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MEASURING AND EXPLAINING LOCALISATION: EVIDENCE FROM TWO BRITISH SECTORS

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Measuring and Explaining Localisation: Evidence from two British Sectors *

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ABSTRACT

The degree of localisation of manufacturing, defined as the excess geographic concentration remaining after correcting for both sectorial concentration and the agglomeration of overall economic activity, has recently gained new techniques of measurement. These techniques are illustrated and theoretically discussed.

The paper then investigates the sectorial scale of localisation, using evidence from two British sectors, SIC 244 (pharmaceutical) and 334 (optical and photographic), and respective sub-sectors. Applying the measures, it is evidenced that the individual sub-sectors are very differently localized both in extent and in location, even within the same sector.

In addition to this, with survey data the paper shows that localisation is due to different economic explanations in different sub-sectors. This is a proof that the economic factors behind localisation are in this case at 5-digit level, making economically not meaningful the measurement of localisation at a different scale.

The study implies that identifying localisation remains a delicate process, since the right sectorial scale has to be detected case by case, the use of more than one technique usually gives additional insights and, finally, the survey confirms that, in field studies, a mix of different theoretical models is generally needed to explain the observed patterns.

1 Introduction

The spontaneous tendency of most economic activities to concentrate in space is today a crucial investigation theme for both economists and economic geographers because of the consequences it brings on regional and national disparities and, consequently, on development policies.

For this reason, it is important to be conscious of what forces really drive to the observed patterns. In the traditional Hooverian (1937) approach, the increasing returns to scale, which are supposed to be the reason for spatial concentration, can arise at three different levels: (1) they can be internal to the firm, and in this case the economic activity will be concentrated in large plants; this case is known in the literature as *sectorial concentration*. (2) Alternatively, they can be internal to the industrial sectors: this is the case in which firms belonging to the same sector take advantage of their co-presence through externalities; this second case is known in literature as *localisation economies*. (3) The third possible level at which one can find increasing returns is out of the industrial sector. In this last case, the firms are clustered in space not because of intra-sector externalities but because the contemporary presence of many firms in the same area is advantageous for all (for example because it allows the provision of services that needs a minimum scale). Since this is what is usually observed in cities, these are known as *urbanisation economies*.

When designing development policies aimed at fostering manufacture in a region, it becomes essential to disentangle which one of the previous three, or which combination, characterize the area and each target sector. Because it is in the detection of the second ones that new instruments have been recently developed, this article concentrates on *localisation*, defining it as the geographical spatial concentration observed in a manufacturing sector, after the effects of sectorial concentration and urbanization economies have been sterilized.

A good measure of localisation, therefore, has to correct both for the agglomeration of the whole economy and for the internal structure of the sector.

The new measures developed, either in the form of indexes or in the form of numerical methods, take this into account and appear to be consistent advancements from the instruments previously available, even if, in applied studies, it seems useful to use both approaches and complement their results, as it will be shown in the rest of the paper.

Unfortunately, after getting rid of the complications due to the possible overlappings of internal returns to scale, localisation and urbanisation

economies[1], three major complications still remain:

The first one comes from the fact that there exist a large number of possible explanations for localisation, coming from different models, in part overlapping, in part mutually exclusive. The difficulty in empirical studies is that generally the observed patterns have features belonging to different theories, with complex results as outcome. This is, in any case, widely recognised in the literature.

The second one concerns the geographical scale in which to measure localisation. We will show in section 3 that the indexes of localisation remain sensible to the used geographical scale. Numerical methods, however, are born as a successful attempt to get rid of this problem.

Finally the third complication concerns the sectorial scale of localisation. In fact, if measured at a larger than appropriate scale, the "observed localisation" is merely the sum of un-related processes happening at different scale, and has no real meaning[2]. When investigating the reasons of localisation, moreover, choosing a larger than appropriate scale can make the results unclear and, more important, economically meaningless.
Despite this, the third complication is too often neglected, and one can read phrases like "y out of z sectors at x-digit level are localised", which are correct and meaningful only if the economic processes take place at x-digit level in all sectors.

