THE POLYCENTRIC KNOWLEDGE ECONOMY IN BARCELONA[1]

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Abstract. This paper studies the employment decentralization process affecting the Barcelona Metropolitan Region (BMR) between 1991 and 2001. Disaggregating employment data between four categories of knowledge-intensive activities (Knowledge-Intensive Services, High-Technology Industries, Producer Services, and Finance, Insurance, and Real Estate) and two groups of other employment (Other Manufacturing and Other Services), the aim is to test whether these four groups decentralized in a similar way to other employment, and whether this process encouraged them to locate in a polycentric or dispersed way. The results show that knowledge-intensive activities and other employment decentralize in a similar way, although the former tends to be more concentrated through the formation of employment subcenters and therefore follows a polycentric location model. As a result, physical proximity is still important for numerous activities, especially those that incorporate more knowledge.

Keywords. Polycentrism, knowledge economy, employment scatteration, agglomeration economies.

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INTRODUCTION

Since the mid-1990s the debate over the future spatial structure of cities has reopened with renewed force. One of the controversies on which the discussion has centered is whether employment decentralization tends to promote a polycentric or dispersed model of a city. Gordon and Richardson (1996) showed that in Los Angeles employment was growing less in subcenters than in the rest of the city, which led them to conclude that polycentrism was nothing more than an intermediate stage between monocentrism and dispersal.[i] According to their predictions, future cities will be increasingly dispersed, with low density and without a recognizable spatial structure, because the likely improvements in telecommunications and the transportation sector will still further increase the radius of action of agglomeration economies, allowing agents to enjoy their advantages without having to suffer their disadvantages (congestion, high land prices, etc.)

Gordon and Richardson's study has not escaped criticism.[ii] One critique is that their predictions assume that improvements in communications will have the same deconcentration effects across all sectors. Spatial concentration might continue to provide significant advantages for activities where information and/or tacit knowledge are important. Even though they have decentralized like other sectors, *PS* (specialized services to businesses: legal and management activities, technical testing and analysis, advertising, staff selection, etc.) and *FIRE* sectors (finance, insurance, and real estate) are usually concentrated on the periphery, forming subcenters that, on a smaller scale, replicate central business district (CBD) functions (Bodenman, 1998; Coffey and Shearmur, 2002; Shearmur et al., 2007). Although the intrametropolitan distribution of this group of sectors has been reliably researched, the same cannot be said for other activities that are intensive in knowledge and advanced technology. *KIS* (knowledge-intensive services: IT activities, research and development, education, etc.) and *HTI* (High-Technology Industries: computer equipment

manufacturing, medical/surgical equipment manufacturing, aerospace construction, etc.) sectors use highly specialized knowledge, advanced technology, and human capital (OECD, 2001, 2003). They are also sectors in which innovation often appears quickly. Therefore, if the friction effect of space in the transmission of information explains the concentration of *FIRE* and *PS* sectors, the same argument should be valid for knowledge-intensive ones (*HTI* and *KIS*). The purpose of this study is to test whether in the Barcelona Metropolitan Region: (1) the four groups of sectors decentralized in a similar way to other employment between 1991 and 2001; and (2) they decentralized by forming subcenters or in a dispersed way. The results indicate that the importance of physical proximity between businesses in these sectors is greater than for others, and although they have undergone a considerable decentralizing trend, this has tended to occur in a compact way in the form of subcenters.

The structure of the study is as follows: Section 2 makes a review of the theoretical and applied literature on the importance of geographical proximity for activities intensive in the use of information and knowledge; Section 3 presents the Barcelona Metropolitan Region (BMR), as well as the data and methods used; the results are presented in Section 4; finally, the last section summarizes the main conclusions of the study.

PROXIMITY, INFORMATION, AND KNOWLEDGE

American cities—and, somewhat later, European cities—have undergone a major process of employment decentralization (Stanback, 1991; Mieszkowski and Mills, 1993; Hall, 1997). The decongesting effect from the fall in transport costs (Richardson, 1995; Gillham, 2002) was strengthened by the revolution in the field of telecommunications, which appeared to forecast a future in which work from home (*telecommuting*) and videoconferencing would reduce the importance of geographical proximity. The basic idea is that virtual communication could replace face-to-face contacts (Pressman, 1985; Castells,

1989; Fishman, 1998; Cairncross, 1997; Kloosterman and Musterd, 2001). Various authors have sought names to characterize new forms of settlement where population and employment are dispersed to the point where the classical image of the compact city is almost completely destroyed. By way of example, there is Castells' *informational city* (1989) as a metaphor for a fragmented space linked by information and production networks; Echevarría's *telepolis* or *remote city* (1996) in which the urban archipelago takes on a huge spatial scale; Lehrer's *flex-space* (1994) or Indovina's *diffused city* (1998), as a representation of a far-reaching change in the relationship between urban and rural characterized by the dissolution of once well-defined boundaries; or Lang's *edgeless city* (2003), an expression of a new discontinuous and dispersed office location pattern. Ultimately, this upsurge of terminology is, to varying degrees, reflecting a vision—a future projection in which the city would disappear, diluting itself into the noncity (Fishman, 1998).

Geographical proximity and knowledge externalities

In contrast with this view, where technology and knowledge promote a low-density, dispersed, delocated, and aspatial geography, there is an alternative view according to which concentration and proximity continue to be important. The fundamental reason put forward is that access to information and tacit knowledge[iii] (i.e., when knowledge cannot be easily transmitted using standard codes) requires physical proximity (Howels, 2002; Storper and Venables, 2004). Face-to-face contact is even needed to transmit codified knowledge, as a certain *know-how* is required to digest it properly. By nature this depends on the intrinsic and nontransferable social and cultural characteristics of each place (Howels, 2002; Maskell and Malmberg, 1999; Simmie, 2005). If the future of the economies of developed countries is in the sectors that use knowledge most intensively (Knight, 1995; van Winden and van den

Berg, 2004; Yigitcanlar et al., 2007), spatial concentration in general—and the dense, compact city in particular—will prevail.

The concept of knowledge as a local public good goes back to Alfred Marshall (1890). In describing the British industrial districts at the end of 19th century *specializing* in a particular sector, Marshall highlighted the fundamental role of a socially articulated local context, institutionally committed and economically competitive but with room for collaboration. He called this "industrial atmosphere." At the end of the 1970s, the Marshallian focus took on a new impulse on both sides of the Atlantic with the literature on industrial districts (Becattini, 1990; Best, 1990; Brenner, 2000), the study by Scott (1988) on the spatial concentration of certain industries, and the *innovative milieu* literature (Maillat and Perrin, 1992; Brackzyk et al., 1998).

Although Marshall's legacy has made it possible to highlight the benefits firms specializing in a particular sector obtain when they are spatially concentrated, there is another line of thought—as rich as that outlined above—upholding the concentration of diversity (sectors and individuals with knowledge and access to different technologies) as the scenario that is most likely to lead to the generation of new ideas. Against the trend for functionalist town planning to radically remodel or destroy the centers of American cities, Jane Jacobs (1961) highlighted their social, cultural, and heritage importance, but above all their economic significance. Their high density, mixing, and disorder facilitated what she called the *cross-fertilization of ideas*. The southern part of Manhattan, with its mixture of artists, executives, teachers, and students, perfectly reflects what we understand as an intellectually vibrant atmosphere (Florida, 2002). Later, the idea of the cross-fertilization of ideas would be a fundamental theoretical element on which to base the idea of the *technopole.* Pierre Laffite, founder of Sophia-Antipolis, used it repeatedly to uphold the concentration of research centers, businesses, universities, entrepreneurial businesspeople, and specialized financial

institutions as the best mechanism for integrating the knowledge-innovation-technology-product circuit. The experience of Silicon Valley, so highly popularized from the 1980s onward, represents the possibility that these phenomena do not only occur based on a public initiative, but also spontaneously.

As for the empirical work carried out on the relationship between proximity, knowledge, and spatial concentration, the studies by Krugman (1991) and Audrestch and Feldman (1996) showed how, as the quantity of knowledge needed to carry out an activity increases, it tends to be more spatially concentrated. Adams and Jaffe (1996) demonstrated that the sectors using codified knowledge most intensively tend to be less spatially concentrated than those making the most intensive use of tacit knowledge. However, recent studies, such as Torre and Rallet (2005), have demonstrated that things might not be so simple. They set out to study the need for the geographical proximity of one firm to others in the context of its life cycle (Gallaud and Towers, 2005). Proximity seems to be particularly necessary in the first few years, when collaboration between firms (Torre and Rallet, 2005) and dependence on specialized, technologically advanced services (t-KIBS) (Bryson et al., 1993; Bryson, 1997) is greatest. On the other hand, some studies have made it possible to contemplate the way in which it is not only access to tacit knowledge that suffers with distance, but also access to knowledge that expands in a codified way in the form of patents (Jaffe et al., 1993; Almeida and Kogut, 1997; Jaffe and Trajtenberg, 1999). Regarding the impact of knowledge externalities on local growth, the available evidence appears to indicate that a diversified environment promotes employment growth (Glaeser et al., 1992; Combes, 2000), the attraction of new investment (Rosenthal and Strange, 2003) and innovation (Harrison et al., 1996; Kelley and Helper, 1999), while a specialized environment increases productivity (Duranton and Puga, 2001; Henderson, 2003).

