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Agglomeration and Economic Growth: Some Puzzles

Federica Sbergami
Graduate Institute of International Studies

Abstract

Knowledge spillovers and technical externalities play a fundamental role in basically all endogenous growth models. In a context of increasing returns to scale and transportation costs it seems reasonable to assume that regional agglomeration of production and R&D activities is linked to aggregate growth. This work is an empirical investigation of the predictions provided by some theoretical studies according to which agglomeration increases with growth and growth increases with agglomeration (Martin and Ottaviano, 2001, Baldwin and Forslid, 2000 and Fujita and Thisse, 2001). The behaviour of six European countries over twelve years (from 1984 to 1995) is analysed using panel data techniques. In particular, a "traditional" growth equation à la Barro, in which an index of regional agglomeration of industrial activities is added to the "typical" regressors, is estimated. Surprisingly, instead of concentration in a few areas, as theory predicts, equal dispersion of economic activities across regions seems to be good for national aggregate growth. Besides, there is also some evidence that regional dispersion of sectors with a high technological content is growth enhancing.

Agglomeration and Economic Growth: Some Puzzles

Federica Sbergami[1]
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1. Introduction

The existence of a positive relationship between economic growth and geographic agglomeration has been widely documented by historians (e.g. see Hohenberg and Lees, 1985). Strangely enough, this issue has not been particularly tackled by the economic literature and the analysis of agglomeration and economic growth has developed along two separate streams. The most part of the economic geography models (Krugman, 1991, Venables, 1996, Krugman and Venables, 1995) focus on static effects of integration and they are not well suited to evaluate the interaction between the concentration of economic activities and long-run growth. Nevertheless, it seems quite reasonable to believe that location affects growth and, in turn, growth affects location. Think, for example, at the role played by knowledge spillovers and technical externalities in basically all endogenous growth models (Grossman and Helpman 1991, just to cite one for all). It has been shown (Eaton and Kortum, 1996) that these externalities are related to the location of economic and R&D activities. Hence, it is reasonable to assume that there is a positive relationship between clustering of industries and R&D activities and growth performances.

There are some theoretical papers that represent an exception to the general line described above. Martin and Ottaviano (2001) show that growth and geographic agglomeration are self-reinforcing processes. The basic logic of their model goes as follows. In a two-regions model, the innovation sector, which is the engine for growth uses as an input a differentiated good, which is produced under increasing returns to scale. Due to the usual interaction between trade costs and increasing returns to scale, the differentiated good sector will locate close to the bigger market (i.e. close to the region where the final demand is higher and the innovation sector is more developed and, consequently, growth is higher). Hence, agglomeration increases with growth (forward linkage). Agglomeration, in turn, will reduce the cost of innovation in the region where the economic activity concentrates and, consequently, will boost growth. Hence, growth increases with agglomeration (backward linkage).

Using a different model, in which there is no vertically linked industry and labor is mobile across regions, Baldwin and Forslid (2000) and Fujita and Thisse (2001) reach basically the same conclusion: agglomeration is favorable to the overall growth and geography does matter for growth.

If we take these models as granted, we should find that countries showing a higher degree of agglomeration of economic activities also have a higher growth rate, at least in their transition to the steady state (in steady state they will grow at the same pace). This prediction has a clear, immediate testability.

[1] I am particularly thankful to Marius Brülhart who helped me a lot in solving the numerous technical problems I found while running this analysis. Discussions with Richard Baldwin have, as usual, been illuminating. I also thank Thierry Mayer and Daria Taglioni for having provided me with part of the data set. I also profited by several opinion exchanges with Hans Genberg, John Cuddy, Gianmarco Ottaviano, Steven Redding, Signe Krogstrup, Maria Pia Victoria-Feser and Mercedes Vera-Martin.

Also the empirical literature has not reserved much attention to the relationship between economic growth and geographic agglomeration, and the econometric analysis of agglomeration and of economic growth and regional inequalities has developed along two separate streams. Indeed, there is a fairly wide empirical literature focusing on location decision of firms both at the national and at the regional level (Combes and Lafourcade, 2001, Head and Mayer, 2001, Brulhart, 1998, Amiti, 1999, Midelfart-Knarvik et al., 2000, just to give some examples), but not on the consequences of agglomeration on growth, or, vice versa, on regional growth as a determinant of the decision of firms on where to locate.

What it has usually been done in the existing literature on location and growth at the regional level (see, for example, Paci and Pigliaru, 1999, and Broadberry, 1998) is to see if the shift of factors across sectors which have different labor productivity is a determinant of aggregate growth. The general conclusion is that sectors do matter for growth, and in particular that the main contribution to the overall labor productivity comes from the increase in the service sector productivity and, to a lesser extent, of industry. In a more recent contribution, Ciccone (2001) shows that the agglomeration of economic activities, measured by employment density, has a positive effect on labor productivity.

None of these studies represent a direct test of the theoretical models cited above. As a matter of fact, there are no empirical works looking at the possible linkage between clustering of economic activities across regions and national growth. The aim of this paper is to explore this issue. In particular, the behavior of six European countries over twelve years (from 1984 to 1995) is analyzed to see if the distribution of manufacturing activities over regional areas has had an impact on their national growth rate. To this end a "traditional" growth equation à la Barro is estimated using panel data techniques. Annual per capita GDP growth is regressed on the typical variables usually used in the literature plus an index of regional agglomeration of industrial activities.

The main problem that has to be solved in this context is how to measure regional agglomeration. Things are complicated by the fact that we are comparing countries split in a different number of non-homogeneous regions. Plainly, there is no perfect index that can be used to measure and compare regional clustering across nations: whatever index is chosen, this will be affected by the areal units on which the phenomenon is plotted and, consequently, comparisons across nations divided in unequal sets of unequally-sized regions are not correct. This problem is part of a more general one known in the literature as the Modifiable Areal Unit Problem (MAUP) for which no general solution has yet been found. In order to go on with the analysis in spite of this problem and, at the same time, try to reduce its impact, we decided to use three different indexes of regional agglomeration of economic activities and see if they provide the same results.

Indeed, two out of the three regional agglomeration indexes we use provide consistent results. Instead of concentration in a few areas, as theory predicts, equal dispersion of economic activities across regional areas seems to be good for national aggregate growth. This unexpected result is robust also to endogeneity checks and to the inclusion of control variables as the distance from the “core” and labor density. The third index is never significant.

Location of sectors with dissimilar characteristics might play a different role in affecting aggregate growth. To account for this we also classify industries according to their technological content and factor intensity (OECD 1997 and 1987 classifications). Surprisingly, there is some evidence that regional dispersion of sectors with a high technological content is good for aggregate growth. If agglomeration of production can be considered a good proxy of R&D activities and technological spillovers (Paci and Usai 2000), we would expect exactly the opposite result.

These puzzling results might depend on the fact that what is important for growth is actually innovation and not production and that high agglomeration in manufacturing does not necessarily mean high agglomeration of innovative activities (Audretsch and Feldman, 1996). Glaeser et al. (1992), for example, show that the Marshall-Arrow-Romer externality hypothesis, according to which high concentration of an industry in a city increases growth of that industry and of the city itself thanks to knowledge spillovers, is not confirmed by data on 170 US cities. According to their findings, industries grow slower in cities where they are more concentrated and less specialized cities know higher growth than more specialized ones. Lack of data on R&D at the regional level makes deeper analysis of this aspect impossible for the time being.

The first two sections of the papers are devoted to a review of the theoretical and of the empirical related literature. The empirical test is set up in Section 4. In Subsection 4.1 the MAUP is addressed and three different indexes of regional agglomeration of manufacturing activities are introduced. The behavior of these indexes in the six countries of interest is analyzed both at the aggregate and at the sectoral level in the following subsection. The results of the estimation of the basic equation and those obtained when sectors are grouped according to their specific characteristics are summarized in 4.3 and 4.4 respectively. Section 5 reports the results of the estimations when distance and labor density are controlled for. Section 6 closes with a summary of the main findings.

2. Agglomeration and growth: a review of the theoretical literature

It is hard to believe that geographical agglomeration does not have any dynamic effect and that it does not affect long run growth. A few theoretical models show that, indeed, the concentration of production and R&D activities creates spillovers that will in turn affect growth.

Martin and Ottaviano (2001), for example, consider a two-region model in which labor, that is assumed to be cross-regionally immobile, is used to produce a homogeneous consumption good and a differentiated good. The differentiated good is also used as an intermediate in the innovation sector. As it is often the case in the standard geography model, the homogeneous good is produced under constant return to scale and perfect competition and it is subject to zero transaction costs. The differentiated good is produced under increasing returns to scale and monopolistic competition and its trade is subject to iceberg costs.

This economic geography framework is merged with an endogenous growth model *a la* Rivera-Batiz and Romer (1991). Aggregate growth depends on the total number of past innovations. In particular the cost of innovation decreases with the number of past innovations. Besides, in the presence of transaction costs, the cost of innovation will be lower in the region where more firms are located. This also implies that, being patents on new inventions subject to free trade, both regions will engage in innovation only in the perfectly symmetric case, i.e. only if manufacturing activities are perfectly spilt between them. If this is not the case, all the innovation is undertaken only in one region.

Since in this model the demand for the differentiated good comes both from consumers and from the growth sector, if innovation is concentrated only in one region, firms will tend to locate in that region (as usual, firms with increasing returns locate where the expenditure level is higher). Hence agglomeration is an increasing function of growth (forward linkage).

At the same time, an increase in the concentration of industries in one region will decrease the cost of innovation and attract more researchers in the sector until profits are back to zero. Hence growth is an increasing function of agglomeration (backward linkage).

The symmetric equilibrium in which the share of manufacturing activities is equal to 1/2 in both regions is unstable for positive equilibrium growth rate, unless the two regions happen to start exactly with the same number of firms and stay there forever. The only stable steady state is the one in which all the innovation activity is concentrated in one region and that region is also relatively specialized in the production of the differentiated good. Note that this implies that both production and R&D activities are geographically concentrated even if at a different degree, innovation being more agglomerated than manufacturing production, which is confirmed by the empirical evidence (Audretsch and Feldman 1996). Lastly note that even if geographic agglomeration results from the forces at work in this model, production activities do not completely leave the periphery region due to the free mobility of the patents and the immobility of consumers.

