Has concentration evolved similarly in manufacturing and services? A sensitivity analysis

Jenifer Ruiz-Valenzuela, Rosina Moreno-Serrano Esther Vayá-Valcarce
AQR Research Group – IREA, Universitat de Barcelona
Av. Diagonal, 690, 08034 Barcelona
email: jruizv@ub.edu; rmoreno@ub.edu; evaya@ub.edu

Abstract:
Our first objective is to compare the degree of concentration in manufacturing and services, with special emphasis on its evolution in these two sectors, using a sensitivity analysis for different concentration indices and different geographic units of analysis: municipalities and local labour systems of Catalonia in 1991 and 2001.
Most concentration measures fail to consider the space in which a particular municipality is located. Our second objective is to overcome this problem by applying two different techniques: by using a clustering measure, and by analysing whether the location quotients computed for each municipality and sector present some kind of spatial autocorrelation process. We take special account of the differences in patterns of concentration according to the technological level of the sectors.

JEL CODES: L60, L80, R12
Keywords: Geographic concentration, Manufacturing, Services, Local Labour Systems, Spatial Econometrics.

1. INTRODUCTION

The phenomenon of industrial concentration has become a central concern for economists and geographers in the last decades. This interest emerges in part due to the processes of regional integration which took place in several areas of the world in the second half of the 20th century and which inspired the strand of literature called New Economic Geography (NEG). The earliest NEG models offered an endogenous explanation for the agglomeration of activity in a territory. In recent decades, several indices for measuring the degree of concentration of economic activity have been put forward. Following these proposals, the vast majority of studies have focused their attention on the measurement of the concentration of manufacturing industries and its determinants. Reading recent empirical work on spatial agglomeration, one might easily get the impression that it is manufacturing that drives economies (Hanson, 2001) and that services follow (Kolko, 1999) However, this naïve (though popular) view is challenged by a recent study by Desmet and Fafchamps (2006) who found that services are driving aggregate employment dynamics in the US.

For several authors, the fact that geographic concentration and location patterns in manufacturing and service sectors tend to differ means that they should be analysed separately (Guillain and LeGallo, 2006; Brülhart and Traeger, 2005). It would be misleading to limit the focus of analysis to manufacturing industries (Desmet and Fafchamps, 2006; Hallet, 2000). As Begg (1993) noted more than a decade ago, the service sector has the twofold paradoxical characteristic of being a major sector in the OECD countries but also a very largely unknown one.

Midelfart-Knarvik *et al*. (2004) suggested two major reasons for the fact that more attention is paid to the manufacturing sector. First, in general, manufacturing products are inherently more tradable than service sector products, and so we would expect to see the largest relocation effects of European integration in manufacturing. Second, data availability severely restricts the ability to describe location patterns of services and to study the forces driving them. However, as these same authors underline, as service industries account for around 60% of EU employment, the geography of those services must be increasingly important. For 2003, the value-added corresponding to service sector activities in the European Monetary Union (EMU) accounted for 69.98% of the Gross Domestic Product (GDP) and it presents a steady upward trend throughout the developed countries. Among the possible reasons for this growth in the service sector's participation in the GDP are the rise in income levels across EU countries, the fact that most manufacturing sectors have become more intensive users of services in production and the fact that the fastest-growing of the manufacturing industries are the ones that are considered highly service-intensive (Midelfart-Knarvik *et al*., 2004).

In general terms, the study of the geographical concentration of economic activity faces two main problems. First, some authors criticize the use of geographic units based on administrative borders. Duranton and Overman (2005) state that most concentration indices transform dots on a map (establishments) into units in boxes (counties, regions or states, that is, spatial units at a given level of aggregation), a fact that implies throwing away a large amount of information, restricting the

analysis to only one spatial scale, and working with spatial units defined according to administrative needs, not to their economic relevance. Second, most of these measures do not account for spatial dependence; that is, most of the empirical work is still based on the computation of very basic statistical measures in which the geographical characteristics of the data play no role (Arbia, 2001). As a result, the same degree of concentration is compatible with very different localization schemes (Arbia, 2001; Lafourcade and Mion, 2007; De Dominicis *et al*., 2006; Guillain and LeGallo, 2006)[1].

To deal with the first problem, the distance-based methods proposed by Duranton and Overman (2005) and Marcon and Puech (2003) represent an alternative way of measuring the concentration of economic activity, but the high level of data required makes the computation of distance-based indices and the comparison of results between different countries a difficult task. The use of Local Labour Systems (LLS) as a geographic unit based not on administrative borders but on economic relevance (that is, on commuting flows) appears to be a good way of dealing with the problem of spatial scale when the data needed to compute distance-based indices are not available. Regarding the second problem, several solutions have been proposed for the issue of spatial dependence when measuring the concentration of economic activity, among them, the distance-based methods described above, the spatial separation index proposed by Midelfart-Knarvik *et al*., (2004), the clustering measure introduced by Hallet (2000) and the use of Exploratory Spatial Data Analysis techniques (Arbia, 2001).

The purpose of this paper is twofold. First, we compare the degree of concentration in manufacturing and services, placing special emphasis on the evolution of this concentration in the two sectors. In doing so, we will check our results through a sensitivity analysis at two levels: we will use a range of concentration indices proposed in the literature (relative concentration of a particular industry, the Locational Gini Index, and Ellison and Glaeser's Index) and we will give results for different geographic units of analysis, municipalities and LLS in Catalonia in 1991 and 2001. However, we are aware that most of the concentration measures used in the literature do not take account of the space in which a particular municipality is located, considering it as an isolated unit and ignoring any possible links with its neighboring municipalities. So our second objective is to overcome this problem in two ways: first, by using the clustering measure proposed by Hallet (2000) which takes specific account of distance between municipalities, and second, by analysing whether the location quotients computed for each municipality and for each sector present some kind of spatial autocorrelation process. Throughout the paper we will pay particular attention to differences in patterns in concentration related to the level of technology in the activities under analysis.

The paper is structured as follows. In the second section we review previous literature on geographic concentration, with special emphasis on papers that have made some kind of comparison between manufactures and services. Section three presents the methodology and section four the database. The main results are given in section five, and section six concludes.

2. PREVIOUS LITERATURE ON GEOGRAPHIC CONCENTRATION

One of the most salient characteristics of economic activity is that it tends to be concentrated geographically. Spatial differences in location and the degree of concentration across sectors may be related to factors such as transport costs or land intensity of production[2]. Using Hoover's (1937) traditional classification of external economies, we would expect manufacturing industries to be affected by external localization economies (firms that benefit from clustering with other firms in the same industry), while external urbanization economies (concentration of firms belonging to different sectors) may be the cause of the concentration of service activities in urban areas. In this section we review the results of several studies that analyse the degree of concentration of the manufacturing and service sectors and its evolution over time.[3]

Kolko (1999) used Ellison and Glaeser's index (henceforth, the EG index) to measure the degree of concentration of only three broad sectors: manufacturing, business services and consumer services, for the US economy in 1995. He found that the EG index was higher for manufacturing than for either business or consumer services. Instead of relying on a single method – β-convergence, σ-convergence, or ergodic distributions – Desmet and Fafchamps (2006) develop a methodology that encompasses them all and find that, for the 13 sectors that they analyse, most services have become more concentrated while most other sectors, such as manufacturing and farming, have exhibited deconcentration in US counties between 1970 and 2000.

Few studies have analysed this issue at the European level. Hallet (2000) used a concentration measure that captures the spatial dispersion of production measured by the coefficient of variation to analyse the degree of concentration of 17 sectors (including 5 service sectors) across 119 regions of the EU-15 in 1995. His results showed that agriculture and day-to-day services were spatially dispersed following the patterns of arable land and of settlement, whereas manufacturing industries with high economies of scale were concentrated in a small number of locations. Using Locational Gini Coefficients for 36 manufacturing industries and 5 service activities, Midelfart-Knarvik *et al*., (2004) also found that services are in general more dispersed than manufacturing. These authors state that two trends – the general shift from manufacturing to services, and catch-up by poorer countries with small initial service sectors –reinforced this spatial dispersion of services between 1982 and 1995. Using entropy indices with data for 17 Western European countries and 8 sectors covering the entire economy, Brülhart and Traeger (2005) found that manufacturing has become more geographically concentrated compared with the spatial spread of total employment between 1975 and 2000. As for services, depending on the particular activities considered they detect no significant changes or significant decrease over time.

At present, studies with a higher level of sectoral disaggregation can only be found at a national level. De Dominicis *et al*. (2006) studied the degree of concentration of 24 manufacturing and 17 service sectors at a 2-digit NACE level, for Local Labour Systems, NUTS-3 and NUTS-2 regions of Italy in 1991 and 2001. Using

the EG and Moran's I index, they found a higher degree of concentration for manufacturing than for service sectors in 1991 in the three areas considered. However, by 2001, only the EG index for NUTS-2 regions produced the same result. They found that manufacturing sectors had spread out over time, while service activities had become increasingly clustered. Braunerhjelm and Johansson (2003) used the EG index and the Locational Gini Index to compute the degree of concentration of 143 industries (4-digit ISIC level) for the LLS of Sweden between 1975 and 1993. Unlike De Dominicis *et al*., (2006), they found that manufacturing had become more concentrated over time and employed fewer people, while service sector presented the opposite pattern, characterized by employment growth and lower concentration.