The intrametropolitan spatial structure of the information- and knowledge-intensive sectors

Intrametropolitan location patterns of employment and population and, especially, the emergence of polycentric urban regions (Anas et al., 1998), is one of the most interesting issues that have been tackled over the last 20 years in the field of geography, economics, and regional planning. It is becoming increasingly clear that big cities, or at least a good number of them, are not organized around a single center that includes the majority of specialized services under high-density conditions. In reaction to this situation—although with a certain delay—a new generation of theoretical models has appeared in the field of *New Urban Economics.* By selectively altering the initial assumptions—generally giving a leading role to the interplay between agglomeration economies and diseconomies—these models have made the appearance of employment subcenters possible.[iv] *New Economic Geography* also provided new theoretical models capable of predicting the formation of polycentric urban regions. In this case, polycentrism largely arises as a way of reducing the transport costs involved in moving goods.[v] The study of polycentrism had a strong impact not only on theoretical research but also on applied research. Since the mid-1980s, intensive work has been carried out seeking methods for identifying subcenters simply, replicably, and as objectively as possible (McDonald, 1987; McDonald and McMillen, 1990; Forstall and Greene, 1997; Muñiz et al., 2003, 2008; Redfearn, 2007).

An examination of the studies of an applied nature also enables us to state that there is no single way of understanding polycentrism. For example, in the United States, the term polycentrism tends to be used to explain phenomena on a smaller spatial scale than that used in Europe. By way of example, we could compare the scale of the maps that are used to study the Chicago urban area—one of the most cited cities in American literature on polycentrism—with that of the Dutch Randstad—possibly the most studied European polycentric urban area (Pain and Hall, 2008; Kloosterman and Moosterd, 2001; Davoudi,

2003; Scott, 2001). Also, the study of applied cases confirms that the origin of subcenters can be very different. They are as likely to arise from the decentralization of employment and population (decentralized polycentrism) as they are from the functional integration of cities of a smaller or similar size that in the past operated as independent cities (integrated polycentrism) (Champion, 2001; Muñiz et al 2003; Cooke and Morgan, 1993).

The diversity of experiences detailed in the studies that applied to specific cities seems to indicate that the polycentric models of the New Urban Economics and New Economic Geography, though useful and rigorous, are of limited capacity for explaining specific experiences. For example, history plays a fundamental role, as the new sites that could nowadays be qualified as the subcenters of a broader urban system could be of pre-industrial origin and respond at origin to a Christallerian-type land occupancy. Geographical accidents also play a central role, especially in the specific location of sites, their size, and their distance to other centers. Finally, government actions are also important, through the regulation of land and the provision of transportation infrastructure, as well as universities and research centers, which also have a significant effect on the resulting urban form (Shearmur and Coffey, 2002).

Edge Cities

The study by Garreau (1991) has probably done most to popularize the polycentrism issue. In the study, he coined the term *edge city* to characterize the concentration of specialized services in places sufficiently far away from the CBD of American metropolitan areas. *Edge cities* are characterized by a high concentration of jobs in a limited space occupied by offices in medium- or high-density conditions and surrounded by homes. This is none other than a small-scale replica of the main CBD, so it shows a high concentration of

jobs in specialized services *PS* (*producer services*) and *FIRE* (*finance, insurance, and real estate*) (Bodenman, 1998; Bogart and Ferry, 1999; Harrington and Campbell, 1997).

Why do these sectors tend to be spatially concentrated? There are basically two explanations. The first is related to synergies between firms, the special nature of the information, and the friction generated by distance in its transmission (*Knowledge Externalities Theory*). The second is associated with the specialized nature of the service they offer and the geographical size of the market area they are trying to cover (*Central Place Theory*). According to *Knowledge Externalities Theory*, the concentration of specialized services arises in response to synergies (agglomeration economies) between firms, either through pecuniary externalities (*backward and forward linkages*) (Shearmur and Alvergne, 2002; Coffey and Shearmur, 2002; Bodenman, 1998) or through informal contacts based on which tacit information is transmitted (Coffey and Shearmur, 2002; Stanback, 1991; Ihlanfeldt, 1995; Leslie and O'Huallacháin, 2006). Other reasons that have been put forward to explain their concentration is the need for frequent face-to-face contacts due to the fact that, in this type of service, contractual conditions are usually frequently reviewed and renegotiated (Stanback, 1991; Daniels, 1993).

According to *Central Place Theory*, concentration does not arise from synergy between firms but rather as a result of strategically convenient geographical centrality (Papageorgeiou and Pines, 1999; Wang, 1999). The more specific the service offered by a firm, the greater its propensity to locate in the most central—and therefore most accessible—area.[vi] *Edge cities* are not only areas that encourage synergies and face-to-face contacts, but also a strategically chosen location for offering a specialized service to customers (firms—*PS*—or end consumers—*FIRE*) who have already decentralized (Harrington and Campbell, 1997; Coffey and Polèse, 1987; Illeris, 1996; Bogart, 2006).[vii]

The Geography of Knowledge-Intensive Activities

As we have already seen, the accumulation of knowledge in cities is considered a powerful driving force for growth. The role of cities in the early phases of a firm's life cycle has also been researched, as well as whether the creation of new firms and growth of employment are affected by a specialized or diversified local environment. The literature on innovation has demonstrated the effect of the friction of space in access to knowledge. The literature on the *innovative milieu*, industrial districts, and technopoles have underlined, with different emphases, that an environment where knowledge flows easily, facilitating innovation is achieved through a complex balance between competition and cooperation between firms, local roots, and the complicity of financial institutions, research centers, and public and private universities. In summary, we are faced with a subject of study that has been tackled in depth from different perspectives. Paradoxically, their intrametropolitan location and contribution to the structuring of an increasingly polycentric metropolitan area have not been studied with the same intensity.[viii] In 1997, Suarez-Villa and Walrod wrote "*(...) Despite the rising importance of metropolitan polycentricity, little is known about how it affects industrial R+D and production in high-technology industries (...)"* (Suárez-Villa and Walrod, 1997: 1345; Suárez-Villa, 1999). Unfortunately, 10 years later things have not changed very much. The ultimate aim of this study is to partly fill this gap, offering empirical evidence on the peripheral concentration of the PS and FIRE sectors, as well as KIS and HTI, in the form of subcenters in the Barcelona Metropolitan Region.

THE BARCELONA METROPOLITAN REGION

BMR: characterization and previous studies

The Barcelona Metropolitan Region is the territory made up of 164 municipalities designated by Catalan territorial organization laws to provide the area with a specific regional

plan. The boundary criteria correspond to the desire of legislators to carry out planning adapted to what they called "the real city" (i.e., an economic area functionally integrated via the labor and housing markets). It currently contains 4,850,000 people and just over 1,822,000 jobs, or more than 65% of Catalonia's population and employment. The BMR is the second most populous urban area in Spain—slightly smaller than Madrid. It is the fourth most populated urban area in Europe, eighth most extensive, and third densest.

It is a region that has repeatedly been characterized as polycentric (Mancomunitat de Municipis de l'Àrea Metropolitana de Barcelona, 1995; Muñiz et al., 2003, 2008; Garcia-López, 2008; Vecslir, 2007), although in recent years an intense debate has opened up on the importance of urban sprawl (Roca et al., 2004; Muñoz, 2005), largely focused on the pace of land occupation (Fig. 1) and the decentralization of population. History, geography, and the provision of infrastructure have had a major impact on the spatial organization of employment and population in the BMR[ix] (Muñiz et al., 2003).

Studies of the knowledge economy in the BMR have been made in various investigations, including those by Trullén et al. (2002) and Boix (2006a, 2006b). Trullén et al. (2002) calculated the number of workers on a municipal level in the industrial sectors with high and average technological intensity and knowledge-intensive services, following the classification used by the OECD (2001, 2003). The municipality of Barcelona is the main concentration for these sectors of activity, although significant concentrations are also observed in such peripheral municipalities as Sabadell, Terrassa, Mataró, El Prat, and Rubí. Boix (2006a) shows the spatial distribution of technology- and knowledge-intensive firms and the changes between 1991 and 2005. Barcelona and its inner ring, together with some traditional subcenters, lose importance in the case of industries, which seem to move toward municipalities that started with smaller numbers of firms. In services exactly the reverse happens, with growth concentrated in Barcelona and the inner ring, as well as in the

traditional subcenters (Sabadell, Terrassa, Mataró, Granollers, etc.). Finally, Boix (2006b) presents the favorable development of different indicators related to the "knowledge economy", such as the number of firms, R+D expenditure, the level of education of the population, the value of production in the sectors that are intensive in the use of advanced technology, and the number of patents as a measure of innovation capacity. The three studies give a very positive view of the capacity of the BMR to reorient its economic base toward activities that use advanced technology and knowledge intensively.

Data and methods

Data

The data used in this study is the *number of jobs located* on a municipal level in 22 activity subsectors. They come from 1991 and 2001 population censuses, which are produced by the Instituto Nacional de Estadística (INE). Although information is collected on a census tract level, most questions relate to a municipal level. Unfortunately, this is the case with employment data, which is taken from municipal commuting flow data.[x]

The activity sectors analyzed are grouped into four categories (Table 1). The *FIRE* (finance, insurance, and real estate) and *PS* (producer services) sectors are the ones which, in the international literature, are usually presented under the general label of *specialized services* (Bodenman, 1998; Harrington and Campbell, 1997; Coffey and Shearmur, 2002). The *HTI sectors*[xi] and the *KIS sectors*[xii] are those OECD (2001, 2003) classifies as *High-Technology Manufacturing* and *Knowledge-Intensive Services,* respectively.[xiii]

One of the problems with using a sectoral approach to the knowledge economy is that behind every sector there are coexisting activities with very different provisions of human capital and intensities in the use of information. One way of dealing with the problem could be, as proposed by Marmolejo and Roca (2008), the use of an occupational rather than

sectoral focus based on the profile of the level of training of workers and the nature of the work they do. However, at present there is no agreed classification regarding what activities we should consider "knowledge economy" and which we should not.

Methods

The spatial organization of intrametropolitan employment can be conceptualized by two spatial dimensions: centralization and concentration (Anas et al., 1998; Lee, 2007). Through a weighted average distance[xiv] to the CBD, the first dimension measures employment proximity to the CBD. Through a Gini index, the latter measures total clusterization levels. Although the method of jointly interpreting the variation in decentralization and concentration indices put forward by Lee (2007) is interesting, it does not allow a definite statement to be made on whether the decentralization of employment tends toward a polycentric or dispersed model, as an increase in the decentralization index and a fall in concentration could be indicating not only a trend toward generalized dispersal, but also a growth in polycentrism—provided the number of subcenters increases. To check this hypothesis, it is necessary to first identify the employment subcenters and then compare the dynamic of employment located in subcenters with that of employment located in the other municipalities—besides the CBD—that do not have a sufficient volume of employment or density to be classified as subcenters.