Baldwin and Forslid (2000) use a different geography model to arrive basically to the same conclusions. In particular, contrary to Martin and Ottaviano (2001), in Baldwin and Forslid firms are not vertically linked and labor is mobile. This "Krugman (1991) type" geography framework is merged with an endogenous growth model *a la* Romer (1990). The monopolistically competitive, increasing return sector uses both labor and an investment good, the production of which is characterized by technological externalities. Due to the presence of local learning spillovers, also in this case agglomeration of economic activities is growth enhancing. Besides, for sufficiently highly localized externalities, growth will also encourage agglomeration.[2]

In a more recent paper, Fujita and Thisse (2001) use a model that is very similar to the one used in Baldwin and Forsild (2000) and, not surprisingly, arrive to the same conclusions concerning the growth-and-agglomeration relationship. Also in this case, a Krugman type geography model is extended to incorporate endogenous growth. The R&D sector uses skilled labor and knowledge capital to create new varieties which are then produced in the manufacturing sector. As in Baldwin and Forsild (2000), the migration behavior of the skilled workers is explicitly modeled. Fujita and Thisse show that, under these assumptions, agglomeration does lead to higher growth and that if this effect is strong enough even those remaining in the periphery are better off, even if absolute discrepancies across individuals leaving in the core and those staying in the periphery may indeed become wider.

3. Overview of the existing empirical literature

Even if the theoretical models presented above seem to deliver a very clear and simple prediction on the growth-agglomeration relationship, there has not been any applied investigation testing the empirical relevance of it. The most part of the applied studies look at labor productivity changes running regressions on levels and generally at the regional level. In the following we report on a couple of these, even if they are not a direct test of the theories presented above.

In a recent paper Antonio Ciccone (2001) analyses the effects of employment-density on average-labor productivity for 5 European countries at the Nuts 3 regional level. He derives the estimating equation from a very simple theoretical model in which the output produced on an acre of land depends on the number of workers employed on that acre, on their average level of

[2] Martin and Ottaviano (1999) have a similar model in which location of innovation matters for growth in the case of localised spillovers.

human capital, on the amount of physical capital, on the total factor productivity and on the density of production in the region, which measures spatial externalities. In order to get an equation that can actually be estimated, Ciccone assumes that the rental rate of capital is the same everywhere within a country. In this way data on the quantity of physical capital, which is, indeed, not available at the regional level, is not necessary. The amount of physical capital and the total factor productivity are, hence, proxied by a country dummy. The estimated equation then is:

$$\text{(1)} \qquad \log Q_{sc} - \log N_{sc} = Country / RegionalDummy + q\left(\log N_{sc} - \log A_{sc}\right) + \sum_{e=0}^{E_c} d_{ec} F_{esc} + u_{ec}$$

where Q is total production in region s of country c, N is total employment, A total acreage and F the fraction of workers with level of education e. The parameter q will capture the effect of regional density of economic activities on regional labor productivity. A positive and significant q will say that the positive externalities deriving from an increase in density of economic activities more than offsets the negative congestion-effects. Using both a simple least squares estimation and an instrumental variable approach in order to solve a possible endogeneity problem (as we know from theory, agglomeration can be the cause of high productivity but also a consequence), the author finds that, indeed, an increase in agglomeration of manufacturing activities and services does have a positive effect on growth of Nuts 3 regions (the sample is given by 628 regions). In a way this result is not surprising: factor productivity *has* to be higher where concentration is higher, otherwise one would not observe any agglomeration phenomenon. Note also that this test accounts for the differences in regional productivity, but it says nothing about GDP growth at the aggregate (i.e. country) level, which is what we are ultimately interested in. Besides and the variable used to measure agglomeration, namely the employment density, is a very simple and primitive one. Other measures that give an idea of "how different" the distribution of economic activities is at the regional level are more widely used in the empirical literature.

Paci and Pigliaru (1999) show that the overall labor productivity growth is affected by the shift of factors across sectors with different productivity levels. Also in this case the analysis is run at a regional level. In particular, according to their results, a positive productivity growth and a structural change effect in services is the main responsible for the average labor productivity increase. Industry contributes positively but less strongly, due to a negative share effect, which partly offset the positive within sector productivity growth. Growth in agriculture, instead, does not show any significant effect.[3] Again, also in this case the analysis is conducted on levels and does not say anything about differences in national growth rates in the transition process.

Even if these studies do show that there is some link between agglomeration and productivity and that sectors matter for growth, they are not a direct test of the theories presented in the previous section. The rest of the paper aims to mend this lack.

4. Regional agglomeration and aggregate growth: an empirical test

In order to test for the existence of a positive relationship between economic growth and geographic agglomeration, as a first step we estimate a "traditional" growth equation (i.e. à la Barro) in which an agglomeration index of industrial activities is included. Annual per capita

[3] These results are in line with the main findings in Broadberry (1998). In this paper the author finds that the shift of resources from the agriculture sector and the improvement of the relative productivity in services (more than industry) are the main causes of Germany's and USA's overtaking of Great Britain.

GDP growth is regressed on annual population growth, secondary school enrollment, trade as a percentage of the GDP, gross domestic fixed investment to GDP ratio, unemployment rate (or alternatively, output gap) and a measure of the degree of agglomeration of economic activities.

Standard growth theory suggests a positive relationship between GDP growth and human capital, which is proxied by the secondary school enrollment variable, trade openness and investment. The predicted sign of the population growth coefficient is less obvious, being population inclusive both of the active labor force and of the inactive segments. Since we are dealing with yearly data, the unemployment rate is included in the estimated regression in order to eliminate the business-cycle noise. Another candidate to serve this scope is the output gap series. As we will see, the main results are not affected by the use of either one of the two business cycle proxies. Lastly, according to the theory presented above, we expect to find a positive relationship between aggregate GDP growth and the economic activity concentration index.

4.1. Data and estimation technique

The sample we consider consists of 6 European countries (Belgium, France, Italy, Netherlands, Spain and UK) and covers 12 years (from 1984 to 1995). All the variables are taken from the World Bank World Development Indicators, with the exception of the two business cycle indicators, that are taken from the OECD Economic Outlook, and the agglomeration index, which is built up using a data set kindly provided by Thierry Mayer[4] and consisting of employment data for 15 manufacturing sectors in 44 Nuts1 European regions. The regions and sectors for which data is available as well as the data sources and variable definitions are listed in the appendix.

Measuring agglomeration of economic activities

All the variables used in this analysis are fairly standard in the literature. A major problem was, instead, to find an appropriate way to measure regional industrial concentration and have an index that can be used to make comparisons across countries that are split in a different number of non-homogeneous regions. The index that is most widely used in the literature to measure concentration is probably the Gini coefficient (see, e.g., Brulhart, 2001, or Amiti, 1999). The way this works is the following. For each sector a series of so-called Balassa indexes is calculated:

(2) $$Balassa_{ij} = \left(\frac{E_{ij}}{\sum_j E_{ij}} \right) \Bigg/ \left(\frac{\sum_i E_{ij}}{\sum_i \sum_j E_{ij}} \right)$$

where, *E* is employment in sector *i* and region *j* (if available, data on output, value added or trade could alternatively be used)[5]. The numerator of this index gives region *j*'s share of the total employment in industry *i*; the denominator is region *j*'s share of total national manufacturing. The more concentrated an industry is, the bigger the corresponding Balassa index will be. In order to

[4] See Head and Mayer, 2001. The data set used in their paper is, in turn, derived from Eurostat and it consists of 2-digit Nace data for NUTS1European regions. Eurostat provides employment data for each combination of industry and region with some gaps in the series. Please refer to Head and Mayer (2001) for details on how missing values have been calculated by the authors.

[5] In general production and employment data are always better than trade data to measure location behavior. Export data are widely available also at a desegregated level and for this reason they are very often used as a proxy for production in location empirical studies. This is correct only if trade propensities are the same across sectors and countries (see Brulhart, 2001 on this). In the end the only direct measure of location patterns is to use production data.

calculate the Gini coefficient, regions are ranked in an increasing order of their Balassa index and the cumulative of regions' shares of the total employment in the industry is reported on the vertical axis, while the cumulative of the regions' shares of total manufacturing is reported on the horizontal axis. Joining all the points a Lorenz curve is obtained. The Balassa indexes are nothing else than the slope of each segment constituting the Lorenz curve. Should employment in the industry under observation be equally distributed across all regions, the corresponding Balassa indexes would all equal one and the Lorenz curve would coincide with the 45-degree line. The more concentrated the industry is in one region, the more the Lorenz curve will departure from the 45-degree line and the wider the area between it and the 45-degree line will be. The Gini coefficient is equal to twice the area between the Lorenz curve and the 45-degree line; hence it is increasing in the degree of concentration.

Now, should the Gini coefficient be unaffected by the number of regions a country is split in, it would be a perfect candidate to be our index of agglomeration of economic activities. In this case it would be enough to average the Gini indexes across sectors, weighting them for the importance of each industry in the country's economy. Unfortunately this is not the case. The Gini coefficient, indeed, depends upon the number of regions considered and hence it is not comparable across countries which are not split homogeneously. To illustrate this point let's consider a concrete case. Figure 1 represents the Lorenz curve for the textile sector in the Italian regions. According to the Eurostat classification, Italy has been divided into 11 Nuts1 regions. Now, suppose that, for some reason, the two regions "North Ovest" and

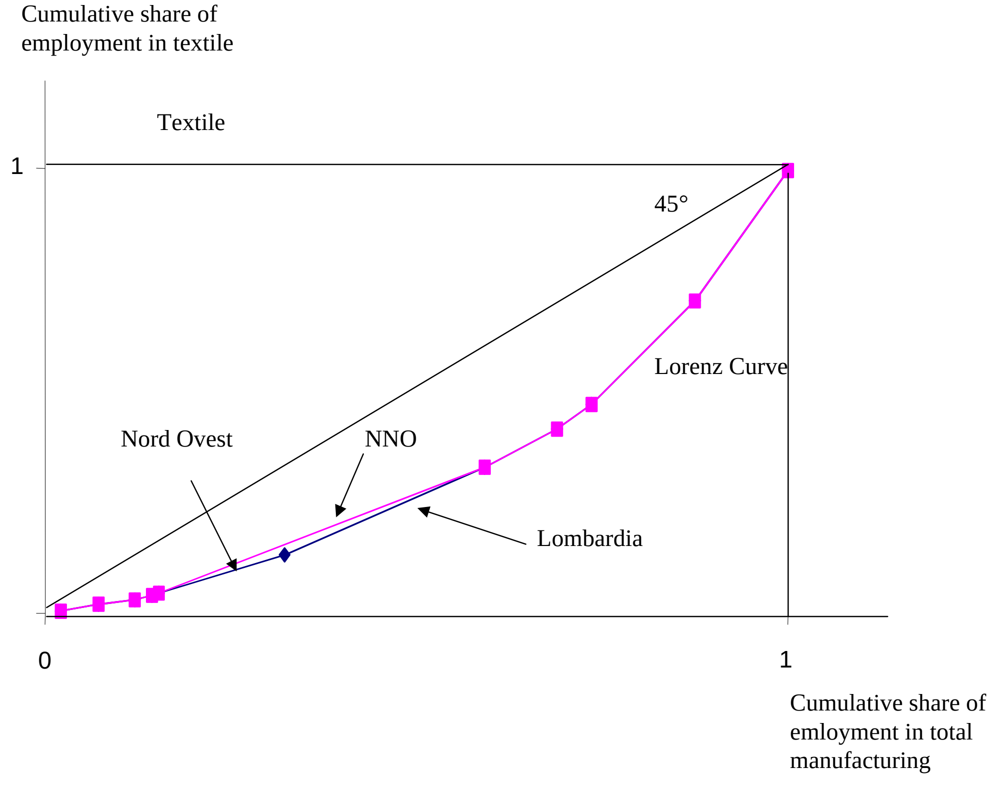

Fig.1 The Gini coefficient and the MAUP

Lombardia were considered together as one region, call it NNO, the corresponding Lorenz curve would change and, consequently, also the Gini coefficient would assume a different value. This simple example tells us that it is not correct to compare Gini coefficients across countries that are divided into differently sized sets of regions.

