Agglomeration Economies and the Location of Industries: A comparison of Three small European Countries

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Abstract

We investigate and compare the spatial distribution of manufacturing activity and its determinants in Belgium, Ireland, and Portugal using comparable, exhaustive micro-level data sets. We find some similarities between Portugal and Belgium, but little for Ireland. Moreover, there is some evidence that forward and backward linkages as well as dependence on natural advantages can be important determinants of agglomeration.

Keywords: agglomeration, spatial autocorrelation, Belgium, Ireland, Portugal

JEL classification: R12, C21, R30

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1 Introduction

It has long been recognized that economic activity is unevenly distributed across space. For example, Fujita and Thisse (2002) illustrate this feature by pointing out that the Japanese core regions with a mere 0.18 per cent of the total area account for about 29 per cent of East Asia's GDP. There is also plenty of similar evidence for other regions in the world, for example, the Blue Banana in Europe, the Manufacturing Belt in the US, industrial districts in Italy (Pyke *et al.* (1990)), Route 128 and Silicon Valley in the US (Saxenian (1996)).

A now large body of theoretical studies in economic geography have provided micro-foundations to explain why agglomeration may arise (see Duranton and Puga (2004) for a review of the literature). These studies generally advocate that external scale economies such as forward/backward linkages, labor market pooling, and technological externalities are the major causes of concentration of economic activities across space. However, theorists have also pointed to the necessity of "buttressing [their] approach with empirical work" (Fujita *et al.* (1999, p.345)). Ideally, empirical studies would rely on micro level data in order to provide a picture of *how* and *why* activities concentrate across space, and also provide results that are comparable across countries. Unfortunately, up to now, existing empirical studies have either used micro level data while being limited to one country (see for instance Ellison and Glaeser (1997), Maurel and Sédillot (1999), Rosenthal and Strange (2001), Duranton and Overman (2002)), or have used aggregated data at the macro level in order to obtain cross-country evidence (Barrios and Strobl (2003), Midelfart-Knarvik *et al.* (2000), Amiti (1999) among others).[1] The present study is an attempt to push the analysis a step further by reconciliating the use of micro level data and the need for comparative cross-country evidence. Specifically, we provide evidence for the pattern of the concentration of manufacturing activities across space and its determinants using plant level data for three different countries, namely Belgium, Ireland, and Portugal. While our country choice was driven by data availability, the three countries under scrutiny constitute an interesting sample in Europe as two of them, Portugal and Ireland, are peripheral countries, while Belgium is located in the core of the EU. Also, we study countries that

[1] Some studies have also provided evidence for the existence of agglomeration economies leading to productivity gains at the city or region-level as, for example, Sveinkauskas (1975) Tabuchi (1986), Moomaw (1981), Rauch (1993), Glaeser *et al.* (1992), Henderson *et al.* (1995), Ciccone and Hall (1996) and Ciccone (2002).

have relatively similar size, which is arguably important when comparing the spatial distribution of economic activities (Combes and Overman (2004)). To our knowledge, this is the first study of this kind.

Understanding industrial concentration in Europe is of substantial importance for a number of reasons. Over the last five decades, European integration has created a need to better understand production patterns among European countries and how activity might be geographically redistributed with the process of integration (European Commission (2000)). From a theoretical point of view, one of the major predictions in economic geography models is that agglomeration forces will increase with the decline in transportation costs. While (geographically) segmented markets may be served from different locations, a significant fall in trade costs is likely to foster the concentration of industries in some particular areas in order to benefit from agglomeration economies (see for instance Fujita *et al.* (1999)). An interpretation of this result has consisted in saying that economic integration can increase regional inequalities. In particular, these inequalities seem to be the cause of differences in GDP per capita levels and unemployment rates across European regions (Puga (2002), Overman and Puga (2002)). European policy makers have thus been primarily concerned with the possible impact of economic integration on disadvantaged regions, as integration may make them less likely to be chosen as potential locations. In view of the amounts of money being devoted to regional policies in order to favor spatial equity, especially at the European level (about 40% of the European commission budget is absorbed by regional policies), the need for a reliable study of geographic concentration across European countries is clear.

The analysis in the present paper relies on the index developed by Ellison and Glaeser (1997), from now on the EG index. These authors shed new light on important conceptual as well as methodological issues. In particular, they develop their index using a simple location model as a starting point, which was not the case of other measures traditionally used up to now as, for example, the Gini index. Once plant-level data is available, Ellison and Glaeser claim that "the index is designed to facilitate comparisons across industries, across countries, or over time" (Ellison and Glaeser (1997), p.890). Despite this assertion, no explicit comparative study across countries has been undertaken so far. Existing applications of the EG index (and of its extensions) have been limited to the intersectorial comparisons at different aggregation levels (see Ellison and Glaeser (1997) as well as the study by Maurel and Sédillot (1999) for the French case). An obvious reason why no such study has been done yet is probably due to data limitation since, because of confidentiality reasons, plant level data is generally publicly not available. Moreover, even though data for different countries may be available, international comparisons require consistency in sorting and classifying data across sectors that may be quite different in their raw form. In the present study we are able to cope with this kind of issue by using common sectorial definitions. Also, special attention is devoted to spatial autocorrelation since the EG index ignores distance decay effects across bordering regions. Hence we also make use of the Moran index in order to provide some insights into the spatial autocorrelation issue. Furthermore, relying on precepts of economic geography models, we try to disentangle the different sources of agglomeration by running parametric estimations and using as dependent variable the EG index.

Our main results point towards substantial differences in the patterns of agglomeration across the three countries. Whereas Belgium and Portugal highlight relatively similar sectorial rankings in terms of agglomeration, Ireland clearly shows up differently. Further, we find that traditional sectors are relatively concentrated in the former countries and that high-tech sectors rank relatively low in terms of agglomeration, which is contrary to common belief. Forward/backward linkages, that are central to new economic geography models, contribute positively to spatial agglomeration, as well as natural advantages. The same, however, does not hold for R&D expenditures, which turn out to be mostly insignificant.

The rest of the paper is organized as follows. In section 2, we provide some details about the tools being used to analyze the patterns of agglomeration. Section 3 proceeds with data source description. Details about country data collection as well as common industrial classification are provided. Results on static patterns of agglomeration are commented in section 4. Section 5 goes on by exploring the sources of agglomeration. Section 6 concludes.

2 Ellison, Glaeser and Moran: spatial agglomeration and spatial autocorrelation

Ellison & Glaeser (EG) index In order to understand the EG index, it is helpful to first discuss the well-known Gini index as this index serves as a starting point in Ellison and Glaeser(1997)'s analysis. The Gini index has probably been the most widely used measure of the agglomeration of economic activities. A primary reason for this probably lies in its ease of computation. Specifically the Gini index measures the concentration of a variable, for instance industry employment and/or output, relative to a perfectly uniform distribution across space. However a major drawback related to the use of the Gini index lies in its sensitivity to economies of scale. As mentioned earlier, the spatial concentration of employment may be due at least partly to the existence of internal economies of scale. Consider for instance the case where there are either 100 plants of industry i, all located in region c, versus the case of only 1 plant for industry j, also located in the same region c. In the first case, one may intuitively expect the clustering of the 100 plants of industry i to be the consequence of agglomeration economies (be it natural advantage or externalities). However, the second case clearly results from large internal economies of scale in industry j, which leads only very few plants (one in the present case) to enter the market. A Gini index calculated from employment data only would make no distinction at all between both these cases. Thus, only agglomeration *per se* is considered, independently of the *source* of this agglomeration. Ellison and Glaeser (1997) have hence proposed an index of spatial concentration which presents the desirable feature of neutralizing the possible influence of industrial concentration resulting from internal economies of scale. Its expression for a particular industry i is given by:

$$\gamma_i = \frac{G_i - \left(1 - \sum_c x_c^2\right) H_i}{\left(1 - \sum_c x_c^2\right)\left(1 - H_i\right)}$$

where G_i is an approximation of the Gini index defined as the sum of squared deviations of s_{ic} (the share of industry i's employment in area c) to x_c (the share of aggregate manufacturing employment in area c), i.e., $G_i = \sum_c (s_{ic} - x_c)^2$. The term $H_i = \sum_j z_{ij}^2$ represents the classical Herfindahl-Hirschman index defined as the sum of squared plant employment shares of industry i, with $j = 1...N$, the plant-indices. When the number of plants in a sector increases, H_i tends to 0. Thus the EG index tends to the Gini index times an industry invariant term, and its expectation tends to 0.

The EG index has the distinctive feature of being comparable across time and across sectors regardless of plants' size distribution. A further important property of the EG index lies in its theoretical foundation as it is based on a location model, i.e., where firms choose location following a Bernoulli process according to the presence of natural advantage and/or spillovers. The EG index thus asks the question whether concentration is greater than would be expected to arise randomly. However, it must also be noted that the EG index suffers from two major drawbacks, the first one being ackowledged by the authors themselves:

- First, as a theoretical limitation, the EG index cannot distinguish between *spillovers* and *natural advantages* to explain the reasons why plants agglomerate. This is simply due to the fact that in their location model, there is an observational equivalence between natural advantages and spillovers.

- A second and more important issue is related to the choice of spatial unit. For example, one can consider the difference between pecuniary externalities, represented by forward backward linkages and technological externalities, represented by knowledge-related spillovers. Theory tells us that pecuniary externalities may reach wider geographical areas than technological externalities (see for instance Lamorgese and Ottaviano (2002) for a discussion on this issue). More intuitively, the first kind of externality could be represented by the manufacturing belt in the US, where upward-downward industries are related to each other and to the concentration of industries in this part of the US States. In turn, examples of the second kind of externality are Akihabara area (also known as Electric City) in Tokyo or the Sillicon Valley in the US, where innovation and growth dynamics rely heavily on local labor markets and technological externalities. Clearly, because these externalities have different geographic scales, a much denser agglomeration shall result from technological externalities that requires strong interactions between agents in activities where information is rather important (for example high-tech industries) rather than from pecuniary externalities that can arise through inter-regional trade. A result of this is that small spatial units of observation will put more emphasis on technological externalities whereas broader spatial units are more prone to highlight pecuniary externalities. However, as the EG index is aspatial, the fact that we may be considering too small spatial units may plague the results with spatial autocorrelation. One way to quantify this issue is to have recourse to a measure of spatial autocorrelation.[2]

Moran index In order to account for spatial autocorrelation, we will rely on a measure developped in the spatial statistics literature, (see Anselin and

[2]Note that Duranton and Overman (2002) circumvent this issue by treating space continously rather than using an arbitrary collection of geographical units. Although appealing, a major drawback of their distance-based localization index stems from the need of having data on the geographic coordinates for each plant, which is rarely available with micro-level data.