In this paper, we show with a case study in two British manufacturing sectors that the sectorial scale of localisation can indeed be very small. In fact, the six 5-digit sub-sectors of two 3-digit sectors are shown to be different the one from the other, both in terms of observed patterns and of economic explanations.

The rest of the paper is organized as follows: first we will briefly introduce the issue of theoretical reasons of localisation and spatial concentration, with some recent classifications (section 2). Then, section 3 will introduce and discuss the features of some recently developed measures of localisation. Section 4 will analyse the localisation patterns existing in the sectors and sub-sectors; this will allow to further discuss the measures and to evidence that sub-sectors of the same sector can be differently localised both in extent and in location.
The second part of the paper, using survey results, will investigate the eco-

[1]Unfortunately, the terminology is not always widely accepted, since the words agglomeration, spatial concentration, localisation, etc. are used by different authors to indicate different objects.

[2]An opposite problem, in which we will not enter directly in this paper, arise when the scale chosen is too small, so that it is again impossible to discover patterns happening at a larger scale by analysing separately smaller scale pieces.

nomic explanations of observed localisation and will show them to be again different among sub-sectors. The last section will conclude with an appraisal of the measures and further evidence the importance of choosing the right sectorial scale for measurement.

2 The determinants of localisation

When trying to explain the empirical patterns of localisation, a large number of theories have to be considered, but, even if not very appealing from a theoretical point of view, the study of natural advantage is the first step. As Ellison and Glaeser (1997) point out, the observed patterns of location may depend on spillovers but also on natural advantage or a mix of the two since "geographic concentration by itself does not imply the existence of spillovers: natural advantages have similar effects and may be important empirically" (p.891). For this reason, we chose for this study two sectors in which natural advantage is not expected to be a pre-eminent issue.

Dealing with spillovers, however, is always difficult since for example (McCann, 1994) a region with a solid fabric of infrastructure and skilled workers, due to the presence of a district of firms in a sector, can experience a crisis due to the crisis of the sector, but, after a few years, the same place could experience a fast resurgence of its industrial activity due to the arrival of firms of different sectors that benefit of the skills of the workforce previously created, rather than of the externalities they directly create.

When linking externalities and clustering, in most of recent economic geography models (Fujita et al., 1999, Ottaviano and Puga, 1998), the clustering of firms is the result of the concurrent effects of localised increasing returns to scale (producer and suppliers or firms and labour locate in the same place with benefits for both) and spatial distance transaction costs, for which a firm may chose its location by taking into account both the costs incurred in providing itself with the material or immaterial inputs needed, and the costs of shipping its products to the market. The firm therefore would chose its location in order to maximise its profit or minimize its costs. The latter is not very different from what arises in the traditional Moses (1958) model, where a firm faces a triangle with the location of its two inputs and its (singular) market at the vertexes and chooses its location and the combination of productive inputs in order to maximise its profit. If the good produced remains the same when changing the combination of factors (but McCann, 1994, is very critical on this hypothesis), if firms have sufficient mobility, and if externalities and market interaction effects are low (so that prices and demands are not significantly affected), industries with similar lo-

cation of inputs and markets will tend to cluster in the same most accessible places.

Externalities or localised increasing returns to scale are also at the base of the effects of historical accidents on long-run consequences, (as it is, again, in most new economic geography models): if firms can take advantage from the presence of other firms, or of particular workers mobile in space or of the variety of inputs available, then positive external economies of scale arise and there is the possibility for circular cumulative processes that make a temporary accidental advantage have long term effects; these effects can not be reversed by an accident of opposite sign and comparable size.

Coming to more applied works, the one of Marshall on English industrial districts is probably the most known example of study on the causes of localisation: he observed in fact the spatial clustering of small and medium sized firms belonging to the same sector and with very intense input-output relations, external economies through the labour market, the presence of furnishers and specialised services. Marshall is often cited by economists as their eldest inspirational source, but is also considered the progenitor of the modern theory of districts. These studies (Becattini, 1990) add to the observation of a sectorially specialised network of small and medium enterprises (SMEs) linked through intense input-output and labour market relations, the observation that in general there is an intense social network that facilitate the economic relations, due to the presence of a relatively uniform cultural and social background of the actors. In many cases it is observed also a thick institutional fabric, composed of formal agencies and informal behaviours; this fabric reduces the uncertainty entailed in the entrepreneurial activity. The formal and informal institutions which assist firm innovation are in fact considered, not only in districts, as a more and more important factor of competitiveness (Cooke, 1996) and, consequently, of location.