Modifiable Areal Unit Problem (MAUP)

This problem is part of a more general one known in the literature as the Modifiable Areal Unit Problem (MAUP) and it seems that no general solution has yet been found to address it. The problem derives from the fact that geographical phenomena cannot be measured at a single point but only within a defined spatial area. Inevitably this means to impose artificial spatial boundaries that will have consequences on the measure used, whatever that is. The MAUP is intrinsic to the measure itself of a phenomenon that has a spatial dimension and it can be decomposed into two interrelated components: the scale effect and the zonation effect. "The *scale effect* is the variation in numerical results that occurs due to the number of zones used in an analysis... The *zonation effect* is the variation in numerical results arising from the grouping of small areas into larger units... It is necessary to understand the ways in which the MAUP affects the results of statistical analysis. Caution, however, is required, as there is a random aspect to the effects of the MAUP. It may be difficult to generalize how different data sets with different spatial units are affected by the MAUP. This caution aside, the use of small areal units has a tendency to provide unreliable rates because the population used to calculate the rate is smaller. On the other hand, using larger areal units will provide more stable rates but may mask meaningful geographic variation evident with smaller areal units... Choosing between the scale of zones depends upon the particular use and requirements of the data." (Oliver, 2001). In order too have an additional example of how statistical descriptive measures are affected by this problem, please refer to the appendix.

Three agglomeration indexes

No definitive solution has been found to solve this problem. One strategy, suggested also by Oliver (2001), could be to undertake the analysis at multiple scales and zones. Unfortunately this is not applicable to our case, since the regions we have data on are defined by Eurostat and we cannot do anything to play around with their boundaries. Hence, what we have decided to do in order to limit, for how it is possible, the problem is to use three different indexes of agglomeration of economic activities and see if they provide the same results in our analysis. We are completely aware of the fact that each of these indexes is far from being perfect and that our results might depend on the spatial units being used, but, again, there in not a lot we can do about that.

The first agglomeration index we consider is the standard deviation of the Balassa index. The more concentrated a sector is in a few regions, the wider the variation of the Balassa indexes and the bigger the standard deviation will be. In order to have an aggregate index, the standard deviation of each index is weighted by the importance of that sector in the national economy and averaged.

As a second measure of agglomeration we use the so-called Entropy, or Theil, index:

(3) $$Entropy_i = \sum_j \left[\left(E_{ij} \Big/ \sum_j E_{ij} \right) \ln \left(E_{ij} \Big/ \sum_j E_{ij} \right) \right] / \ln(k)$$

where k is the number of regions. This index varies between zero, corresponding to perfect concentration, and -1, corresponding to equal dispersion. Again, in order to have an aggregate index, each index is weighted by the importance of that sector in the national economy and averaged.

Lastly we consider the Krugman concentration index (derived from the Krugman specialization index):

(4) $$Krugman_i = \sum_j \left| E_{ij} \Big/ \sum_j E_{ij} - \sum_{z \neq i} E_{ij} \Big/ \sum_j \sum_{z \neq i} E_{ij} \right|$$

This coefficient takes value zero in the case of an industry perfectly homogeneously distributed across regions and two in the case of total concentration. In order to have an aggregate Krugman index, also in this case each sectoral index is weighted and averaged.

The panel data is estimated using Feasible Generalised Least Square, FGLS, and allowing both for heteroscedasticity and cross-sectional correlation. A more complex structure in which also time series autocorrelation is considered has been rejected by the data.

4.2. Agglomeration of production in six European countries: evidence from 1984 to 1995

Before turning to the actual empirical estimation, it is worthwhile to briefly examine the path followed by the concentration indexes just introduced in the six countries of interest.

Figure 2 shows the behavior of the three indexes over time. Basically all of them reveal a reduction in regional average clustering of economic activities over the twelve-year time span for almost all the countries. In general, in spite of this tendency to a decrease, it doesn't seem there has been a huge variation in the indexes over time and for some countries they are rather stable. The three indexes give more or less the same picture and countries that look highly concentrated for one index are also highly concentrated for the other two, the only exception being Belgium which is among the most agglomerated countries for the Balassa and the Entropy index and turns out to be at the opposite extreme when the Krugman index is used. The other country with the highest degree of regional agglomeration is Italy (in this case all indexes agree), while Netherlands, France and UK are always the less agglomerated.

This visual, loose analysis is confirmed by a more formal one. Table 1 reports the value of each agglomeration index and the rank of each country at the beginning and at the end of the period and the estimation of the agglomeration index annual growth rate.[6] Clearly countries tend to keep their rank. At most they switch to the next ranking position. In almost all the countries there is a slight reduction of the agglomeration index over time, even if the Entropy index shows more often stability in the degree of regional clustering.[7]

[6] The average annual growth rate of the regional agglomeration index is estimated from the OLS regression $\ln(\text{agglomeration})_t = a + b(\text{time trend}) + u_t$

[7] Brulhart (2001) provides some evidence that concentration of overall economic activities at the country level has increased during the 1972-1996 period. Of course, this is not incompatible with a reduction of regional agglomeration within countries.

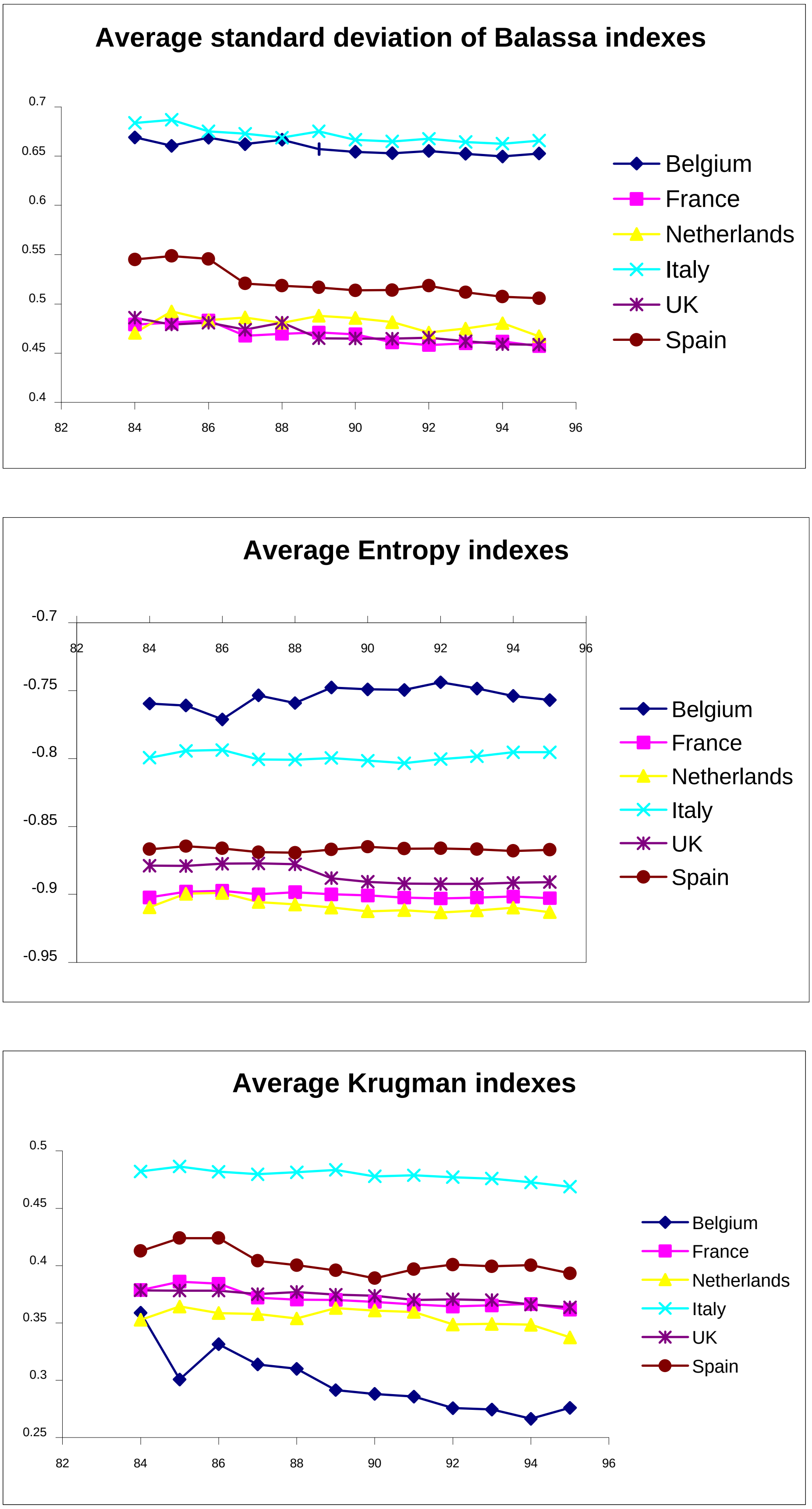

Fig.2 Regional agglomeration of economic activities over the 1984-1995 period for six European countries

Table 1. Regional agglomeration of economic activities in some European countries

Standard deviation of the Balassa index

Nation	Balassa_84	Balassa_95	rank_84	rank_95	% growth rate
Belgium	0.6691	0.6528	2	2	-0.25*
France	0.4791	0.4571	5	6	-0.49*
Italy	0.6839	0.6660	1	1	-0.28*
Netherlands	0.4706	0.4673	6	4	-0.20
Spain	0.5452	0.5057	3	3	-0.71*
UK	0.4859	0.4586	4	5	-0.52*

Entropy index

Nation	Entropy_84	Entropy _95	rank_84	rank_95	% growth rate
Belgium	-0.7596	-0.7570	1	1	-0.15*
France	-0.9021	-0.9027	5	5	0.04*
Italy	-0.7993	-0.7953	2	2	0.00
Netherlands	-0.9094	-0.9131	6	6	0.11*
Spain	-0.8667	-0.8672	3	3	0.00
UK	-0.8787	-0.8908	4	4	-0.52*

Krugman index

Nation	Krugman_84	Krugman_95	rank_84	rank_95	% growth rate
Belgium	0.3588	0.2760	5	6	-2.17*
France	0.3788	0.3615	3	4	0.42
Italy	0.4821	0.4688	1	1	-0.25*
Netherlands	0.3527	0.3374	6	5	-0.41*
Spain	0.4129	0.3933	2	2	-0.54*
UK	0.3785	0.3637	4	3	-0.35*

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 6 the highest dispersion. The growth rate of each agglomeration index is given by 100* the coefficient b of the OLS regression $\ln(\text{agglomeration})_t=a+b(\text{time trend})+u_t$. A * denotes significance at the 95% level.