With a few exceptions (Shearmur and Coffey, 2002), the identification of subcenters has been carried out on the basis of total employment data. In contrast to the general trend, we propose identifying the subcenters not only by total jobs but also by jobs within each of the 22 activity subsectors grouped in the *HTI*, *FIRE*, *PS,* and *KIS* categories, which involves the identification of *specialized subcenters*. Following Muñiz et al. (2008), we adopt the double threshold proposed by Giuliano and Small (1991) using statistical thresholds:

Subcenters are municipalities with a gross employment (total or subsectoral) density ($D_{i,t}$) greater than or equal to the average density for the BMR ($\bar{D}_{BMR,t}$) and with a level of employment (total or subsectoral) ($E_{i,t}$) measured at 1% or more of the total for the BMR ($E_{BMR,t}$)

$$D_{i,t} \geq \bar{D}_{BMR,t}$$
$$E_{i,t} \geq 1\% E_{BMR,t}$$

A statistical threshold makes it possible to neutralize the inflationary effect that the considerable growth in employment occurring in the BMR has on the number of subcenters, when they are identified by using numerical thresholds. At the same time, it manages to reduce the degree of subjectivity involved in using a single threshold (statistical and therefore adaptable) for each year, as well as for the subsectors and for total employment (Muñiz et al., 2008). Therefore, the adopted method, though useful for our aims, still involves problems at the beginning with subjectivity related to the threshold-based identification methods.

ANALYSIS

The analysis carried out is developed in five steps. First, we investigate the employment dynamism in the sectors studied (*FIRE*, *PS*, *KIS*, and *HTI*) in relation to the growth of employment in other services and manufacturing. Second, we examine whether less of a decentralizing and deconcentrating trend has been followed than in the other sectors. Third, employment subcenters are identified using the total jobs to check whether the relative presence of the sectors studied and their growth is greater than the other sectors. Fourth, *specialized subcenters* are identified using only the employment data from the sectors analyzed, and their level of decentralized concentration (employment in subcenters) is compared with their dispersed presence (other areas in the BMR apart from the CBD).

Finally, a classification of subcenters is proposed, which we consider useful for interpreting their main differences.

Dynamism, decentralization, and deconcentration

Employment Dynamism

The total employment growth rate in the BMR between 1991 and 2001 was 16.3%, while the sum of jobs in the *HTI, FIRE, PS,* and *KIS* sectors increased by 45% (Table 2). The greater dynamism of this group of sectors has made its relative importance in the economy of the BMR increase, moving from 24.3% of total employment to 30.25%. There are important differences between sectors. *HTI* jobs fell 25%, a stronger reduction than in manufacturing sectors. On the other hand, the *PS* and especially *KIS* sectors grew more than other services—43.8% and 70.2%, respectively, compared to 28.9%—although the *FIRE* sectors grew less (21.6%). In summary, although the knowledge base of the BMR economy is intensifying, this has not translated into an increase in jobs in high-technology industries. Instead it has been services, particularly *KIS*, that have been largely responsible for the dynamism observed on an aggregate level.

Decentralization

Employment in the *HTI sectors* is more centralized than in the other manufacturing sectors (Table 3). The same pattern is observed for the *FIRE*, *PS,* and *KIS* compared with other services. These results appear to support the idea that these are sectors seeking accessibility concerning their customers (producers and consumers) and proximity to the urbanization economies that arise from the center of the region. On a subsector level, international airport accessibility needs are more clear, with *PS* and *FIRE* sectors (744, 67, and 66) being the most centralized and the least influenced by the decentralization process.[xv]

On the other hand, the dynamic observed indicates that the *HTI* have decentralized more than the other manufacturing, and *FIRE* more than other services. The *PS* have decentralized to approximately the same degree and only the *KIS* have decentralized significantly less than other services. Therefore, taken together, information- and knowledge-intensive activities have experienced a decentralizing trend similar to the other sectors.

Deconcentration

The *Gini index* measures the municipal concentration of employment.[xvi] The data shows how *HTI sectors* and *FIRE, PS*, and *KIS* are more concentrated than other manufacturing and services sectors, respectively (Table 4). Lee (2007) has proposed a joint reading of the variation in time of the decentralization indices (weighted average distance to the CBD) and concentration (Gini index) to determine whether the decentralization of employment has occurred polycentrically (increase in the decentralization and concentration index) or in a dispersed way (increase in the decentralization index and fall in the concentration index). According to this criterion, between 1991 and 2001, three of the five *HTI* sectors (30, 244, and 353) and only one of the *KIS* sectors (73) and one of the *PS* sectors (745) would be decentralized in a concentrated way (polycentric). Although there is major variability between sectors, under this criterion it seems that employment in the *FIRE, PS,* and *KIS* sectors would have tended to be dispersed.

Polycentrism

Total Employment Subcenters

Of the 150 municipalities making up the BMR, not including Barcelona and its conurbation, only 6 in 1991 and 9 in 2001 have an above average employment density, accounting for more than 1% of employment (Table 5).

Concerning the importance of the different spatial areas measured according to their relative importance in employment, the results (Table 6) may be summarized in the following points: (1) the CBD (Barcelona + conurbation) has a high proportion of the jobs in the four group sectors, although the trend is lower; (2) the percentage of employment in the *HTI*, *FIRE, PS*, and *KIS* sectors concentrated in the CBD and subcenters is greater than in other manufacturing services and services, respectively; (3) the growth in employment in the *HTI, FIRE, PS,* and *KIS* sectors has been stronger in the subcenters than in other municipalities; and (4) in the subcenters, the growth of employment in the *HTI, FIRE, PS,* and *KIS* sectors has been greater than that of other manufacturing sectors and services. From the above it can be deduced that, rather than a process of dispersed decentralization, there appears to have been a trend toward polycentrism that has extended over a growing number of subcenters. The results support the idea that geographical proximity continues to be important, especially for information and knowledge-intensive sectors. As the subcenters are identified with the total number of jobs, this could mean that for these sectors that access to *urbanization economies* occurring in subcenters continues to be important, that the location is particularly convenient for attracting the maximum number of buyers located on the periphery, or both things at once.

Specialized Subcenters

A list of municipalities emerges for each of the 22 subsectors belonging to the categories *FIRE, PS, KIS,* and *HTI* from the identification of specialized subcenters, both for 1991 and for 2001.[xvii] From this information, we propose a typology of municipalities depending on the number and combination of subsectors in which they appear identified as subcenters (Table 7):

Edge city type of municipalities/subcenters. Within this category, we find three different groups. The first is made up of the municipalities identified as subcenters for a large number of subsectors—mainly *FIRE* and *PS* but also *KIS* and *HTI*. Their outstanding features are their diversity and capacity to incorporate *HTI* and *KIS* sectors into a specialization in *FIRE* and *PS* sectors, which are characteristic of edge cities. The municipalities corresponding to this profile are Terrassa, Sabadell, and Mataró, and to a lesser degree (less often identified as subcenters) Granollers, Martorell, and Vilanova.[xviii] The second group is made up of municipalities identified in a significant number of *PS* and *FIRE* sectors, as well as some *HTI* sectors. Castelldefels, Rubí, Barberà, Mollet, and Montcada make up this group. In 1991 they already showed clear specialization in *HTI*, and between 1991 and 2001 they advanced significantly, specializing in *FIRE* and *PS* sectors. The third group is made up of a single municipality, Vilafranca, which we can classify as a pure *edge city* (i.e., only specializing in the *FIRE* and *PS* subsectors).

Technopole type of municipalities/subcenters. These are municipalities identified as subcenters specializing in *HTI* and *KIS* subcenters and, to a lesser degree, *PS* and *FIRE* subcenters. Sant Cugat and Cerdanyola are in this category.

High-technology, small industrial poles. This is made up of municipalities identified only as subcenters specializing in *HTI*. Some municipalities are identified for several subsectors (Lliçà de Vall, Gavà, Franqueses del Vallès) and others in a single one (Llagosta, Abrera, Esparraguera, Palau, Vacarisses, Montornés, Martorelles, Masnou, Ripollet, Vilassar de Dalt, Sant Sadurní, Sant Quirze del Vallès, Cabrils).

Edge city type of subcenters form an arc around Barcelona at an average radius of around 25 km (Fig. 2). Their spatial arrangement corresponds to their origin as second-order Christallerian centers. The two *technopole* municipalities are contiguous and very near Barcelona, which could indicate the fact that they require fast access to the urbanization economies arising in the municipality of Barcelona. Finally, the *HTI industrial* poles are largely distributed in the northeastern quadrant, the area with greatest density of roads. The size of the points appearing on the map identifying the subcenters is proportional to the number of jobs contained in the four categories of sectors studied. In the case of *industrial HTI poles,* the most noticeable features are their small size and large number. In most cases they are medium/small municipalities where small industrial estates have proliferated over the last 20 years.

SUMMARY AND CONCLUSIONS

The results of the study can be summarized in the following points:

(1) The calculations of the decentralization and concentration indices and their variation between 1991 and 2001 indicate that the information- and knowledge-intensive sectors of the BMR are more concentrated and more centralized than other manufacturing and services. However, they do not appear to offer greater resistance to the decentralizing and deconcentrating trends than the other sectors, which would suggest a generalized trend towards dispersal.