Bera (1998)). This literature has developped a set of techniques aimed at describing and visualizing spatial distributions, identifying spatial outliers, detecting patterns of spatial association and suggesting spatial regimes or other forms of spatial heterogeneity. Central to this concept is the notion of spatial autocorrelation or spatial association. More specifically, spatial autocorrelation considers the possibility that observations of a variable (here the location of industries) may not be independent across space. More generally, clusters of events, people or facilities are likely to be affected by positive spatial autocorrelation, whereas negative spatial autocorrelation refers to arrangements where people, events or facilities are dispersed.

There are a number of formal statistics that attempt to measure spatial autocorrelation. Among these, Moran's I statistic (Moran, 1950) is probably the most popular one. This statistic compares the value of a continuous variable at any location with the value of the same variable at surrounding locations. Formally, it is defined as:

$$I = \frac{N}{S} \cdot \frac{\sum_i \sum_j w_{ij} \left(x_i - \bar{x}\right) \left(x_j - \bar{x}\right)}{\sum_i \left(x_i - \bar{x}\right)^2}$$

with $S = \sum_i \sum_j w_{ij}$, $\bar{x} = \frac{\sum_i x_i}{N}$ and $i \neq j$, where x_i represents the value of the observation in region i, N is the total number of observations, $\bar{x}$ is the mean of the variable across all observations and w_{ij} is a weight between region i and region j. Our w_{ij} has been set equal to 1 when regions i and j are contiguous and 0 elsewhere.

Values of I significantly larger than the expected value of the Moran statistic, $E\left[I\right] = -\frac{1}{N-1}$, indicate positive spatial association, i.e., similar values are more spatially clustered than could be caused purely by chance, whereas values of I smaller than $E[I]$ indicate negative spatial association. In the sequel, we will use the Moran index in order to discuss our choice of spatial units.

3 Data

In order to compute our EG index, we use three different data sources. For Ireland, we draw on information from the Forfàs Employment Survey, for Belgium, we used data on employment from the Social Security, and for Portugal data originates from the Ministry of Employment. Furthermore, for the econometric analysis in section 5, Eurostat data has been the main source of our data. Detailed description of our various data are given in the Appendix. A distinctive deature of our data sets is that they potentially cover all existing plants in the three countries considered. In addition, in choosing the year of our analysis, we used the latest year that was common to all our data, namely 1998.

An important task when undertaking a cross-country study is to unify the data. Essentially, we had to take care of two dimensions: the *sectorial* and the *spatial* ones. In terms of the sectorial classification issue, data for all three countries was essentially collected for NACE (*Nomenclature générale des activités économiques dans les Communautés européennes* - General Industrial Classification of Economic Activities within the European Communities) and ISIC (International Standard Industrial Classification) classifications, which are the standards used at the European respectively international level. Portuguese data was readily available as ISIC Rev. 2 and it was converted into ISIC Rev.1, while Irish data was available at NACE Rev.1 at four-digit level of disaggregation. For Belgium data was originally collected according to the NACE-BEL sectors which, apart from some small differences, follows very closely NACE Rev.1 classification. In order to work with a common set of sectors we made use of the concordance tables between ISIC and NACE made available by Eurostat (the European statistics office) in order to convert Irish and Belgian data.[3] Four-digit ISIC sectors roughly corresponded to three-digit NACE sectors, for which Belgian and Irish data had been collected so we took ISIC Rev.1 as common classification for which no changes for Portugal data was required.[4] After having put this data together and keeping only those sectors that were common to the three countries we ended up with 63 common four-digit ISIC sectors, which represent between 85 to 95 per cent of total manufacturing employment for these three countries.

In terms of the choice of spatial units, the task of unification has been more cumbersome. The only common spatial unit at the European level is the *Nomenclature des unités territoriales statistiques/Nomenclature of territorial units for statistics* (NUTS). The NUTS is a five-level hierarchical classification (three regional levels and two local levels).[5] However, the regional classification available to us did not always correspond to this spatial

[3] These tables are available at http://europa.eu.int/comm/eurostat/ramon/

[4] Final conversion tables that were used to perform a unified data set are available from the authors upon request.

[5] The current NUTS nomenclature subdivides the territory of the European Community into 78 NUTS1 regions, 211 NUTS2 regions and 1093 NUTS3 regions. At the local level, the NUTS4 level is defined only for the following countries: Finland, Greece, Ireland, Luxembourg, Portugal and the United Kingdom. The NUTS 5 level consists of 98433 townships or their equivalent.

classification, especially for Ireland so our choice of spatial units was essentially driven by data availability. Two spatial units have been retained, one regional and one local. These units are finer than the US State and county levels. For Belgium, NUTS3 (43 *arrondissements*) and NUTS5 (589 *communes*) spatial units have been retained. In the Irish case, at the regional level, NUTS4 (27 *counties*) spatial units were chosen, whereas for the local level an intermediate level between NUTS4 and NUTS5 (504 *townships*) spatial units was used.[6] Finally, for Portugal, no analogous regional level was available, so we used a somewhat rougher spatial unit than NUTS3 spatial units, namely districts (18 *distritos*) and, for the local level, NUTS4 (275 *concelhos-municipos*) spatial units. Here below, we provide maps with regional level breakdowns as well as average areas and population density for the broader spatial units that have been used. A comparison with US counties and States is provided in Tables 1a and 1b. Accordingly, population seems far more concentrated in Ireland and Portugal compared to Belgium. If population distributions are representative of the spatial spread of the industries, then one should expect a higher concentration in the former two countries.

[Maps 1, 2 and 3]

[Tables 1a and 1b]

4 Belgium, Ireland and Portugal's pattern of agglomeration

In Table 2, results on Moran indices for local spatial units and using contiguity matrices are provided. Except for Ireland, we find that about a third of all sectors do highlight positive and statistically significant spatial autocorrelation.[7] This represents a non-negligeable number of sectors and suggests that some care should be taken when interpreting EG index results obtained from *local* spatial units. Indeed, given the presence of positive spatial autocorrelation, EG indices might be biased downward. As a matter of fact, when computing the EG index, it makes no difference whether two plants are located in two neighboring locations or in the two most remote locations

[6] As an exception for Ireland we used NUTS5 (3445 spatial units called DEDs) to compute the Moran index because we only had information about the contiguity matrix at this geographical level.

[7] Considering the column for Ireland in Table 2, only four sectors do highlight positive spatial autocorrelation. This result is essentially driven by our choice of spatial unit to compute the Moran index, namely DEDs rather than townships.

one from the other in the country. That is, the EG index treats such data symmetrically, so that there are no distance decay effects. One must thus bear in mind the possibility of spatial autocorrelation. That is why results for *regional* spatial units will be more extensively described.

[Table 2]

Finally, some brief descriptive statistics on sectorial share of employment are provided in Table 3. Specialization patterns appear to be rather different across countries. Portugal is more specialized in traditional industries like textiles and wood industries, while Ireland highlights an important share of its employment in high-tech industries such as machinery equipment. The picture is quite mixed for Belgium. These differences may, in turn, have direct implications in terms of spatial concentration given that agglomeration are likely to vary across industries. We consider these questions with greater detail in the following section.

[Table 3]

4.1 Basic results on agglomeration

4.1.1 Belgium

EG indices have been computed at two degrees of spatial aggregation: *communes* (local level) and *arrondissements* (regional level).[8] For reasons outlined above, we will rely on regional results, but a comparison with local level results will be provided at a later stage. As shown in Table 4, the most agglomerated sector in Belgium is *Misc. products of petroleum and coal* (3540). This is not a great surprise given that this sector is directly related to seashore locations. The same holds for sector 3841, *Shipbuilding and repairing*, ranked fifth. On the contrary, sectors related to food and beverages tend to be dispersed. This is particularly true for *Manufacture of dairy products* (3112), *Slaughtering, preparing and preserving meat* (3111), *Grain mill products* (3116), and *Manufacture of food products, N.E.C.* (3121) which are ranked between 43 and 58. As most of these products are perishable, it seems of importance that they locate close to their consumption market, which explains their spatial dispersion. A further interesting observation is related to high-tech sectors.[9] Contrary to common belief, high-tech sectors

[8] Figures followed by a star for E&G indices in Tables 4 to 6 refer to a measure of statistical significance. We will come back to this point later.

[9] Definition of high-tech sectors stems from Hatzichronoglou (1997). In our data base, seven hi-tech sectors are available: *Drugs and medicines* (3522), *Spec. indus. machinery and equipment except 3823* (3824), *Office, computing and accounting machinery* (3825), *Electrical industrial machinery and apparatus* (3831), *Radio, tele., communications equip-*

have a lower average EG index than the remaining sectors (0.0012 against 0.053). Similar results have been found using German (Alecke *et al.* (2003)) and UK data (Devereux *et al.* (1999)). Three factors can explain this result: first, the widely held belief that high-tech clusters like Silicon Valley in the US or Sofia Antipolis in France, for instance, are representative of general agglomeration processes is untrue.

[Table 4]

A second and complementary explanation may come from the possibility that our *sectorial disaggregation* is too rough to capture very specific high-tech clusters.[10] A last and related explanation may be due to the fact that our choice of spatial unit is not appropriate to identify high-tech clusters. Indeed, taking *communes*, the average high-tech EG index is 0.0035, and 0.026 for the non high-tech sectors. Thus, whereas for non high-tech sectors, the EG index has been halved, it has tripled for high-tech sectors! Still, agglomeration of high-tech sectors remain far below the rest of the manufacturing industry.

Having coped with sectors strongly bound to natural advantages as well as high-tech sectors, a striking feature of our results comes from the recognition that most of the highly agglomerated sectors are indeed traditional sectors. Thus, in the top ten ranking, *Jewelry and related articles (3901)*, *Pottery, china and earthware* (3610), *Knitting mills* (3213), *Manufacture of carpets and rugs* (3214) are encountered. Ellison and Glaeser (1997) and Maurel and Sédillot (1999) find similar results. This may point to *history* as a major explanation for today's location patterns of economic activity for traditional sectors, as advocated by Ottaviano (1999).

All in all, the weighted average EG index for Belgian manufacturing industries is 0.027, hence falling just above the lower bound of the range Ellison and Glaeser term as not very localized (0.02 to 0.05).[11] Moreover, about half of the sectors are dispersed or not significantly agglomerated (EG index lower than 0.02). This is consistent with previous studies (Ellison and

ment and apparatus (3832), *Prof., scientific, measuring and control equipment* (3851) and *Photographic and optical goods* (3852).

[10] This latter explanation is indeed supported by Bertinelli and Decrop (2002), where it has been shown that several high-tech sectors in Belgium are ranked in the top 20 using a 237-sector classification. This result is consistent with Maurel and Sédillot (1999) and Teixeira (2002). Furthermore, note that by dropping some sectors across countries for the sake of consistency, two high-tech sectors have been deleted for Belgium: *Aircraft* (3845) and *Watches and clocks* (3853). The ranking of these sectors were however in the bottom 25 per cent at the regional level classification (and 12^{th} respectively 60^{th} at the local level classification).

[11] Sectorial employment level were used as weights.

Glaeser (1997), Maurel and Sédillot (1999)).