Taking some features of industrial districts, but with a different focus, some authors (Camagni, 1991, Ratti et al., 1997) have developed the concept of Innovative Milieu. This approach has at the core the observation, common to other theories (e.g. Porter, 1998), that innovative activity is at the basis of success for modern firms, with the specific addition that in many cases a network of SMEs located in the same place can be able to compete worldwide because the innovative activity, in general too complex to be performed by a single SME, remain external to the firm but internal to the milieu. This is possible through intense labour relations, personal knowledge among the economic actors and institutions. Market and technical knowledge, both tacit and codified, can in this way flow from one firm to the other.

In professional texts, on the contrary, the list of the causes to be considered is generally ample and quite traditional; for example Meissner (1997)

enumerates the following factors to be considered when choosing the location of a pharmaceutical plant: environmental considerations, labor availability and productivity, raw material availability, accessibility to transportation, property costs, tax, electric power availability and cost, regulations.

Since the reasons for the localisation of manufacture are complex to disentangle, both in theory and in the empirical investigations, Gordon and McCann (2000a) provide a useful effort to build a systematic classification of the conditions under which industrial clustering can arise. They distinguish three cases: first there is the model of *pure agglomeration*, in which there is a large number of firms in the same place, all benefiting of the co-presence of the others. This happens without any benevolent behaviour of the economic agents; instead, it is due to external economies stemming from the co-presence of many and different firms which makes possible to find the most suitable partner for each contract. The relations between firms, in this case, are not stable over time but, through the law of the large numbers, they can each time find what they need in the area in which they operate. A mechanism of self selection may also operate and choose the firms that provide the inputs more needed in the area, or that use the outputs of other firms of the neighbourhood.

The second model is the *industrial complex*, in which the cause of agglomeration resides in stable input-output relations between firms. When the firms have such a stable relations, their optimising behaviour may lead them to cluster together in order to minimize the spatial transaction costs, which include traditional transport costs alongside with logistics costs (McCann, 1998) . If in the pure agglomeration model, there is "open membership" (Gordon and McCann, 2000a p.518), since a new firm located in an agglomerated area can benefit of the wide number of furnishers and buyers available, the industrial complex model is instead a "closed club" (ibid. p.519) since a new firm installed in the area does not benefit of the presence of the others, unless it becomes involved in input-output relations. In fact, investment decisions are often successive to the conception of trading relations.

The third model is the *social network*. Differently from the previous two, this model is based more on social factors than economic ones. Institutions play a major role in this case, since they establish an order in inter-firm relations and reinforce the trust between economic agents. Such a trust makes the firms in the social network "willing to undertake risky co-operation without fear of opportunism [...] willing to reorganise their relationships without fear of reprisal [...] more willing to act as a group in support of common mutual and beneficial goals" (ibid. p.520); the presence of social and professional networks also decrease the uncertainty and costs associated with start up activities (Almeida and Kogut, 1991). The characteristics of the social

network can be present at the same time as one of the previous two models, as in a number of new industrial districts, and therefore the Gordon and McCann contribution has to be considered a useful framework for hypotheses testing[3] and should not be confused with a tri-partition of industrial clusters. The social network is presented as the main source of competitive advantage of a number of local production systems, but there is also evidence that it is not a necessary condition (Simmie and Hart, 1999).