In the appendix we run the same kind of analysis but at a disaggregated level in order to find facts that might be washed out when looking at regional agglomeration at the manufacturing aggregate level. For each sector we report the degree of agglomeration across regions at the beginning and at the end of the period, the corresponding rank and the percentage average annual growth rate of the clustering measure.

The fact that three different indexes are used makes comparisons and the detection of a general behavior more difficult. Some general facts can anyway be recognized.

Even if, of course, they don't respect exactly the same ranking, sectors that are regionally highly concentrated in one nation tend to be regionally highly concentrated also in the others. For example, taking the standard deviation of the Balassa index, sectors as metal primary, electronics, motor vehicles and parts, food and drinks and textile are, either at the beginning or at the end of the period or both, regionally highly concentrated in the most part of the countries, while sectors like office machines, precision equipment, toys and sport, paper printing and publishing and rubber and plastics are usually more uniformally distributed at the regional level. Unfortunately it does not seem there is any sort of regularity in this agglomeration behavior, in the sense that there are no special characteristics, in terms of factor contents or technology intensity, that are shared by these sectors. For example, textile and electronics result both among the highly concentrated sectors, but the first one is classified as a low-tech, labor-intensive sector, while the second one as a high-tech, technology-intense sector (see the appendix for a classification of industries according to their technology and factor content).

Besides, in general, there is a relatively strong tendency for the sectors to maintain the same ranking position they had at the beginning of the time period (see the fourth and fifth columns of the table in appendix A5). Sectors that were highly concentrated in 1984 are also highly concentrated in 1995 and changes in the ranking position are usually very small (the most part of the sectors does not move more than two places up and down in the ranking), this being true both across countries and indexes.

The three indexes do not usually provide the same ranking of sectors. In particular the Entropy index delivers a very different picture than the one given by the other two. In spite of this, the sign of the estimated annual growth rate of regional agglomeration is usually the same whatever index is used. Sectors that are highly concentrated in a few regions usually show a reduction in their agglomeration degree, even remaining the most clustered, while those that are more dispersed show a tendency towards an increase in agglomeration.

4.3. Main results: aggregate growth and regional agglomeration

Table 2 reports the main results of our basic equation. As said above, two different variables have been used to capture the business cycle. Since there are no major changes in the results according to which one of the two is used, at least not in the coefficient of the variables we are most interested in, we report here only those that refer to the unemployment rate.

The first column refers to a simple growth equation in which aggregate per capita GDP growth is a function of population growth, schooling, trade openness, investment to GDP and the unemployment rate. All the estimated coefficients have the expected signs, with the exception of the secondary school enrollment variable, which is unexpectedly negative. This might mean that, indeed, the secondary school enrollment is not a good measure of human capital for developed countries. Unfortunately other more suitable variables, such as tertiary school enrollment or labor force with high education degree, have many missing years.

The following three columns report the results of the regression when each of the agglomeration index calculated is included. Note that the coefficients of the basic equation's variables are rather stable at inclusion of this extra explanatory variable. More interestingly, the coefficient of the Balassa and of the Entropy index turns out to be significant at the 5% level, but with an unexpected sign. As we said in the previous section, a bigger standard deviation of the Balassa index and a bigger Entropy index indicate higher concentration. Hence, contrary to what the theoretical models predict, the negative sign on the agglomeration index induces to think that, indeed, a higher concentration of production in a few areas is not a good thing for growth. The coefficient on the Krugman index is instead non-significant at the typical levels.[8]

[8] In order to check for the robustness of these results we have also run all the regressions dropping one country at a time. In general all the coefficients are stable to this check. Besides the coefficient on the agglomeration index never

Table 2. Growth and agglomeration

Dependent Variable: per capita gdp annual growth

	no agglomeration	Balassa	Entropy	Krugman
aggl		-.0458*	-.0589*	.0255
		(.0191)	(.0288)	(.0358)
pop	-.0039	-.0159*	-.0148*	-.0032
	(.0060)	(.0072)	(.0071)	(.0061)
school	-.0330**	-.0514*	-.0366**	-.0220
	(.0176)	(.0240)	(.0219)	(.0230)
open	.0134*	.0169*	.0162*	.0161*
	(.0032)	(.0040)	(.0043)	(.0046)
inv	.2034*	.1669*	.1562*	.2245*
	(.0642)	(.0727)	(.0690)	(.0713)
unmpl	.0010*	.0008*	.0007**	.0008*
	(.0003)	(.0004)	(.0004)	(.0004)
Wald Test	$\chi^2(5)=33.30$	$\chi^2(5)=33.79$	$\chi^2(5)=29.95$	$\chi^2(5)=34.63$
	p=0.00	p=0.00	p=0.00	p=0.00

Note: 72 Observations. FGLS estimation, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

Now, these results might very well be affected by a possible endogeneity problem. Indeed the models we have presented above predict a two-way relationship between agglomeration and growth. On one side, production and R&D concentration enhances growth thanks to local spillovers, but on the other growth acts as an additional centripetal force that pushes industries to locate all in the same area. In order to keep this into account we have run the estimation again using Instrumental Variables' techniques (IV).

The main problem is to find a variable that is highly correlated with the agglomeration index but not with aggregate growth. One very good candidate could be the distribution of capital to labor ratios across regions. Together with the different regional market size, a different factor endowment could well explain why firms tend to locate in one region instead than in another (these are among the country characteristics that Midelfart-Knarvik et al., 2000, recognize as determinants of industries' location decisions). Unfortunately data on capital and labor are available at the regional level only for a couple of recent years. Hence we have tried a series of

changes sign or significance. The only two cases in which the Balassa and the Entropy indexes become non significant but still keep their signs, are when Italy and UK are dropped from the sample. This is not a bad result after all, given how small our sample is. It is not that surprising that results are a bit affected when two important countries like Italy and UK are dropped.

other possible instruments subject to the data availability, among these the standard deviation of regional population, regional population density, per capita GDP and employment in agriculture.

Table 3 summarizes the results when the agglomeration index is instrumented for using the standard deviation of the regional population density as an instrument, that being the variable among all the available measures which is more highly correlated with the Balassa and the Entropy index. The Krugman index turns out to be more highly correlated with the standard deviation of employment in agriculture, instead. As it is possible to see from the table, all the main results are confirmed. Once again dispersion of economic activities and not concentration seems to be good for aggregate growth.

Table 3. Growth and agglomeration with instrumental variables

Dependent Variable: per capita gdp annual growth

	Balassa	Entropy	Krugman
aggl	-.0510*	-.0758*	-.1542
	(.0198)	(.0295)	(.1683)
pop	-.0148*	-.0177*	-.0019
	(.0068)	(.0073)	(.0068)
school	-.0605*	-.0420**	-.1003
	(.0257)	(.0218)	(.0815)
open	.0185*	.0177*	.0053
	(.0044)	(.0042)	(.0080)
inv	.1469*	.1463*	.1754*
	(.0702)	(.0702)	(.0640)
unmpl	.0008*	.0007**	.0014*
	(.0004)	(.0004)	(.0006)
Wald Test	$\chi^2(5)=230.58$	$\chi^2(5)=230.58$	$\chi^2(5)=198.60$
	p=0.00	p=0.00	p=0.00

Note: 72 Observations. Two stage FGLS estimation, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

4.4. Classification of manufacturing sectors

In theoretical models manufacturing is seen as a whole. When it comes to the applied analysis it is hard to believe, though, that traditional sectors as food, beverages, clothing have the same effect on the economic performance as sectors in which R&D and high tech investments are particularly important. Averaging out and putting very different sectors all together might cancel out part of the effect of allocation on growth.

In order to keep this aspect into account we have classified the sectors according to their technology intensity, calculated a weighted average of the standard deviation of the Balassa index and a weighted average of the Entropy index for each group of sectors and run a new growth regression including an agglomeration index for each group. Building up these indexes is very long and laborious, hence, since it is never significant in our analysis, the Krugman index has not been considered.

According to our priors, a high concentration of high-tech activities should have a positive effect on aggregate growth. Indeed, we expect R&D and technical spillovers to be stronger where production of goods with a high technological content is agglomerated.

The grouping of sectors according to their technological content is based on the OECD 1997 classification (see the ITC, 2000, mimeo on this). Each manufacturing sector is classified as high, medium or low tech (details are reported in the appendix). Being the available data very aggregated, this classification of manufacturing activities is far from being perfect. It might well happen that in a 2-digit Nace sector coexist 3-digit sectors that are classified in different groups according to their technological content. Luckily there was only a case like this: sector 34, electronics, includes both electronic machinery and telecommunications, which is classified as a high-tech sector, and electrical machinery and apparatus, a "medium-high-tech" sector. Due to the prevalence of high-tech 3-digit level sectors, in the end electronics has been classified as a high-tech sector.

Table 4 reports the results of this new regression. The first two columns refer to the Balassa index and the third and the forth to the Entropy index and show the results obtained using FGLS and IV estimation techniques respectively.

As it is possible to see in this case endogeneity is most likely to play a role and the estimation through instrumental variables techniques considerably affects the results. The most unexpected and puzzling of these is the negative sign on the high-tech agglomeration index. As said above, if the concentration of R&D activities is positively correlated with the concentration of production in high-tech sectors, we would expect clustering of sectors with a high technological content to be positive for growth. Audretsch and Feldman (1996) show, anyway, that this has not necessarily to be the case: according to their findings, sectors exhibiting high geographic agglomeration in production are not the same sectors that show high clustering in innovation activities, which means that "the propensity for innovative activity to spatially cluster cannot be simply explained by the geographic concentration of the location of manufacturing activity". Under this hypothesis we could infer that a negative sign on the high-tech sectors' agglomeration coefficient is not a conclusive evidence for the absence of positive local spillovers effects on economic performance.