Coming to the spatial unit issue, one can first note that the correlation between EG indices at the *arrondissement* level and at the *communes* level is relatively high: 0.80 (0.70*** for Spearman's rank correlation). However, the weighted average EG index at the local spatial unit falls to 0.009, compared to 0.027 for district-level computations. Following Ellison and Glaeser (1997) and taking the median of the ratio of local and regional level indices, we get 0.48 so that about half of the excess tendency of plants to locate in the same *arrondissement* involves plants locating in the same *communes*.

4.1.2 Ireland

As for Belgium, we rely mainly on the most aggregate spatial units in the Irish case, namely *counties*, in our analysis. Table 5 displays a Spearman's rank correlation between *county* and *township* EG indices that is much lower than in the Belgian case: 0.10 against 0.70***. As a consequence, the underlying pattern of agglomeration differs strongly, depending on the spatial units used. Among high ranked sectors, no common feature can be deduced at the *county* level. The top five ranked sectors are *Photographic and optical goods* (3852), *Manufacture of pulp, paper and paperboard* (3411), *Syn. resins, plastic mat. man-made fibers exc. glass* (3513), *Knitting mills* (3213) and *Printing, publishing and allied industries* (3420). Among these, only sector 3852 ranks in the top five of both *county* and *township* level EG indices, and three if one considers the top ten.

Except sector 3852, which is ranked first, no other high-tech sector is found in the top 26.[12] Sectors related to food and beverages (roughly corresponding to two-digit ISIC 31 sectors) are much more spread across our distribution, going from rank 9 to 61. The fact that sectors like *Manufacture of dairy products* (3112) rank 15 may be related to a more skewed population distribution in Ireland than in Belgium as around 30% of Irish population is concentrated in Dublin and its surrounding area. Moreover, one has to bear in mind that Ireland is an island. Hence, contrary to inland countries, a border location is never efficient in terms of minimizing distance to all other locations (at least when the local market is important). Finally, the spatial configuration of more natural advantage-related industries like *Shipbuilding and repairing* (3841), *Misc. products of petroleum and coal* (3540) is likely

[12] This result still holds at the regional level, when considering the two high-tech sectors (*Aircraft* (3845) and *Watches and clocks* (3853)) dropped for consistency across the three countries. At the local level, sector 3845 and sector 3853 are ranked 13^{th} and 65^{th} respectively for the whole classification.

to be an artifact due to the small size of these industries (0.2 respectively 0.1 per cent of total manufacturing employment).

At the *township* level, results on patterns of agglomeration differ substantially, as mentioned earlier. As for *county* level ranking, the first ranked sector is *Photographic and optical goods* (3852). Ranked second, we find *Iron and steel basic industries* (3710), a traditional sector involving concentrated production, preferably near sea shores to minimize land transportation of inputs. *Can., Preserv., and process of fish, crustacean* (3114) may be strongly bound to ports, explaining its high ranking.

[Table 5]

For the remaining top ranked sectors, no straightforward explanation can be deduced. One should, however, note that these sectors represent all in all 6.5 per cent of total manufacturing employment, and only about 3 per cent when excluding the largest sector (*Motor vehicles* (3843)). Finally, if EG indices reflect local spillovers, one would expect high-tech sectors to be highly ranked, especially when dealing with township level data. In the case of Ireland, high-tech sectors are, however, mostly concentrated in mid-level rankings.

4.1.3 Portugal

For Portugal, interpretations are mainly based on results using *distritos* (regional level) as the main geographical breakdown, although results for *concelho* (local level) are relatively comparable (Spearman's rank correlation between *distrito* and *concelho* EG indices is 0.49***). As for Belgium, we find some traditional sectors that are high ranked (*Tanneries and leather finishing* (3231), *Manufacture wood and cork products N.E.C.* (3319)). Among other highly ranked sectors, we also find *Miscellaneous products of petroleum and coal* (3540) and *Shipbuilding and repairing* (3841), which are the sectors top ranked in Belgium as well, due to obvious reasons related to location-specific natural advantages. Interestingly, we also find the *Tobacco manufactures* (3140) to be ranked high (9^{th}). A similar result has been found for US data by Ellison and Glaeser (1997). As for Ireland, we have one high-tech sector which ranks in the top ten (*Drugs and medicines* (3522)). All other high-tech sectors are ranked mid-level and lower. Other dispersed sectors are those related to food and beverages industry. The reason is likely to be the same as we argued for Belgium.

The *cement* industry is also worth mentioning. This sector is generally dispersed because of high transportation costs. For Belgium and Ireland, the cement industry is ranked among the last third of all industries, but ranks fifteenth in Portugal. The only explanation we can propose is that the degree of sectorial disaggregation is not detailed enough so as to isolate the sole effect of cement industry. Indeed, this sector includes *lime* and *plaster* industry too. Unfortunately, however, we are not able to tell whether these two other sub-sectors may be responsible for the difference between Portugal and the other two countries at glance. The *Iron and steel basic industries* (3710) are relatively dispersed. This may hint at the absence of ovens which have very high minimum efficient scale and are located near the sea for easy access to inputs. Rather, Portugal might be characterized by the presence of electric furnaces, which are usually smaller, and located near large consumption markets to collect the iron scrap.

[Table 6]

Among results at the *concelho* level, two high-tech sectors are among the top ten ranked sectors (*Office, computing and accounting machinery* (3825) and *Prof., scientific, measuring and control equipment* (3851)), whereas none of these two sectors ranked high at the *distrito* level. Again, traditional sectors are found to highlight large EG indices, which is consistent with what has been found at the *distrito* level. Except for few sectors, the overall distribution remains relatively unaltered compared to the *distrito* level results. Four sectors can be considered as outliers in this respect, i.e., top quarter ranking at the *distrito* level and low ranking at the *concelho* level: *Soap, cleansing preparations, perfumes, cosmetics* (3523), *Shipbuilding and repairing* (3841), *Musical instruments* (3902) and *Tobacco manufactures* (3140).

4.2 (Dis)similarities among countries

When comparing results among countries, a striking feature is Portugal's level of agglomeration which is not only much higher than for Belgium and Ireland, but also higher than results found for France and the US in previously mentioned studies. The weighted average EG index for Belgium is 0.027 and 0.038 for Ireland, whereas for Portugal, it is 0.133.[13] Intuitively, Ireland being an island, one would have hypothesized agglomeration to be higher there, as more central locations in this case minimize transportation costs to domestic markets. In the case of Portugal, one obvious reason why

[13] These measures concern the EG indices computed at the regional level of aggregation. When going to the local level, the same ranking is found among countries but amplitudes are smaller. Note also that the median value of the EG index for Portugal is 0.080, to be contrasted with 0.023 and 0.023 for Ireland and Belgium, as well as 0.023 for the US (Ellison and Glaeser (1997)).

the average EG index is higher relates to the fact that Portuguese areas are larger than those used for Ireland and Belgium. We have already tackled the issue of the sensitivity of the EG index with respect to the size of the chosen spatial units, and mentioned the fact that spatial autocorrelation can be one explanation to this. In addition, as shown in Table 3, Portugal is more specialized in traditional industries, which are found to be more concentrated.

In the case of Portugal it is noteworthy that population is largely concentrated on the western part of the country, close to the Atlantic shores (see map in section 3). However, this does not solve the issue of why production is concentrated in Portugal, but rather transfers the problem to population concentration. This is typically the problem of the chicken and the egg: does the population follow firms or rather the reverse? This point is especially relevant when performing cross-country comparisons. In addition, as the EG index is sensitive to the choice of spatial unit, direct comparisons of the levels of this index between countries must be carefully undertaken.

Whereas Portuguese industries' level of concentration clearly depart from Belgian and Irish ones, the picture changes when it comes to compare the *patterns of agglomeration*. Taking the rank correlations in Table 7, Ireland appears to clearly diverge from Portugal and Belgium, whereas these two latter countries do highlight a positive (although not very high) and statistically significant Spearman rank correlation.

[Table 7]

This supports results from the previous sub-section, where Ireland showed up very different rankings of its sectors according to the EG index. Several explanations can possibly explaining this result. First, whereas Belgium and Portugal have roughly similar population levels of around 10 million inhabitants, Ireland has 3.5 million inhabitants. Smaller country size in turn implies fewer plants, meaning that agglomeration patterns are harder to disentangle for particular sectors. Put differently, few plants imply that the marginal impact of one plant's location on the EG index is more important, which could well explain our results. A second explanation has already been mentioned earlier and relates to Ireland's geographic situation: Ireland is an island, hence the centrifugal and centripetal forces at work are likely to act differently. In particular, cross-border effects which are likely to be important in the case of Belgium for instance, are obviously not relevant in the case of Ireland. Belgium is located at the heart of western Europe and is geographically close to countries such as France, Netherlands and Germany with which trade relationships are rather intense. One could well expect for example that industry clusters do exist across borders, as for example, the traditional steel industries which are common to French and Belgium bordering regions.

Another feature, common to both Ireland and Portugal, is the peripheral location with respect to the rest of Europe. Coupled with the fact that these two countries entered the European Common Market relatively late (in 1973 for Ireland and 1986 for Portugal), one might expect to find common features between these two countries. In particular, both countries have strong export-led economies, as it is generally the case of a small country. As has been shown elsewhere, exporting firms tend to be larger on average, and have different patterns of agglomeration (Bernard and Jensen (1995), Holmes and Stevens (2002)). It should also be noted that FDI has played a large role with multinationals increasingly choosing this country in order to get access to the EU market (Barry and Bradley (1997)). Multinationals' presence may, in turn, have influenced the location pattern of industries if externalities arise between domestic and foreign plants (see Barrios *et al.* (2003) for evidence concerning Ireland).

Finally, these dissimilarities that have already been noted when comparing Belgian results with the UK, the US and France in Bertinelli and Decrop (2002) reinforce the fact that cross-country comparisons have to be interpreted within the appropriate context because country specific characteristics such as transaction costs, labor mobility and others may drive part of the results concerning the agglomeration patterns.

4.3 Are industries *significantly* agglomerated?[14]

Ellison and Glaeser provide some value range according to which they classify sectors as not very concentrated (EG index smaller than 0.02), relatively concentrated (EG index between 0.02 and 0.05) and highly concentrated (EG index larger than 0.05). However, given that the variance of their index of raw concentration is provided (Ellsion and Glaeser (1997) footnote, page), it is straightforward to check whether sectors are *significantly* concentrated by using the two standard deviation rule. As the expectation of the EG index is zero, one has to check whether the absolute values of the EG indices we find are larger than twice the standard deviation of this index. Significant results thus are reported with a star in Tables 4 to 6. These results deserve some discussion as we find important differences between countries.