Though we cannot compare the results of these studies directly, because they use different measures, different geographic units and different periods of time (see Table 1), we can nonetheless use both their results and the theoretical foundations regarding the concentration of economic activity to make some predictions for Catalonia. We would expect services to be more dispersed than manufacturing, for several reasons. On the one hand, plant level economies of scale, which are more capital- and R&D- intensive, predominate in manufacturing production. On the other hand, service industries are less likely to cluster in a single location or in a small number of locations (Kolko, 1999), because service production is, to a large extent, based on proximity to customers and markets: most services involve at least some face-to-face interaction. As for the evolution of concentration over time, no

general agreement seems to exist. While some authors find deconcentration of manufacturing and concentration of service sectors, others report the opposite.

[Insert Table 1 around here]

3. METHODOLOGY

In this section we present the measures we will use in our sensitivity analysis. The first is the *Relative Concentration Index* of industry *j*, given by:

$$L_j = \frac{1}{2}\sum_{i=1}^{N}\left|\frac{Y_{ij}}{Y_j} - \frac{Y_i}{Y}\right|, \qquad (1)$$

where Y_{ij} is the employment in industry *j* and municipality *i*, Y_i represents total employment in municipality *i*, Y_j is the total employment in industry *j*, and Y is the total employment in Catalonia. This index varies between 0 and 1, and measures the differences for all municipalities between their respective participation in total employment in industry *j* and the share of their employment in the total. The index will be equal to 0 if industry *j*'s share of employment in municipality *i* is always equal to industry *j*'s share of employment in total employment; that is, in this situation industry *j* shows no concentration at the municipal level.

The *Locational Gini Index* developed by Krugman (1991a) is a summary measure of spatial dispersion derived from a spatial Lorenz curve. Formally, the Locational Gini coefficient for an industry *j* is calculated as (Kim *et al.*, 2000):

$$G_j = \frac{\Delta}{4\bar{\mu}_x}, \qquad (2)$$

with: $$\Delta = \frac{1}{N(N-1)} \sum_{i=1}^{N} \sum_{m=1}^{N} |x_i - x_m|,$$

$$x_i = \frac{Y_{ij} / Y_j}{Y_i / Y},$$

$\bar{\mu}_x$ is the mean of x_i : $\bar{\mu}_x = \sum_{i=1}^{N} x_i / N$,

where *N* is the number of municipalities and *i* and *m* are indices for two different municipalities ($i \neq m$). The Locational Gini coefficient has a value of zero if employment in industry *j* is distributed identically to total employment (that is, if the total employment of industry *j* equals the total employment share), and a value of 0.5 if industry employment is totally concentrated in one municipality. Locational Gini coefficients are easy to compute and have low data requirements, but fail to account for industrial concentration.

The *EG index* (Ellison and Glaeser, 1997) has been widely used in recent years. It improves on the results of the indices mentioned above by purging spatial concentration from industrial concentration. This index measures the concentration of a particular sector after discounting the effect of the size of establishments (sometimes called industrial concentration). Derived from a model of location choice, Ellison and Glaeser (1997) define an index of geographic concentration that uses a primary concentration index very similar to the two indices described above, and the Hirschman-Herfindhal index of industrial concentration, which measures the degree of concentration that is due to the size of establishments. If a sector is highly concentrated as a result of operating in large establishments, the Hirschman-

Herfindhal index will be close to 1. The authors discount the effect of establishment size when computing their index because their aim is to separate the part of the concentration of economic activity that is due to industrial concentration (for instance, a sector where 80% of workers are employed by two big firms) from the part of concentration that is explained by agglomerative forces[4]. The EG index is computed as follows:

$$EG_j = \frac{G_j - \left(1 - \sum_i y_i^2\right) H_j}{\left(1 - \sum_i y_i^2\right)\left(1 - H_j\right)}, \qquad (3)$$

$$\text{with } G_j = \sum_i \left(s_i - y_i\right)^2$$

where s_i is the share of a particular industry in municipality i, y_i is the share of aggregate employment in municipality i, G_j is an index of raw geographic concentration of industry j and H_j is the Hirschman-Herfindhal index for the industry j.

Computing the EG index can provide three different outcomes. It will be negative when, after taking establishment size into account, the economic activity of a particular industry is less concentrated than overall employment; a value near zero indicates a level of agglomeration similar to that of the overall economic activity and, finally, a positive EG score shows the existence of agglomerative forces for a particular industry.

These measures have one major shortcoming: they fail to take into account the space in which each municipality or LLS is located, considering it as an isolated

unit and ignoring any possible links with its neighboring municipalities. We will try to overcome this problem by using two techniques: first, by using the clustering measure proposed by Hallet (2000), and second by analysing whether the location quotients computed for each municipality and for each industry present some kind of spatial autocorrelation process.

The *clustering measure* proposed by Hallet (2000) introduces the use of distances between municipalities. This measure is based on the gravity model, adding up the distance-weighted production of all pairs of municipalities and analysing whether employment in industry *j* is more concentrated in municipalities that are geographically close to each other than total production. The index is computed as follows:

$$C_j = \frac{\sum_i \sum_m \left(\frac{y_i^j y_m^j}{\delta_{im}} \right)}{\sum_i \sum_m \left(\frac{p_i p_m}{\delta_{im}} \right)} \quad \text{with } i \neq m, \qquad (4)$$

where y_i^j is the employment in industry j in municipality i relative to the total employment of Catalonia in industry j; p_i is the production in municipality i relative to total production in Catalonia and δ_{ij} is the geographical distance between centroids of municipalities i and m. A high result for the clustering measure will indicate that employment in a certain industry is high in municipalities that are geographically close to each other in comparison with the pattern of overall production.

As well as computing the clustering measure to include the geographical question, we also use Exploratory Spatial Data Analysis techniques to perform a more in-depth study of the geographical distribution of economic activity. Specifically, we compute the location quotients for each municipality and for each industry:

$$L_{ij} = \frac{Y_{ij} / Y_i}{Y_j / Y} \quad i = 1, ..., N; \; j = 1, ..., R$$

and study whether there is a spatial dependence process in their distribution. Spatial dependence, or spatial autocorrelation, is said to exist when the values observed at one location (for instance, in one municipality) depend on the values observed in its neighboring municipalities. Although various statistics have been proposed for verifying the existence of spatial autocorrelation in a specific variable, one of the most widely used is the Moran I test (Moran, 1948), computed as follows:

$$I = \frac{N}{S} \frac{\sum_i \sum_h w_{ih} z_i z_h}{\sum_i z_i^2} \qquad (9)$$

where N is the number of observations, w_{ih} is the element of the spatial weights matrix *W* that expresses the potential interaction between two municipalities *i* and *h*, *S* is the sum of all the weights (all the elements in the weights matrix) and z_i represents the normalized value of a variable *x* being analysed in municipality *i*. Though there is no consensus on the specification of W, the contiguity criterion is usually applied. So, w_{ih} will be 1 if municipalities *i* and *h* are neighbors and 0 if

otherwise. In our analysis, we used a row standardized contiguity matrix (in which each row sums 1).

Once standardized, a significant and positive value for this statistic indicates a trend for similar values of the variable to cluster in space (known as positive spatial dependence). On the other hand, when the test is significant and negative, the trend is for dissimilar values to cluster in neighboring locations (negative spatial dependence). This latter case might represent a situation where the strength of centripetal forces within the municipality is such that it prevents the diffusion of manufacturing activities to its neighbours. Non-significance of the Moran I test implies the non-rejection of the null hypothesis, that is, the non-existence of spatial autocorrelation, indicating the prevalence of a random distribution of the concentration index throughout space.

4. DATA

We use data for employment in each municipality of Catalonia with a 2-digit level of disaggregation corresponding to the NACE Rev. 1.1 (National Classification of Economic Activities), that is, we have information for 60 activities covering the entire range of economic activities for the 946 municipalities and 61 LLS[5] in Catalonia. The data contain information on the location of activity, say, of people working in each municipality for each activity. The data are provided by Idescat (the Statistical Office of Catalonia), and are based on the 1991 and 2001 Population Censuses. We stress that the data refer to people working, not living, in a particular municipality. The Hirschman-Herfindhal indices are provided by the Spanish

Institute of Statistics (INE), for the manufacturing industries only (the value of the index for some of these industries is not shown, due to statistical privacy regulations).

In our case, as we lack production data at the municipality level, we will proxy this concept by means of the distribution of earnings declared by income tax payers (IRPF, provided by Idescat). Geographical distance between municipalities and LLS[6] are calculated using a GIS software program which, after assigning a center to each municipality and establishing its coordinates, calculates the distance between centroids.

Table 2 provides a first impression of the distribution of economic activity in the different broad sectors in Catalonia. As can be observed, manufactures and services account for around 88% of employment in both 1991 and 2001. However, the evolution over time in the two sectors is diametrically opposed: whereas services increased from 52% to 63% of Catalan employment, manufacturing, fell from 35% to 25%. Thus, the general pattern of employment in Catalonia follows that of Europe as a whole, where service industries account for around 60% of EU employment (Midelfart-Knarvik et al, 2004). For 2003, the value-added corresponding to service sector activities of the in the European Monetary Union (EMU) totalled 69.98% of the Gross Domestic Product (GDP), and the general trend in the developed countries shows a steady rise. As noted in the introduction, this feature is common across EU countries. Therefore, one would expect the

geographical location of services to be increasingly important and the analysis of its concentration could provide interesting conclusions.