(2) However, it is possible that the fall in the Gini index conceals a concentrated decentralization process (polycentrism) linked to an increasing number of subcenters. The identification of subcenters with total employment appears to confirm this idea (six subcenters identified in 1991, nine in 2001). The growth of the four groups of sectors has been stronger in the subcenters than in other municipalities (excluding BCN and its urban

continuum); and in the subcenters, the growth in employment in these sectors has been greater than in the other sectors. As the subcenters have been identified with total employment, this dynamism could be due to the fact that the information- and knowledge-intensive sectors are seeking good access to the urbanization economies in the subcenters (*agglomeration economies/knowledge externalities hypothesis*); although it could also indicate a trend toward seeking a location likely to capture the maximum peripheral market possible given the distribution of the other subcenters (*central place hypothesis*).

(3) The identification of *specialized subcenters* makes it possible to state that in 1991 they tended to coincide in the same municipalities regardless of the sector. These are the municipalities that have historically structured the peripheral territory, offering relatively specialized services (*PS and RIRE*) to the town and businesses of their area of influence, following a typically Christallerian pattern. It is important to highlight the fact that, as well as fulfilling this function, they have also been able to play an important role in the activities of the *KIS* and *HTI sectors.* On comparing these results with those of 2001, a trend is observed that the number of specialized subcenters is increasing—especially in the case of the HTI sectors—and that a major agglomeration of contiguous municipality-subcenters is emerging in the central part of the region. This change in the center of gravity of activity in the BMR may be due either to central place logic, or an increase in the radius of action of agglomeration economies so that such a spatially homogeneous distribution of the subcenters—typical of the Christallerian model—is not now as necessary as it was in 1991.

(4) The identification of specialized subcenters also makes it possible to detect three differentiated categories of municipality-subcenters: (a) those that basically bring together the *PS* and *FIRE* sectors, following a typical *edge-city* pattern, although in many cases also absorbing *KIS* and *HTI* activities; (b) *technopole*-municipalities with an outstanding

specialized profile in the KIS and HTI sectors; and (c) the smaller municipalities specializing in one or more HTI sectors (*HTI industrial poles*).

The main conclusion of the study is that the sectors that intensively use information and knowledge tend to be more concentrated than the others, either in the CBD or in subcenters. The results do not allow conclusions to be drawn as to whether this phenomenon is due to issues related to the physical proximity between firms that is required in order to generate and benefit from certain agglomeration economies (knowledge externalities) or a reorganization of productive space under a Christallerian central place logic. An interesting conclusion is that knowledge-intensive services (*KIS*) tend to be located where the concentration of *PS* and *FIRE* is large, while manufacturing sectors using advanced technology (*HTI*) appear to correspond to a different spatial logic. In addition, in the case of *HTI* sectors, the identification of specialized subcenters in 2001 has given rise to a list of municipalities so long that it prevents any kind of definitive declaration on whether the governing location model is polycentric or dispersed.

In relation to the theoretical debate regarding the impact of new communication technologies and the lowering of the costs of transport on the spatial concentration of economic activity, the results of the study suggest that physical proximity is important for numerous activities, especially those that incorporate more knowledge. If it is true that agglomeration economies have extended their radius of action, it is also true that they remain valid, and that for some sectors the radius is still small. The change in the spatial structure of cities should not be characterized as a simple process of dispersed decentralization because, while some sectors disperse, others stay highly concentrated in the center or periphery in the form of subcenters.

[i]Studies such as Pfister et al. (2000) or Lang (2003) found similar results for other cities.

[ii]Shearmur and Alvergne (2003) maintain that it is not appropriate to deduce a general law that is valid for any city from what is happening in a particular city (i.e., Los Angeles). Desmet and Fafchamps (2005) and Leslie and O'Huallacháin (2006) state that the available empirical evidence does not make it possible to maintain that employment growth in low-density, discontinuous environments follows a destructured or amorphous model. Giuliano et al. (2007) highlight the fact that polycentrism and dispersal should not have been presented as two incompatible models when the emergence of new subcenters has occurred despite the increasing importance of employment outside them.

[iii]Although there is no commonly accepted way of differentiating information and knowledge, in general it seems reasonable to state that knowledge implies complex use, both in abstract and applied terms, of information, and takes the form of people in the shape of human capital.

[iv]Ogawa and Fujita (1980), Palivos and Wang (1996), Berliant et al. (2002) among others. See White (1999) for an exhaustive review of the polycentric theoretical models of the NUE.

[v]Fujita (1988), Liu and Fujita (1991), Fujita and Mori (1997) among others.

[vi]This location logic must not be confused with so-called *forward linkages*. Normally the concept of *backward and forward linkages* is used in a very limited spatial context, where proximity between firms is an essential prerequisite. On the other hand, the idea of maximum accessibility of markets does not require extreme proximity between firm and customer, but rather a geographical location oriented according to the market area to be covered.

[vii]From this point of view, firms locating in edge cities would offer less specialized services than those locating in the main CBD, but more specialized than those distributed in a dispersed way.

[viii]In general, the work has been done with the idea of a city or metropolitan area as a single point within the inside-outside logic. In the case of industrial districts and technopoles, the trend has been to place the emphasis on the new opportunities emerging for medium-sized

cities. On an intrametropolitan level, the role of the CBD has been highlighted as bringing together human capital. The few studies adapted to a polycentric approach are Scott (1992) and especially Suárez-Villa and Walrod (1997).

[ix]For the case of population, Muñiz et al. (2003) estimate a cubic spline density, which admits the existence of local maxima and minima for different samples of the metropolitan territory. The methodology used enables them to analyze for each center of employment/population their relative position (distance from CBD), their size, the delimitation of their boundaries, the density conditions that arise in their surroundings, and most of all the different impacts of their history, geography, and provision of infrastructures.

[x]See http://www.ine.es/censo2001/cuestionarios.htm for more information.

[xi]Based on the percentage of R+D expenditure (OECD, 2001, 2003).

[xii]In this case, the sectors were selected according to R+D expenditure, the use of incorporated technology, and the qualifications of workers (OECD, 2001, 2003).

[xiii]Together, although grouped in a different way, the sectors studied are those the OECD classifies as high technology and knowledge sectors, excluding average/high technology manufacturing (sectors 24—except 244—29, 31 34, 352, 354, and 355) and services sector 71 (hire of machinery and equipment without operators and of personal and household goods). The reason for not including average/high technology manufacturing is that, for the objectives of the study, we consider the knowledge component more important than the application of new technologies or R+D expenditure (Godin, 2004; van Oort and Raspe, 2005) and we do not consider sector 71 because it does not usually include the FIRE or PS groupings that are commonly used in the international literature.

[xiv]Weighted by the share of municipal employment.

[xv]Barcelona's airport is very close to the municipality of Barcelona. Computations of a weighted distance to Barcelona's airport showed similar results to the weighted distance to the CBD.

[xvi]Due to its size in terms of employment, the municipality of Barcelona has been removed from the sample in order not to distort the concentration measurements concerning the more peripheral municipalities.

[xvii]Available from authors upon request.

[xviii]In 1991 Sabadell was the municipality which particularly showed a clear balance between the three groups of subsectors. Terrassa and Mataró have caught up with Sabadell and Granollers, although they originally had a lesser presence of *HTI* sectors and *KIS* sectors. The case of Martorell is somewhat peculiar as in 1991 it was identified as a subsector only for *HTI* sectors, so it has experienced major dynamism in *PS, FIRE,* and *KIS* sectors compared to its initial situation.

REFERENCES

Adams, J. D. and Jaffe, A. B., 1996, Bounding the effects of R&D: an investigation using matched establishment-firm data. *The Rand Journal of Economics*, Vol. 94, 700-721.

Almeida, P. and Kogut, B., 1997, The exploration of technological diversity and the geographic localization of innovation. *Small Business Economics*, Vol. 9, 21-31.

Anas, A. Arnott, R. y K.A. Small, 1998. Urban spatial structure, Journal of Economic Literature, 36, pp. 1426-1464.

Audretsch, D. B. and Feldman, M., 1996, Spillovers and the geography of innovation and production. *American Economic Review*, Vol. 86, 630-640.

Becattini, G., 1990, The Marshallian industrial district as a socio-economic notion. In F. Pyke, G. Becattini and W. Sengenberger, editors, *Industrial Districts and Inter-firm Cooperation in Italy*, Geneva: International Institute for Labour Studies, 37-52.

Berliant, M., Peng, S. K., and Wang, P., 2002, Production externalities and urban configuration. *Journal of Economic Theory*, Vol. 104, 275-303.

Best, M., 1990, *The new competition. Institutions of industrial restructuring*. Cambridge, MA: Harvard University Press.

Bodenman, J. E., 1998, The suburbanization of the institutional investment advisory industry. Metropolitan Philadelphia, 1983-1993. *Professional Geographer*, Vol. 50, 112-126.

Bogart, W. T., 2006, *Don't call it sprawl*. Cambridge, MA: Cambridge University Press.

Bogart, W. T. and Ferry, W. C., 1999, Employment centres in Greater Cleveland: Evidence of evolution in a formerly monocentric city. *Urban Studies*, Vol. 36, 2099-2110.

Boix, R., 2006a, Localización de empresas en sectores intensivos en conocimiento en la región metropolitana de Barcelona (Firm location in knowledge sectors in the Barcelona metropolitan region). In C. Guallarte, editor, *Global Entrepreneurship Monitor, Informe Ejecutivo—Cataluña*. Barcelona: Institut d'Estudis Regionals i Metropolitans de Barcelona, 144-147.

Boix, R., 2006b, *Barcelona ciudad del conocimiento: Economía del conocimiento, tecnologías de la información y la comunicación de nuevas estrategias urbanas. (Knowledge economy, information Technologies and new urban strategies communication)*. Barcelona: Ajuntament de Barcelona, Gabinet Tècnic de Programació.

Brackzyk, H. J., Cooke, P. and Heidenreich, M., 1998, *Regional innovation systems: The role of governance in a globalised world*. London: UCL Press.

Brenner, T., 2000, Industrial districts: A typology from an evolutionary perspective. Unpublished paper presented at the DRUID's Summer 2000 Conference, Rebild, Denmark.