About 25 per cent of the EG indices are significant in the Irish case, 49 per cent in Belgium and 75 per cent when considering Portugal, at the

[14] We are very grateful to Giordano Mion and Henry Overman who suggested this discussion.

regional level.[15] A striking feature is the increasing significance of the EG index with country size (in terms of population). Unreported results on the standard deviations reveal that actually, rather than having smaller EG results on average for smaller countries, the variances of the EG indices decrease with country size. This result immediately proceeds from the expression of the variance of the Gini index used by Ellison and Glaeser (1997, p.907), which increases with the Herfindahl-Hirschmann index. As smaller countries tend to have higher industrial concentration due to less firms, they will also have larger Herfindahl-Hirschmann indices. The variance of the EG index depending positively and linearly on the variance of the Gini, everything else being constant, smaller countries will have larger variance of their EG indices. This result is consistent with unpublished results on Italy, where about 90 per cent of the EG indices turn out to successfully pass the two standard deviation rule.[16] The same is true for Maurel and Sédillot (1999) who work on French data and find that for their index (which is very close to Ellison and Glaeser's), 270 out of 273 sectors are statistically significant.[17]

5 Agglomeration and its determinants

Theoretical contributions in geographical as well as urban economics have provided a number of explanations for agglomeration of economic activities to occur. The main arguments can roughly be classified according to so-called Marshallian externalities: agglomeration economies arise through input-output linkages (Fujita *et al.* (1999)), labor market pooling (Monfort and Ottaviano (2000)), and through technological externalities (Henderson (1974, 1988).

Despite the amount of theoretical contributions, evidence concerning the *determinants* of agglomerations remains scarce. Most studies have been devoted to analyzing their consequences. This is especially true in the case of urban economics, where great efforts have been devoted to measure how far city size shifts the production function (see for instance Tabuchi (1986)). It

[15] These percentages are 19, 46 and 78 respectively when considering the local level.

[16] Results for Italy have been made available by Giordano Mion.

[17] Note however that their result may suffer from overestimation. Indeed, as they work on a sample of plants, rather than the whole population of plants, and on a sectorial disaggregation of 273 industries, they have on average about 160 plants per industry. Kim *et al.* (2000) have shown that whenever the number of plants in an industry is smaller than the number of spatial units, the EG indices are over-estimated. Given that Maurel and Sédillot use 95 french departments and that the average number of plants per sector is about 160, there is high suspicion for over-estimation in several industries.

is only very recently that studies ahve tried to identify the determinants of geographic concentration. In particular, Dumais *et al.* (2002), decompose the index developed by Ellison and Glaeser (1997), determining the contribution of plant entry and exit on agglomeration. Holmes and Stevens (2002) also decompose an index of agglomeration, isolating the impact of establishment scale on agglomeration. Kim *et al.* (2000), Rosenthal and Strange (2001) and Teixeira (2002) shed new light on the causes of agglomeration by using standard parametric estimation techniques, an approach we also follow here.

5.1 Explanatory variables

In this section we relate the EG indices to some relevant explanatory variables according to the theoretical priors. A major issue in doing so is to use comparable data across countries. For our pooled regressions, we generally have recourse to Eurostat data.[18] This, however, limits our choice to essentially six explanatory variables, related to Marshallian externalities. Some limitations concerning the variables used, and more generally, cross-industry regressions, are discussed at the end of section 5.

Total purchases of goods and services (total inputs): this variable includes the value of all goods and services purchased during the accounting period for resale or consumption in the production process, excluding capital goods. Producers want to choose locations that have good access to large markets and to suppliers of intermediates. A concentration of producers tends to offer a large market and a good supply of inputs and consumer goods, hence attracting new producers and new consumers. These are the forward and backward linkages that have largely been used in the Krugman-type models of agglomeration.

Gross investment in tangible goods: this variable includes new and existing tangible capital goods, whether bought from third parties or produced for own use. The introduction of this variable follows the same idea as for the purchase of inputs. Positive effects on agglomerations are expected from these two variables.

Wages and salaries: wages and salaries are defined as the total remuneration, in cash or in kind, payable to all persons counted on the payroll.

[18] Detailed description of the data is reported in the appendix.

Wages play a crucial role in Krugman-type models. In particular, for low trade cost, agglomeration unravels as the share of industry in regions with lower wages gradually increases. However, wages constitute probably also the least clearcut variable to include in the regressions, as it is highly endogenous according to the Krugman-type of framework: higher wages attract new workers creating a larger output market and hence attracting more firms. More firms (i.e., higher agglomeration) in turn, tend to raise wages. In the three countries under scrutiny, wages are largely set in a centralized manner, thus one can expect this variable to act as a proxy for congestion, and thus, discourage agglomeration.

Purchases of energy products: this variable includes energy products only if they are used as fuel, and hence excludes energy products purchased for resale without transformation. To derive their index, Ellison and Glaeser (1997), start from a model, where agglomeration either results from externalities, or common natural advantages. Although scholars have mainly been interested in the former explanation, to illustrate for example Silicon Valley-type of agglomerations, natural advantages play a crucial role in explaining the distribution of manufacturing activity, especially when the concerned industries are natural resources intensive. For instance, Ellison and Glaeser (1999) show that for the US manufacturing activity, about 20 per cent of *observed* geographic concentration can be explained by a *small set* of natural advantages in the United States. Here we consider energy as a generic variable to account for natural advantages. Ideally, one would have liked to include purchases of natural resources as well, but no comparable variable is available for the three countries.

Total intra-mural Research and Development expenditure: intra-mural expenditures are all expenditures for R&D, regardless of the source of funds. This variable is typically intended to capture knowledge spillovers. It has been shown elsewhere (see for instance Audretsch and Feldman (1996), Feldman and Audretsch (1999), Bottazzi and Peri (2003) and Jaffe *et al.* (1993)) that agglomeration favors innovation. Hence one may expect R&D intensive sectors to concentrate in order to fully benefit from these knowledge spillovers.

Average plant size: this is the ratio of the number of persons employed (per 1000) by the number of enterprises. In a recent contribution, Holmes and Stevens (2002) show that there is a strong link between plant size and agglomeration. The previous authors find that the connection between size and concentration is stronger than one would expect to find if plants were randomly distributed. Plant size may also be interpreted as a proxy for the presence of increasing returns to scale, which are central in the models of the New Economic Geography.

As countries are of very different sizes, all variables listed above have been weighted by the number of workers in each sector we account for. Total production weights have also been used and led to qualitatively analogous results. Note that for some variables and some countries, four-digit sectorial observations were not available so that we had to fill up by three-digit counterparts. Details are provided in the data appendix.

5.2 Econometric results

We pool the data set for the three countries. We first consider slope coefficients to be the same across countries while, later, we relax this assumption by allowing for possible heterogeneity across countries. Accordingly, the tested equations are given by the following expressions:

$$\Gamma_{i,j}^{c} = \left(X_i^c\right)' \beta + \epsilon_{i,j}^{c} \tag{1}$$

$$\Gamma_{i,j}^{c} = \left(\hat{X}_i^c\right)' \beta^c + \epsilon_{i,j}^{c} \tag{2}$$

where Γ refers to the Ellison and Glaeser index, X' is a vector of K explanatory variables of dimension $N \times K$, and β represents the vector of coefficients to be estimated and is $K \times 1$. Indices i and j refer to industries respectively the chosen spatial unit (local or regional level), and $c = 1...C$ is the country-specific superscript. In specification (1), we hypothesize that ϵ is an i.i.d. random term, whereas in specification (2), the disturbance term is given by $\epsilon_{i,j}^{c} = Z_\omega \omega_{i,j} + \xi_{i,j}^{c}$ where $Z_\omega = I_C \otimes \iota_{I_c}$, ($I_C$ is an identity matrix of dimension C, the number of countries, and ι_{I_c} is a vector of dimension I_c) and $\hat{X}'$ is $N \times KC$ and is obtained from an element by element multiplication between each column of X' and each column of Z_ω.[19] Thus country-specific intercepts, as well as country-specific slope coefficients (β^c is now $KC \times 1$) are also being considered.

Columns (1) and (2) of Table 8 provide results for the region-level regressions, where we consider the slope coefficients to be the same across

[19] Note that if i would run from 1 to I_c for each of the three countries, than we would just have $N = C \times I$. However, due to lack of data, I_c varies across c.

countries. Results of column (1) are as expected for *total inputs* and *energy purchases* and the coefficient on the *wage* variable is negative, supporting the congestion effect explanation. In column (2), we further control for sector-specific effects.[20] Doing so induces a 4 percentage point increase in the explanatory power of our model, but leaves the qualitative results of column (1) unaltered. This preliminary evidence points towards the existence of forward and backward linkages, as new economic geography models would predict. However, investment in tangible goods does not seem to affect significantly the pattern of agglomeration. First nature agglomeration economies, proxied by the *energy* variable, add a non negligeable contribution to agglomeration as already pointed out by Ellison and Glaeser (1999) and Rosenthal and Strange (2001). Conversely, *R&D expenditure* coefficients are positive but non-significant. As noted earlier, a possible explanation for this result might be that the geographical unit used is far too large in order to capture local knowledge spillovers.

In equation (2) we allow for different slope coefficients across countries. More specifically, we slightly depart from specification (2) by taking Portugal as the base country and controlling for the added effect whenever observations come from Belgium or Ireland. Results in column (3) point to a positive effect of wages on concentration of manufacturing activity in Portugal, hence, contradicting explanations given above for common slope coefficients across countries. If one sticks to the idea of perfect competition on the labor market, then it is reasonable to hypothesize that wages actually proxy skills, and hence are correlated positively with agglomeration. The same result does not hold for Belgium, however, since the interaction term of the wage variable with the Belgium dummy is negative and significant. Given that the interaction term of the wage variable for Ireland is insignificant, the overall effect of wages is zero when adding both the overall coefficient and the Ireland specific effect. The same results holds when adding industry specific dummies (column (4)). This result thus points toward significant differences in terms of the potential effect of wages on spatial agglomerations. The same kind of result holds for the size variable which turns out to be significant when considering country-specific effects as shown in column (3), although, in this case, the size variable is no longer significant when adding industry-specific effects. In addition, the energy variable turns out to be insignificant when using the same interaction terms while it was significant when considering common slopes, showing that our

[20] These fixed effects are measured at the ISIC two-digit in order to have sufficient degrees of freedom.

general results are likely to be a simple artifact. As a consequence, very little can be said from results in columns (3) and (4) as most explanatory variables turn out to be insignificant.

So far, the EG index used as dependent variable was based on the regional level, which are relatively large spatial units, especially when it comes to capture externalities that are subject to strong distance decay effects.

[Table 8]

In Table 9, we use the EG index computed at the local level as dependent variable while explanatory variables remain the same as in Table 8. For columns (1) and (2), results are very similar at both level of spatial aggregation. Forward/backward linkages and natural advantages foster agglomeration at the sectorial level. Conversely, *wages and salaries* play towards dispersion. The results for these three variables appear to be robust to the inclusion of industry dummies as shown in column (2). Moreover, *average size of firms* displays a positive and significant (at 10%) coefficient which tends to support Holmes and Stevens' (2002) findings.

