (1982) Land Use Change in Suburban Clusters and Corridors, Transportation Research Record, 891, pp. 7-12.

BATTY, M. (2001) Polynucleated Urban Lanscapes, Urban Studies, 38, pp. 635-655.

BAUMONT, C., ERTUR, C. and J. LE GALLO (2004) Spatial Analysis of Employment and Population Density : The Case of the Agglomeration of Dijon 1999, Geographical Analysis, 36, pp. 146-176.

BENDER, B. and H. HWANG (1985) Hedonic House Prise Indices and Secondary Employment Centers, Journal of Urban Economics, 17, pp. 90-107.

BOIX, R. (2004) Redes de Ciudades y Externalidades, Investigaciones Regionales 4, 5-27.

BOGART, W.T. and W.C. FERRY (1999) Employment Centres in Greater Cleveland: Evidence of Evolution in a Formerly Monocentric City, Urban Studies, 36, pp. 2099-2110.

BOURNE, L.S. (1989) Are New Urban Forms Emerging? Empirical Tests for Canadian Urban Areas, Canadian Geographer, 33, pp. 312-328.

BURNS, M.C., BOIX, M. and J. ROCA (2001) Contrasting Indications of Polycentrism within Spain's Metropolitan Urban Regions, Paper for the Eighth European Estate Society Conference, Alicante, Junio 26-29.

CAMAGNI, R. and C. SALONE (1993) Network Urban Structures in Northern Italy: Elements for a Theoretical Framework, Urban Studies, 30, pp. 1053-1064.

CAPELLO, R. (2000) The New City Network Paradigm: Measuring Urban Network Externalities, Urban Studies, 37, pp. 1925-1945.

CERVERO, R. (1989) America's Suburban Centers: The Land Use Transportation Link, Unwin Hyman, Boston, MA.

CERVERO, R. and K-L WU (1997) Polycentrism, Commuting, and Residential Location in the San Francisco Bay area, Environment and Planning A, 29, pp. 865-886.

CRAIG, S.G. and P.T. NG (2001) Using Quantile Smoothing Splines to Identify Employment Subcenters in a Multicentric Urban Area, Journal of Urban Economics, 49, pp. 100-120.

CHRISTALLER, W. (1933) Die Zentralen Orte in Suddeutschland, Gustav Fischer Verlag, Jena.

DEMATTEIS, G. (1990) Modelli Urbani e Rete. Considerazioni Preliminari, in CURTI, F. and L. DIAPPI (Eds.), Gerarchie e Reti di Città: Tendenze e Politiche. Milan, Franco Angeli.

DOWALL, D.E. and A. TREFFEISEN (1991) Spatial Transformation in Cities of the Developing World. Multinucleation and Land-Capital Suburbanisation in Bogota, Colombia, Regional Science and Urban Economics, 21, pp. 201-224.

DUNPHY, R.T. (1982) Defining Regional Employment Centers in an Urban Area, Transportation Research Record, 861, pp. 13-15.

ERICKSON, R.A. and M. GENTRY (1985) Suburban Nucleations, Geographic Review, 75, pp. 96-121.

EWING, R (1997) Is Los Angeles-Style sprawl desirable? Journal of the American Planning Association 63(1), pp. 107-123.

FUJITA, M. and H. OGAWA (1982) Multiple Equilibria and Structural Transition of Non-Monocentric Urban Configurations, Regional Science and Urban Economics, 12: 161-196.

FONT, A., C. LLOP and J.M. VILANOVA (1999) La Construcció del Territori Metropolita. Morfogènesi de la Regió Urbana de Barcelona. Àrea Metropolitana de Barcelona, Mancomunitat de Municipis.

GIULIANO, G. and K.A. SMALL (1991) Subcenters in the Los Angeles Region, Regional Science and Urban Economics 21, 163-182.

GORDON, P. and H.W. RICHARDSON (1996) Beyond Polycentricity. The Dispersed Metropolis, Los Angeles, 1970-1990, Journal of the American Planning Association, 62, pp. 289-295.

GORDON, P., H.W. RICHARDSON and H.L. WONG (1986) The Distribution of Population and Employment in a Polycentric City: The case of Los Angeles, Environment and Planning A, 18, pp. 161-173.