If this is true for the USA States, though, it doesn't seem to be true for Europe. According to Paci and Usai (2000) there is a positive and significant correlation between sectoral innovative clustering and manufacturing concentration across European regions. Hence, if, in the end, agglomeration of production can be considered a good proxy of R&D activities, the puzzling result remains. Indeed, the finding that regional dispersion of sectors with a high technological content is good for aggregate growth is in line with what Paci and Usai conclude. In their 2000 paper they find that there is a negative correlation between the degree of concentration of sectoral innovative activity in each region and its productivity level. "In other words, European regions which enjoy a more homogeneous distribution of their technological capability across different industrial sectors appear to be also characterized by a higher productivity level". It seems that this phenomenon has consequences also on the level of aggregate growth and that countries in which the range of manufacturing and innovative activities is more homogeneously distributed across regions are more successful in growth performances.

The other result that confirms the puzzle is the fact that of all the coefficients, the only other ones that are significant, namely the low- and medium-tech groups when the Balassa index is used, show a positive sign, indicating that concentration of these activities is good for growth, while, according to the previous reasoning it should be the opposite, if anything.

Table 4. Growth and agglomeration of high-medium-low-tech sectors

Dependent Variable: per capita gdp annual growth

	Balassa FGLS	Balassa IV	Entropy FGLS	Entropy IV
aggl_ht	.0499	-.0824**	.1492	-1.4089**
	(.0339)	(.0468)	(.2075)	(.8003)
aggl_mt	.2465*	.2204	.0111	-.0870
	(.1251)	(.1646)	(.0344)	(.0650)
aggl_lt	.0841**	-.0871	-.0445	-.1470
	(.0496)	(.0637)	(.0671)	(.1074)
pop	-.0146**	-.0078	-.0037	.0289
	(.0080)	(.0081)	(.0068)	(.0204)
school	-.0570*	-.1850*	-.0250	-.1559*
	(.0257)	(.0585)	(.0053)	(.0547)
open	.0127*	.0178*	.0103*	.0128
	(.0053)	(.0077)	(.0053)	(.0083)
inv	.1029	.1784**	.1773*	.2113*
	(.0871)	(.0949)	(.0835)	(.1008)
unmpl	.0001	.0010**	.0005	.0019*
	(.0005)	(.0005)	(.0006)	(.0009)
Wald Test	$\chi^2(5)=31.71$	$\chi^2(5)=39.21$	$\chi^2(5)=30.75$	$\chi^2(5)=39.21$
	p=0.00	p=0.00	p=0.00	p=0.00

Note: 72 Observations. FGLS estimation and two stage FGLS, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

Another way of classifying manufacturing sectors is according to their factor intensity content. It's again the OECD (1987) that provides this classification that groups sectors in resource-intensive, labor-intensive, scale-intensive and technology-intensive (differentiated goods and science based) classes. In this case there were more "problematic" sectors to classify. Just to give an example, in the Metal-Primary sector (sector 22 in the 2-digit Nace 1970 classification), four 3-digit sectors coexist: "Iron and steel Industry", "Manufacture of steel tubes", "Drawing, cold rolling and cold folding of steel", which are all classified as scale-intensive, and "Production and preliminary processing of non-ferrous metals", which is classified as resource-intensive. Again, in order to avoid cases like this a finer level of analysis would be necessary and sectors should be classified at least at the 3-digit level. Being not possible to resort on this level of details, when in situations in which the classification was not straightforward, the 2-digit sector has been classified according to the higher number of 3-digit sectors belonging to the same categories. Hence, to conclude with the example, the Metal-Primary sector has been considered as a scale-intensive one.

Note that sectors in the first two groups, i.e. resource and labor intensive ones, have been considered together, our priors being that concentration in particular of technology and scale-intensive sectors should be positive for growth basically for the same reasons presented above in relation to the high-tech industries.

Results of this alternative grouping are presented table 5. As usual the first column reports the coefficients estimated through FGLS and the second one those estimated using IV when agglomeration is measured by the average standard deviation of the Balassa index. The third and the forth columns refer to the Entropy index.

Table 5. Growth and agglomeration of resource- and labour-intensive, scale-intensive and technology-intensive sectors

Dependent Variable: per capita gdp annual growth

	Balassa FGLS	Balassa IV	Entropy FGLS	Entropy IV
aggl_ti	-.0270	-.3195**	-.0473	-.1993*
	(.0458)	(.1815)	(.0520)	(.0921)
aggl_si	-.0288	-4.0255	.0529	.1686
	(.0979)	(3.0054)	(.0567)	(.2226)
aggl_rli	-.0413	-.2044	.0055	.2211
	(.0526)	(.1493)	(.0616)	(.2027)
pop	-.0003	.0928	-.0095	-.0107
	(.0072)	(.0644)	(.0069)	(.0115)
school	-.0561**	-.4963*	-.0055	.0085
	(.0294)	(.2222)	(.0272)	(.0736)
open	.0196**	.0615*	.0187*	.0160
	(.0944)	(.0301)	(.0058)	(.0144)
inv	.1956*	1.1649	.2895*	.4409*
	(.0944)	(.8643)	(.0989)	(.1772)
unmpl	.0010*	.0042	.0008	.0040
	(.0944)	(.0030)	(.0006)	(.0026)
Wald Test	$\chi^2(5)=31.32$	$\chi^2(5)=39.21$	$\chi^2(5)=33.85$	$\chi^2(5)=28.63$
	p=0.00	p=0.00	p=0.00	p=0.00

Note: 72 Observations. FGLS estimation and two stage FGLS, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

Once again the puzzling result obtained under the technology content classification is confirmed: of all the coefficients on the agglomeration index the only one that is significant, namely the one on the technology-intensive sector clustering, turns out to be unexpectedly negative.

5. Controlling for distance and density

Looking at a map of Europe it is immediately clear that the distribution of economic activities does not follow national borders. Industries are mainly concentrated in a cross-national area known as the "hot-banana". This area goes from Northern Italy to London and includes regions belonging to different nations: Southern Germany, South East France, the Ruhr area, the Île de France, Belgium, Netherlands and South East England. Countries that are more faraway from this central area are more likely to show a higher agglomeration degree than countries that are in the center. Take for example Italy. The most part of the industrial activities are located in

Table 6. Growth and agglomeration controlling for distance

Dependent Variable: per capita gdp annual growth

	no agglomeration	Balassa	Entropy	Krugman
aggl		-.0371**	-.0501**	.0503
		(.0226)	(.0300)	(.0411)
pop	-.0042	-.0145*	-.0157*	-.0032
	(.0060)	(.0060)	(.0063)	(.0061)
school	-.0754*	-.0812*	-.0697*	-.0630*
	(.0250)	(.0256)	(.0251)	(.0267)
open	.0147*	.0182*	.0177*	.0188*
	(.0033)	(.0039)	(.0041)	(.0048)
inv	.2518*	.2326*	.2368*	.2792*
	(.0757)	(.0834)	(.0831)	(.0790)
unmpl	.0019*	.0016*	.0015*	.0019*
	(.0005)	(.0006)	(.0006)	(.0005)
dist	-.0097*	-.0074	-.0083**	-.0118*
	(.0039)	(.0051)	(.0047)	(.0043)
Wald Test	$\chi^2(5)=40.35$ p=0.00	$\chi^2(5)=47.02$ p=0.00	$\chi^2(5)=44.69$ p=0.00	$\chi^2(5)=41.65$ p=0.00

Note: 72 Observations. FGLS estimation, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

Northern Italy, a region that actually belongs to the hot banana area, while the part of the country which is farther away from the hot banana is less developed and basically empty. Hence, we might expect that countries located at the periphery of the market will show a higher agglomeration degree than countries belonging to the center.[9]

Now, it might well be that these economies, in transition to the steady state, grow slower because they are farther away from the "big market" and not because agglomeration of economic activities matters in itself. To keep this possible effect of distance on growth into account we run the regressions again controlling for the distance of the country from the "center" of the market. The way this is measured is taking the distance of each capital city from Luxembourg, which is chosen at the center of the market being, indeed, in the middle of the hot banana and not in our sample.

Table 7. Growth and agglomeration controlling for distance with instrumental variables

Dependent Variable: per capita gdp annual growth

	Balassa	Entropy	Krugman
aggl	-.0398**	-.0572**	-.08541**
	(.0230)	(.0331)	(.4931)
pop	-.0147*	-.0165*	-.0092
	(.0061)	(.0066)	(.0127)
school	-.0797*	-.0712*	-.3276*
	(.0267)	(.0256)	(.1532)
open	.0185*	.0179*	.0266
	(.0043)	(.0041)	(.0048)
inv	.2175*	.2252*	-.0493
	(.0854)	(.0830)	(.2126)
unmpl	.0015*	.0016*	.0003
	(.0006)	(.0006)	(.0011)
dist	-.0067	-.0082**	0.0327
	(.0052)	(.0048)	(.0260)
Wald Test	$\chi^2(5)= 44.04$	$\chi^2(5)=44.04$	$\chi^2(5)=44.04$
	p=0.00	p=0.00	p=0.00

Note: 72 Observations. Two stage FGLS estimation, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

FGLS and IV estimations are reported in table 6 and 7, respectively. Interestingly, the agglomeration coefficient remains negative and significant, even if only slightly, also when

[9] This is not always true in our small sample of countries. For example, the average standard deviation of the Balassa index of a country like Belgium, which is located exactly at the center of the hot banana, has more or less the same magnitude of the Italian one.

controlling for distance, indicating that clustering of activities has an independent effect on growth.

Another interesting experiment is to control for employment density. Applying what Ciccone (2001) says about regions to nations, we might expect that countries where the overall employment density is higher also grow faster. Smaller countries as Belgium or Netherlands in our sample show a high density of employment compared to bigger nations. At the same time, in principle, labor will tend to be distributed more unevenly in big countries and it will be more likely to find some regions empty and others more economically active. Hence, bigger countries should have at the same time a lower density of total employment and a bigger agglomeration index.[10] It is worthwhile to discern also between these two effects and see if regional clustering of economic activities has an independent effect on aggregate growth.