[Insert Table 2 around here]

5. RESULTS

5.1 Comparing concentration evolution in manufacturing and services: sensitivity analysis

Table 3 presents some descriptive statistics (weighted average and the coefficient of variation) for the relative concentration index and the locational Gini coefficient computed with both the municipalities and the LLS as geographic units. The results are shown both for the overall population of sectors and by groups, with regard to their level of technology (for the manufacturing sectors) or their knowledge intensity (for the service sectors), and for each year under study.[7] Spearman rank correlations are also shown in the lower part of this table, to give a rapid idea of the similarity or dissimilarity of the results obtained using different indices and for different years. The general ranks for the sectors in the first two indices are very similar, showing a coincidence of around 80% for both municipalities and LLS over the period under study. In other words, although their interpretation differs essentially in that the values obtained for the L_j are always interpreted with respect to the average productive structure of Catalonia, patterns shown by the two indices are similar.

[Insert Table 3 around here]

The average value for the relative concentration index is around 0.23. This figure is low if we take into account that a maximum concentration would be reached at a

value of 1, whereas the Gini index average is 0.28 out of a maximum of 0.5. Additionally, these average values are quite stable over our 10 year period, though they have fallen slightly by 2001. However, as expected, the dispersion is very high. For this reason it seems important to analyse the behaviour of both concentration indices at each point of the distribution. The distributional analysis indicates the probability of sectors reaching different concentration levels, and so, discovering the existence of heterogeneity in concentration. Figures 1 to 4 show the density functions in 1991 and 2001 obtained with the first two measures for both municipalities and LLS. In the case of the relative concentration index (L_j), the highest dispersion is found above the average value (0.23), with sectors reaching concentration levels of around 0.8/1 in the case of both municipalities and LLS. In the case of the locational Gini the highest dispersion is observed for low values of the index, with a clear mass of probability emerging around concentration levels of 0.45 for municipalities. This points to the existence of a certain number of sectors with high levels of concentration in Catalonia. Additionally, the distribution of concentration for the two indices is quite stable over time, with no clear changes or shifts between 1991 and 2001; the only exception is the relative concentration index in the case of municipalities, where there is a certain shift to the right, indicating that a slightly higher number of sectors reach high concentration levels in 2001.

[Insert Figures 1, 2, 3 and 4 around here]

Turning to the analysis of the average concentration by groups of sectors and paying special attention to the comparison between manufacturing and services (Table 3), we observe that, as most previous papers have found, both the L_j and

locational Gini indices find higher concentration in manufacturing than in services. The result is also consistent both for municipalities and LLS. However, given the lack of consensus in previous studies, the results on the evolution are more interesting. The first point to note is the high degree of correlation between the results on concentration in 1991 and 2001 obtained with the same index – around 80% with the L_j and even higher (87-92%) in the case of the Gini index, in accordance with the general trend obtained previously with the density functions. Second, Table 3 shows a clear decrease in concentration in services no matter which index is used, and an increase for the most part in the manufacturing sector. However, this is not always true for the case of the Gini coefficient at the municipality level.

Analysing the evolution of concentration in more depth through a comparison of the behaviour of the concentration indexes at each point of the distribution uncovers patterns that would be hidden under an analysis based on the mean distribution. As Figure 5 shows, the distribution of the relative concentration index for manufacturing shifts to the right for most concentration levels (higher mass of probability at high concentration values and lower mass of probability at low values), which is interpreted as a generalized increase in concentration of manufacturing over time. The opposite pattern is observed for the service sector (Figure 6), with a higher mass of probability in 2001 at low values of concentration and a lower mass of concentration for high values, indicating that the relative concentration index for service activities has decreased over time. The comparison over time with the locational Gini index (Figures 7 and 8) leads to the same

conclusion, a decrease in concentration for services, though there is no clear pattern in the case of manufacturing.

[Insert Figures 5, 6, 7 and 8 around here]

With respect to the level of technology, services present a clear pattern of behaviour, with knowledge intensive services being more concentrated than non-intensive services. The conclusion is not so clear in the case of manufacturing. According to the L_j index, industries with low technological levels are the most concentrated, whereas the Locational Gini index places the high tech industries as the most concentrated. This description applies to 1991 and 2001 using both municipalities and LLS. So the common conclusion is that medium tech manufactures present the lowest levels of concentration.

The results in table 3 present a general picture of the concentration of overall economic activity in Catalonia. However, as discussed in the methodology section, the two indices presented in Table 3 (*relative concentration index* and the *Locational Gini coefficient*) do not take establishment size into account. This is not the case of the *EG index*, which uses the Hirschman-Herfindhal index in order to capture the excess concentration that is not due to the size of firms. The EG index is computed after purging for industrial concentration, that is, after taking into account the effect of the size of firms in the industry. This index tries to capture the economic concentration that is due to spillovers or natural advantages and to eliminate the part caused by establishment size. Thus, the industries that show a high level of industrial concentration captured by the Hirschman-Herfindhal index

are normally those that display negative EG index scores, indicating dispersion, not concentration, of the activity in this particular sector.

We therefore compared our results for the manufacturing sector with those obtained with the EG index.[8] Looking at the level of coincidence shown by the Spearman rank values, we see that, though higher for the LLS, the general rank of the first two measures computed in this study differs notably from that obtained with the EG. In other words, the concentration pattern changes when the size of firms is taken into account. The weighted average of high and medium high tech industries becomes negative in almost all cases. This negative result indicates that employment in these particular groups is less concentrated than total employment when the size of establishments is taken into account. These results are to some extent at odds with those obtained with the first two measures, which placed the high tech industries among the most concentrated groups of economic activity (especially with the Gini index). This result suggests that the high concentration observed with the L_j and Gini coefficients in high tech industries is the consequence of the existence of large establishments, with a high number of employees, and not a consequence of a concentration of a high number of small firms that locate close to each other to take advantage of potential agglomeration economies.[9] In contrast, whereas low-medium and low tech industries score relatively low on the Locational Gini index, their values on the EG are positive. This suggests that, after controlling for establishment size, these industries have a concentration level higher than that of total employment, indicating the more likely presence of agglomerative forces.

[Insert Table 4 around here]

Which sectors are the most and least concentrated in Catalonia? Table 5[10] shows a general pattern for both indices, L_j and Locational Gini, and both years, according to which the Construction sector (45) is one of the most dispersed over the period, whereas Fishing, fish farming and related service activities (05) and most of the energy industries (10-14) are among the most concentrated. What is more interesting from our perspective is that among the 10 most concentrated sectors, in addition to some low tech and medium-low tech manufactures such as Manufacture of tobacco products (16), Manufacture of textiles (17) and Manufacture of coke, refined petroleum products and nuclear fuel (23), as well as one high tech industry, Manufacture of office machinery and computers (30), we also find some service industries, including knowledge intensive activities such as Water and Air transport (61 and 62) and Research and Development (73). The non-knowledge intensive activity Sewage and refuse disposal, sanitation (90) is also among the most concentrated sectors.

[Insert Table 5 around here]

As for the less concentrated sectors, apart from Construction, we find some non-knowledge intensive services such as Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50), Wholesale trade and commission trade, except motor vehicles and motorcycles (51), Retail trade, except motor vehicles and motorcycles; repair of personal and household goods (52), Hotels and restaurants (55), Public administration and defence; compulsory social security (75) and Other service activities (93). An interesting result is that two

knowledge intensive activities, Health and social work (85) and Education (80) appear in the list of the least concentrated sectors.[11]

The values for each sector using LLS are displayed in table 6. In general, both the least and most concentrated sectors found most frequently in the municipality analysis re-appear here. However, one interesting change should be noted: though at the LLS level we again find mostly non-knowledge intensive activities, and also intensive ones such as Health and Education among the least concentrated activities, now we also find, especially with the Gini coefficient, the knowledge-intensive activities Renting of machinery and equipment (71), Post and Telecommunications (64) and Financial intermediation (65).

[Insert Table 6 around here]

5.2 Taking geography into account when measuring concentration

The three concentration indexes calculated above do not account for spatial proximity; that is, a sector that employs a certain number of workers in some areas displays the same value if these areas are close in space as if they are at a considerable distance from each other. The *clustering measure*, C_j, considers geographical distance between municipalities or LLS. High scores on this index indicate that employment in a particular sector is found in municipalities that are geographically close to each other, compared to the pattern in the case of total income.

Tables 7 and 8 suggest that the clustering of similar activities is more important in manufacturing than in service activities throughout the period, both for municipalities and LLS. Spillover effects could be behind the higher clustering found in manufacturing activities than in income as a whole. Compared to total income, Agriculture, forestry and fishing and Energy appear to be less clustered geographically. The same result was obtained by HALLET (2000) studying the clustering measure for 119 European regions. Specifically, all manufacturing industries except low technology activities ones present values higher than one, indicating that the distribution of employment is more clustered than that of income. As for services, the magnitude of the clustering of similar activities is slightly below the average, with knowledge intensive services presenting a slightly higher concentration (with weighted averages of 0.858 and 0.933 in 1991 and 2001 respectively) in closer municipalities than non-knowledge intensive services (with weighted averages of 0.844 and 0.882 in 1991 and 2001 respectively).