GREENE, D.L. (1980) Recent Trends in Urban Spatial Structure, Growth and Change, 11, pp. 29-40.

GRIFFITH, D.A. (1981) Modelling Urban Population Density in a Multi-Centered City, Journal of Urban Economics, 9, pp. 298-310.

GUILLAIN, R. and J. LE GALLO (2004) The Evolution of the Spatial and Sectoral Patterns in Ile-De-France over 1978-1997, mimeo.

HALL.P, REY, T., GRACEY, H. and R. DREWETT (1973) The containment of Urban England, London:Allen & Unwin.

HEIKKILA, E., GORDON, P., KIM, J.I., PEISER, B, RICHARDSON, H.W. and D. DLAE-JOHNSON (1989) What Happened to the CBD-Distance Gradient?: Land Values in a Polycentric City, Environment and Planning A, 21, pp. 221-232.

HENDERSON, J.V. and E. SLADE (1993) Developmnet Games in Non-Monotonic Cities, Journal of Urban Economics, 34, 207-229.

HOHENBERG, P.M. and L.M. LEES (1985) The Making of Urban Europe: 1000-1950. Cambridge: Harvard University Press.

HOLMES, G. (ED.) (1992) The Oxford History of Medieval Europe. Oxford: Oxford University Press.

LAHIRI, K. and R.P. NUMRICH (1983) An Econometric Study on the Dynamics of Urban Spatial Structure, Journal of Urban Economics, 14, 55-79.

LÖSCH, A. (1940) Die Räumliche Ordnung der Wirstchaft, Jena, Gustav Fischer.

MALPEZZI, S. and W-K. GUO (2001) Measuring "Sprawl": Alternative Measures of Urban Form in U.S. Metropolitan Areas, mimeo.

MARTORI, J.C. and J. SURIÑACH (2002) Urban Population Density Functions: The Case of the Barcelona Region, Documents de Recerca, Universitat de Vic, 6, pp. 1-18.

McDONALD, J.F. (1987) The Identification of Urban Employment Subcenters, Journal of Urban Economics, 21, 242-258.

McDONALD, J.F. and D.P. McMILLEN (1990) Employment Subcenters and Land Values in a Polycentric Urban Areas: the Case of Chicago, Environment and Planning A, 22, pp. 1561-1574.

McDONALD, J.F. and D.P. McMILLEN (2000) Employment Subcenters and Subsequent Real Estate Development in Suburban Chicago, Journal of Urban Economics, 48, pp. 135-157.

McDONALD, J.F. and P.J. PRATHER (1994) Suburban Employment Centres: The Case of Chicago, Urban Studies, 31, pp. 201-218.

McMILLEN, D.P. (2001) Nonparametric Employment Subcenter Identification, Journal of Urban Economics, 50, pp. 448-473.

McMILLEN, D.P. (2003) The Return of Centralization to Chicago: Using Repeat Sales to Identify Changes in House Price Distance Gradients, Regional Science and Urban Economics, 33, 287-304.

McMILLEN, D.P. and T.W. LESTER (2003) Evolving Subcenters: Employment and Population Densities in Chicago, 1970-2020, Journal of Housing Economics, 12, pp. 60-81.

McMILLEN, D.P. and J.F. McDONALD (1997) A Nonparametric Analysis of Employment Density in a Polycentric City, Journal of Regional Science, 37, pp. 591-612.

McMILLEN, D.P. and J.F. McDONALD (1998) Suburban Subcenters and Employment Density in Metropolitan Chicago, Journal of Urban Economics, 43, pp. 157-180.

MIRALLES, C. (1997) Transport i Ciutat. Reflexió sobre la Barcelona contemporània. Universitat Autònoma de Barcelona. Servei de Publicacions.

MUÑIZ, I., GALINDO, A. and M.A. GARCIA (2003a) Cubic Spline Population Density Functions and Satellite City Delimitation: The Case of Barcelona, Urban Studies, 40, pp. 1303-1321.

MUÑIZ, I., GALINDO, A. and M.A. GARCIA (2003b) ¿Es Barcelona una Ciudad Policéntrica?, Document de Treball, 03.09, Departament d'Economia Aplicada.