Bryson, J. R., 1997, Business service firms, service space and management of change. *Entrepreneurship and Regional Development*, Vol. 9, 93-111.

Bryson, J. R., Wood, P. and Keeble, D., 1993, Business networks, small firm flexibility and regional development in UK business services. *Entrepreneurship and Regional Development*, Vol. 5, 265-277.

Cairncross, F., 1997, *The death of distance: How the communications revolution will change our lives*. Boston, MA: Harvard Business School.

Castells, M., 1989, *The informational city*. Oxford: Basil Blackwell.

Champion, A.G., 2001, A changing demographic regime and evolving polycentric urban regions: Consequences for the size, composition and distribution of city populations. *Urban Studies*, 38, 657-677.

Coffey, W. and Polèse, M., 1987, The distribution of high technology manufacturing and services in the Canadian urban space. *Revue d'Economie Régionale et Urbaine*, Vol. 2, 279-299.

Coffey, W. and Shearmur, R., 2002, Agglomeration and dispersion of high-order service employment in the Montreal metropolitan region. *Urban Studies*, Vol. 39, 359-378.

Combes, P., 2000, Economic structure and local growth: France, 1984-1993. *Journal of Urban Economics,* Vol. 47, 329-355.

Cooke, P. and Morgan, K, 1993, The network paradigm: new departures in corporate and regional development. *Environment and Planning D*, Vol. 11, 543-564.

Daniels, P., 1993, *Service industries in the world economy*. Oxford: Blackwell.

Davoudi, A., 2003, Polycentricity in European Spatial Planning: From an analytical tool to a normative agenda. *European Spatial Planning*, Vol. 11, 979-999.

Desmet, K. and Fafchamps, M., 2005, Changes in the spatial concentration of employment across US counties: A sectoral analysis 1972-2000. *Journal of Economic Geography*, Vol. 5, 261-284.

Duranton, G. and Puga, D., 2001, Nursery cities: Urban diversity, process innovation, and the life cycle of products. *American Economic Review*, Vol. 91, 5, 1454-1477.

Echevarría, J., 1996, *Telépolis, la ciudad sin territorio (Telepolis, the city without territory)*. Girona: Universitat de Girona.

Fishman, R., 1998, Beyond Utopia: Urbanism after the end of cities. In Various Authors, *Real city, ideal city. Signification and function in modern space.* Barcelona: Centre de Cultura Contemporània de Barcelona, 29-36.

Florida, R., 2002, *The rise of the creative class*. New York: Basic Books.

Forstall, R. L. and Greene, R. P., 1997, Defining job concentrations: The Los Angeles case. *Urban Geography*, Vol. 18, 705-739.

Fujita, M., 1988, A monopolistic competition model of spatial agglomeration: Differentiated products approach. *Regional Science and Urban Economics*, Vol. 18, 87-124.

Fujita, M. and Mori, T., 1997, Structural stability and evolution of urban systems. *Regional Science and Urban Economics*, Vol. 27, 399-442.

Gallaud, D. and Torre, A., 2005, *Dynamiques de Proximité*. Paris: L'Harmattan.

Garcia-López, M. A., 2008, Quince años de suburbanización en la Barcelona metropolitana, ¿se está dispersando la población? (Fifteen years of suburbanization in the Barcelona Metropolitan Region, is the population dispersing?). *Investigaciones Económicas*, Vol. 32, 53-86.

Garreau, J., 1991, *Edge city: Life in the new frontier*. New York: Doubleday.

Gillham, O., 2002, *The limitless city. A primer on the urban sprawl debate*. Washington: Island Press.

Giuliano, G., Redfearn, C. L., Agarwal, A., Li, C., and Zhuang, D., 2007, Employment concentrations in Los Angeles, 1980-2000. *Environment and Planning A*, Vol. 39, 2935-2957.

Giuliano, G. and Small, K. A., 1991, Subcenters in the Los Angeles region, *Regional Science and Urban Economics,* Vol. 21, 163-182.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A. and Shleifer, A., 1992, Growth in cities. *Journal of Political Economy*, Vol. 100, 1126-1152.

Godin, B., 2004, The New Economy: What the concept owes to the OECD. *Research policy*, Vol. 33, 679-690.

Gordon, P., and Richardson, H. W., 1996, Beyond polycentricity. The dispersed metropolis, Los Angeles, 1970-1990. *Journal of the American Planning Association*, Vol. 62, 289-295.

Hall, P., 1997, The future of the metropolis and its form. *Regional Studies*, Vol. 31, 211-220.

Harrington, J. W. and Campbell, H. S., 1997, The suburbanization of Producer Services Employment. *Growth and Change*, Vol. 28, 335-359.

Harrison, B., Kelley, M. R. and Gant, J., 1996, Specialization versus diversity in local economies: The implications for innovative private-sector behaviour. *Cityscape*, Vol. 2, 61-93.

Henderson, J. V., 2003, Marshall's scale economies. *Journal of Urban Economics*, Vol. 53, 1-28.

Howells, J. R. L., 2002, Tacit knowledge, innovation and Economic Geography. *Urban Studies*, Vol. 39, 871-884.

Ihlanfeldt, K. R., 1995, The importance of the central city to the regional and national economy. A review of the arguments and empirical evidence. *Cityscape*, Vol. 1, 125-150.

Illeris, S., 1996, *The Service Economy. A geographical approach*, Chichester: John Wiley.

Indovina, F., 1998, Algunes consideracions sobre la ciutat difusa (Some considerations about the diffuse city). *Documents d'Anàlisi Geogràfica*, Vol. 33, 21-32.

Jacobs, J., 1961, *The death and life of great American cities*. New York: Random House.

Jaffe, A. B. and Trajtenberg, M., 1999, International knowledge flows: evidence from patent citations. *Economics of Innovation and New Technology*, Vol. 8, 105-136.

Jaffe, A. B., Trajtenberg, M. and Henderson, R., 1993, Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, Vol. 108, 577-598.

Kelley, M. R. and Helper, S., 1999, Firm size and capabilities, regional agglomeration, and the adoption of new technology. *Economics of Innovation and New technology*, Vol. 8, 79-103.

Kloosterman, R. and Musterd, S., 2001, Polycentric urban region as a research concept. *Urban Studies*, Vol. 38, 619-629.

Knight, R. V., 1995, Knowledge-based development: Policy and planning implications for cities. *Urban Studies*, Vol. 32, 225-260.

Krugman, P., 1991, *Geography and trade*. Cambridge, MA: MIT Press.

Lang, R. E., 2003, *Edgeless cities: Exploring the elusive metropolis*. Washington DC: Brookings Institution.

Lee, B., 2007, "Edge" or "edgeless" cities? Urban spatial structure in U.S. metropolitan areas, 1980 to 2000. *Journal of Regional Science*, Vol. 47, 479-515.

Lehrer, U. A., 1994, Images of the periphery. *Environment and Planning D*, Vol. 12, 187-205.

Leslie, T. F. and ÓhUallacháin, B., 2006, Polycentric Phoenix. *Economic Geography*, Vol. 82, 167-192.

Liu, H. L. and Fujita, M., 1991, A monopolistic competition model of spatial agglomeration with variable density. *Annals of Regional Science*, Vol. 25, 81-99.

Maillat, D. and Perrin, J. C., 1992, *Enterprises Innovatrices at réseaux locaux*. Neuchâtel: GREMI.

Mancomunitat de Municipis de l'Àrea Metropolitana de Barcelona, 1995, *Dinàmiques metropolitanes a l'àrea i la regió de Barcelona*. Barcelona: Diputació de Barcelona.

Marshall, A., 1890, *Principles of economics*. London: MacMillan.

Marmolejo, C. and Roca, J. (2008) La localización intrametropolitana de las actividades de la información: un análisis para la Región Metropolitana de Barcelona 1991-2001 (The intra-metropolitan location of information activities: A spatial analysis for the Barcelona

Metropolitan Region). *Scripta Nova. Revista electrónica de geografía y ciencias sociales,* Vol. 268, 1-30.

Maskell, P. and A, Malmberg, 1999, Localised learning and industrial competitiveness. *Cambridge Journal of Economics*, Vol. 21, 167-185.

McDonald, J. F., 1987, The identification of urban employment subcenters. *Journal of Urban Economics,* Vol. 21, 242-258.

McDonald, J. F. and McMillen, D. P., 1990, Employment subcenters and land values in a polycentric urban area: The case of Chicago. *Environment and Planning A*, Vol. 22, 1561-1574.

Mieszkowski, P. and Mills, E. S., 1993, The causes of metropolitan suburbanization. *Journal of Economic Perspectives*, Vol. 7, 135-147.

Muñiz, I., Galindo, A. and Garcia-López, M. A., 2003, Cubic spline population density functions and satellite city delimitation: The case of Barcelona. *Urban Studies*, Vol. 40, 1303-1321.

Muñiz, I., Garcia-López, M. A., and Galindo, A., 2008, The effect of employment subcenters on population density in Barcelona. *Urban Studies*, Vol. 45, 627-649.

Muñoz, F., 2005, La producció residencial de baixa densitat (The low density residential production). *Elements de Debat Territorial*, Vol. 21, Diputació de Barcelona, Xarxa de Municipis.

OECD, 2001, *OECD Science, technology and Industry Scoreboard 2001: Towards a knowledge based economy*. Paris: Organisation for Economic Co-operation and Development.

OECD, 2003, *OECD Science, technology and Industry Scoreboard 2003.* Paris: Organisation for Economic Co-operation and Development.

Ogawa, H. and Fujita, M., 1980, Equilibrium land use patterns in a nonmonocentric city. *Journal of Regional Science*, Vol. 20, 455-475.

Pain, K. and Hall, P., 2008, Information quantity versus informational quality: The perils of navigating the space of flows. *Regional Studies*, Vol. 42, 1065-1077.

Palivos, T. and Wang, P., 1996, Spatial agglomeration and endogenous growth. *Regional Science and Urban Economics*, Vol. 26, 645-669.