Coming to regressions with country-specific slope coefficients shown in columns (3) and (4), significant differences appear for Ireland. Here the variables *total inputs purchase*, *purchase of energy products* and *average plant size* display significantly lower coefficients for Ireland compared to the other two countries. In turn, *wages and salaries* and *gross investment* display a significantly higher coefficient for Ireland. However, these differences hold only for the *total input purchase* and the *wages and salaries* variables after including sector-specific effects as shown in column (4). Our econometric results thus appear to be more robust only when the EG index is measured at a local rather than regional level.

[Table 9]

Results on the determinants of agglomeration presented so far deserve some further explanations. As can be deduced from the discussion of the results, coefficients that have been found are not very robust according to the specification. Different explanations can account for this fact. First, there is the problem of data quality, in particular, our explanatory data which stem from the Eurostat Regio database are of poor quality. As is shown in the appendix, we had to fill up the gaps by different means. Besides the data quality issue, there is more fundamentally the problem of whether proceeding with cross-industry regressions is the right way to capture the determinants of agglomeration. Indeed, there is no spatial dimension in the EG indices as they are presented in Tables 4 to 6. If inputs, R&D, energy production are very concentrated and the sector under scrutiny relies heavily on these inputs, R&D, energy source, then the production should be very concentrated. But to check this rigorously, one would then need sector-region share-regressions, rather than regressions on sector-specific EG indices. This may then explain poor results of our regressions, and on these types of regressions in general, as can be deduced from Rosenthal and Strange (2001)'s analysis.

6 Conclusion

This paper analyses the spatial distribution of manufacturing activity and its determinants across three European countries: Belgium, Ireland, and Portugal. To our knowledge, this is the first comparative study of the location of manufacturing activities using plant level data across countries. Our analysis mainly relies on the index developed by Ellison and Glaeser (1997), which has been designed to allow for comparisons across industries *and* countries. Results confirm some previous findings on French, UK and US data, with traditional sectors ranking among the most agglomerated. Among the three countries under scrutiny, Ireland clearly stands out with significantly different patterns of spatial distribution of manufacturing activity. More precisely, despite being two peripheral countries, Ireland and Portugal appear to have rather different distribution of industries across space.

Our econometric results appear to be more robust when measuring the level of concentration at a local rather than a regional level. This suggests that the kind of agglomeration forces considered here are most likely to occur at relatively small geographical scale. In this case we find that forward and backward linkages affect positively agglomeration, whereas wages act as a negative determinant. This evidence is in line with some predictions of theoretical models of economic geography. In addition, we observe that the reliance on primary resources fosters agglomeration.

Finally, this study shows that one has to be somewhat careful when conducting cross-country comparisons of the spatial distribution of economic activities. There are a lot of country-specific forces that can drive results and should be considered before drawing any conclusions regarding concentration indices.

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Appendix: Data

Belgium

Social Security data on employment

The database that has been used for the present study covers all plants established in Belgium in 1998. For each plant, we have the number of jobs, the industry it belongs to (up to five-digit classification), and the township it is located in. Employment data come from the national office for social security (ONSS), which collects employment data for all wage earners in Belgium.

In Belgium, the notion of a *plant* is clearly distinguished from the employer, the latter corresponding to the notion of a *firm* in a general sense. If the employer has only one activity at one location, then it is considered as a plant. But if the employer carries out its activity in two or more locations (branches or operation units) and/or carries out two different types of activity, each operation unit is seen as a separate plant. However, if several operation units of the same firm are located in the same township, only one plant is taken into account.

Concerning employment data, it is worth noticing that it corresponds to the number of jobs and not to the number of workers.[21] If a worker is working for two or more employers, he is counted several times. Another limit of the database is that it does not take into account the difference between part-time and full-time workers within plants.

Ireland

Forfás Employment Survey

This is an annual plant level survey collected by Forfás since 1972, the policy and advisory board for industrial development in Ireland. The response rate to this survey is argued by Forfás to essentially be nearly 100 per cent, i.e., our data can be seen as including virtually the whole population of manufacturing plants in Ireland. Information at the plant level include time invariant variables such as the sector of production, detailed regional location of each plant, as well as the level of employment in each year. In addition to the Forfas Employment Survey we used the *Irish Expenditure Survey* in order to gather information for variables missing for Ireland in the Eurostat database described below. The *Irish Expenditure Survey* is an annual plant level survey collected by Forfás since 1983. Information is collected for plants of at least 20 employees, although it must be noted that a

[21] The number of jobs occupied on June 30.

plant, once included, is generally still surveyed even if its employment level falls below the initial cut-off point. The response rate ranges on average from between 60 and 80 per cent. Information provided at the plant level, are amongst other things, the time invariant identifiers as for the Forfás Employment Survey, output, wages, R&D expenditure and the employment level.

Portugal

Ministry of Employment

This is an exhaustive annual plant level survey collected by the Portuguese Ministry of Employment since 1985, for all the companies operating in Portugal. It matches employers and employees and reported data include the companies' location, age, sector of activity, sales, ownership structure and number of employees. A company may be a single or a group of plants, which can be at different locations. The locations, reflecting the spatial units used, take place at the municipalities (NUTS 5) and districts levels.

Eurostat data

Total purchases of goods and services

Purchases of goods and services include the value of all goods and services purchased during the accounting period for resale or consumption in the production process, excluding capital goods the consumption of which is registered as consumption of fixed capital. The goods and services concerned may be either resold with or without further transformation, completely used up in the production process or, finally, be stocked. Included in these purchases are the materials that enter directly into the goods produced (raw materials, intermediary products, components), plus non-capitalised small tools and equipment. Also included are the value of ancillary materials (lubricants, water, packaging, maintenance and repair materials, office materials) as well as energy products. Included in this variable are the purchases of materials made for the production of capital goods by the unit. Also included are the services paid for during the reference period regardless of whether they are industrial or non-industrial. In this figure are payments for all work carried out by third parties on behalf of the unit including current repairs and maintenance, installation work and technical studies. Amounts paid for the installation of capital goods and the value of capitalised goods are excluded. Also included are payments made for non-industrial services such as legal and accountancy fees, patents and licence fees (where they are not capitalised), insurance premiums, costs of meetings of shareholders and governing bodies, contributions to business and professional associations, postal, telephone, electronic communication, telegraph and fax charges, transport services for goods and personnel, advertising costs, commissions (where they are not included in wages and salaries), rents, bank charges (excluding interest payments) and all other business services provided by third parties. Included are services which are transformed and capitalised by the unit as capitalised production. Expenditure classified as financial expenditure or extra-ordinary expenditure in company accounts is excluded from the total purchases of goods and services. Purchases of goods and services are valued at the purchase price excluding deductible VAT and other deductible taxes linked directly to turnover. All other taxes and duties on the products are therefore not deducted from the valuation of the purchases of goods and services. The treatment of taxes on production is not relevant in the valuation of these purchases.

Wages and salaries

Wages and salaries are defined as the total remuneration, in cash or in kind, payable to all persons counted on the payroll (including homeworkers), in return for work done during the accounting period. regardless of whether it is paid on the basis of working time, output or piecework and whether it is paid regularly or not. Wages and salaries include the values of any social contributions, income taxes, etc. payable by the employee even if they are actually withheld by the employer and paid directly to social insurance schemes, tax authorities, etc. on behalf of the employee. They do not include social contributions payable by the employer. Wages and salaries include: all gratuities, bonuses, ex gratia payments, "thirteenth month payments", severance payments, lodging, transport, cost-of-living, and family allowances, tips, commission, attendance fees, etc. received by employees, as well as taxes, social security contributions and other amounts payable by employees and withheld at source by the employer. Payments for agency workers are not included.

Gross investment in tangible goods

This variable represents investment during the reference period in all tangible goods. Included are new and existing tangible capital goods, whether bought from third parties or produced for own use (i.e., capitalised production of tangible capital goods), having a useful life of more than one year including non-produced tangible goods such as land. The threshold for the useful life of a good that can be capitalised may be increased according to company accounting practices where these practices require a greater expected useful life than the 1 year threshold indicated above. All investments are valued prior to (i.e., gross of) value adjustments, and before the deduction of income from disposals. Purchased goods are valued at purchase price, i.e., transport and installation charges, fees, taxes and other costs of ownership transfer are included. Own produced tangible goods are valued at production cost. Goods acquired through restructurations (such as mergers, take-overs, break-ups, split-off) are excluded. Purchases of small tools which are not capitalised are included under current expenditure. Also included are all additions, alterations, improvements and renovations which prolong the service life or increase the productive capacity of capital goods. Current maintenance costs are excluded as is the value and current expenditure on capital goods used under rental and lease contracts. Investment in intangible and financial assets are excluded.

Purchases of energy products (in value)

Purchases of all energy products during the reference period are included in this variable only if they are purchased to be used as fuel. Energy products purchased as a raw materials or for resale without transformation are excluded.

Total intra-mural R&D expenditure

Research and experimental development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. Intra-mural expenditures are all expenditures for R&D performed within the unit, regardless of the source of funds. R&D must be distinguished from expenditures for a wide range of related activities. The following are therefore excluded from R&D expenditure: expenditures on education and training; expenditures on other scientific and technological activities (e.g. information services, testing and standardization, feasibility studies etc.); expenditures on other industrial activities (e.g. industrial innovations n.e.s.); expenditures on purely financing activities (other administration and other indirect supporting activities are included). Intra-mural expenditures are valued at production cost and include all operating costs including the labor cost and capital expenditure.

Missing Eurostat data by country

Whenever data was missing or unavailable at a given sectorial level, we extrapolated with data from the next available aggregation level. Only for R&D expenditure in Ireland, no data was available. In this case, we had recourse to national data sources. Henceforth, we studentized this variable so as make cross-country pooled regressions feasible.

Belgium

Sectors (nacecode) with no data : 1592, 192, 193, 242, 246

Sectors with missing data : 1591 (inputs, wages, energy, R&D exp.); 1753, 1754, 231, 232 (inv. in tang.)

Ireland

Sectors (nacecode) with no data : 1591, 1596, 1597, 1598, 182, 191, 192, 23, 232, 246, 247, 265, 266, 271, 272, 273, 282, 2912, 334, 36,362, 365, 366

Variables with no data : R&D exp

Sectors with missing data : 154, 158, 262, 263 (inputs, wages, inv. in tang., energy); 262, 263, 364 (inputs, wages, inv. in tang., energy)

Sectors with only zeros : 1592, 176, 231

Portugal

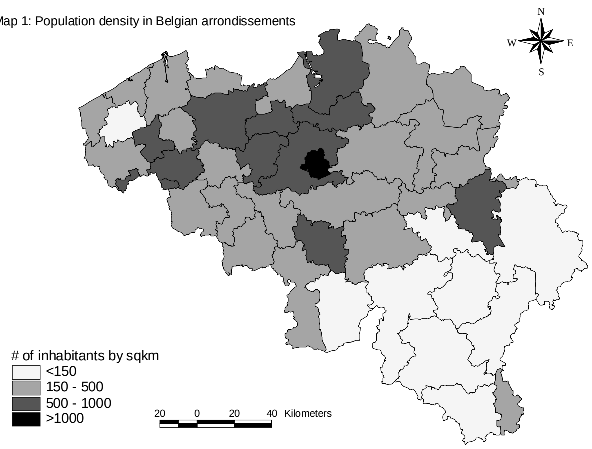
Sectors (nacecode) with no data : 1597

Sectors with missing data : 1592, 314 (inv. in tang., R&D exp.)