The spatial concentration of highly innovative firms, although a particular case, is topical because of the effects innovation brings on the competitiveness of firms in advanced countries. Simmie (1998) identifies four possible explanations for the development of the "Islands of Innovation" (i.e. core urban or sub-urban regions in which innovative firms are observed to agglomerate): the first is the presence of location-specific factor-cost efficiencies, due for example to the contemporary presence in space of a qualified workforce and of capital; the second possible explanation occurs in the overcoming of spatial transaction costs. The third one lies in the fact that productive relations between highly innovative firms must be often re-negotiated and for this reason face to face contacts are extremely important, so that the advantage of being located close to other innovative firms can overcome the reduction in costs that could be achieved elsewhere, where there is not the upward pressure on factor costs due to the clustering of innovative firms.
The fourth reason lies in demand rather than costs: the market for innovative products can be spread across the world but can also be specifically located, as it happens for the military industry or public customers; as a consequence, firms take into account the closeness to their market when taking their location decisions and not because of shipping costs but because fast reaction to changing demand conditions is important for their success; this applies even more to highly innovative firms. As the Gordon-McCann classifications, these four Simmie's explanations do not exclude each other but can coexist and, therefore, their mix should be, case by case, investigated.

3 Measuring localisation

In the past few years, following the renewed interest for spatial issues, a number of papers addressed the problem of the measurement of localisation

[3]According to Gordon and McCann (2000) the most suitable method to detect the industrial complex model is to investigate the input-output links and their stability in time. For the pure agglomeration model they advocate the use of the estimation of the aggregate production function. For the social network they argue that a qualitative analysis is needed.

in industrial sectors. In fact, simple location coefficients are not an adequate instrument since population and economic activities cluster in some agglomerated areas. For this reason the fact that an industry is, for example, more present in the Greater London than in Lincolnshire, is not by itself an indicator that such an industry is really clustered in London, where there are both more labour and more total manufacturing.
The theoretical distinction between urbanisation and localisation economies, outlined in section 1, has a large importance in these measures, since urbanisation economies refer to the fact that firms from different sectors tend to take advantage from a concentrated location. The result of urbanisation economies is that economic activity is agglomerated in space with its concentration appearing to increase (Puga, 2001). Localisation economies, instead, refer to the advantages that a firm obtains from being located close to other firms of the same sector. In the measurement of localisation economies, therefore, the correction for the concentration of overall manufacturing activity becomes essential, and essential also becomes to correct for the industry concentration. It is in the measurement of these economies that a number of advancements were made available in the past few years. Six approaches will be analysed and the issues above are important in each of them.

The first contribution is that of Krugman (1991), which builds "locational Gini coefficients" for US sectors. The procedure involves the calculation of regional shares of sectorial and total manufacturing. Then the ratios of these two shares are calculated and the regions ordered according to their ratio. Finally, as in all Gini coefficients, the area between the Lorenz curve and the 45 degrees line gives the value of the coefficient. This methodology was a consistent advancement, but fails to take into account the characteristics of the industry (Maurel and Sedillot, 1999), i.e. the sectorial concentration. In addition to this, as all indexes, it fails to take into account spatial proximity and the different sizes of geographical units, as Krugman himself is aware of (Krugman, 1991, p.57).

In a contribution of 1997, Ellison and Glaeser develop a "model-based index of geographic concentration". Their model is built so that it reproduces the overall distribution of economic activities within the country. In their model the firms sequentially chose their location taking into account both spillovers and natural advantage, whose role is acknowledged.

Their index of industry concentration (γ_{eg}) uses the Herfindhal index of plant distribution in the industry (H) and an index of geographical concentration (G_{eg}) defined as:

$$H = \sum\nolimits_j z_j^2 \; ; \; G_{eg} = \sum\nolimits_i (s_i - x_i)^2 \; , \tag{1}$$

where z_j are the shares of the industry employment in the plants j, s_i are the shares of industry employment of the regions i and x_i are the shares of total manufacturing employment of the regions. γ_{eg} is defined as:

$$\gamma_{eg} = \frac{G_{eg} - (1 - \sum_i x_i^2)H}{(1 - \sum_i x_i^2)(1 - H)} \ . \tag{2}$$

They claim four major advantages for their index: first, it is easy to compute, since it only needs a breakdown of industry and total employment in some geographic units; second it is scaled so that it takes the value of zero not if the industry is evenly spread across space but if "employment is only as concentrated as it would be expected to be had the plants in the industry chosen locations by throwing darts at a map" (p.890); third it is comparable across industries in which the size distribution of firms differ; fourth it is comparable across industries regardless of differences in the level of geographic aggregation at which employment data are available in the different industries.