Table 8. Growth and agglomeration controlling for employment density with instrumental variables

Dependent Variable: per capita gdp annual growth

	Balassa	Entropy	Krugman
aggl	-.0635*	-.1083*	-.3030*
	(.0239)	(.0357)	(.0999)
pop	-.01131*	-.0169*	-.0061
	(.0065)	(.0069)	(.0062)
school	-.0833*	-.0681*	-.1649*
	(.0280)	(.0246)	(.0507)
open	.0286*	.0314*	-.0036
	(.0086)	(.0092)	(.0089)
inv	.1513*	.1472*	.1519*
	(.0694)	(.0698)	(.0694)
unmpl	.0007*	.0006**	.0002*
	(.0003)	(.0003)	(.0005)
dens	-.0067	-.0087	.0023
	(.0052)	(.0055)	(.0052)
Wald Test	$\chi^2(5)= 40.23$	$\chi^2(5)=40.23$	$\chi^2(5)=40.23$
	p=0.00	p=0.00	p=0.00

Note: 72 Observations. Two stage FGLS estimation, allowing for heteroschedasticity and cross-sectional correlation. Standard errors in parenthesis, with * and ** denoting significance respectively at the 95% and 90% level. Constants are not reported. Wald Test: joint test for the significance of the slope coefficient estimates.

This time we report, in table 8, only the results obtained implementing the IV estimation technique (there are no major changes when simple FGLS is used).

[10] Once again, this is not always true in our sample countries: Belgium shows a relatively high employment density but, at the same time, has a relatively high agglomeration index.

Once again the negative relationship between regional agglomeration and national growth is confirmed also when controlling for density of labor. Notice that, for the first time, also the Krugman index is significant and its sign confirms the evidence provided by the other two agglomeration indexes.

6. Conclusions

Knowledge spillovers and technical externalities, which are the engine of growth in any endogenous growth model, can go through industrial or R&D activities. The interaction of economies of scale and trade costs can create a situation such that the cost of innovation is reduced the more economic activities cluster in a few areas.

Analyzing, through panel data techniques, the impact of regional agglomeration degree of manufacturing industries on aggregate growth in six European countries, what we have shown here is that externalities going through production even of high tech goods do not necessarily go in the expected direction and, hence, that inducing production agglomeration might not have the positive effect on growth one expects from the theory.

One possible explanation for this puzzling result is that, indeed, what really matters for growth is location of R&D activities and not of industrial production as the evidence in Eaton and Kortum (1996) shows. As a matter of fact, there is not general agreement in the literature that manufacturing concentration is a good proxy for the agglomeration of innovation activities (see Audretsch and Feldman, 1996, and Paci and Usai, 2000). It would be interesting to see what happens when clustering of R&D is directly considered in the empirical analysis. Unfortunately data on R&D expenditure or R&D employment at the regional level are inexistent.

Even if very preliminary, our results are in line with the evidence presented in other empirical works (Glaeser et al., 1992, Paci and Usai, 2000), according to which diversification of manufacturing or innovative activities is indeed better than specialisation for growth performances and productivity gains.

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Appendix

A1. List of European regions

Nuts1 regions	(Regio) Code	Nuts1 regions	(Regio) Code
Belgium		Netherlands	
Brabant	BE0	Noord-Nederland	NL1
Brussels	BE1	Oord-Nederland	NL2
Vlaams	BE2	Zuid-Nederland	NL3
Region Vallone	BE3	West-Nederland	NL4
Italy		United Kingdom	
Nord Ovest	IT1	North	UK1
Lombardia	IT2	Yorkshire and Humberside	UK2
Nord Est	IT3	East Midlands	UK3
Emilia Romagna	IT4	East Anglia	UK4
Centro	IT5	South East	UK5
Lazio	IT6	South West	UK6
Abruzzi-Molise	IT7	West Midlands	UK7
Campania	IT8	North West	UK8
Sud	IT9	Wales	UK9
Sicilia	ITA	Scotland	UKA
Sardegna	ITB	Northern Ireland	UKB
Spain		France	
Noroeste	ES1	Ile de France	FR1
Noreste	ES2	Bassin Parisien	FR2
Madrid	ES3	Nord-Pas-De-Calais	FR3
Centro	ES4	Est	FR4
Este	ES5	Ouest	FR5
Sur	ES6	Sud-Ouest	FR6
		Centre-Este	FR7
		Mediterranee	FR8

A2. List of manufacturing sectors

Industry	Nace 2-digit code (1970)	OECD technological content classification[11]	OECD factor content classification[12]
Metal-Primary	22	mt	si
Non-metallic mineral products	24	mt	rli
Chemical industry	25	mt	ti
Machinery	32	mt	ti
Office machines	33	ht	ti
Electronics	34	ht	ti
Motor vehicles and parts	35	mt	si
Manufacture of other means of transport	36	mt	si
Precision equipment	37	mt	ti
Food, Drinks and Tobacco	41	lt	rli
Textiles	43	lt	rli
Textile, wearing apparel and footwear industries	45	lt	rli
Paper, Printing and Publishing	47	lt	si
Rubber and Plastics	48	mt	si
Toys and Sport	49	mt	rli

[11] This classification of sectors according to their technological content is done by the OECD and it is taken from the ITC mimeo "Cluster Classifications for International Trade Statistics". Obviously ht, mt and lt stand for high- medium- and low- technology.
[12] This classification of sectors according to their factor intensity is done by the OECD and it is taken from the ITC mimeo "Cluster Classifications for International Trade Statistics". Obviously ti, si and rli stand for technology- scale- and resource/labour-intensive.

A3. Data sources and definitions

Annual per capita GDP growth: Annual growth rate of per capita GDP at market prices (constant 1995 US$); source: World Bank World Development Indicators

Annual population growth: Annual growth of population; source: World Bank World Development Indicators

Secondary school enrolment: School enrolment at the secondary school level, (% of total); source: World Bank World Development Indicators

Volume of trade as a percentage of the GDP: Trade as a % of GDP; source: World Bank World Development Indicators

Gross domestic fixed investment to GDP ratio: Gross domestic fixed investment as a % of GDP; source: World Bank World Development Indicators

Unemployment rate: Annual rate of unemployment; source: OECD Outlook

Output gap: Output gap; source: OECD Outlook

Standard deviation of regional population: Standard deviation of the total regional population (1-year lagged); source: Regio (Eurostat), available on Crenos, University of Cagliari

Standard deviation of regional population density: Standard deviation of regional population density (total regional population over region area in Km2, 1-year lagged); source: Regio (Eurostat), available on Crenos, University of Cagliari

Standard deviation of regional per capita GDP: Standard deviation of regional per-capita GDP at constant 1985 prices (2-year lagged); source: Regio (Eurostat), available on Crenos, University of Cagliari

Standard deviation of regional employment in agriculture: Standard deviation of regional total employment in agriculture (3-year lagged) ; source: Regio (Eurostat), available on Crenos, University of Cagliari

Distance: Distance of each capital city from Luxembourg; source: www.viamichelin.com

Employment density: Total employment over country area in Km2; source: OECD outlook

Standard deviation of the Balassa index: Weighted average of the standard deviation of regional Balassa indexes based on employment data in manufacturing sectors (see Section 4.1 for a definition of the Balassa index), where the weights are given by the sector i employment over total country manufacturing employment; source: Regio (Eurostat), provided by Thierry Mayer

Entropy index: Weighted average of the Entropy indexes based on employment data in manufacturing sectors (see Section 4.1 for a definition of the Entropy index), where the weights are given by the sector i employment over total country manufacturing employment; source: Regio (Eurostat), provided by Thierry Mayer

Krugman index: Weighted average of the agglomeration Krugman indexes based on employment data in manufacturing sectors (see Section 4.1 for a definition of the agglomeration Krugman index), where the weights are given by the sector i employment over total country manufacturing employment; source: Regio (Eurostat), provided by Thierry Mayer

A4. An illustration of the MAUP

The fact that statistics on a phenomenon that has a geographical nature are sensitive to the units for which the data are collected is known as Modifiable Areal Unit Problem. An illustration of the two components of the MAUP, namely the scale effect and the zonation effect, is given in the following examples, both taken from Amrhein (1995).

The scale effect

The scale effect is attributed to variations in numerical results owing strictly to the number of areal units used in the analysis of a area. (Amrhein, 1995)

5	10	15
10	20	20
15	20	40

n=9

$\bar{x} = 18.33$

10	16.67	28.33

n=3

$\bar{x} = 11$

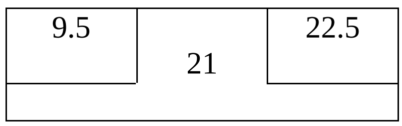
The zonation effect

The zonation effect is attributed to changes in numerical results owing strictly to the manner in which a larger number of smaller (in area) areal units are grouped into a smaller number of larger areal units. (Amrhein, 1995)

10	16.67	28.33

n=3

$\bar{x} = 11$



n=3

$\bar{x} = 17$

A5. Regional agglomeration of manufacturing sectors: Industry-level evidence

Belgium

Standard deviation of the Balassa index

Sector	Balassa_84	Balassa_95	rank_84	rank_95	growth rate
Metal Primary	0.112592	0.089015	1	1	-.0252603*
Non metallic mineral products	0.048846	0.055412	8	7	.0180397*
Chemical industry	0.049464	0.053981	7	8	.0140081*
Machinery	0.06975	0.065287	4	6	-.0090633*
Office machines	0.002008	0.000984	14	15	-.0902716*
Electronics	0.080545	0.079466	2	3	-.0024142
Motor vehicles and parts	0.069346	0.081393	5	2	.0112317*
Manufacture of other means of transport	0.046093	0.027232	9	9	-.0532145*
Precision equipment	0.001823	0.001852	15	14	-.0022421
Food, drinks and tobacco	0.074773	0.072852	3	4	.0006701
Textiles	0.018141	0.014861	10	11	-.0212003*
Textile, wearing apparel and footwear	0.017534	0.011858	12	12	-.0356643*
Paper, printing and publishing	0.053904	0.072828	6	5	.0317159*
Rubber and plastics	0.017646	0.023504	11	10	.0258929*
Toys and sport	0.006733	0.002268	13	13	-.1094021*