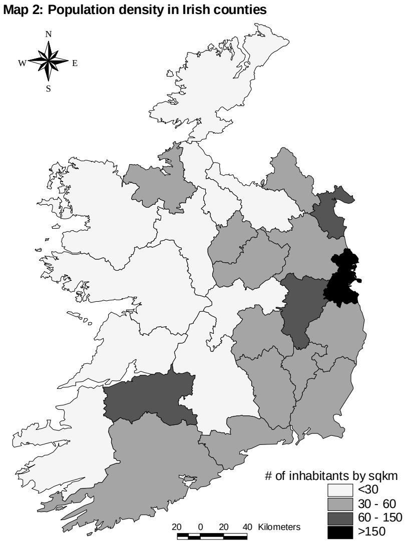
Sectors with only zeros : 231

Maps and Tables

Map 1: Population density in Belgian arrondissements



Map 2: Population density in Irish counties



Map 3: Population density in Portuguese distritos

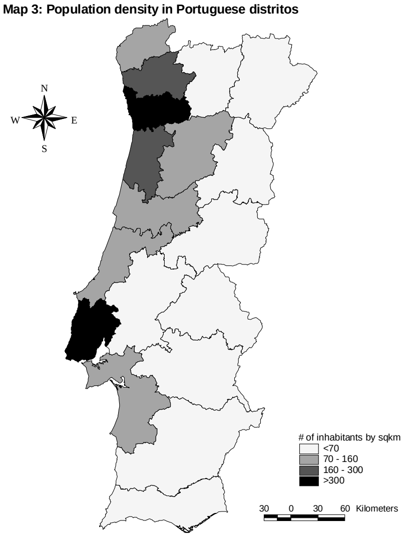


Table 1a: Average Areas

	Regional level	Local level
Belgium	43 arrondissements: 710skm	589 communes: 52skm
Ireland	27 counties: 2603skm	504 Townships: 139.4skm/ 3445 DEDs: 20.4skm
Portugal	18 distritos: 4887skm	275 concelhos: 320skm
United States	51 States: 70322skm	3141 Counties: 1142skm

Note: areas are average ones. One square kilometer corresponds to 0.3861 square miles.

Table 1b: Average Population (Density)

	Population (in 1000)		Population Density (pop/skm)
	regional	*local*	
Belgium	240	17.5	338
Ireland	144.5	7.5 / 1	55.5
Portugal	576	37.5	118
United States	5518	89.5	78.5

Note: figures are averages for 2002 (respectively 2000 for the US)

Table 2: Moran indices

		Belgium (communes)		Ireland (DEDs)		Portugal (concelhos)	
	ISIC code	**Moran I**	**p-value**	**Moran I**	**p-value**	**Moran I**	**p-value**
Slaughtering, preparing and preserving meat	3111	0.0877	0.0002	-0.0061	0.5617	-0.0325	0.3841
Manufacture of dairy products	3112	0.0111	0.5822	0.0119	0.2038	0.0083	0.7029
Canning and preserving of fruits and vegetables	3113	0.0252	0.2373	0.0021	0.7801	-0.0129	0.777
Can., Preserv., and process of fish, crustacean	3114	0.0333	0.0336	0.0088	0.341	-0.0075	0.8979
Manufacture of vegs. and animal oils and fats	3115	-0.0068	0.6499	-0.0009	0.9422	0.0168	0.4542
Grain mill products	3116	-0.0092	0.6491	-0.0046	0.635	0.0151	0.5574
Manufacture of food products, N.E.C.	3121	0.0514	0.0218	-0.0031	0.7565	0.0545	0.0669
Manufacture of prepared animal feeds	3122	0.0884	0	0.0037	0.658	0.0455	0.1028
Distilling, rectifying and blending spirits	3131	0.0939	0	-0.0007	0.9612	0.0859	0.0009
Malt liquors and malt	3133	-0.0065	0.8142	-0.0008	0.9565	0.0825	0.0015
Soft drinks and carbonated waters industries	3134	-0.0191	0.4113	-0.0035	0.7205	-0.0197	0.6117
Tobacco manufactures	3140	-0.0084	0.7654	-0.0011	0.9266	-0.0099	0.7388
Spinning, weaving and finishing textiles	3211	0.2624	0	0.0048	0.5823	0.0026	0.8304
Manufacture made-up textile goods except wearing apparel	3212	0.0307	0.0596	0.004	0.6657	0.0205	0.0794
Knitting mills	3213	0.058	0	0.0022	0.1708	0.0763	0.0015
Manufacture of carpets and rugs	3214	0.2873	0	-0.002	0.8381	0.0108	0.6116
Manufacture of textiles, N.E.C.	3219	0.019	0.3227	-0.0016	0.8826	0.0364	0.2092
Manufacture of wearing apparel except footwear	3220	0.1238	0	-0.005	0.6345	0.0725	0.0243
Tanneries and leather finishing	3231	0.0549	0.0018	-0.0018	0.8592	-0.0116	0.6764
Manufacture prods. leather except footwear and apparel	3233	-0.0035	0.7667	-0.002	0.8485	-0.001	0.9307
Manufacture footwear except rubber or plastic	3240	0.0097	0.6119	-0.0004	0.9841	-0.0107	0.8169
Sawmills, planting and other wood mills	3311	0.1366	0	-0.004	0.6544	0.015	0.5871
Manufacture of wooden, cane containers, small cane ware	3312	0.0163	0.4181	-0.0009	0.9063	0.0287	0.3183
Manufacture wood and cork products N.E.C.	3319	-0.0067	0.8266	-0.0052	0.615	0.0035	0.4599
Manufacture furniture, fixtures except primarily mental	3320	0.2945	0	-0.0044	0.6573	-0.0012	0.9273
Manufacture of pulp, paper and paperboard	3411	-0.0198	0.3972	-0.0027	0.8032	0.0053	0.7791
Manufacture articles of pulp, paper, paperboardN.E.C.	3419	0.0505	0.0259	-0.0034	0.6139	0.0642	0.0358
Printing, publishing and allied industries	3420	0.1619	0	-0.0045	0.6678	0.0286	0.1963
Basic industrial chemicals except fertilizers	3511	0.0888	0	-0.0025	0.7832	0.1839	0
Fertilizers and pesticides	3512	0.029	0.1103	-0.0019	0.8393	0.0396	0.1178
Syn. resins, plastic mat. man-made fibers exc. glass	3513	0.0168	0.3717	-0.0004	0.9806	-0.0025	0.9712
Paints, varnishes and lacquers	3521	0.0323	0.1214	-0.001	0.943	-0.0087	0.8561
Drugs and medicines	3522	0.0186	0.3288	0.0187	0.0534	0.0569	0.0441
Soap, cleansing preparations, perfumes, cosmetics	3523	0.073	0.0012	-0.0036	0.7215	0.1492	0
Chemical products, N.E.C.	3529	0.2181	0	0.0114	0.2053	0.0284	0.3329
Misc. products of petroleum and coal	3540	-0.0027	0.8043	-0.0006	0.9681	-0.0038	0.985
Manufacture of rubber products N.E.C.	3559	0.0068	0.6887	-0.0037	0.7058	-0.002	0.9577
Plastic products N.E.C.	3560	0.0263	0.2354	0.0174	0.0756	0.086	0.0043
Pottery, china and earthware	3610	0.0072	0.6139	-0.0047	0.6314	0.0533	0.0765
Glass and glass products	3620	0.1538	0	-0.0015	0.8607	-0.0049	0.9439
Structural clay products	3691	0.0385	0.0698	-0.0036	0.7277	0.0413	0.1804
Cement, lime and plaster	3692	0.0224	0.3071	0.0013	0.8586	0.1011	0.0008
Non-metallic mineral products, N.E.C.	3699	0.0233	0.2483	-0.0028	0.7228	0.0801	0.0011
Iron and steel basic industries	3710	0.0186	0.3237	-0.0005	0.9524	-0.0199	0.6218
Non-ferrous metal basic industries	3720	0.0073	0.6743	-0.0031	0.7566	0.0398	0.1906
Cutlery, hand tools and general hardware	3811	0.024	0.0927	-0.0017	0.8833	0.1005	0.0019
Structural metal products	3813	0.1251	0	-0.0028	0.7999	0.1328	0
Fabricated metal products except machinery and equipment N.E.C.	3819	-0.0211	0.3588	-0.0022	0.8459	0.0275	0.3482
Agricultural machinery and equipment	3822	0.0135	0.2019	0.0048	0.6014	0.0033	0.8157
Spec. indus. machinery and equipment except 3823	3824	0.0268	0.1754	0.0061	0.4598	0.0999	0.0021
Office, computing and accounting machinery	3825	0.0236	0.208	0.0116	0.0883	-0.0059	0.9284
Electrical industrial machinery and apparatus	3831	0.0188	0.2782	0.0061	0.4304	0.0288	0.255
Radio, tele., communications equipment and apparatus	3832	-0.0035	0.9349	-0.0021	0.8475	-0.0037	0.999
Electrical appliances and housewares	3833	-0.0038	0.9244	-0.0013	0.8967	-0.0184	0.5827
Electrical apparatus and supplies, N.E.C.	3839	-0.0091	0.735	0.0014	0.8544	0.0978	0.0024
Shipbuilding and repairing	3841	0.0746	0	0.0149	0.0676	0.1388	0
Motor vehicles	3843	-0.0263	0.2414	0.0075	0.3994	0.0195	0.4778
Prof., scientific, measuring and control equipment	3851	0.0133	0.4888	-0.0046	0.6027	-0.0053	0.9415
Photographic and optical goods	3852	-0.0101	0.5917	-0.001	0.8596	-0.0219	0.5252
Jewelry and related articles	3901	0.0586	0	0.0055	0.2706	-0.0062	0.8743
Musical instruments	3902	0.017	0.409	-0.0012	0.9147	-0.0065	0.9065
Sporting and athletic goods	3903	0.0623	0.0016	-0.0013	0.8727	-0.013	0.7618
Manufacturing industries N.E.C.	3909	-0.0038	0.9198	0.0047	0.5369	0.0306	0.2957
E(I)		-0.0017		-0.0003		-0.0036	

Note: Moran indices are computed for first order contiguity matrices.