[Insert Tables 7 and 8 around here]

If we take a closer look at the particular values for this measure in Tables 7 and 8, among the 10 most clustered sectors over the period there is one high-tech industry, Manufacture of radio, television and communication equipment (32), three medium-high tech industries, Manufacture of chemicals (24), Manufacture of machinery and equipment (29) and Manufacture of medical, precision and optical instruments, watches and clocks (33), the medium-low tech industry of Manufacture of basic metals (27) and the low tech industry of Publishing, printing and reproduction of recorded media (22), together with the knowledge intensive activity of Air transport (62). With the LLS, the medium-high tech industry of

Manufacture of electrical machinery (31) should be added to this list. Comparing this list with the one obtained with the measures of concentration, we see that only the knowledge intensive activity (62) appears in the lists of most concentrated sectors according to the L_j and Locational Gini Indexes, while only the Manufacture of basic metals (27) appears in the EG lists, a fact that clearly reveals that the first three measures of concentration computed in this paper do not account for spatial proximity.

In general, during the period under consideration, overall employment and employment by groups have tended to cluster in space, as we can see from the weighted average values of Tables 7 and 8. These higher values reveal that for sectors where the value of the index increases over time, employment has tended to locate more closely together than overall income. The density kernel estimations in Figures 9 and 10 show that this has been the case at almost all points of the distribution of concentration, except for its highest values. Except for those sectors which are the most concentrated in nearby municipalities or LLS, which have maintained those levels of high concentration, in the rest of sectors we observe that there has been a shift to the right of the density function between 1991 and 2001. This leads to the conclusion that the increase in concentration of employment in nearby areas in Catalonia is observed for most concentration levels except the highest ones, in which the values are maintained. Analysing the differences in the evolution of this clustering measure in manufactures (Figure 11) and services (Figure 12) we observe that service activities follow the general pattern of increases over time in concentration of employment in nearby municipalities,

whereas this is not so clear for manufacturing industries; for manufacturing this is only the case in industries with already high values of concentration of employment.

[Insert Figures 9, 10, 11 and 12 around here]

Another way of considering the relevance of geography in the analysis of concentration of economic activity is through the concept of spatial dependence, that is, because the concentration pattern in one municipality or LLS may be associated to the one in neighbouring municipalities or LLS. We can evaluate whether municipalities or LLS with similar levels of concentration tend to be clustered in space by means of Moran's I statistic. We computed Moran's I based on a contiguity weight matrix, where unity represents the case of two municipalities or LLS sharing a boundary, and zero the opposite case. When we use municipalities to study the concentration in Catalonia, the Moran index for both municipalities and LLS (see Table 7) in most sectors shows the existence of a strong positive spatial autocorrelation process that remains in place during the period under consideration. We do not obtain a significant negative autocorrelation in any case. It seems therefore that the concentration values are not randomly distributed in space but, on the contrary, that there is a trend towards spatial clustering of these values: in other words, a municipality with high values of concentration for a sector tends to be surrounded by municipalities with high values for this same sector. The same applies to municipalities presenting low values of concentration.

At the municipality level there are very few exceptions to this general pattern, though we should mention knowledge intensive services such as Water and Air Transport (61 and 62), Insurance (66) and Activities auxiliary to financial intermediation (67), Renting of machinery and equipment (71) and R&D (73). In the case of these activities there is no evidence of spatial autocorrelation, so their level of concentration is randomly distributed. Some energy industries and two non-knowledge intensive activities (Sewage and refuse disposal (90) and Activities of membership organizations (91)) do not present a specific geographical distribution either. These conclusions are less clear when we calculate the Moran's I using the LLS. Although most sectors present a spatial dependence process in their concentration distributions, there are now more exceptions than for municipalities. The decline in the value of the Moran's I statistic for the LLS reflects the fact that the level of concentration in neighbouring LLS is not the same as the level we find in neighbouring municipalities. Part of the externalities in municipalities close in space are already internalized in the LLS. These results reflect the fact that when the geographic unit changes from municipality to LLS level, the productive structure of the units is, on average, closer to the productive structure of Catalonia as a whole.

6. CONCLUSIONS

Through a sensitivity analysis carried out both for different concentration indices and at different geographic units of analysis (municipalities and local labour systems of Catalonia in 1991 and 2001) this paper compares the degree of concentration in manufacturing and service sectors. From 1991 to 2001

concentration is clearly higher in manufacturing than in services, both in municipalities and LLS. There are several possible reasons for this pattern. On the one hand, plant level economies of scale, which are more capital- and R&D-intensive, predominate in manufacturing. On the other hand, service industries are less likely to cluster in a single location or in a small number of locations because service production depends, to a large extent, on proximity to customers and markets. As for evolution over time, it seems that the degree of concentration has mostly increased in the manufacturing sector (especially according to the relative concentration index) whereas the service sector presents the opposite trend (though not at a high rate).

We also analysed the concentration pattern according to the level of technology. Services present a clear pattern of behaviour, with knowledge intensive services being more concentrated than non-intensive services. The conclusion is not so clear in the case of manufacturing: the only conclusion suggested by all the indices computed in the paper is that medium tech manufactures present the lowest level of concentration.

A problem with most of the concentration measures used in the literature is that they fail to take into account the space in which the considered municipality is located. To overcome this difficulty, we applied a clustering measure and also analysed whether the location quotients computed for each municipality and for each sector present some kind of spatial autocorrelation process. Among the main results, it seems that clustering of similar activities is more important in

manufacturing than in service activities. Spillover effects could be behind the higher clustering of manufactures (high and medium tech manufactures) compared with the clustering of overall income. As for services, the magnitude of the clustering of similar activities is slightly below average, with knowledge intensive services presenting higher concentration in closer municipalities than non-knowledge intensive services. In general, during the period under consideration, overall employment and employment by groups have tended to cluster in space.

The results of the spatial dependence test suggest that concentration values are not randomly distributed in space but that, on the contrary, there is a trend towards spatial clustering of these values. In other words, municipalities with high concentration values for a particular sector tend to be surrounded by other municipalities with high values for this same sector. The same applies for municipalities presenting low values of concentration.

Finally, we should mention the sensitivity of the results to the use of different concentration indices. Whereas the relative concentration index and the locational Gini index offer very similar results, the Ellison-Glaeser index displays a different pattern of distribution of economic activity, indicating that the concentration pattern changes when the size of establishments is taken into account. Specifically, we observe that the high concentration observed with the relative concentration and Gini coefficients in high tech industries is the consequence of the existence of large establishments, with a high number of employees, and not due to the concentration of a high number of small firms located close to each other in order to take

advantage of potential agglomeration economies. In contrast, whereas low-medium and low tech industries had relatively low values on the Locational Gini index they had positive values on the EG. This suggests that, after controlling for the size of the establishments, these industries present a higher concentration than total employment, revealing the more likely presence of agglomerative forces.

To conclude, the lack of consensus in the results in the previous literature on concentration may be due to the use of different indices of concentration, especially in cases in which only one index is used. We found that the concentrations obtained with the Ellison-Glaeser index and the Gini index were totally unrelated. Also, the evolution over time described for manufactures differs slightly when using either the relative concentration index or the Gini coefficient. Therefore, a global analysis like the one presented here, using different indices, will probably produce more accurate conclusions regarding the location of activity. We found low tech activities to be characterized by a high degree of concentration (after controlling for firm size), but not clustered in close spatial units. This suggests the possible existence of agglomeration economies from which these sectors would benefit. For their part, high tech industries show low levels of concentration, again after controlling for firm size, but they tend to be clustered in the territory, probably in order to capitalize on knowledge externalities.

REFERENCES

ARBIA G. (2001) The role of Spatial Effects in the Empirical Analysis of Regional Concentration, *Journal of Geographical Systems* 3, 271-281

BEGG I. (1993) The Service Sector in Regional Development, *Regional Studies* 27.8, 817-825

BERTINELLI L. and DECROP J. (2005) Geographical Agglomeration: Ellison and Glaeser's Index Applied to the Case of Belgian Manufacturing Industry, *Regional Studies* 39.5, 567-583

BRAUNERHJELM P. and JOHANSSON D. (2003) The determinants of spatial concentration: the manufacturing and service sectors in an international perspective, *Industry and Innovation* 10.1, 41-63

BRÜLHART M. and TRAEGER R. (2005) An account of geographic concentration patterns in Europe, *Regional Science and Urban Economics* 35, 597-624

CALLEJÓN M. (1997) Concentración geográfica de la industria y economías de aglomeración, *Economía Industrial*, 317-V, 61-68

DE DOMINICIS L., ARBIA G. AND DE GROOT H.L.F. (2006) Spatial distribution of economic activities in Local Labour Market Areas: The case of Italy. Paper presented at the ERSA Conference 2006.