All the first three properties are useful for analyses like the one of this paper. On the fourth claimed property (less important in this case because data for the pharmaceutical and optical and photographic sectors were available at the same spatial scale) some doubts arise. The main limit of this index, in fact, is that it is not really geographical because it does not take into account the proximity relations of the regions. For this reason it fails to detect cases in which the regions of localisation are adjacent instead that far away; it is not also able to signal as localised an industry which has a cluster across the border between two regions. For this reason, the approach of the dartboard is therefore not completely such, since the darts are not really thrown to the space but rather randomly allocated to spatial units (Duranton and Overman, 2002). This also affects the reliability of the fourth property, since by changing the spatial scale of data it is possible to divide clusters in parts or to join separate clusters, so that, as all indexes, also γ_{eg} measures the "heterogeneity of the spatial structure at a single geographic level" (Marcon and Puech, 2003)

In addition to the claimed features, the index developed by Ellison and Glaeser, as those that will be described afterwards, proves to be quite resistant to modifications in the industry structure (see section 4).

Maurel and Sedillot (1999), develop an index based on the Ellison and Glaeser model and on the probability of two plants to be located in the same region. Their proposed index (γ_{ms}) is defined as:

$$\gamma_{ms} = \frac{G_{ms} - H}{1 - H} \text{ where } G_{ms} = \frac{\sum_i s_i^2 - \sum_i x_i^2}{1 - \sum_i x_i^2} \ . \tag{3}$$

Both γ_{eg} and γ_{ms} are (Maurel and Sedillot, 1999) unbiased estimators for the agglomeration forces in the Ellison and Glaeser model. They differ by a term whose expectations is 0 and, in practice (section 4) behave similarly.

Devereux et al. (1999) propose a computationally simpler approach: they calculate the Herfindhal index of industry concentration (H) and the Herfindhal index of geographic concentration ($J = \sum_i s_i^2$). Then they make a correction to both to take into account the fact that the number of plants may be smaller than the number of regions and build M and G_d respectively as: $M = H - \frac{1}{N}$; $G_d = J - \frac{1}{K}$, where N is the number of plants in the sector and K the number of regions.
Then, to address the problem of an industry with less plants than the number of regions, (case that does not happen in this analysis) they substitute F to G_d: $F = J - \frac{1}{K^*}$ where $K^* = min[N, K]$. Their final index of geographic agglomeration is α defined as:

$$\alpha = F - M \ . \tag{4}$$

This index has the advantage of lying between -1 and $+1$ with positive values for industries in which the distribution across regions is more concentrated than across plants, i.e. there is localisation, and negative in the opposite case. It is able to overcome the problem of employment concentration in plants but this index too is not immune to the critique of failing to consider the proximity relations between regions, and so real geography.

To overcome the problems with space, other authors developed "distance-based methods" (Duranton and Overman, 2002, Marcon and Puech, 2003). These methods share the feature of using real, even if approximate, geographical space, but are computationally intensive and, in addition to this, need a knowledge of the coordinates of establishments. We used in this work the methodology of Duranton and Overman (2002), for which UK computations were made available to us by the authors.
Since in the UK each postcode only comprises a very small amount of space (often one property or a few dwellings) and the postcode of 95% of the firms is available in the ARD database (described in Appendix), and since a correspondence between each postcode and a point in the UK National Grid exists (Raper et al., 1992), it is possible to know the location of most UK manufacturing plants with an approximation of only 100 meters. Duranton and Overman (2002), therefore, calculate all the distances between couples of plants in the UK (excluded Northern Ireland) so that, for an industry of n establishments, $n(n-1)$ distances exist and, rounded to the closest 100 meters, they are plotted as k-density functions (or un-smoothed distance

densities), defined as:

$$K(d) = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{\delta(i,j,d)}{n(n-1)} \ , \tag{5}$$

where $\delta(i,j,d) = 1$ if the distance from i to j is equal to d and $\delta(i,j,d) = 0$ otherwise