MUTH, R.F. (1969) Cities and housing, Chicago, Chicago University Press.

PAPAGEORGIOU, Y.Y. and D. PINES (1999) An Essay on Urban Economic Theory. Kluwer Academic Publishers.

SHEARMUR, R. and W.J. COFFEY (2002) A Tale of Four Cities: Intrametropolitan Employment Distribution in Toronto, Montreal, Vancouver, and Otawa-Hull, 1981-1996, Environment and Planning A, 34, pp. 575-598.

SHUKLA, V. and P. WADDEL (1991) Firm Location and Land Use in Discrete Urban Space, Regional Science and Urban Economics, 21, pp. 225-253.

SMALL, K.A. and S. SONG (1994) Population and Employment Densities: Structure and Change, Journal of Urban Economics, 36, 292-313.

SONG, S. (1994) Modelling Worker Residence Distribution in Los Angeles Region, Urban Studies, 31, pp. 1533-1544.

SULLIVAN, A.M. (1986) A General Equilibrium Model with Agglomerative Economies and Decentralized Employment, Journal of Urban Economics, 20, pp. 55-75.

TRULLÉN, J. (1998) Factors Territorials de Competitivitat de la Regió Metropolitana de Barcelona, Revista Econòmica de Catalunya, 34, pp. 34-56.

WHITE, M.J. (1990) Commuting and Congestion: A Simulation Model of a Decentralized Urban Area, Journal of the American Real Estate and Urban Economics Association, 18, pp. 335-368.

WHITE, M.J. (1999) Urban Areas with Decentralized Employment: Theory and Empirical Work, in MILLS, E.S. and P. CHESHIRE (Eds.), Handbook of Regional and Urban Economics Volume 4, pp. 1375-1412.

WIEAND, K. (1987) An Extension of the Monocentric Urban Spatial Equilibrium Model to a Multi-Center Setting: The Case of Two Center City, Journal of Urban Economics, 21, pp. 259-271.

ANNEX

TABLE A.1. BMR employment data, 1986-1996 – Manufacture Subsectors

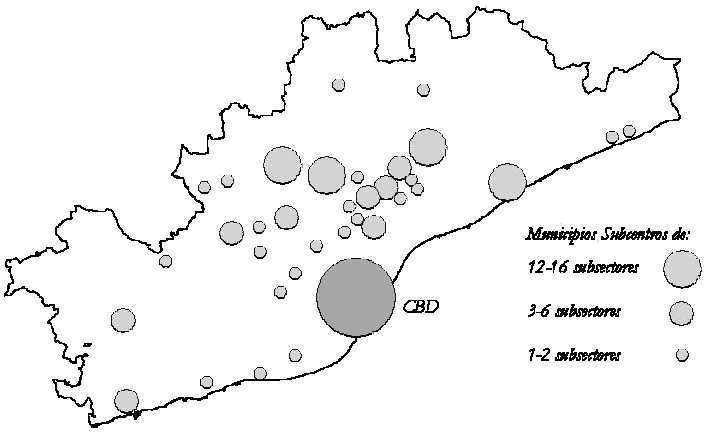
	Empleoyment BMR		*% Total BMR*		*% Employment Growth*
	1986	*1996*	*1986*	*1996*	
Chemical Industry	48,433	53,414	4.55%	3.63%	10.28%
Metallurgy, Electrical Equipment	123,678	149,111	11.63%	10.13%	20.56%
Production of Transport Material	35,282	40,789	3.32%	2.77%	15.61%
Food Industry	33,855	57,148	3.18%	3.88%	68.80%
Textile, Leather, and Dressmaking	97,898	73.342	9.21%	4.98%	-25.08%
Timber and Furniture	18,182	12,145	1.71%	0.82%	-33.20%
Paper, Graphic Arts and Edition	37,977	47,248	3.57%	3.21%	24.41%
Rubber and Plastic	26,058	34,318	2.45%	2.33%	31.70%