DESMET K. and FAFCHAMPS M. (2006) Employment concentration across U.S. counties, *Regional Science and Urban Economics* 36, 482-509

DEVEREUX M.P., GRIFFITH R. and SIMPSON H. (2004) The geographic distribution of production activity in the UK, *Regional Science and Urban Economics* 34, 533-564

DURANTON, G. and OVERMAN, H. G. (2005) Testing for Localization Using Micro-Geographic Data, *Review of Economic Studies* 72(4), 1077-1106

ELLISON E. and GLAESER E. L. (1997) Geographic Concentration in US. Manufacturing industries: A dartboard approach, *Journal of Political Economy* 105.51, 879-927

GUILLAIN R. and LEGALLO, J. (2006) Measuring agglomeration: An exploratory spatial analysis approach applied to the case of Paris and its surroundings. Paper presented in the ERSA Conference 2006.

HALLET M. (2000) Regional Specialization and Concentration in the EU. *Economic Papers of the European Commission, Directorate-General for Economic and Financial Affairs*, n.141.

HANSON G.H. (2001) Scale economies and the geographic concentration of industry, *Journal of Economic geography* 1, 255-276

HOOVER E.M. (1937) Location theory and the shoe and leather industries. Cambridge, Mass. Harvard University Press.

KIM Y., BARKLEY D. L. and HENRY M. S. (2000) Industry Characteristics Linked to Establishments Concentration in Nonmetropolitan Areas, *Journal of Regional Science* 40.2, 231-259.

KOLKO, J. (1999) Can I get some service here? Mimeo, Harvard University.

KRUGMAN P. (1991a) Geography and Trade. The MIT Press, Cambridge, Massachusetts.

KRUGMAN, P. (1991b) Increasing Returns and Economic Geography. *Journal of Political Economy* 99.3, 483-499

KRUGMAN P. and VENABLES A. J. (1995) Globalization and the Inequality of Nations, *The Quarterly Journal of Economics* 110.4, 857-880

KRUGMAN P. and VENABLES A. J. (1996) Integration, Specialization and Adjustment, *European Economic Review* 40, 959-967

LAFOURCADE M. and MION G. (2007) Concentration, agglomeration and the size of plants, *Regional Science and Urban Economics*, 37(1), 46-68.

MARCON F. and PUECH F. (2003) Evaluating the geographic concentration of industries using distance-based methods, *Journal of Economic Geography* 3, 409-428

MAUREL F. and SÉDILLOT B. (1999) A measure of the geographic concentration in French manufacturing industries, *Regional Science and Urban Economics* 29, 575-604

MIDELFART KNARVIK K.H., OVERMAN H.G., REDDING S.G., and VENABLES A.G. (2004) The location of European industry, In DIERX A., ILZKOVITZ, F. and SEKKAT K. (Eds) European Integration and the Functioning of Product Markets, E. Edgar Publishing.

MORAN P. (1948) The interpretation of statistical maps, *Journal of the Royal Statistical Society* B10, 243-251

MORI T., NISHIKIMI K. and SMITH T. E. (2005) A divergence statistic for industrial localization, The Review of Economics and Statistics 87-4, 635-651

ROMANI, J. (2006) Mobilitat laboral obligada i sistemes urbans a la provincia de Barcelona, 1991-2001. *Informe Territorial de la Província de Barcelona, 2006.* Cambra Oficial de Comerç, Indústria i Navegació Barcelona.

Table 1. Review of papers comparing concentration in manufactures and services

Papers	Area of analysis	Time period	Sectoral disaggregation	Indices	Main results
Kolko (1999)	US	1995	3 broad sectors (manuf, business and consumer services)	EG index	Concentration higher for manufacturing than for services
Hallet (2000)	119 regions of the EU-15	1995	17 sectors	A concentration measure that captures the spatial dispersion of production by the coefficient of variation	Day-to-day services are spatially dispersed, whereas manufacturing is concentrated
Braunerhjelm and Johansson (2003)	LLS in Sweden	1975-1993	143	EG and Locational Gini indices	Manufacturing has become more concentrated over time and the opposite applies to service sectors
Midelfart-Knarvik et al (2004)	14 EU countries (EU-15 except Lux)	1985-1997	36 industries	Gini coefficients	Services are more dispersed than manufacturing
Brülhart and Traeger (2005)	236 NUTS-2 and NUTS-3 regions in 17 West European countries	1975-2000	8 sectors	Entropy indices	Manufacturing has become more geographically concentrated. Services do not present changes over time
De Dominicis et al (2006)	LLS, NUTS-3 and NUTS-2 regions in Italy	1991 and 2001	41 sectors	EG and Moran's I indices	Degree of concentration higher for manufacturing than for service sectors in 1991. Not always the case in 2001.
Desmet and Fafchamps (2006)	US counties	1970-2000	13 sectors	New methodology to encompass several methods (sigma and beta convergence and ergodic distributions)	Most services have become more concentrated and manufacturing exhibits deconcentration

Table 2. Distribution of employment in Catalonia

Employees by big sectors (%)	**1991**	**2001**
Agriculture, forestry and fishing	3,68	2,43
Energy and others	1,08	0,76
Construction	8,23	9,02
Manufacturing	34,99	25,28
Services	52,02	62,51
Total number of employees in Catalonia	2.246.545	2.615.491

Table 3. Descriptive statistics Lj and Gini indices, Municipalities and LLS

Municipalities					LLS				
	Lj 1991	**Lj 2001**	**Gini 1991**	**Gini 2001**		**Lj 1991**	**Lj 2001**	**Gini 1991**	**Gini 2001**
OVERALL POPULATION									
Weighted average	0.234	0.224	0.297	0.272	Weighted average	0.182	0.174	0.175	0.154
Coeff variation	0.515	0.550	0.228	0.251	Coeff variation	0.615	0.610	0.419	0.463
HIGH TECHNOLOGICAL LEVEL									
Weighted average	0.317	0.367	0.458	0.455	Weighted average	0.249	0.299	0.315	0.362
Coeff variation	0.117	0.040	0.006	0.041	Coeff variation	0.227	0.077	0.086	0.042
MEDIUM - HIGH TECHNOLOGICAL LEVEL									
Weighted average	0.266	0.365	0.376	0.389	Weighted average	0.205	0.287	0.278	0.314
Coeff variation	0.282	0.193	0.125	0.106	Coeff variation	0.316	0.231	0.211	0.062
MEDIUM - LOW TECHNOLOGICAL LEVEL									
Weighted average	0.297	0.336	0.342	0.334	Weighted average	0.243	0.262	0.220	0.217
Coeff variation	0.318	0.416	0.180	0.170	Coeff variation	0.355	0.558	0.259	0.258
LOW TECHNOLOGICAL LEVEL									
Weighted average	0.347	0.381	0.364	0.362	Weighted average	0.280	0.318	0.263	0.268
Coeff variation	0.331	0.296	0.160	0.157	Coeff variation	0.430	0.327	0.246	0.257
KNOWLEDGE INTENSIVE SERVICES									
Weighted average	0.212	0.200	0.305	0.270	Weighted average	0.164	0.155	0.139	0.116
Coeff variation	0.367	0.441	0.208	0.261	Coeff variation	0.446	0.519	0.417	0.480
NON KNOWLEDGE INTENSIVE SERVICES									
Weighted average	0.138	0.136	0.246	0.232	Weighted average	0.097	0.093	0.112	0.109
Coeff variation	0.641	0.626	0.311	0.318	Coeff variation	0.717	0.768	0.677	0.659
AGRICULTURE, FORESTRY AND FISHING									
Weighted average	0.652	0.601	0.262	0.290	Weighted average	0.556	0.520	0.251	0.252
Coeff variation	0.043	0.106	0.338	0.282	Coeff variation	0.078	0.210	0.277	0.254
ENERGY AND OTHERS									
Weighted average	0.300	0.261	0.435	0.429	Weighted average	0.217	0.178	0.298	0.284
Coeff variation	0.525	0.494	0.060	0.074	Coeff variation	0.766	0.597	0.252	0.301
CONSTRUCTION									
	0.144	0.144	0.184	0.153	Weighted average	0.104	0.119	0.101	0.085
Spearman rank correlation test									
Municipalities	Lj 1991 - Gini 1991		0.78*		Lj 1991 - Lj 2001			0.858*	
	Lj 2001 - Gini 2001		0.784*		Gini 1991 - Gini 2001			0.916*	
LLS	Lj 1991 - Gini 1991		0.804*		Lj 1991 - Lj 2001			0.789*	
	Lj 2001 - Gini 2001		0.831*		Gini 1991 - Gini 2001			0.865*	

* Significant values (5% level)

Table 4. Descriptive statistics EG, Municipalities and LLS

	MUNICIPALITIES		LOCAL LABOUR SYSTEMS	
	EG 1991	**EG 2001**	**EG 1991**	**EG 2001**
OVERALL POPULATION				
Weighted average	-0.002	0.010	0.007	0.056
Coeff of variation	-8.582	-3.674	-17.651	13.575
HIGH TECHNOLOGICAL LEVEL				
Weighted average	-0.211	-0.120	-0.205	-0.069
Coeff of variation	-1.109	-1.213	-1.131	-1.368
MEDIUM - HIGH TECHNOLOGICAL LEVEL				
Weighted average	-0.027	-0.013	-0.021	0.037
Coeff of variation	-1.540	-3.265	-1.897	0.573
MEDIUM - LOW TECHNOLOGICAL LEVEL				
Weighted average	0.003	0.033	0.016	0.075
Coeff of variation	-2.845	0.332	-3.294	0.210
LOW TECHNOLOGICAL LEVEL				
Weighted average	0.032	0.036	0.042	0.080
Coeff of variation	0.939	0.637	0.861	0.418
ENERGY AND OTHERS				
Weighted average	-0.168	-0.250	-0.149	-0.191
Coeff of variation	12.317	-1.381	7.081	-110.267