In order to check the so obtained k-density function versus a counterfactual non localised distribution of plants, they consider all the locations of all productive establishments in every sector as all the possible locations for a plant (assume they are N), then repeatedly simulate the random location of n plants in these N available possibilities and get the corresponding k-density functions. In this way they are able to build confidence intervals that allow to detect whether for some distances there is non-random excess localisation or for other distances there is excess dispersion: both should have non accidental reasons. Their methodology is then extended in order to weight for establishment size; the figures belonging to section 4, however, will represent the un-weighted k-densities, since we wanted to detect the proximity between establishments.

This methodology has the main advantages of taking into account real (even if approximate) space and of allowing to test against counterfactuals. It is not very sensible to the dimension of an industry but still has a theoretical and a practical limit, plus an interpretative care: the first one lies in the fact that all the locations of plants, when computing the counterfactuals, are considered as equal sized and, therefore, exchangeable. This is actually far from true since very small plants occupy far less space than the largest and therefore many of them at the same time may often be hosted in the same place (e.g. a business centre); it is in fact common to find many small establishments in the same postcode whereas this is much less common for the large ones.

The practical limit is that this methodology is still not easily transferrable out of the UK: for most countries, in fact, it will be impossible to have, even in the future, a sufficiently detailed grid with the location of plants; in addition to this, for larger countries, the earth curvature would be more relevant than for Britain, where it can produce a maximum error in distances of 1 Km (Duranton and Overman, 2002) and ought to be taken into account; finally, the smoothing for the geographical features of the landscape would be even more problematic for geographical entities (as the EU or Italy) whose physical geography is very articulated.

The interpretative care, pointed out by Marcon and Puech (2003), is that, since both the K-density function and the benchmark sum to unity, if the K

Sub-sector	Pharmaceutical sector	Basic pharmaceuticals	Medicaments	Non medicaments	Optical and Photographic sector	Spectacles and lenses	Optical Instruments	Photographic equipment	Modified photographic equipment
SIC-code	*244*	*24410*	*24421*	*24422*	*334*	*33401*	*33402*	*33403*	*M33403*
Herfindhal of industry concentration	0.0138	0.0612	0.0204	0.0610	0.0179	0.0164	0.0733	0.1775	0.0496
Herfindhal of geographic concentration	0.0559	0.0884	0.0689	0.1224	0.0666	0.0876	0.1267	0.2040	0.1212
Locational Gini coefficients	0.2652	0.3281	0.3063	0.3710	0.2337	0.2467	0.3448	0.3843	0.3546
Ellison and Glaeser	0.0208	0.0009	0.0283	0.0487	0.0160	0.0357	0.0321	-0.0001	0.0445
Maurel and Sedillot	0.0044	-0.0098	0.0114	0.0281	0.0116	0.0352	0.0200	-0.0064	0.0385
Devereux et al.	0.0142	0.0029	0.0221	0.0397	0.0206	0.0440	0.0306	0.0034	0.0486
K-density		high excess localisation 0-70 km	excess localisation 30-50 km	no excess localisation		no excess localisation	excess localisation 80-90 km	high excess localisation 0-80 km	high excess localisation 0-80 km
Map of coefficients of Variation	clustering around London + Cheshire	clustering around Bedfordshire Hertfordshire	clustering around London	low clustering in center-northern England plus Eastern Scotland	clustering in southern England	clustering in southern England	no particular clustering	non significant because of a very large plant	clustering around London
Moran's I	0.0703	0.1721	0.1239	0.0297	0.1909	0.1525	0.0070	0.0059	0.2050

Figure 1: Synthesis of the observed localisation patterns.

function is above the benchmark for some distances will necessary be below it for some others.