Entropy index

Sector	Entropy _84	Entropy _95	rank_84	rank_95	growth rate
Metal Primary	-0.08293	-0.05819	12	9	-.0369502*
Non metallic mineral products	-0.04269	-0.04265	8	8	.0045086
Chemical industry	-0.08107	-0.08979	11	13	.0125177*
Machinery	-0.08439	-0.08893	13	12	-.0004772
Office machines	-0.0032	-0.00168	2	1	-.0854876*
Electronics	-0.11054	-0.10387	15	14	-.011078*
Motor vehicles and parts	-0.05731	-0.07235	9	10	.0243454*
Manufacture of other means of transport	-0.0297	-0.01997	5	4	-.042106*
Precision equipment	-0.00212	-0.00207	1	2	-.0045627
Food, drinks and tobacco	-0.1059	-0.11177	14	15	.0062662*
Textiles	-0.03234	-0.02665	7	6	-.0232418*
Textile, wearing apparel and footwear	-0.03223	-0.02205	6	5	-.0326254*
Paper, printing and publishing	-0.06092	-0.08484	10	11	.0315355*
Rubber and plastics	-0.02458	-0.02898	4	7	.0106113
Toys and sport	-0.0097	-0.00324	3	3	-.1057142*

Krugman index

Sector	Krugman _84	Krugman _95	rank_84	rank_95	growth rate
Metal Primary	0.060125	0.044849	1	2	-.0344972*
Non metallic mineral products	0.024696	0.028491	7	4	.0175748*
Chemical industry	0.012733	0.007897	11	11	-.0549269*
Machinery	0.037628	0.024792	4	5	-.0388284*
Office machines	0.000289	0.000181	15	15	-.0878739*
Electronics	0.028915	0.020554	6	6	-.0309831*
Motor vehicles and parts	0.039773	0.045306	3	1	.0123721*
Manufacture of other means of transport	0.010196	0.006658	12	12	-.0380509
Precision equipment	0.000433	0.000472	14	14	-.0381956
Food, drinks and tobacco	0.020418	0.010843	8	10	-.0655045*
Textiles	0.051199	0.018327	2	7	-.0683315*
Textile, wearing apparel and footwear	0.029537	0.017902	5	8	-.023037*
Paper, printing and publishing	0.020371	0.029151	9	3	.0382391*
Rubber and plastics	0.003412	0.014728	13	9	.0932161*
Toys and sport	0.019113	0.005821	10	13	-.1157241*

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 15 the highest dispersion. The growth rate of each agglomeration index is given by the coefficient b of the OLS regression $\ln(\text{agglomeration})_t=a+b(\text{time trend})+u_t$. A * and a ** denote significance at the 95% and 90% level respectively.

France

Standard deviation of the Balassa index

Sector	Balassa_84	Balassa_95	rank_84	rank_95	growth rate
Metal Primary	0.046734	0.030696	2	7	-.0445375*
Non metallic mineral products	0.021225	0.024641	11	10	.0157947*
Chemical industry	0.035635	0.043665	6	4	.0201544*
Machinery	0.027206	0.031912	10	6	.0136122*
Office machines	0.013678	0.012409	13	13	-.0109064*
Electronics	0.044521	0.046945	3	3	.0059829**
Motor vehicles and parts	0.064029	0.061005	1	1	-.0012367
Manufacture of other means of transport	0.043499	0.027692	4	8	-.0472426*
Precision equipment	0.010034	0.011336	14	14	.0009478
Food, drinks and tobacco	0.043436	0.052476	5	2	.0179095*
Textiles	0.035326	0.024801	7	9	-.0389809*
Textile, wearing apparel and footwear	0.033915	0.022976	9	11	-.0380108*
Paper, printing and publishing	0.015486	0.019219	12	12	.0252271*
Rubber and plastics	0.034675	0.039661	8	5	.0142932*
Toys and sport	0.009733	0.007662	15	15	-.0233606*

Entropy index

Sector	Entropy _84	Entropy _95	rank_84	rank_95	growth rate
Metal Primary	-0.0547	-0.03294	7	5	-.0455709*
Non metallic mineral products	-0.04632	-0.04658	5	7	.0030383
Chemical industry	-0.06956	-0.08314	11	11	.0150573*
Machinery	-0.07171	-0.08337	12	12	.0132225*
Office machines	-0.0112	-0.01481	1	3	.0261966*
Electronics	-0.11206	-0.13309	15	15	.0149236*
Motor vehicles and parts	-0.10871	-0.10229	13	13	.0010883
Manufacture of other means of transport	-0.04897	-0.02984	6	4	-.0511841*
Precision equipment	-0.01161	-0.01457	2	2	.0251887*
Food, drinks and tobacco	-0.11131	-0.12331	14	14	.0088209*
Textiles	-0.06724	-0.04683	10	8	-.0369877*
Textile, wearing apparel and footwear	-0.06495	-0.04344	8	6	-.0360041*
Paper, printing and publishing	-0.06675	-0.07589	9	10	.0114105*
Rubber and plastics	-0.04159	-0.05956	4	9	.0329568*
Toys and sport	-0.01539	-0.01307	3	1	-.0152643*

Krugman index

Sector	Krugman _84	Krugman _95	rank_84	rank_95	growth rate
Metal Primary	0.03314	0.019746	4	9	-.0531012*
Non metallic mineral products	0.015211	0.015598	12	12	.00373*
Chemical industry	0.026362	0.03285	9	5	.0237057*
Machinery	0.021416	0.029682	10	6	.0278847*
Office machines	0.012717	0.011659	13	13	-.0110936*
Electronics	0.040091	0.039532	3	2	-.0004847
Motor vehicles and parts	0.041019	0.036754	2	3	-.0129446*
Manufacture of other means of transport	0.031439	0.01985	5	8	-.0469527*
Precision equipment	0.006608	0.007279	15	14	-.0006099
Food, drinks and tobacco	0.041312	0.048456	1	1	.0140022*
Textiles	0.030771	0.021156	6	7	-.0393226*
Textile, wearing apparel and footwear	0.029139	0.019517	7	11	-.0374012*
Paper, printing and publishing	0.015635	0.019587	11	10	.024893*
Rubber and plastics	0.026903	0.034149	8	4	.0220882*
Toys and sport	0.006926	0.005732	14	15	-.0143409*

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 15 the highest dispersion. The growth rate of each agglomeration index is given by the coefficient b of the OLS regression $\ln(\text{agglomeration})_t=a+b(\text{time trend})+u_t$.. A * and a ** denote significance at the 95% and 90% level respectively.

Netherlands

Standard deviation of the Balassa index

Sector	Balassa_84	Balassa_95	rank_84	rank_95	growth rate
Metal Primary	0.038263	0.027923	7	9	-.0280152*
Non metallic mineral products	0.022755	0.022355	11	10	.0053787
Chemical industry	0.051309	0.04546	2	3	.0035449
Machinery	0.031832	0.052359	8	2	.0456825*
Office machines	0.011627	0.015301	14	14	.02204*
Electronics	0.059765	0.068377	1	1	.0100308*
Motor vehicles and parts	0.023154	0.018486	10	11	-.0875985*
Manufacture of other means of transport	0.014136	0.015544	13	13	.0061942
Precision equipment	0.003628	0.003847	15	15	.0011948
Food, drinks and tobacco	0.041664	0.03541	6	6	-.0001725
Textiles	0.041828	0.033828	5	7	-.021057*
Textile, wearing apparel and footwear	0.042716	0.03717	4	5	-.0120006*
Paper, printing and publishing	0.046633	0.044887	3	4	-.0006253
Rubber and plastics	0.023274	0.029568	9	8	.0224707*
Toys and sport	0.018028	0.01676	12	12	-.0090643*

Entropy index

Sector	Entropy _84	Entropy _95	rank_84	rank_95	growth rate
Metal Primary	-0.02933	-0.02185	4	4	-.02567*
Non metallic mineral products	-0.03727	-0.03938	8	7	.0092933*
Chemical industry	-0.10978	-0.09491	13	11	-.0181983*
Machinery	-0.08263	-0.11407	11	13	.0307758*
Office machines	-0.01574	-0.01607	3	3	.0018808
Electronics	-0.12488	-0.12272	14	14	-.0010026
Motor vehicles and parts	-0.05039	-0.05307	9	10	-.015099**
Manufacture of other means of transport	-0.06023	-0.044	10	9	-.0261024*
Precision equipment	-0.00593	-0.00694	1	1	.0165469*
Food, drinks and tobacco	-0.17775	-0.18374	15	15	.0071495*
Textiles	-0.03549	-0.0271	7	6	-.0247038*
Textile, wearing apparel and footwear	-0.03505	-0.02551	6	5	-.0239539*
Paper, printing and publishing	-0.10368	-0.10951	12	12	.0081716*
Rubber and plastics	-0.0314	-0.04342	5	8	.0348183*
Toys and sport	-0.00985	-0.01076	2	2	.0361607**

Krugman index

Sector	Krugman _84	Krugman _95	rank_84	rank_95	growth rate
Metal Primary	0.025901	0.017262	7	9	-.034932*
Non metallic mineral products	0.016879	0.016358	11	10	.0062929
Chemical industry	0.046216	0.042818	1	2	.0127186**
Machinery	0.021916	0.037695	8	3	.0533724*
Office machines	0.007727	0.009416	14	14	.0164447*
Electronics	0.043768	0.046744	2	1	.0029485
Motor vehicles and parts	0.020007	0.01394	9	11	-.1043743*
Manufacture of other means of transport	0.009083	0.009618	13	13	.0024767
Precision equipment	0.002955	0.003172	15	15	.0012825
Food, drinks and tobacco	0.032755	0.025464	4	5	-.0076884
Textiles	0.027753	0.021567	6	8	-.0245044*
Textile, wearing apparel and footwear	0.029772	0.022789	5	7	-.0193005*
Paper, printing and publishing	0.037601	0.036594	3	4	.0016321
Rubber and plastics	0.018581	0.023826	10	6	.0266908*
Toys and sport	0.011816	0.010116	12	12	-.0153169*

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 15 the highest dispersion. The growth rate of each agglomeration index is given by the coefficient b of the OLS regression $\ln(\text{agglomeration})_t = a + b(\text{time trend}) + u_t$.. A * and a ** denote significance at the 95% and 90% level respectively.