Spearman rank correlation test		
Municipalities	EG 1991 - Lj 1991	0.286
	EG 1991 - Gini 1991	-0.341
	EG 2001 - Lj 2001	0.358
	EG 2001 - Gini 2001	-0.309
	EG 1991 - EG 2001	0.781*
LLS	EG 1991 - Lj 1991	0.407*
	EG 1991 - Gini 1991	-0.029
	EG 2001 - Lj 2001	0.629
	EG 2001 - Gini 2001	-0.068
	EG 1991 - EG 2001	0.625*

* Significant values (5% level)

Table 5. Relative concentration of a particular industry and Locational Gini coefficients, 1991 and 2001. MUNICIPALITIES

Code	Tech content	**Lj 1991**	Code	Tech content	**Lj 2001**	Code	Tech content	**Gini 1991**	Code	Tech content	**Gini 2001**
10 most concentrated sectors											
05	AFF	0.695	12	EN	0.981	11	EN	0.496	11	EN	0.500
01	AFF	0.648	10	EN	0.801	90	NKIS	0.494	12	EN	0.500
02	AFF	0.643	23	MLT	0.776	99	NKIS	0.494	10	EN	0.497
14	EN	0.605	13	EN	0.749	10	EN	0.487	13	EN	0.495
16	LT	0.601	05	AFF	0.691	62	KIS	0.487	99	KNIS	0.493
10	EN	0.570	14	EN	0.672	05	AFF	0.485	23	MLT	0.491
23	MLT	0.522	16	LT	0.616	16	LT	0.484	16	LT	0.488
17	LT	0.518	11	EN	0.614	13	EN	0.483	73	KIS	0.485
62	KIS	0.505	17	LT	0.599	23	MLT	0.476	30	HT	0.480
90	NKIS	0.501	01	AFF	0.596	61	NKIS	0.470	62	KIS	0.478
10 least concentrated sectors											
52	NKIS	0.081	52	NKIS	0.092	45	C	0.184	45	C	0.153
93	NKIS	0.085	93	NKIS	0.100	52	NKIS	0.185	52	NKIS	0.181
80	KIS	0.103	51	NKIS	0.101	80	KIS	0.216	80	KIS	0.191
50	NKIS	0.131	80	KIS	0.111	75	NKIS	0.232	75	NKIS	0.206
60	NKIS	0.132	60	NKIS	0.128	01	AFF	0.242	55	NKIS	0.230
45	C	0.144	45	C	0.144	60	NKIS	0.245	74	KIS	0.243
71	KIS	0.157	50	NKIS	0.152	93	NKIS	0.258	93	NKIS	0.251
55	NKIS	0.162	55	NKIS	0.157	55	NKIS	0.270	51	NKIS	0.253
51	NKIS	0.165	90	NKIS	0.161	50	NKIS	0.288	50	NKIS	0.259
75	NKIS	0.176	75	NKIS	0.162	15	LT	0.290	85	KIS	0.266

Note: For description of the technological content: AFF: Agriculture, forestry and fishing; EN: Energy and others; LT: Low tech manuf; MLT: Medium-low tech manuf; MHT: Medium-high tech manuf; HT: High-tech manuf; NKIS: Non-Knowledge Intensive services; KIS: Knowledge intensive services.

Table 6. Relative concentration of a particular industry and Locational Gini coefficients, 1991 and 2001. LLS

Code	Tech content	**Lj 1991**	Code	Tech content	**Lj 2001**	Code	Tech content	**Gini 1991**	Code	Tech content	**Gini 2001**
10 most concentrated sectors											
05	AFF	0.626	12	EN	0.788	05	AFF	0.419	11	EN	0.466
16	LT	0.563	23	MLT	0.741	99	NKIS	0.408	13	EN	0.460
01	AFF	0.551	10	EN	0.713	16	LT	0.390	10	EN	0.458
02	AFF	0.546	05	AFF	0.619	10	EN	0.390	99	NKIS	0.426
14	EN	0.462	17	LT	0.536	90	NKIS	0.387	16	LT	0.418
17	LT	0.455	16	LT	0.519	35	MHT	0.366	05	AFF	0.396
10	EN	0.455	01	AFF	0.517	11	EN	0.363	23	MLT	0.390
23	MLT	0.454	14	EN	0.516	17	LT	0.348	17	LT	0.376
99	NKIS	0.438	62	KIS	0.502	21	LT	0.344	32	HT	0.364
62	KIS	0.405	19	LT	0.477	62	KIS	0.340	19	LT	0.352
10 least concentrated sectors											
93	NKIS	0.034	52	NKIS	0.043	93	NKIS	0.066	80	KIS	0.057
52	NKIS	0.038	93	NKIS	0.049	52	NKIS	0.072	93	NKIS	0.061
80	KIS	0.047	51	NKIS	0.062	80	KIS	0.072	65	KIS	0.069
50	NKIS	0.078	41	EN	0.067	65	KIS	0.077	50	NKIS	0.077
71	KIS	0.091	80	KIS	0.068	60	NKIS	0.086	52	NKIS	0.081
60	NKIS	0.102	60	NKIS	0.083	50	NKIS	0.097	45	EN	0.085
45	EN	0.104	90	NKIS	0.090	45	EN	0.101	74	KIS	0.099
41	EN	0.116	50	NKIS	0.106	75	NKIS	0.119	60	NKIS	0.100
55	NKIS	0.119	85	KIS	0.113	64	KIS	0.127	51	NKIS	0.106
51	NKIS	0.124	75	NKIS	0.119	71	KIS	0.133	85	KIS	0.110

Note: For description of the technological content: AFF: Agriculture, forestry and fishing; EN: Energy and others; LT: Low tech manuf; MLT: Medium-low tech manuf; MHT: Medium-high tech manuf; HT: High-tech manuf; NKIS: Non-Knowledge Intensive services; KIS: Knowledge intensive services.

Table 7. Clustering and Moran's I, Municipalities

	1991			2001			
Code	**Cj**	**Moran's I**	**Prob (Moran's I)**	Code	**Cj**	**Moran's I**	**Prob (Moran's I)**
OVERALL POPULATION							
30	1.303	4.711	0.000	30	1.098	2.277	0.023
32	1.247	7.011	0.000	32	1.458	9.052	0.000
HIGH TECHNOLOGICAL LEVEL							
24	1.173	9.774	0.000	24	1.275	11.226	0.000
29	1.267	10.512	0.000	29	1.351	11.479	0.000
31	1.061	5.608	0.000	31	1.029	2.452	0.014
33	1.368	7.192	0.000	33	1.309	1.612	0.107
34	1.037	6.712	0.000	34	1.230	12.881	0.000
35	1.222	8.038	0.000	35	1.085	5.124	0.000
MEDIUM - HIGH TECHNOLOGICAL LEVEL							
23	0.681	8.485	0.000	23	1.841	16.010	0.000
25	1.305	14.011	0.000	25	1.136	6.360	0.000
26	0.941	9.107	0.000	26	0.825	6.141	0.000
27	1.194	10.755	0.000	27	1.165	3.354	0.001
28	1.138	14.364	0.000	28	1.054	11.581	0.000
36	0.933	8.962	0.000	36	0.902	9.175	0.000
MEDIUM - LOW TECHNOLOGICAL LEVEL							
15	0.781	8.931	0.000	15	0.668	7.340	0.000
16	0.413	6.209	0.000	16	0.408	2.853	0.004
17	0.840	18.216	0.000	17	0.884	16.526	0.000
18	0.863	10.045	0.000	18	0.874	11.383	0.000
19	0.832	3.258	0.001	19	0.841	2.987	0.003
20	0.610	7.469	0.000	20	0.536	4.574	0.000
21	0.889	9.847	0.000	21	0.792	12.006	0.000
22	1.359	14.163	0.000	22	1.314	13.703	0.000
LOW TECHNOLOGICAL LEVEL							
61	0.568	-0.561	0.575	61	0.763	1.492	0.136
62	1.245	-0.107	0.915	62	1.331	0.502	0.616
64	0.774	0.927	0.354	64	1.032	3.292	0.001
65	0.721	3.492	0.000	65	0.884	3.593	0.000
66	0.600	-0.256	0.798	66	0.816	1.809	0.070
67	0.619	-0.248	0.804	67	0.700	0.186	0.853
70	0.601	13.410	0.000	70	0.854	9.411	0.000
71	0.904	1.881	0.060	71	1.068	1.146	0.252
72	0.813	4.504	0.000	72	1.082	8.697	0.000
73	1.053	1.131	0.258	73	0.957	-0.538	0.591
74	0.863	12.355	0.000	74	0.926	14.013	0.000
80	0.944	4.520	0.000	80	0.902	5.993	0.000
85	0.925	3.307	0.001	85	0.923	1.929	0.054
92	0.890	6.379	0.000	92	0.996	7.001	0.000
KNOWLEDGE INTENSIVE SERVICES							
50	0.815	2.736	0.006	50	0.825	1.834	0.067
51	0.957	11.069	0.000	51	1.027	11.197	0.000
52	0.878	8.376	0.000	52	0.903	9.990	0.000
55	0.728	13.807	0.000	55	0.757	13.099	0.000
60	0.990	3.468	0.001	60	1.005	3.459	0.001
63	0.670	1.810	0.070	63	1.098	4.848	0.000
75	0.764	5.693	0.000	75	0.785	6.490	0.000
90	1.071	-0.110	0.913	90	1.011	1.425	0.154
91	0.651	-0.027	0.978	91	0.698	-0.166	0.868
93	0.840	3.153	0.002	93	0.865	2.093	0.036
95	0.808	8.275	0.000	95	0.900	7.123	0.000
99	0.447	-0.607	0.544	99	0.706	2.992	0.003
NON KNOWLEDGE INTENSIVE SERVICES							
01	0.408	23.687	0.000	01	0.426	23.855	0.000
02	0.518	5.409	0.000	02	0.581	6.868	0.000
05	0.384	6.576	0.000	05	0.391	7.070	0.000
AGRICULTURE, FORESTRY AND FISHING							
10	0.601	11.064	0.000	10	0.988	0.541	0.589
11	0.628	3.755	0.000	11	0.876	0.531	0.596
13	0.888	4.768	0.000	13	0.734	0.509	0.611
14	0.625	1.417	0.156	14	0.672	2.584	0.010
37	0.000	-0.586	0.558	37	1.141	0.918	0.358
40	0.627	3.976	0.000	40	0.763	2.145	0.032
41	0.873	2.761	0.006	41	0.898	4.324	0.000
ENERGY AND OTHERS							
45	0.728	11.464	0.000	45	0.737	8.813	0.000