Table 3: Share of total manufacturing employment

	ISIC 2-digit	Belgium	Ireland	Portugal
Manufacturing of food, beverages and tobacco	31	*14.19%*	*19.81%*	*10.38%*
Textile, wearing apparel and leather industries	32	*9.31%*	*7.06%*	*34.94%*
Manufacture of wood and wood products	33	*4.81%*	*4.83%*	*9.05%*
Manufacture paper, paper prods., printing, publishing	34	*7.64%*	*6.08%*	*5.06%*
Manufacture of chemicals and chemical products	35	*15.25%*	*13.33%*	*1.83%*
Manufacture non-metallic mineral prods. except fuel	36	*5.35%*	*4.58%*	*7.22%*
Basic metal industries	37	*6.37%*	*0.39%*	*1.41%*
Fabricated metal products, machinery and equipment	38	*30.33%*	*39.71%*	*12.04%*
Other manufacturing industries	39	*0.88%*	*2.04%*	*1.08%*
Total		*94%*	*98%*	*83%*

Note: *percentages only include sectors that are effectively used in the present study, so they do not sum up to 100 per cent.*

Table 4: EG index for Belgium

	ISIC code	E&G communes	E&G arrondissements	Rank E&G arr.
Misc. products of petroleum and coal	3540	0.4037*	0.3749*	1
Jewelry and related articles	3901	0.1342*	0.1784*	4
Pottery, china and earthware	3610	0.1136*	0.1398*	10
Knitting mills	3213	0.1103*	0.1656*	6
Can., Preserv., and process of fish, crustacean	3114	0.1065*	0.1585*	7
Shipbuilding and repairing	3841	0.0847*	0.1766*	5
Manufacture of vegs. and animal oils and fats	3115	0.0682*	0.1993*	3
Fertilizers and pesticides	3512	0.0525	0.0982	13
Basic industrial chemicals except fertilizers	3511	0.0436*	0.0502*	19
Manufacture of carpets and rugs	3214	0.037*	0.1575*	8
Spinning, weaving and finishing textiles	3211	0.033*	0.1368*	11
Manufacture of textiles, N.E.C.	3219	0.0301*	0.0565*	16
Canning and preserving of fruits and vegetables	3113	0.0287*	0.0361*	27
Cutlery, hand tools and general hardware	3811	0.0275*	0.027*	30
Drugs and medicines	3522	0.0273*	0.0991*	12
Agricultural machinery and equipment	3822	0.0239	0.0397	24
Musical instruments	3902	0.022*	0.0478*	21
Glass and glass products	3620	0.0184*	0.0436*	23
Manufacture footwear except rubber or plastic	3240	0.0161	0.0122	41
Sawmills, planting and other wood mills	3311	0.016*	0.0344*	28
Manufacture of prepared animal feeds	3122	0.0158*	0.0382*	25
Manufacture of dairy products	3112	0.0145*	0.0104	43
Structural clay products	3691	0.0144	0.0064	46
Photographic and optical goods	3852	0.0119	-0.0483	63
Tobacco manufactures	3140	0.0116	0.0244	31
Office, computing and accounting machinery	3825	0.0102	0.0535	17
Manufacture furniture, fixtures except primarily mental	3320	0.0099*	0.0137*	38
Paints, varnishes and lacquers	3521	0.0096	0.0514*	18
Manufacture made-up textile goods except wearing apparel	3212	0.0093	0.0372*	26
Sporting and athletic goods	3903	0.0088	0.0574	15
Cement, lime and plaster	3692	0.0087*	-0.0001	52
Manufacture prods. leather except footwear and apparel	3233	0.0086	0.0485	20
Non-metallic mineral products, N.E.C.	3699	0.0083*	0.0133*	39
Prof., scientific, measuring and control equipment	3851	0.0079	0.0188*	35
Tanneries and leather finishing	3231	0.0078	0.0796	14
Soap, cleansing preparations, perfumes, cosmetics	3523	0.0074	0.0144	37
Electrical appliances and housewares	3833	0.0074	0.0023	51
Manufacture of rubber products N.E.C.	3559	0.0071	0.0149	36
Slaughtering, preparing and preserving meat	3111	0.0068*	0.0055*	47
Manufacture of wearing apparel except footwear	3220	0.0064*	0.0209*	33
Distilling, rectifying and blending spirits	3131	0.0062	0.2159*	2
Manufacturing industries N.E.C.	3909	0.0061	-0.0056	56
Manufacture wood and cork products N.E.C.	3319	0.0051	0.0028	50
Printing, publishing and allied industries	3420	0.0051*	0.0228*	32
Plastic products N.E.C.	3560	0.0051*	0.0117*	42
Manufacture of food products, N.E.C.	3121	0.0045*	0.0055*	47
Manufacture of wooden, cane containers, small cane ware	3312	0.0035	0.0046	49
Manufacture articles of pulp, paper, paperboardN.E.C.	3419	0.0032	0.0098	44
Electrical apparatus and supplies, N.E.C.	3839	0.003	-0.0063	57
Structural metal products	3813	0.0023*	0.0093*	45
Non-ferrous metal basic industries	3720	0.0014	0.0123	40
Malt liquors and malt	3133	0.0013	0.0272	29
Manufacture of pulp, paper and paperboard	3411	0.001	0.0206	34
Fabricated metal products except machinery and equipment N.E.C.	3819	-0.0041	-0.0029	53
Spec. indus. machinery and equipment except 3823	3824	-0.0049	-0.0036	54
Electrical industrial machinery and apparatus	3831	-0.0072	-0.0053	55
Grain mill products	3116	-0.009	-0.0162	58
Iron and steel basic industries	3710	-0.0091	0.0447	22
Soft drinks and carbonated waters industries	3134	-0.0144	-0.0284	60
Chemical products, N.E.C.	3529	-0.0154	0.1496*	9
Syn. resins, plastic mat. man-made fibers exc. glass	3513	-0.0175	-0.018	59
Radio, tele., communications equipment and apparatus	3832	-0.0202*	-0.0301	61
Motor vehicles	3843	-0.0272	-0.0373	62

Note: results were computed for 1998; stars stand for statistical significance according to the two standard deviation rule; sectors are ranked according to the local-level E&G index ranking; *communes* and *arrondissements* correspond to the local respectively the regional geographic breakdown.

Table 5: EG index for Ireland

	ISIC code	E&G township	E&G county	Rank E&G county
Photographic and optical goods	3852	0.488*	0.2957*	1
Iron and steel basic industries	3710	0.1342*	0.0432	25
Manufacture of wooden, cane containers, small cane ware	3312	0.0949	-0.1267	63
Electrical appliances and housewares	3833	0.0922	0.0752	14
Malt liquors and malt	3133	0.0863	-0.0441	61
Can., Preserv., and process of fish, crustacean	3114	0.0793*	0.1147*	9
Syn. resins, plastic mat. man-made fibers exc. glass	3513	0.0734	0.1774	3
Motor vehicles	3843	0.072*	0.0297	30
Manufacture of vegs. and animal oils and fats	3115	0.0683	0.065	17
Manufacture of prepared animal feeds	3122	0.0483*	0.046*	23
Manufacture of carpets and rugs	3214	0.0438	0.0747	16
Misc. products of petroleum and coal	3540	0.0432	0.0104	39
Musical instruments	3902	0.0399	-0.073	62
Manufacture articles of pulp, paper, paperboardN.E.C.	3419	0.0393	0.0543	18
Glass and glass products	3620	0.038	0.1297*	6
Jewelry and related articles	3901	0.0363*	0.01	41
Office, computing and accounting machinery	3825	0.036	0.0025	46
Chemical products, N.E.C.	3529	0.0319	0.0204	34
Prof., scientific, measuring and control equipment	3851	0.0272*	0.0373*	27
Structural clay products	3691	0.0251	0.0303	29
Soft drinks and carbonated waters industries	3134	0.02	-0.0289	56
Slaughtering, preparing and preserving meat	3111	0.0173*	0.0411*	26
Canning and preserving of fruits and vegetables	3113	0.0168	0.0448	24
Manufacture of pulp, paper and paperboard	3411	0.0159	0.2171*	2
Drugs and medicines	3522	0.0156*	0.0213*	33
Manufacture wood and cork products N.E.C.	3319	0.015	0.0011	49
Manufacture furniture, fixtures except primarily mental	3320	0.0135*	0.0507*	20
Manufacture of wearing apparel except footwear	3220	0.0131*	0.0515*	19
Sawmills, planting and other wood mills	3311	0.013	0.0359*	28
Electrical apparatus and supplies, N.E.C.	3839	0.0111	0.0058	43
Radio, tele., communications equipment and apparatus	3832	0.0108	-0.0215	53
Plastic products N.E.C.	3560	0.0103*	0.0039	44
Basic industrial chemicals except fertilizers	3511	0.01	-0.0396	59
Manufacture of dairy products	3112	0.0079	0.0752*	15
Manufacture made-up textile goods except wearing apparel	3212	0.007	-0.0072	52
Manufacture of rubber products N.E.C.	3559	0.0052	0.0137	37
Cement, lime and plaster	3692	0.0037	0.0103	40
Soap, cleansing preparations, perfumes, cosmetics	3523	0.0029	-0.0242	54
Cutlery, hand tools and general hardware	3811	0.0027	0.015	36
Spinning, weaving and finishing textiles	3211	0.0015	0.1178*	8
Printing, publishing and allied industries	3420	0.0014	0.1671*	5
Structural metal products	3813	0.001	0.0011	48
Agricultural machinery and equipment	3822	-0.0008	0.1005*	11
Manufacture of food products, N.E.C.	3121	-0.0009	0.0199*	35
Non-ferrous metal basic industries	3720	-0.0009	0.0034	45
Fertilizers and pesticides	3512	-0.0016	-0.0302	58
Fabricated metal products except machinery and equipment N.E.C.	3819	-0.0016	0.0013	47
Spec. indus. machinery and equipment except 3823	3824	-0.0028	0.0134	38
Paints, varnishes and lacquers	3521	-0.0036	0.0465	22
Manufacturing industries N.E.C.	3909	-0.0044	-0.0005	50
Manufacture of textiles, N.E.C.	3219	-0.0056	0.0078	42
Knitting mills	3213	-0.0097	0.1753	4
Pottery, china and earthware	3610	-0.0111	0.0229	32
Non-metallic mineral products, N.E.C.	3699	-0.0131	-0.0039	51
Tobacco manufactures	3140	-0.0133	-0.029	57
Distilling, rectifying and blending spirits	3131	-0.0136	0.0763	13
Manufacture prods. leather except footwear and apparel	3233	-0.0144	-0.0411	60
Tanneries and leather finishing	3231	-0.016	0.1082	10
Shipbuilding and repairing	3841	-0.0175	0.0502	21
Grain mill products	3116	-0.0194	0.0243	31
Electrical industrial machinery and apparatus	3831	-0.0368	-0.025	55
Manufacture footwear except rubber or plastic	3240	-0.0514	0.0809	12
Sporting and athletic goods	3903	-0.0529	0.1185	7

Note: results were computed for 1998; stars stand for statistical significance according to the two standard deviation rule; sectors are ranked according to the local-level E&G index ranking; *townships* and *counties* correspond to the local respectively the regional geographic breakdown.