Italy

Standard deviation of the Balassa index

Sector	Balassa_84	Balassa_95	rank_84	rank_95	growth rate
Metal Primary	0.067726	0.046738	2	7	-.0361766*
Non metallic mineral products	0.038405	0.032548	9	12	-.0129698*
Chemical industry	0.05702	0.059846	6	4	.0073781*
Machinery	0.064613	0.07807	4	1	.0121278*
Office machines	0.009441	0.009516	15	15	-.0200116*
Electronics	0.048788	0.053818	7	6	.0067571**
Motor vehicles and parts	0.067504	0.067062	3	3	.0009993
Manufacture of other means of transport	0.047665	0.039139	8	8	-.0151714*
Precision equipment	0.029074	0.035721	13	10	.0139697*
Food, drinks and tobacco	0.032456	0.033915	11	11	-.0008208
Textiles	0.062002	0.058801	5	5	-.0041194
Textile, wearing apparel and footwear	0.073785	0.067907	1	2	-.0025212
Paper, printing and publishing	0.03162	0.029401	12	13	-.004091**
Rubber and plastics	0.0157	0.015014	14	14	-.009967**
Toys and sport	0.038088	0.0385	10	9	-.0007811

Entropy index

Sector	Entropy _84	Entropy _95	rank_84	rank_95	growth rate
Metal Primary	-0.05508	-0.03396	7	4	-.0434095*
Non metallic mineral products	-0.06248	-0.05383	10	8	-.0085601*
Chemical industry	-0.05842	-0.05482	8	9	.0003021
Machinery	-0.08745	-0.10498	14	14	.0118661*
Office machines	-0.00558	-0.00691	1	1	.0042652
Electronics	-0.09266	-0.11692	15	15	.0193132*
Motor vehicles and parts	-0.05884	-0.05955	9	10	.0030001
Manufacture of other means of transport	-0.04129	-0.03486	5	5	-.0176639*
Precision equipment	-0.01255	-0.01521	2	3	.0166542*
Food, drinks and tobacco	-0.07813	-0.0801	12	13	.0023995
Textiles	-0.06825	-0.06152	11	11	-.0089602*
Textile, wearing apparel and footwear	-0.0819	-0.07007	13	12	-.0085008*
Paper, printing and publishing	-0.04418	-0.04457	6	6	.0034609
Rubber and plastics	-0.03774	-0.0467	4	7	.0131712*
Toys and sport	-0.01472	-0.01126	3	2	-.0176739*

Krugman index

Sector	Krugman _84	Krugman _95	rank_84	rank_95	growth rate
Metal Primary	0.025513	0.016507	9	11	-.0410066*
Non metallic mineral products	0.038899	0.034214	6	7	-.0085367*
Chemical industry	0.034721	0.036256	7	6	.0144683**
Machinery	0.052936	0.062751	3	2	.0116852*
Office machines	0.008385	0.007781	14	14	-.0273964*
Electronics	0.046835	0.049379	5	5	.00284
Motor vehicles and parts	0.065437	0.06631	1	1	.0018956
Manufacture of other means of transport	0.020808	0.016955	10	10	-.0188602*
Precision equipment	0.009245	0.010903	13	13	.0122875*
Food, drinks and tobacco	0.027461	0.026498	8	8	-.0084616
Textiles	0.049517	0.050788	4	4	-.0038831
Textile, wearing apparel and footwear	0.060915	0.053211	2	3	-.0058136
Paper, printing and publishing	0.018423	0.017502	11	9	-.0012837
Rubber and plastics	0.015085	0.013384	12	12	-.0160129*
Toys and sport	0.007973	0.006351	15	15	-.0117434

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 15 the highest dispersion. The growth rate of each agglomeration index is given by the coefficient b of the OLS regression $\ln(\text{agglomeration})_t = a + b(\text{time trend}) + u_t$.. A * and a ** denote significance at the 95% and 90% level respectively.

Spain

Standard deviation of the Balassa index

Sector	Balassa_84	Balassa_95	rank_84	rank_95	growth rate
Metal Primary	0.084915	0.047258	2	3	-.0549732*
Non metallic mineral products	0.025358	0.027017	11	10	.0089359*
Chemical industry	0.025359	0.028121	10	9	.01849*
Machinery	0.036283	0.042285	6	4	.0120382*
Office machines	0.001227	0.003423	15	15	.0870782*
Electronics	0.05645	0.052317	3	2	-.0094965**
Motor vehicles and parts	0.028585	0.031067	9	7	-.0039153
Manufacture of other means of transport	0.044192	0.031483	4	6	-.0385539*
Precision equipment	0.00395	0.004784	14	14	.0106984
Food, drinks and tobacco	0.102354	0.116731	1	1	.0113568*
Textiles	0.030395	0.017539	8	12	-.0603501*
Textile, wearing apparel and footwear	0.032495	0.028767	7	8	.004049
Paper, printing and publishing	0.036467	0.039573	5	5	.01546*
Rubber and plastics	0.024643	0.026986	12	11	.0055447
Toys and sport	0.012547	0.008373	13	13	-.0308294*

Entropy index

Sector	Entropy _84	Entropy _95	rank_84	rank_95	growth rate
Metal Primary	-0.04405	-0.02218	6	4	-.0640222*
Non metallic mineral products	-0.07363	-0.07343	11	13	.0054389**
Chemical industry	-0.05579	-0.06032	9	9	.0074817*
Machinery	-0.05172	-0.05851	7	8	.0108704*
Office machines	-0.00065	-0.00212	1	1	.0936427*
Electronics	-0.06139	-0.0653	10	11	.0018808
Motor vehicles and parts	-0.07947	-0.09095	13	14	.0106697*
Manufacture of other means of transport	-0.03791	-0.02641	4	5	-.0381117*
Precision equipment	-0.00356	-0.00459	2	2	.0254709*
Food, drinks and tobacco	-0.18919	-0.21258	15	15	.0126669*
Textiles	-0.08029	-0.05035	14	6	-.0506938*
Textile, wearing apparel and footwear	-0.07723	-0.07288	12	12	-.0036546
Paper, printing and publishing	-0.05578	-0.06185	8	10	.0133355
Rubber and plastics	-0.04123	-0.05535	5	7	.0209667*
Toys and sport	-0.01484	-0.01034	3	3	-.0233965*

Krugman index

Sector	Krugman _84	Krugman _95	rank_84	rank_95	growth rate
Metal Primary	0.063266	0.031733	2	3	-.06542*
Non metallic mineral products	0.022066	0.022103	9	9	.0016219
Chemical industry	0.024898	0.030277	6	4	.0286299*
Machinery	0.02391	0.027621	7	5	.0125264*
Office machines	0.001271	0.002123	15	15	.0333205**
Electronics	0.036136	0.035397	3	2	-.0056629
Motor vehicles and parts	0.015303	0.018751	12	11	.0059555
Manufacture of other means of transport	0.030228	0.020197	4	10	-.0442571*
Precision equipment	0.003169	0.003885	14	14	.0204625*
Food, drinks and tobacco	0.091309	0.110052	1	1	.0183638*
Textiles	0.020743	0.014664	4	5	-.0569437*
Textile, wearing apparel and footwear	0.027858	0.02326	5	6	-.0108122*
Paper, printing and publishing	0.023006	0.023141	8	7	.0064355
Rubber and plastics	0.018106	0.02251	11	8	.0161262*
Toys and sport	0.011616	0.00755	13	13	-.0365221*

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 15 the highest dispersion. The growth rate of each agglomeration index is given by the coefficient b of the OLS regression $\ln(\text{agglomeration})_t=a+b(\text{time trend})+u_t$.. A * and a ** denote significance at the 95% and 90% level respectively.

UK

Standard deviation of the Balassa index

Sector	Balassa_84	Balassa_95	rank_84	rank_95	growth rate
Metal Primary	0.051246	0.034324	2	8	-.0410562*
Non metallic mineral products	0.020756	0.018436	11	11	-.0120274*
Chemical industry	0.03826	0.041735	8	4	.0165362*
Machinery	0.035532	0.031855	9	10	-.0159658*
Office machines	0.008357	0.013651	13	13	.0561415*
Electronics	0.041419	0.037545	7	5	-.015422*
Motor vehicles and parts	0.050259	0.047468	3	2	-.0031649
Manufacture of other means of transport	0.046107	0.037366	4	6	-.0136394
Precision equipment	0.007814	0.009194	14	14	.0135107*
Food, drinks and tobacco	0.056908	0.055587	1	1	-.0022357
Textiles	0.042794	0.035468	6	7	-.0239882*
Textile, wearing apparel and footwear	0.043006	0.045018	5	3	.0032562
Paper, printing and publishing	0.026549	0.031991	10	9	.025318*
Rubber and plastics	0.010287	0.014038	12	12	.0290091*
Toys and sport	0.006622	0.004881	15	15	-.028798*

Entropy index

Sector	Entropy _84	Entropy _95	rank_84	rank_95	growth rate
Metal Primary	-0.03439	-0.02492	4	4	-.0308544*
Non metallic mineral products	-0.0437	-0.04004	6	5	-.0058189
Chemical industry	-0.05988	-0.06367	9	11	.0146279*
Machinery	-0.11374	-0.10226	14	13	-.0167617*
Office machines	-0.00597	-0.01223	1	2	.0797939*
Electronics	-0.10494	-0.11133	13	14	.0033766*
Motor vehicles and parts	-0.05813	-0.05466	7	9	-.0025359
Manufacture of other means of transport	-0.0631	-0.05342	11	7	-.007001
Precision equipment	-0.01369	-0.01663	2	3	.0208609*
Food, drinks and tobacco	-0.13117	-0.14579	15	15	.0117889*
Textiles	-0.06111	-0.0517	10	6	-.0198835*
Textile, wearing apparel and footwear	-0.05862	-0.06259	8	10	.0002857
Paper, printing and publishing	-0.07661	-0.08608	12	12	.0112894
Rubber and plastics	-0.03982	-0.05436	5	8	.0346881*
Toys and sport	-0.01383	-0.01112	3	1	-.014159**

Krugman index

Sector	Krugman _84	Krugman _95	rank_84	rank_95	growth rate
Metal Primary	0.033019	0.023222	4	8	-.0350388*
Non metallic mineral products	0.019451	0.016646	11	11	-.0141496*
Chemical industry	0.031697	0.036025	6	3	.0248311*
Machinery	0.022236	0.023097	10	9	-.0007571
Office machines	0.007588	0.01215	14	13	.0541832*
Electronics	0.045851	0.034349	1	4	-.0375931*
Motor vehicles and parts	0.036461	0.033362	3	5	-.0148962*
Manufacture of other means of transport	0.026463	0.021902	9	10	-.0104347
Precision equipment	0.007941	0.009363	13	14	.0097862*
Food, drinks and tobacco	0.043	0.04448	2	1	.0064169*
Textiles	0.032871	0.024576	2	4	-.0280181*
Textile, wearing apparel and footwear	0.029542	0.030944	8	6	.0014435
Paper, printing and publishing	0.029752	0.0362	7	2	.0245043*
Rubber and plastics	0.008017	0.013588	12	12	.0462828*
Toys and sport	0.004634	0.003842	15	15	-.018893*

Note: The rank is in descending order: 1 indicates the highest agglomeration degree, 15 the highest dispersion. The growth rate of each agglomeration index is given by the coefficient b of the OLS regression $\ln(\text{agglomeration})_t = a + b(\text{time trend}) + u_t$.. A * and a ** denote significance at the 95% and 90% level respectively.