Table 8. Clustering and Moran's I, LLS

	1991			2001			
Code	**Cj**	**Moran's I**	**Prob (Moran's I)**	Code	**Cj**	**Moran's I**	**Prob (Moran's I)**
HIGH TECHNOLOGICAL LEVEL							
30	1.047	7.588	0.000	30	1.135	2.641	0.008
32	1.280	3.355	0.001	32	1.518	6.545	0.000
MEDIUM - HIGH TECHNOLOGICAL LEVEL							
24	1.124	2.800	0.005	24	1.192	3.254	0.001
29	1.209	2.112	0.035	29	1.296	3.188	0.001
31	1.072	2.537	0.011	31	1.080	0.831	0.406
33	1.236	5.282	0.000	33	1.123	3.434	0.001
34	1.037	2.793	0.005	34	1.150	1.761	0.078
35	0.937	3.672	0.000	35	1.053	3.231	0.001
36	0.964	1.218	0.223	36	0.956	-1.017	0.309
MEDIUM - LOW TECHNOLOGICAL LEVEL							
23	0.521	0.487	0.627	23	0.264	2.520	0.012
25	1.226	2.971	0.003	25	1.076	1.485	0.137
26	0.986	0.398	0.691	26	0.888	0.372	0.710
27	1.192	3.517	0.000	27	1.138	0.780	0.436
28	1.122	4.309	0.000	28	1.075	5.068	0.000
LOW TECHNOLOGICAL LEVEL							
15	0.824	1.806	0.071	15	0.747	1.227	0.220
16	0.366	0.621	0.535	16	0.369	-0.019	0.985
17	1.027	3.830	0.000	17	1.034	3.157	0.002
18	0.950	1.274	0.203	18	0.994	1.220	0.223
19	0.860	1.616	0.106	19	0.903	0.072	0.942
20	0.730	5.626	0.000	20	0.636	4.170	0.000
21	0.897	0.950	0.342	21	0.790	0.494	0.621
22	1.131	6.218	0.000	22	1.178	5.956	0.000
KNOWLEDGE INTENSIVE SERVICES							
61	0.590	1.731	0.083	61	0.628	0.782	0.434
62	1.007	1.507	0.132	62	0.877	1.472	0.141
64	0.765	1.929	0.054	64	0.894	4.700	0.000
65	0.762	0.031	0.975	65	0.916	1.210	0.226
66	0.659	0.533	0.594	66	0.808	2.656	0.008
67	0.615	0.255	0.798	67	0.730	0.582	0.560
70	0.621	6.025	0.000	70	0.894	5.084	0.000
71	0.895	0.439	0.661	71	1.023	2.890	0.004
72	0.780	5.271	0.000	72	0.996	6.692	0.000
73	1.042	3.537	0.000	73	0.992	0.761	0.447
74	0.819	3.498	0.000	74	0.916	5.082	0.000
80	0.973	2.072	0.038	80	0.949	1.281	0.200
85	0.885	1.580	0.114	85	0.916	0.052	0.959
92	0.902	5.407	0.000	92	0.945	6.373	0.000
NON KNOWLEDGE INTENSIVE SERVICES							
50	0.870	1.701	0.089	50	0.873	2.525	0.012
51	0.914	2.302	0.021	51	1.016	3.601	0.000
52	0.896	1.811	0.070	52	0.919	3.433	0.001
55	0.787	5.516	0.000	55	0.806	5.690	0.000
60	0.933	2.475	0.013	60	0.973	2.079	0.038
63	0.624	3.098	0.002	63	1.026	2.187	0.029
75	0.786	2.203	0.028	75	0.816	4.322	0.000
90	1.110	2.577	0.010	90	0.990	3.866	0.000
91	0.655	1.311	0.190	91	0.715	2.085	0.037
93	0.892	3.547	0.000	93	0.916	2.923	0.003
95	0.864	3.563	0.000	95	0.929	3.992	0.000
99	0.460	-0.684	0.494	99	0.625	0.302	0.763
AGRICULTURE, FORESTRY AND FISHING							
01	0.508	7.272	0.000	01	0.515	7.386	0.000
02	0.591	2.997	0.003	02	0.679	2.636	0.008
05	0.470	1.816	0.069	05	0.454	1.615	0.106
ENERGY AND OTHERS							
10	0.651	0.947	0.343	10	0.523	2.090	0.037
11	0.607	1.308	0.191	11	0.594	-0.838	0.402
13	0.914	-0.686	0.493	13	0.758	0.450	0.653
14	0.613	-0.742	0.458	14	0.575	0.851	0.395
37	0.000	-0.868	0.385	37	1.120	2.308	0.021
40	0.696	3.306	0.001	40	0.797	0.754	0.451
41	0.914	3.586	0.000	41	0.932	3.000	0.003
CONSTRUCTION							
45	0.828	4.517	0.000	45	0.822	3.693	0.000

Figure 1. L_j, Municipalities

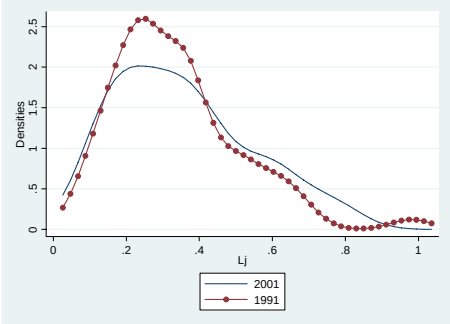


Figure 2. L_j, LLS

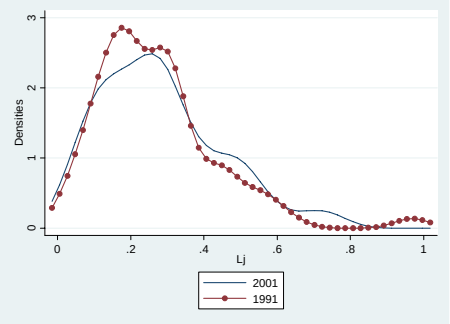


Figure 3. Locational Gini, Municipalities

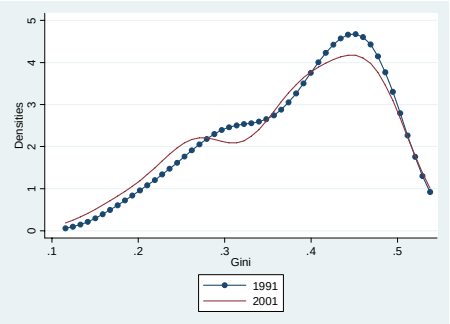


Figure 4. Locational Gini, LLS

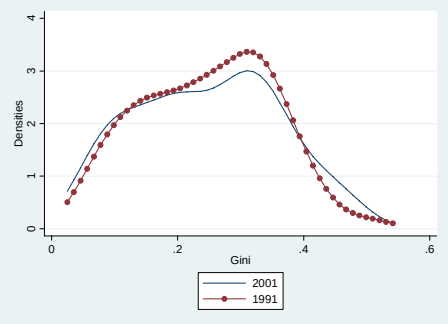


Figure 5. L_j, Manufacturing. Municipalities

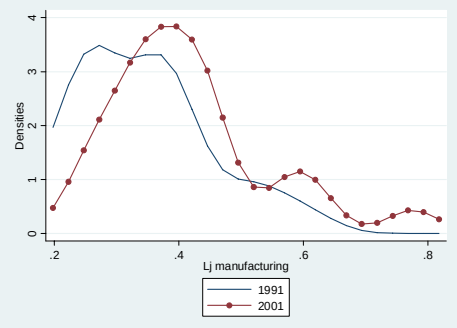


Figure 6. L_j, Services. Municipalities

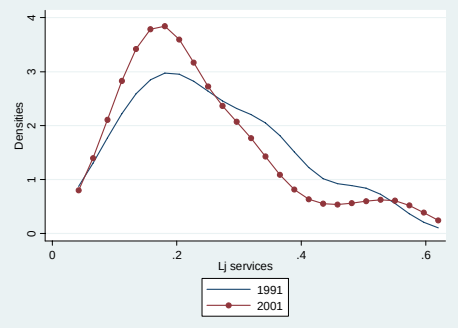


Figure 7. Gini, Manufacturing. Municipalities.