Table 6: EG index for Portugal

	ISIC code	E&G concelho	E&G distrito	Rank E&G dist.
Tanneries and leather finishing	3231	0.3941*	0.417*	4
Manufacture wood and cork products N.E.C.	3319	0.3272*	0.3781*	6
Office, computing and accounting machinery	3825	0.3134*	0.0766	33
Jewelry and related articles	3901	0.2859*	0.3038*	10
Glass and glass products	3620	0.2085*	0.305*	8
Misc. products of petroleum and coal	3540	0.2032*	0.6313*	1
Manufacture made-up textile goods except wearing apparel	3212	0.1655*	0.2034*	12
Prof., scientific, measuring and control equipment	3851	0.0845*	0.1248*	27
Fertilizers and pesticides	3512	0.0824*	0.1799*	17
Spinning, weaving and finishing textiles	3211	0.0796*	0.1801*	16
Manufacture furniture, fixtures except primarily mental	3320	0.0776*	0.138*	24
Manufacture footwear except rubber or plastic	3240	0.0756*	0.1254*	26
Drugs and medicines	3522	0.0747*	0.5357*	2
Printing, publishing and allied industries	3420	0.0739*	0.1634*	18
Manufacture prods. leather except footwear and apparel	3233	0.069*	0.0349*	46
Manufacture of dairy products	3112	0.0657	0.0258	50
Distilling, rectifying and blending spirits	3131	0.0651*	0.0268	49
Can., Preserv., and process of fish, crustacean	3114	0.0583*	0.0325*	48
Knitting mills	3213	0.0549*	0.2042*	11
Soap, cleansing preparations, perfumes, cosmetics	3523	0.0539*	0.483*	3
Paints, varnishes and lacquers	3521	0.0505*	0.0705*	35
Electrical industrial machinery and apparatus	3831	0.0494	-0.0301	62
Iron and steel basic industries	3710	0.0492*	0.0496	42
Electrical appliances and housewares	3833	0.0471	-0.024	61
Shipbuilding and repairing	3841	0.0461*	0.4065*	5
Manufacture of carpets and rugs	3214	0.0452*	0.1344*	25
Pottery, china and earthware	3610	0.0429*	0.2006*	13
Syn. resins, plastic mat. man-made fibers exc. glass	3513	0.0354*	0.1391*	22
Manufacture of vegs. and animal oils and fats	3115	0.0334	0.1385*	23
Manufacture of food products, N.E.C.	3121	0.0332*	0.1503*	21
Manufacture of prepared animal feeds	3122	0.0332*	0.0948*	30
Manufacture of pulp, paper and paperboard	3411	0.0314*	0.1163*	28
Basic industrial chemicals except fertilizers	3511	0.0263*	0.1839*	14
Structural clay products	3691	0.0248*	0.1522*	20
Agricultural machinery and equipment	3822	0.0241*	0.0821*	31
Motor vehicles	3843	0.0217*	0.063*	38
Cement, lime and plaster	3692	0.0214	0.1816*	15
Plastic products N.E.C.	3560	0.0212*	0.0577*	40
Non-metallic mineral products, N.E.C.	3699	0.0178*	0.0483*	43
Non-ferrous metal basic industries	3720	0.0167*	0.0185	53
Soft drinks and carbonated waters industries	3134	0.0164*	0.0695*	36
Manufacture of wooden, cane containers, small cane ware	3312	0.014*	0.0019	58
Fabricated metal products except machinery and equipment N.E.C.	3819	0.0137*	0.0222*	52
Manufacturing industries N.E.C.	3909	0.0136*	0.0137*	54
Cutlery, hand tools and general hardware	3811	0.0129*	0.0124*	55
Structural metal products	3813	0.0113*	0.08*	32
Manufacture of wearing apparel except footwear	3220	0.0112*	0.0625*	39
Slaughtering, preparing and preserving meat	3111	0.0111*	0.0685*	37
Manufacture articles of pulp, paper, paperboardN.E.C.	3419	0.0111*	0.0347*	47
Chemical products, N.E.C.	3529	0.0102	0.0432	44
Manufacture of rubber products N.E.C.	3559	0.0095*	-0.0056	59
Sawmills, planting and other wood mills	3311	0.009*	0.0373*	45
Spec. indus. machinery and equipment except 3823	3824	0.0067*	0.0101	56
Electrical apparatus and supplies, N.E.C.	3839	0.0054	0.0575*	41
Canning and preserving of fruits and vegetables	3113	0.0031	0.1566*	19
Grain mill products	3116	0.0031	0.0741*	34
Radio, tele., communications equipment and apparatus	3832	-0.0019*	0.023*	51
Musical instruments	3902	-0.0051	0.3684	7
Manufacture of textiles, N.E.C.	3219	-0.0114*	0.1087*	29
Sporting and athletic goods	3903	-0.026	0.0061	57
Malt liquors and malt	3133	-0.0306	-0.1542	63
Photographic and optical goods	3852	-0.0483	-0.0138	60
Tobacco manufactures	3140	-0.4349	0.3044	9

Note: results were computed for 1998; stars stand for statistical significance according to the two standard deviation rule; sectors are ranked according to the local-level E&G index ranking; *concelhos* and *distritos* correspond to the local respectively the regional geographic breakdown.

Table 7: Rank correlation of EG indices between countries

	Belgium (arrondissements)	Ireland (counties)	Portugal (distritos)
Belgium (arrondissements)	*1*	-	-
Ireland (counties)	*0.196* *(0.123)*	*1*	-
Portugal (distritos)	*0.416* *(0.000)*	*0.057* *(0.656)*	*1*

(p-values in parentesis)

Table 8 : Regional level

	E&G, regional level regressions			
	(1)	(2)	(3)	(4)
Total input purchases	0.121*	0.167**	0.107	0.338
	(0.070)	(0.079)	(0.302)	(0.312)
Wages and salaries	-4.897***	-5.300***	11.619**	14.560**
	(1.081)	(1.124)	(5.185)	(5.616)
Gross inv. in tang. capital goods	1.089	0.343	-3.013	-4.097
	(0.940)	(0.980)	(3.140)	(3.265)
Purchase of energy products	4.150**	4.564**	1.406	0.371
	(1.771)	(2.063)	(5.809)	(6.211)
R&D expenditure	8.431	16.030	46.440	60.886
	(14.774)	(15.166)	(49.783)	(49.756)
Average plant size	0.010	0.013	0.133*	0.109
	(0.011)	(0.011)	(0.071)	(0.073)
Dummy B.			0.047	0.029
			(0.075)	(0.073)
Total input purchases B.			0.057	-0.138
			(0.313)	(0.314)
Wages and salaries B.			-13.785**	-14.952**
			(5.797)	(5.782)
Gross inv. in tang. K goods B.			2.484	3.955
			(3.728)	(3.680)
Purchase of energy products B.			1.755	0.804
			(6.325)	(6.479)
R&D expenditure B.			-48.724	-57.894
			(57.707)	(57.508)
Average plant size B.			-0.205	-0.148
			(0.294)	(0.288)
Dummy I.			-0.023	-0.017
			(0.083)	(0.085)
Total input purchases I.			-0.148	-0.313
			(0.349)	(0.343)
Wages and salaries I.			-8.517	-10.396
			(6.674)	(6.770)
Gross inv. in tang. K goods I.			1.673	1.945
			(3.571)	(3.837)
Purchase of energy products I.			-2.356	1.098
			(6.613)	(6.612)
R&D expenditure I.			-50.984	-53.205
			(52.978)	(52.356)
Average plant size I.			-0.023*	-0.097
			(0.083)	(0.074)
Constant	0.124***	0.056	0.018	-0.080
	(0.019)	(0.051)	(0.041)	(0.067)
2-digit ISIC dummy	No	Yes	No	Yes
Observations	179	179	179	179
Adjusted R-squared	0.11	0.15	0.23	0.28

Note : Standard errors in parentheses. ***, **, and * signify 1, 5, and 10 per cent significance levels. Data sources are Eurostat, except for R&D expenditure in Ireland, which stems from a national source (see data appendix). All specifications performed using OLS estimators. B and I refer to Ireland and Belgium respectively. When a variable is followed by B or I, it has been interacted with the corresponding country dummy.

Table 9 : Local level

	E&G, local level regressions			
	(1)	(2)	(3)	(4)
Total input purchases	0.129**	0.191***	0.390*	0.580**
	(0.051)	(0.058)	(0.236)	(0.248)
Wages and salaries	-2.507***	-2.860***	-8.632**	-9.178**
	(0.790)	(0.819)	(4.049)	(4.470)
Gross inv. in tang. capital goods	-0.786	-1.102	-5.241**	-5.644**
	(0.687)	(0.714)	(2.452)	(2.599)
Purchase of energy products	3.468***	3.839**	9.480**	9.705*
	(1.294)	(1.504)	(4.536)	(4.944)
R&D expenditure	10.295	15.617	64.193	69.390*
	(10.796)	(11.053)	(38.876)	(39.606)
Average plant size	0.009	0.014*	0.108*	0.091
	(0.008)	(0.008)	(0.055)	(0.058)
Dummy B.			-0.076	-0.074
			(0.059)	(0.058)
Total input purchases B.			-0.249	-0.393
			(0.244)	(0.250)
Wages and salaries B.			6.874	7.160
			(4.527)	(4.603)
Gross inv. in tang. K goods B.			3.842	4.581
			(2.911)	(2.929)
Purchase of energy products B.			-5.432	-6.366
			(4.939)	(5.157)
R&D expenditure B.			-62.847	-56.547
			(45.065)	(45.777)
Average plant size B.			-0.182	-0.145
			(0.230)	(0.230)
Dummy I.			-0.127*	-0.119*
			(0.065)	(0.068)
Total input purchases I.			-0.529*	-0.593**
			(0.272)	(0.273)
Wages and salaries I.			10.735**	10.605*
			(5.212)	(5.389)
Gross inv. in tang. K goods I.			5.745**	5.033
			(2.788)	(3.054)
Purchase of energy products I.			-9.298*	-7.017
			(5.164)	(5.263)
R&D expenditure I.			-58.288	-55.886
			(41.371)	(41.676)
Average plant size I.			-0.096*	-0.076
			(0.056)	(0.059)
Constant	0.057***	0.026	0.117***	0.070
	(0.014)	(0.037)	(0.032)	(0.053)
2-digit ISIC dum.	No	Yes	No	Yes
Observations	179	179	179	179
Adjusted R-squared	0.09	0.13	0.10	0.12

Note : Standard errors in parentheses. ***, **, and * signify 1, 5, and 10 per cent significance levels. Data sources are Eurostat, except for R&D expenditure in Ireland, which stems from a national source (see data appendix). All specifications performed using OLS estimators. B and I refer to Ireland and Belgium respectively. When a variable is followed by B or I, it has been interacted with the corresponding country dummy.