TABLE A.2. BMR employment data, 1986-1996 –Services Subsectors

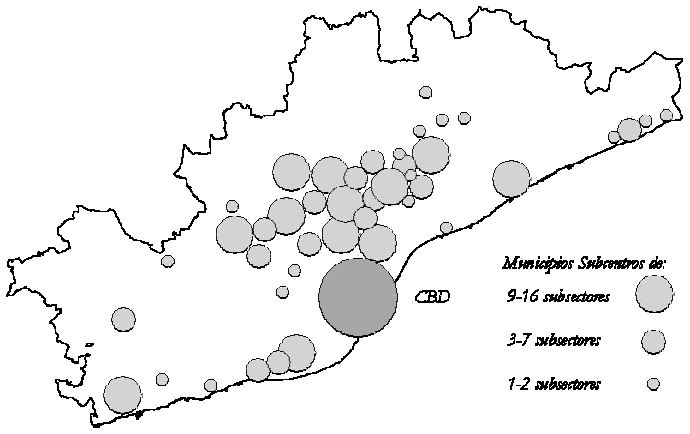
	Employment BMR		*% Total BMR*		*% Employment Growth*
	1986	*1996*	*1986*	*1996*	
Trade and Repair	157,728	213,856	14.83%	14.53%	35.58%
Hotel and Restaurant Services	45,257	70,073	4.26%	4.76%	54.83%
Transport and Comunication	82,814	106,552	7.79%	7.24%	28.66%
Financial Institutions and Firm Services	84,455	204,167	7.94%	13.87%	141.75%
Public Administration	62,684	91,837	5.89%	6.24%	46.51%
Education and Research	73,834	85,084	6.94%	5.78%	15.24%
Health and Social Services	40,023	131,032	3.76%	8.90%	227.39%
Other Services	44,761	11,082	4.21%	0.75%	-75.24%

FIGURE A.1. BMR employment subcentres, 1986-96 – Manufacture and Services Subsectors