Papageorgiou, G. J. and Pines, D., 1999, *An essay on Urban Economic theory*. Boston, MA: Kluwer Academic Publishers.

Pfister, N., Freestone, R. and Murphy, P., 2000, Polycentricity or dispersion? Changes in center employment in Metropolitan Sydney. *Urban Geography*, Vol. 21, 428-442.

Pressman, N., 1985, Forces for spatial change. In J. Brotchie, P. Newton, P. Hall and P. Nijkamp, editors, *The future of urban form. The impact of new technology*. London: Routeledge, 349-361.

Redfearn, C. L., 2007, The topography of metropolitan employment: Identifying centers of employment in a polycentric urban area. *Journal of Urban Economics*, Vol. 61, 519-541.

Richardson, H. W., 1995, Economies and diseconomies of agglomeration. In H. Giersch, editor, *Urban agglomeration and economic growth*, Berlin: Springer-Verlag, 123-155.

Roca, J., Burns, M. C. and Carreras, J. M., 2004, *Monitoring urban sprawl around Barcelona's Metropolitan Area with the aid of satellite imagery.* Unpublished paper presented at the XX Congress of the International Society for Photogrammetry and Remote Sensing (ISPRS), Istanbul, Turkey.

Rosenthal, S. S. and Strange, W. C., 2003, Geography, industrial organization, and agglomeration. *Review of Economics and Statistics*, Vol. 85, 377-393.

Scott, A. J., 1988, *Metropolis. From the division of Labour to urban form*. Berkeley: University of California Press.

Scott, A. J., 1992, The role of large producers in industrial districts: A case study of high technology systems houses in Southern California. *Regional Studies*, Vol. 26, 265-275.

Scott, A. J., 2001, Global city-regions: Trends, theory, policy. Oxford: Oxford University Press.

Shearmur, R. and Alvergne, C., 2002, Intrametropolitan patterns of high-order business service location: A comparative study of seventeen sectors in Ile-de-France. *Urban Studies*, Vol. 39, 1143-1163.

Shearmur, R. and Alvergne, C., 2003, Regional planning policy and the location of employment in the Ile-de-France. Does policy matter? *Urban Affairs Review*, Vol. 39, 3-31.

Shearmur, R. and Coffey, W. J., 2002, A tale of four cities: Intrametropolitan employment distribution in Toronto, Montreal, Vancouver and Ottawa-Hull 1981-1996. *Environment and Planning A*, Vol. 34, 575-598.

Shearmur, R., Coffey, W., Dubé, C. and Barbonne, R., 2007, Intrametropolitan employment structure: Polycentricity, scatteration, dispersal and chaos in Toronto, Montreal and Vancouver, 1996-2001. *Urban Studies*, Vol. 44, 1713-1738.

Simmie, J. (2005) Innovation and space: A critical review of the literature, *Regional Studies*, 39: 789-804.

Stanback, T. M., 1991, *The new suburbanization*. Boulder, CO: Westview Press.

Storper, M. and Venables, A. J., 2004, Buzz: Face-to-face contact and the urban economy. *Journal of Economic Geography*, Vol. 4, 351-370.

Suárez-Villa, L., 1999, El sur de California como región global: policentrismo y segmentación de redes como ventaja competitiva (Southern California as global region: polycentrism and network segmentation as competitive advantage). *Ciudad y Territorio*, Vol. 121, 521-536.

Suárez-Villa, L. and Walrod, W., 1997, Operational strategy, R&D and intra-metropolitan clustering in a polycentric structure: The advanced electronics industries of the Los Angeles basis. *Urban Studies*, Vol. 34, 1343-1380.

Torre, A. and Rallet, A., 2005, Proximity and localization. *Regional Studies*, Vol. 39, 47-59.

Trullén, J., Lladós, J. and Boix, R., 2002, Economía del conocimiento, ciudad y competitividad (Knowledge economy, city and competitiveness). *Investigaciones Regionales*, Vol. 1, 139-164.

van Oort, F. G. and Raspe, O., 2005, The knowledge economy and Dutch cities. Paper presented at the European Regional Science Conference (ERSA), Amsterdam, Holland.

van Winden, W. and van den Berg, L., 2004, Cities in the knowledge economy: New governance challenges. Rotterdam: European Institute for Comparative Urban Research Discussion paper.

Vesclir, L., 2007, Paisajes de la nueva centralidad (New centrality landscapes). *Urban*, Vol. 12, 34-55.

Wang, F., 1999, Modeling a central place system with interurban transport costs and complex rural hinterlands. *Regional Science and Urban Economics*, Vol. 29, 381-409.

White, M. J., 1999, Urban areas with decentralized employment: Theory and empirical work. In P. Cheshire and E. S. Mills, editors, *Handbook of Regional and Urban Economics Volume 3 Applied Urban Economics*. Amsterdam: North-Holland, 1375-1412.

Yigitcanlar, T., Baum, S. and Horton, S., 2007, Attracting and retaining knowledge workers in knowledge cities. *Journal of Knowledge Management*, Vol. 11, 6-17.

TABLES

TABLE 1.—Specialized Services, and Knowledge- and Technology-Based Activities*

High-technology industries (HTI)	**Finance, insurance, and real estate (FIRE)**
30 Manufacture of office, accounting, and computing machinery 32 Manufacture of radio, television, and communication equipment and apparatus 33 Manufacture of medical, precision and optical instruments, watches and clocks 244 Manufacture of pharmaceutical products 353 Manufacture of aircraft and spacecraft	65 Financial intermediation, except insurance and pension funding 66 Insurance and pension funding, except compulsory social security 67 Activities auxiliary to financial intermediation 70 Real estate activities
Producer services (PS)	**Knowledge-intensive services (KIS)**
741 Legal, accounting, bookkeeping, and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy 742 Architectural and engineering activities 743 Technical tests and analysis 744 Advertising 745 Staff selection 746 Security and investigation services 747 Industrial cleaning activities 748 Other producer services	64 Post and telecommunications 72 Computer and related activities 73 Research and development 80 Education 85 Health and social work

*Spanish sectoral classification CNAE-93 Rev.1 based on the International Standard Industrial Classification Rev. 3.

TABLE 2.—Employment Dynamics in the BMR, 1991-2001

	1991	**2001**	**1991-2001**
Total	1,557,417	1,811,304	253,887 (16.30%)**
HTI	40,104 (2.58%)*	29,785 (1.64%)	-10,319 (-25.73%)
Other manufacturing	538,566 (34.58%)	442,528 (24.43%)	-96,038 (-17.83%)
FIRE	65,556 (4.21%)	79,726 (4.40%)	14,170 (21.62%)
PS	92,863 (5.96%)	133,580 (7.37%)	40,717 (43.85%)
KIS	179,617 (11.53%)	305,708 (16.88%)	126,091 (70.20%)
Other services	525,866 (33.77%)	678,111 (37.44%)	152,245 (28.95%)

*Percentage of employment compared to the total for the BMR in brackets.
**Employment growth rate in brackets.

TABLE 3.—Decentralization in the BMR, 1991-2001: HTI, FIRE, PS and KIS

Weighted average distance to the CBD (km)	1991	2001	1991-2001
30 Manufacture of office, accounting, and computing machinery	4.73	9.55	4.81
32 Manufacture of radio, television, and communication equipment	9.31	13.43	4.12
33 Manufacture of medical, precision and optical instruments	8.31	10.03	1.72
244 Manufacture of pharmaceutical products	8.92	10.96	2.03
353 Manufacture of aircraft and spacecraft	11.41	11.78	0.37
HTI	**8.38**	**11.57**	**3.19**
Other manufacturing	**12.15**	**15.06**	**2.91**
65 Financial intermediation, except insurance and pension funding	6.46	8.70	2.24
66 Insurance and pension funding	4.42	5.62	1.20
67 Activities auxiliary to financial intermediation	3.89	5.53	1.64
70 Real estate activities	4.57	9.39	4.82
FIRE	**5.63**	**7.91**	**2.28**
741 Legal, accounting activities, and management consultancy	4.55	6.86	2.31
742 Architectural and engineering activities	5.02	7.59	2.56
743 Technical tests and analysis	5.34	12.58	7.24
744 Advertising	2.96	4.76	1.81
745 Staff selection	6.68	8.67	1.99
746 Security and investigation services	5.61	6.93	1.32
747 Industrial cleaning activities	7.02	9.36	2.34
748 Other producer services	7.76	7.58	-0.19
PS	**5.69**	**7.52**	**1.83**
64 Post and telecommunications	5.64	5.85	0.21
72 Computer and related activities	4.61	5.63	1.02
73 Research and development	6.48	6.90	0.42
80 Education	9.16	9.99	0.84
85 Health and social work	7.07	8.98	1.92
KIS	**7.56**	**8.51**	**0.95**
Other services	**8.37**	**10.32**	**1.95**