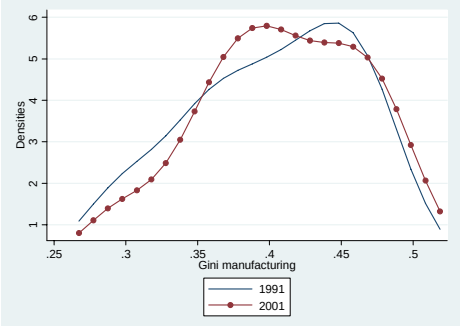


Figure 8. Gini, Services. Municipalities

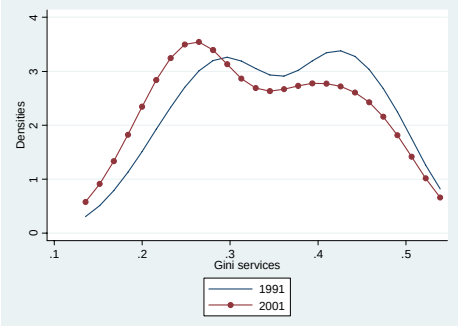


Figure 9. Clustering, Municipalities

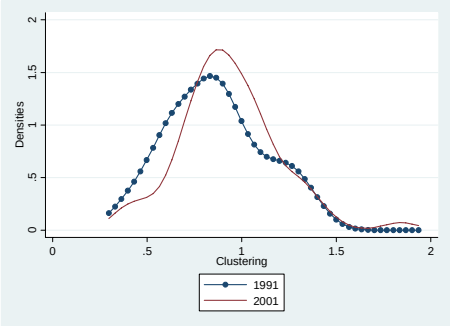


Figure 10. Clustering, LLS

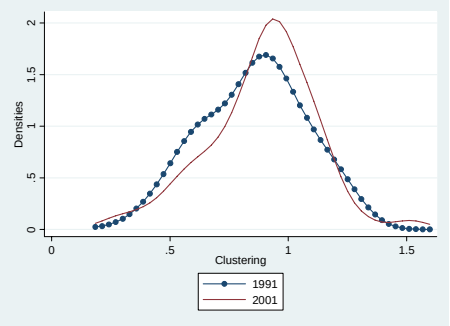


Figure 11. Clustering, Manufacturing. Municipalities

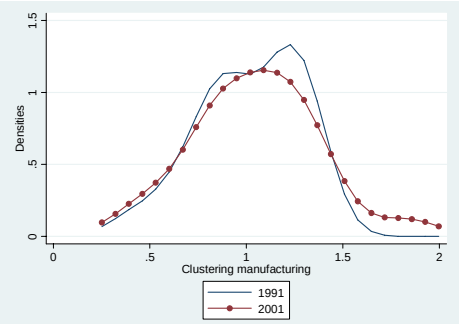
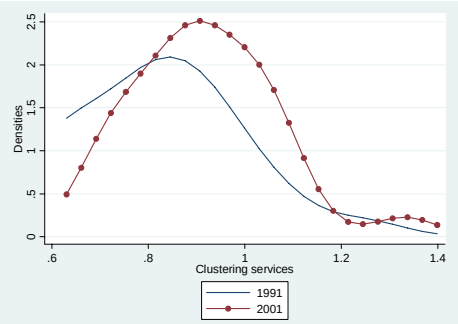


Figure 12. Clustering, Services. Municipalities



ANNEX

Code	Description of sectors (2-digit level)	Tech content
1	Agriculture, hunting and related service activities	AFF
2	Forestry, logging and related service activities	AFF
5	Fishing, fish farming and related service activities	AFF
10	Mining of coal and lignite; extraction of peat	EN
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	EN
12	Mining of uranium and thorium ores	EN
13	Mining of metal ores	EN
14	Other mining and quarrying	EN
15	Manufacture of food products and beverages	LT
16	Manufacture of tobacco products	LT
17	Manufacture of textiles	LT
18	Manufacture of wearing apparel; dressing and dyeing of fur	LT
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	LT
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	LT
21	Manufacture of pulp, paper and paper products	LT
22	Publishing, printing and reproduction of recorded media	LT
23	Manufacture of coke, refined petroleum products and nuclear fuel	LMT
24	Manufacture of chemicals and chemical products	MHT
25	Manufacture of rubber and plastic products	LMT
26	Manufacture of other non-metallic mineral products	LMT
27	Manufacture of basic metals	LMT
28	Manufacture of fabricated metal products, except machinery and equipment	LMT
29	Manufacture of machinery and equipment n.e.c.	MHT
30	Manufacture of office machinery and computers	HT
31	Manufacture of electrical machinery and apparatus n.e.c.	MHT
32	Manufacture of radio, television and communication equipment and apparatus	HT
33	Manufacture of medical, precision and optical instruments, watches and clocks	HT
34	Manufacture of motor vehicles, trailers and semi-trailers	MHT
35	Manufacture of other transport equipment	MHT
36	Manufacture of furniture; manufacturing n.e.c.	LT
37	Recycling	EN
40	Electricity, gas, steam and hot water supply	EN
41	Collection, purification and distribution of water	EN
45	Construction	C
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	NKIS
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	NKIS
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	NKIS
55	Hotels and restaurants	NKIS
60	Land transport; transport via pipelines	NKIS
61	Water transport	KIS
62	Air transport	KIS
63	Supporting and auxiliary transport activities; activities of travel agencies	NKIS
64	Post and telecommunications	KIS
65	Financial intermediation, except insurance and pension funding	KIS
66	Insurance and pension funding, except compulsory social security	KIS
67	Activities auxiliary to financial intermediation	KIS
70	Real estate activities	KIS
71	Renting of machinery and equipment without operator and of personal and household goods	KIS
72	Computer and related activities	KIS
73	Research and development	KIS
74	Other business activities	KIS
75	Public administration and defence; compulsory social security	NKIS
80	Education	KIS
85	Health and social work	KIS
90	Sewage and refuse disposal, sanitation and similar activities	NKIS
91	Activities of membership organizations n.e.c.	NKIS
92	Recreational, cultural and sporting activities	KIS
93	Other service activities	NKIS
95	Activities of households as employers of domestic staff	NKIS
99	Extra-territorial organizations and bodies	NKIS

Note: For description of the technological content: AFF: Agriculture, forestry and fishing; EN: Energy and others; LT: Low tech manuf; MLT: Medium-low tech manuf; MHT: Medium-high tech manuf; HT: High-tech manuf; NKIS: Non-Knowledge Intensive services; KIS: Knowledge intensive services.

[1] Following ARBIA (2001), all these papers contain illustrative examples of the difference between concentration and polarization-agglomeration.

[2] See KOLKO (1999) for a fuller discussion of the location of service activities.

[3] We will focus only on comparative studies of the manufacturing and service activities. Other studies that deal only with the degree of concentration of manufacturing industries include ELLISON and GLASER (1997), CALLEJÓN (1997), MAUREL and SÉDILLOT (1999), DEVEREUX *et al*., (2004), DURANTON and OVERMAN (2005), BERTINELLI and DECROP (2005) and MORI *et al*., (2005), among others.

[4] The EG index determines the degree of concentration of a particular sector after discounting the effect of the size of the establishments, but does not indicate the origin of this excessive concentration beyond industrial concentration that a particular economic activity has. It only points out that plants locate together either to benefit from local natural advantages or to internalize externalities from other establishments.

[5] For the definition of the LLS we have followed the ones given in Romaní (2006).

[6] As DE DOMINICIS *et al*., (2006) point out, LLS are aggregations of two or more municipalities identified on the basis of the self-containment of the daily commuting flows between the place of residence and the place of work. Given this definition, LLS have to be updated periodically. However, we will use the same territorial division established in 2001 both for 1991 and 2001 for the sake of comparison, working with a total number of 61 LLS

[7] We will examine the weighted average by groups for a comparison of the values of different groups ordered by their technological level instead of looking at the simple average. We weight each sector according to its participation in total employment of the group because there are great differences in size concerning the number of employees.

[8] Due to restrictions on data availability, we do not have the computation of the EG index for services.

[9] This conclusion is corroborated by the data on establishments for 2001 in Catalonia (DIRCE, INE). The two high tech industries: Manufactures of office machinery and apparatus n.e.c (30) and Manufacture of radio, television and communication equipment and apparatus (32), are in seventh and fifth place respectively in the table of sectors, according to the percentage of establishments with 200 or more employees.

[10] Note that the Recycling industry (37) employed only 1 worker in 1991, and the Mining of uranium and thorium ores industry (12) employed 3 workers in 2001 (table 5).

[11] The biggest difference between the results obtained for the L_j and the Locational Gini Indexes is that the latter places the Agriculture, hunting and related service activities (01) among the 10 least concentrated, while the former places it among the most concentrated ones. The other activities present similar results in the two indices, confirming the high rank correlation between them, especially for the most dispersed sectors.