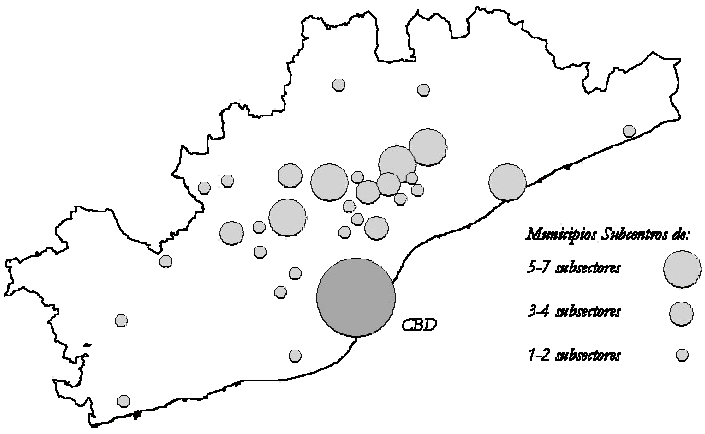
Total Subsectors 1986



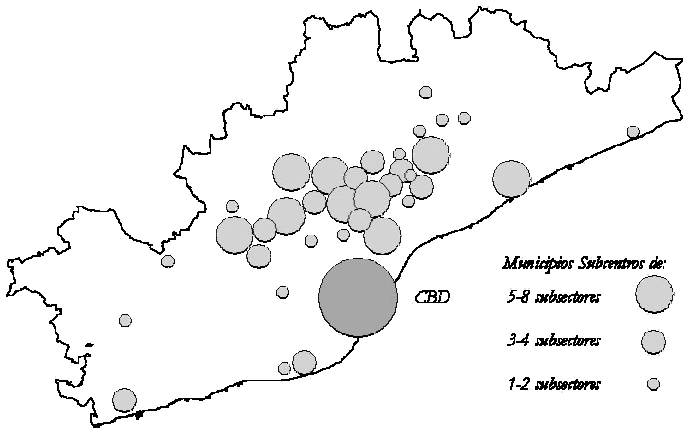
Total Subsectors 1996



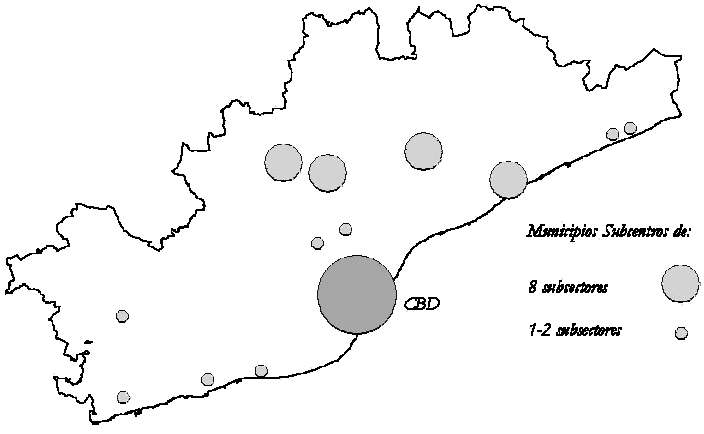
Manufacture Subsectors 1986



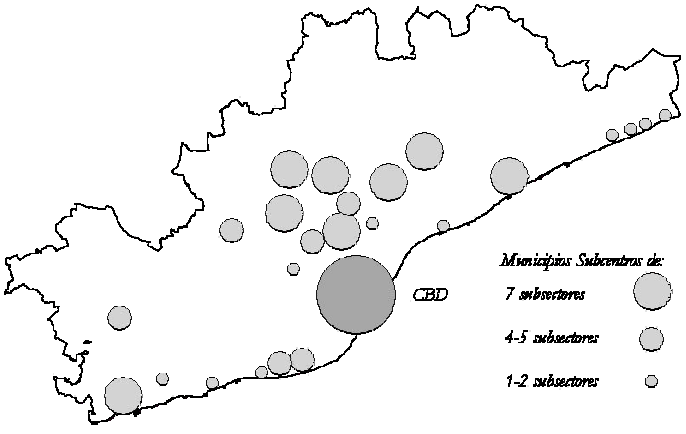
Manufacture Subsectors 1996



Services Subsectors 1986



Services Subsectors 1996



Últims documents de treball publicats

NUM	TÍTOL	AUTOR	DATA
05.11	Employment descentralisation: polycentric compaction or sprawl? The case of the Barcelona Metropolitan Region 1986-1996	Miguel Ángel García López Ivan Muñiz	Juny 2005
05.10	Nuevos instrumentos de política ambiental	Joan Pasqual Rocabert	Maig 2005
05.09	El impacto espacial de las economías de aglomeración y su efecto sobre la estructura urbana.El caso de la industria en Barcelona, 1986-1996	Miguel Ángel García Ivan Muñiz	Maig 2005
05.07	ANÁLISIS DE LAS EMISIONES DE CO2 Y SUS FACTORES EXPLICATIVOS EN LAS DIFERENTES ÁREAS DEL MUNDO	Vicent Álcantara Emilio Padiila	Abril 2005
05.06	Descentralización del empleo: ¿compactación policéntrica o dispersión? El caso de la región metropolitana de Barcelona 1986-1996	Miguel Ángel García Ivan Muñiz	Abril 2005
05.05	Descentralización, integración y policentrismo en Barcelona	Ivan Muñiz/ Anna Galindo / Miguel Ángel García	Abril 2005
05.04	Knowledge, networks of cities and growth in regional urban systems	Joan Trullen / Rafael boix	Febrer 2005
05.03	Inequality in CO2 emissions across countries and its relationship with income inequality: a distributive approach	Emilio Padilla / Alfredo Serrano	Gener 2005
05.02	Environmental management problems, future generations and social decisions	Joan Pasqual / Emilio Padilla	Gener 2005
05.01	International inequalities in per capita CO2 emissions: a decomposition methodology by Kaya factors	Juan Antonio Duro / Emilio Padilla	Gener 2005
04.12	Eficiencia y equidad en la ubicación de bienes colectivos locales indivisibles	Joan Pasqual	Novembre 2004
04.11	Regional Income Inequalities in Europe: An Updated Measurement and Some Decomposition Results	Juan Antonio Duro	Octubre 2004
04.10	Caracterización de la privación y de la pobreza en Catalunya	Sara Ayllon / Magda Mercader / Xavier Ramos	Octubre 2004
04.09	Social exclusion mobility in Spain, 1994-2000	Ambra Poggi	Setembre 2004
04.08	Sources of Competitiveness in Tourist Local Systems	Rafael Boix / Francesco Capone	Setembre 2004