4 Observed localisation patterns

We used the measures described and theoretically discussed in section 3 to analyse the patterns of localisation of two 3-digit British manufacturing sectors (SIC 244, Pharmaceutical Sector and SIC 334, Optical and Photographic Sector) and their respective 5-digit sub-sectors[4] (SIC 24410, Basic Pharmaceuticals; SIC 24421, Medicaments; SIC 24422, Non-Medicaments; SIC 33401 Spectacles and Lenses; SIC 33402, Optical Instruments; SIC 33403, Photographic Equipment). These sectors were chosen because they belong to advanced manufacturing sectors, in which organisational aspects are expected to play a more important role with respect to geographical comparative advantage or to historical reasons. The first sector was directly or indirectly involved in a number of case studies (e.g. Simmie, 1998 and McIntyre, 1999), whereas the second, whose weight in the British economy is less relevant, has been less studied.

From the analysis of the observed localisation, whose results are synthesized in table 1, we see that the three indexes of localisation (Ellison and Glaeser, Maurel and Sedillot, Devereux et al.) tend to behave similarly.

[4]A more extensive analysis of the location patterns sub-sector by sub-sector is provided in Appendix B.

Since they give a coherent picture of the various sectors, the use of more than one at once does not appears to significantly increase the knowledge of an industrial sector, apart from an always useful error checking.

All the three indexes are fairly robust to modifications in the sectorial structure. We implemented a major one, the subtraction of the largest establishment, and this only affects the indexes if the size of this plant is comparable with the aggregate size of the sector. This only happens, in this study, for the Photographic Equipment sub-sector, whose new values are reported in the table; the empirical analysis of this sub-sector will leave apart the largest plant and concentrate on the rest of the sub-sector, where localisation economies appear to be very strong.

Since the Locational Gini Coefficients of Krugman (1991) don't correct for sectorial concentration, they behave similarly to the localisation indexes for sectors with a low Herfindhal of the industry, and differently when the Herfindhal is high; in this sense, the new indexes can be considered an advancement.

The main remaining limit of the three indexes (Duranton and Overman, 2002), is that they may fail to capture important features of the location patterns because of their inability to take spatial proximity into account. For this reason, in an empirical study, a map of the regional coefficients of variation proves to be a very useful and easy to produce instrument to complement the information obtained and check for spatial relations, which can also be made more evident by the use of a Moran's I; the map also makes it easier to detect where the sector is localised, which is of paramount importance in case studies.

In this study, the k-density function gives sometimes very different results from those of the indexes; this is not really surprising since we used the un-weighted form because we wanted to measure a different aspect: the localisation of establishments (i.e. their closeness) and not of sectorial employment.

Since the indexes, the un-weighted k-density function and the map of the coefficients of variation reveal different and complementary aspects of the localisation patterns, in empirical studies it is advisable to use all the available measures at the same time.

Coming to the sectorial scale of localisation the analysis shows that, in this case, the study at 3-digit level hides many features of the sub-sectors, in particular, if the sub-sectors are localised in different areas (in this case this is generally true, although not always sharply) then the sector is less localised than the sub-sectors.

In addition to this, we see that sub-sectors of the same sector are differently localised, both in terms of extent and in terms of location.

Finally, again within sub-sectors of the same sector, there are some for which employment is localised, and others for which the establishments as points in space also tend to be close to each other.

For all these reasons, one should hypothesize that the economic processes in the optical and pharmaceutical sectors take place at the smaller 5-digit scale, instead of at 3-digit level, making in this case non meaningful economically the measurement of localisation at 3 of 4 digit level. The next section will study in depth the localisation causes sub-sector by sub-sector, to see if the explanations are indeed different.

5 Empirical Analysis

The observed location pattern of an industrial sector can be very complex, with different sub-sectors behaving differently. The economic reasons behind the observed patterns can be even more complex to disentangle, with different explanations for sub-sectors belonging to the same sector and the need to complement pieces of different theories. For this reason, we conducted a comprehensive survey, suitable to cover as many aspects as possible without any a-priori prejudice in favour of a theory. The survey, and the choice of the establishment as its scale, are illustrated in Appendix A.

Some theoretical explanations were clearly rejected, other clearly accepted but also a minor number had mixed evidence, and everything different across sub-sectors. Differences among sub-sectors, in any case, were submitted to Anova testing before being considered in the analysis.