TABLE 4.—Deconcentration in the BMR, 1991-2001: HTI, FIRE, PS and KIS

Municipal Gini (without Barcelona)	1991	2001	1991-2001
30 Manufacture of office, accounting, and computing machinery	0.8393	0.8559	0.0166
32 Manufacture of radio, television, and communication equipment	0.8166	0.7708	-0.0458
33 Manufacture of medical, precision, and optical instruments	0.8157	0.7963	-0.0194
244 Manufacture of pharmaceutical products	0.7717	0.8075	0.0358
353 Manufacture of aircraft and spacecraft	0.8649	0.9215	0.0566
HTI	**0.7685**	**0.7582**	**-0.0103**
Other manufacturing	**0.7133**	**0.6803**	**-0.0330**
65 Financial intermediation, except insurance and pension funding	0.8045	0.7813	-0.0232
66 Insurance and pension funding	0.8439	0.8023	-0.0416
67 Activities auxiliary to financial intermediation	0.8236	0.7813	-0.0423
70 Real estate activities	0.7772	0.7335	-0.0437
FIRE	**0.8034**	**0.7696**	**-0.0338**
741 Legal, accounting activities, and management consultancy	0.8077	0.7783	-0.0293
742 Architectural and engineering activities	0.7657	0.7349	-0.0308
743 Technical tests and analysis	0.8442	0.7759	-0.0683
744 Advertising	0.8225	0.7689	-0.0536
745 Staff selection	0.8220	0.8360	0.0140
746 Security and investigation services	0.8315	0.7884	-0.0432
747 Industrial cleaning activities	0.8172	0.7627	-0.0544
748 Other producer services	0.7936	0.7482	-0.0454
PS	**0.7997**	**0.7552**	**-0.0445**
64 Post and telecommunications	0.8219	0.7795	-0.0424
72 Computer and related activities	0.8351	0.8095	-0.0256
73 Research and development	0.8138	0.8474	0.0336
80 Education	0.7809	0.7308	-0.0501
85 Health and social work	0.8464	0.7864	-0.0600
KIS	**0.8035**	**0.7589**	**-0.0446**
Other services	**0.7452**	**0.7163**	**-0.0289**

TABLE 5.—Employment Subcenters Identified with Total Employment Thresholds

1991	2001
Granollers Mataró Rubí Sabadell Terrassa Cerdanyola del Vallès	Granollers Mataró Rubí Sabadell Terrassa Cerdanyola del Vallès Martorell Sant Cugat del Vallès Vilanova i la Geltrú

TABLE 6—Employment Dynamics in the Spatial Areas, 1991-2001 (I): HTI, FIRE, PS, KIS

	1991	2001	1991-2001	1991	2001	1991-2001
		HTI			**Other manufacturing**	
Barcelona	19,391 (48.35%)*	9,767 (32.79%)	-9,624 (-49.63%)**	188,903 (35.08%)	102,945 (23.26%)	-85,958 (-45.50%)
CBD (Barcelona and conurbation)	26,599 (66.33%)	14,478 (48.61%)	-12,121 (-45.57%)	286,310 (53.16%)	175,530 (39.67%)	-110,780 (-38.69%)
Subcenters***	3,966 (9.89%)	5,365 (18.01%)	1,399 (35.27%)	88,833 (16.49%)	99,267 (22.43%)	10,434 (11.75%)
Centers (CBD and subcenters)	30,565 (76.21%)	19,843 (66.62%)	-10,722 (-35.08%)	375,143 (69.66%)	274,797 (62.10%)	-100,346 (-26.75%)
Other municipalities	9,539 (23.79%)	9,942 (33.38%)	403 (4.22%)	163,423 (30.34%)	167,731 (37.90%)	4,308 (2.64%)
		FIRE			**PS**	
Barcelona	46,174 (70.43%)	46,520 (58.35%)	346 (0.75%)	61,990 (66.75%)	78,127 (58.49%)	16,137 (26.03%)
CBD (Barcelona and conurbation)	51,647 (78.78%)	55,399 (69.49%)	3,752 (7.26%)	73,317 (78.95%)	94,917 (71.06%)	21,600 (29.46%)
Subcenters***	7,318 (11.16%)	13,317 (16.70%)	5,999 (81.98%)	9,197 (9.90%)	19,749 (14.78%)	10,552 (114.73%)
Centers (CBD and subcenters)	58,965 (89.95%)	68,716 (86.19%)	9,751 (16.54%)	82,514 (88.86%)	114,666 (85.84%)	32,152 (38.97%)
Other municipalities	6,591 (10.05%)	11,010 (13.81%)	4,419 (67.05%)	10,349 (11.14%)	18,914 (14.16%)	8,565 (82.76%)
		KIS			**Other services**	
Barcelona	100,652 (56.04%)	161,655 (52.88%)	61,003 (60.61%)	284,845 (54.17%)	307,719 (45.38%)	22,874 (8.03%)
CBD (Barcelona and conurbation)	128,961 (71.80%)	207,338 (67.82%)	78,377 (60.78%)	367,533 (69.89%)	420,723 (62.04%)	53,190 (14.47%)
Subcenters***	24,692 (13.75%)	51,425 (16.82%)	26,733 (108.27%)	59,912 (11.39%)	108,766 (16.04%)	48,854 (81.54%)
Centers (CBD and subcenters)	153,653 (85.54%)	258,763 (84.64%)	105,110 (68.41%)	427,445 (81.28%)	529,489 (78.08%)	102,044 (23.87%)
Other municipalities	25,964 (14.46%)	46,945 (15.36%)	20,981 (80.81%)	98,421 (18.72%)	148,622 (21.92%)	50,201 (51.01%)

*Percentage of employment compared to the total for the BMR in brackets.
**Employment growth rate in brackets.
***Subcenters identified with total employment thresholds: 6 in 1991 and 9 in 2001.

TABLE 7.—A typology of Employment Subcenters, 2001

Type	Municipalities		
Edge cities	Terrassa	Castelldefels	
	Sabadell	Rubí	
	Mataró	Barberà	Vilafranca del
	Granollers	Mollet	Penedès
	Vilanova G.	Montcada i	
	Martorell	Reixac	
Technopoles	Sant Cugat del Vallès		
	Cerdanyola del Vallès		
High-technology industrial poles	Lliçà de Vall		
	Gavà		
	Les Franqueses del Vallès		
	Parets del Vallès		
	Vacarisses		La Llagosta
	Montornés		Abrera
	Masnou		Esparraguera
	Ripollet		Palau de Plegamans
	Vilassar de Dalt		
	Sant Sadurní d'Anoia		
	Sant Quirze del Vallès		
	Cabrils		

TABLE 8.—Employment Dynamics in the Spatial Areas, 1991-2001 (II): HTI and FIRE

		CBD			Subcenters***			Other municipalities		
		1991	**2001**	**91-01**	**1991**	**2001**	**91-01**	**1991**	**2001**	**91-01**
HTI	30 Manufacture of office, accounting, and computing machinery	3,530 (79.34%)*	259 (50.88%)	-3,271 (-92.66%)**	389 (8.74%)	177 (34.77%)	-212 (-54.50%)	530 (11.91%)	73 (14.34%)	-457 (-86.23%)
	32 Manufacture of radio, television, and communication equipment	3,189 (60.42%)	3,542 (41.00%)	353 (11.07%)	1,421 (26.92%)	3,320 (38.43%)	1,899 (133.64%)	668 (12.66%)	1,777 (20.57%)	1,109 (166.02%)
	33 Manufacture of medical, precision, and optical instruments	5,935 (66.47%)	1,575 (61.43%)	-4,360 (-73.46%)	1,438 (16.10%)	493 (19.23%)	-945 (-65.72%)	1,556 (17.43%)	496 (19.34%)	-1,060 (-68.12%)
	244 Manufacture of pharmaceutical products	13,868 (65.08%)	9,010 (50.31%)	-4,858 (-35.03%)	3,143 (14.75%)	5,538 (30.92%)	2,395 (76.20%)	4,299 (20.17%)	3,362 (18.77%)	-937 (-21.80%)
	353 Manufacture of aircraft and spacecraft	77 (55.80%)	92 (56.44%)	15 (19.48%)	42 (30.43%)	60 (36.81%)	18 (42.86%)	19 (13.77%)	11 (6.75%)	-8 (-42.11%)
FIRE	65 Financial intermediation, except insurance and pension funding	29,390 (75.82%)	26,013 (66.03%)	-3,377 (-11.49%)	5,020 (12.95%)	7,014 (17.81%)	1,994 (39.72%)	4,352 (11.23%)	6,366 (16.16%)	2,014 (46.28%)
	66 Insurance and pension funding	13,576 (82.84%)	15,686 (78.39%)	2,110 (15.54%)	1,719 (10.49%)	2,206 (11.03%)	487 (28.33%)	1,093 (6.67%)	2,117 (10.58%)	1,024 (93.69%)
	67 Activities auxiliary to financial intermediation	1,317 (85.69%)	3,061 (78.87%)	1,744 (132.42%)	70 (4.55%)	307 (7.91%)	237 (338.57%)	150 (9.76%)	513 (13.22%)	363 (242.00%)
	70 Real estate activities	7,364 (83.03%)	10,639 (64.70%)	3,275 (44.47%)	485 (5.47%)	2,630 (15.99%)	2,145 (442.27%)	1,020 (11.50%)	3,174 (19.30%)	2,154 (211.18%)

*Percentage of employment compared to the total for the BMR in brackets.
**Employment growth rate in brackets.
***Subcenters identified with subsectoral thresholds.

TABLE 9.—Employment Dynamics in the Spatial Areas, 1991-2001 (II): PS and KIS

		CBD			Subcenters***			Other municipalities		
		1991	**2001**	**1991-2001**	**1991**	**2001**	**1991-2001**	**1991**	**2001**	**1991-2001**
PS	741 Legal, accounting activities, and management consultancy	14,476 (82.75%)*	32,901 (73.61%)	18,425 (127.3%)**	1,346 (7.69%)	5,308 (11.88%)	3,962 (294.35%)	1,672 (9.56%)	6,486 (14.51%)	4,814 (287.92%)
	742 Architectural and engineering activities	8,276 (80.47%)	14,769 (69.53%)	6,493 (78.46%)	738 (7.18%)	3,182 (14.98%)	2,444 (331.17%)	1,271 (12.36%)	3,290 (15.49%)	2,019 (158.85%)
	743 Technical tests and analysis	796 (78.04%)	608 (52.32%)	-188 (-23.62%)	126 (12.35%)	314 (27.02%)	188 (149.21%)	98 (9.61%)	240 (20.65%)	142 (144.90%)
	744 Advertising	8,176 (88.65%)	9,941 (82.34%)	1,765 (21.59%)	182 (1.97%)	758 (6.28%)	576 (316.48%)	865 (9.38%)	1,374 (11.38%)	509 (58.84%)
	745 Staff selection	3,096 (74.28%)	1,167 (63.18%)	-1,929 (-62.31%)	558 (13.39%)	474 (25.66%)	-84 (-15.05%)	514 (12.33%)	206 (11.15%)	-308 (-59.92%)
	746 Security and investigation services	15,387 (80.30%)	7,989 (74.27%)	-7,398 (-48.08%)	1,385 (7.23%)	980 (9.11%)	-405 (-29.24%)	2,389 (12.47%)	1,787 (16.61%)	-602 (-25.20%)
	747 Industrial cleaning activities	15,164 (74.04%)	20,707 (64.29%)	5,543 (36.55%)	2,943 (14.37%)	5,606 (17.41%)	2,663 (90.49%)	2,373 (11.59%)	5,896 (18.31%)	3,523 (148.46%)
	748 Other producer services	7,946 (72.03%)	6,835 (71.22%)	-1,111 (-13.98%)	1,262 (11.44%)	1,106 (11.52%)	-156 (-12.36%)	1,824 (16.53%)	1,656 (17.26%)	-168 (-9.21%)
KIS	64 Post and telecommunications	14,331 (79.84%)	30,276 (78.23%)	15,945 (111.26%)	1,572 (8.76%)	3,132 (8.09%)	1,560 (99.24%)	2,046 (11.40%)	5,293 (13.68%)	3,247 (158.70%)
	72 Computer and related activities	11,712 (80.59%)	29,496 (75.43%)	17,784 (151.84%)	1,643 (11.31%)	5,384 (13.77%)	3,741 (227.69%)	1,178 (8.11%)	4,225 (10.80%)	3,047 (258.66%)
	73 Research and development	5,424 (71.51%)	730 (69.06%)	-4,694 (-86.54%)	1,169 (15.41%)	204 (19.30%)	-965 (-82.55%)	992 (13.08%)	123 (11.64%)	-869 (-87.60%)
	80 Education	47,977 (65.02)	66,542 (61.20%)	18,565 (38.70%)	13,046 (17.68%)	18,812 (17.30%)	5,766 (44.20%)	12,760 (17.29%)	23,367 (21.49%)	10,607 (83.13%)
	85 Health and social work	49,517 (75.29%)	80,294 (67.97%)	30,777 (62.15%)	8,711 (13.25%)	17,155 (14.52%)	8,444 (96.93%)	7,539 (11.46%)	20,675 (17.50%)	13,136 (174.24%)

*Percentage of employment compared to the total for the BMR in brackets.
**Employment growth rate in brackets.
***Subcenters identified with subsectoral thresholds.

FIGURES

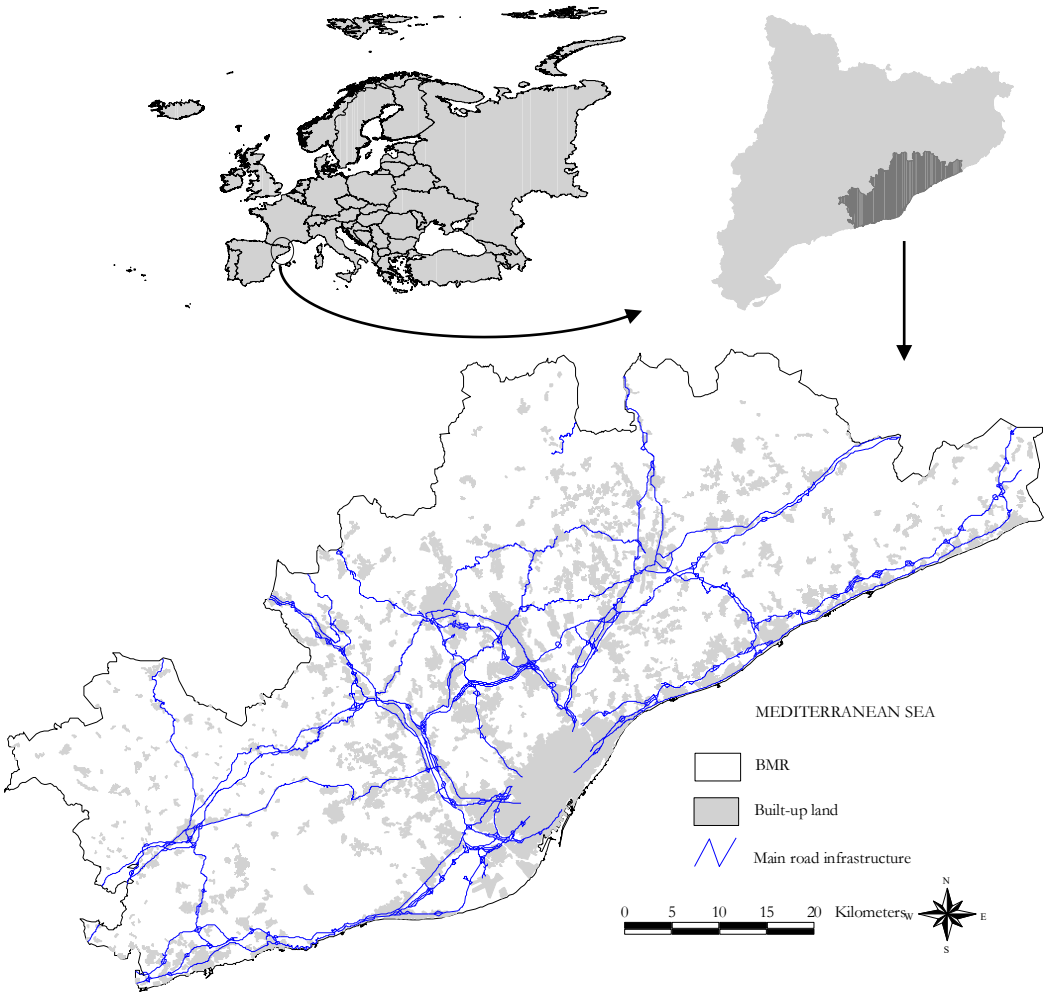

Fig. 1. BMR: Location, main road infrastructure, and built-up land.

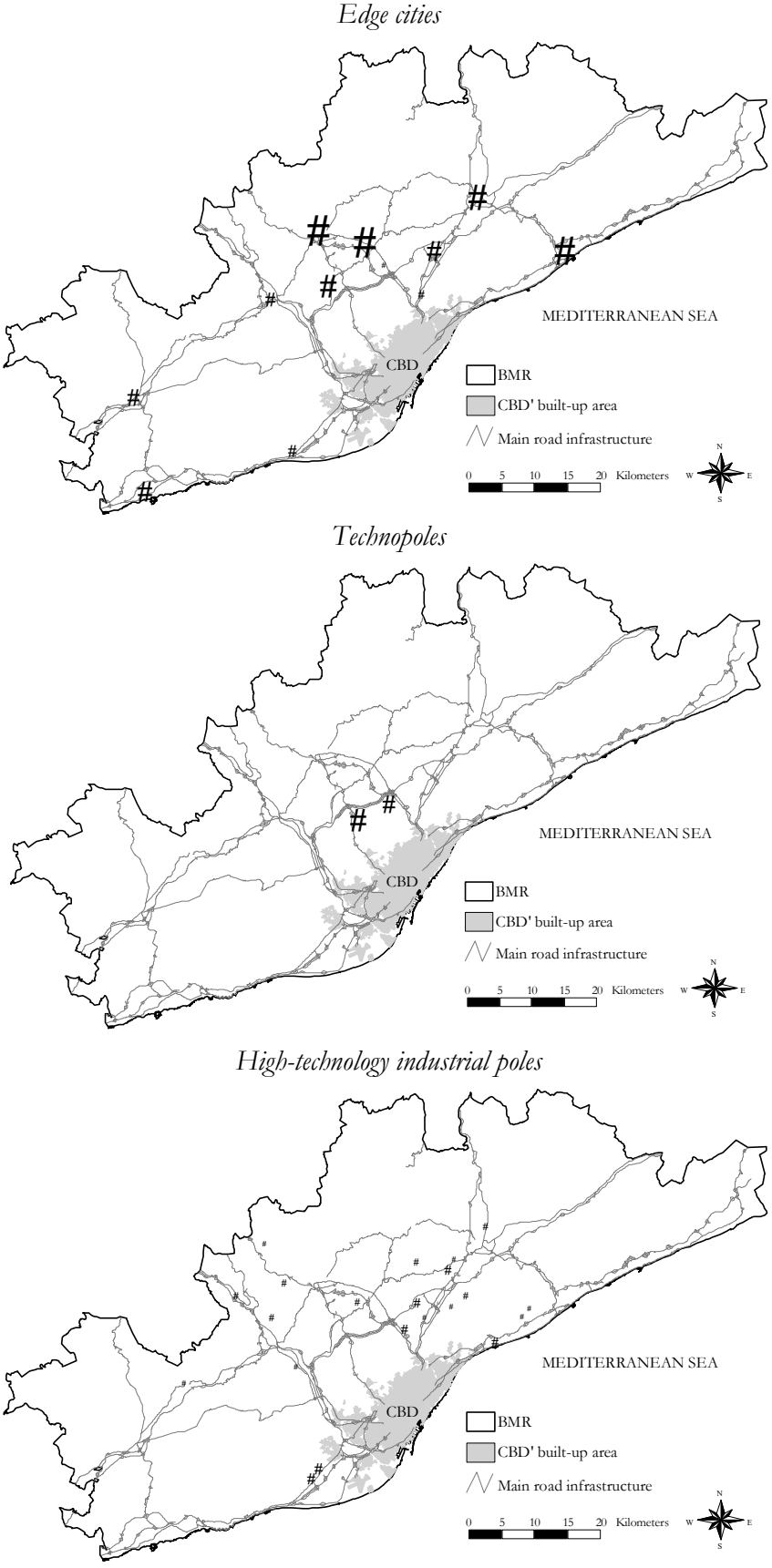

Fig. 2. Subsectoral employment subcenters, 2001: location and type.