The survey made use of a large number of indicators and proxies for the various processes taking place in the sub-sectors. Since some of these proxies are new, the investigations which used new proxies are usually included even when they did not prove to be the most relevant factors for these specific sectors.

5.1 Local characteristics

In an investigation of the reasons of the localisation in an industrial sector, the first hypothesis that must be tested is the presence of specific advantages in the localities where the production plants are situated. This would be the easiest explanation and, even if it is not the most appealing from a theoretical point of view, the analysis can be wrong if it disregards it (section 2). In this specific case, the study of the local characteristics is made more difficult by the fact that both the Pharmaceutical and the Optical sub-sectors are to a different extent localised, but they are not present in a few districts only; on

the contrary, they are in many places around the UK, even if there is higher probability to find an establishment of the sector in an area where other establishments of the sector are located. For this reason, the only way to test the presence of specific advantages of the areas was not an investigation of the areas themselves, but to ask the establishments to rate the endowments of the localities in which they are. These specific aspects can also be in part due to existing urbanisation economies.

The infrastructure and services which were possibly relevant were classifies into five groups: roads and trains, airports, banks and financial services, other business services, building areas (in order to investigate the availability of land to set up new business units or expand or rationalise the old ones). For each of these groups, the managing directors were asked to rate the presence in the area where the establishment is located.
The average scores obtained are in the middle of the scale and there is no significant difference between the Optical and the Pharmaceutical sectors, nor there are significant differences among sub-sectors; the only mean which may be significantly different between sub-sectors, refers to the endowment of banks and financial services, which are seen slightly more important by the sub-sectors Optical Instruments and Medicaments.

The establishment were also asked to assess the importance of the same five groups of infrastructure for their business. There is still no significant (at 95%) difference between the Optical and Pharmaceutical sectors but here the results are more interesting because the sub-sectors whose establishments are close to each other with the D-O methodology (Photographic Equipment and Basic Pharmaceuticals) consider more important the presence of road and train transport infrastructure. Moreover there is a different attitude towards airports, which are more important for Optical Instruments and considerably less important for Spectacles and Lenses.
To test the coherence of the answers, we analysed the association between the endowment of infrastructure and their recognised importance by the managing directors: there is a significant positive association for all types of infrastructure but road and trains, for which the association is positive but not significant.

Another aspect to investigate is whether foreign owned establishments are more willing to locate close to the airports: in fact there is a weakly significant association between the nationality of the owner and the importance attributed to airports, but there is no significant association between the owner's nationality and the actual endowment of airports; airports are therefore seen as an important factor but are not a cause of localisation.

The analysis of local characteristics, in conclusion, supports that these factors are taken into account in the location choices, since the establish-

ments which attribute more importance to the presence of certain services or infrastructure are in general located in areas with higher endowment. However, the fact that the importance is never very high, rejects the hypothesis that location patterns in the Pharmaceutical and Optical sectors are determined by the local characteristics, even if some significant variability among sub-sectors exists.

5.2 Innovative behaviour

A number of theories focus on the necessity to cluster for the firms that produce innovative goods (section 2). In addition to the frequency of introduction of innovations, the sources of innovation are a very relevant factor for localisation; in fact, the more often innovations come from outside the establishments, the more the establishments should be close to the innovation source to facilitate this flow of knowledge.
To investigate if this happens in the Pharmaceutical and Optical sectors, the general managers of the establishments were asked if they had introduced innovations in the past two years and, in this case, if the main source of these innovations was "inside the establishment itself", "coming from other branches of the same firm" or if it came from "outside the firm". The same questions were asked about the introduction of both product and process innovations.

5.2.1 Product innovations

The Pharmaceutical and the Optical sectors are both innovative sectors, especially the first one, in which the cost of a new compound was estimated by The Economist at $ 300 million in 1998. This is confirmed in the survey: respectively 77% and 70% of establishments report to have introduced product innovations in the past 2 years, compared with an all-sectors average of 52% in the London Employer Survey of 1988. This evidence is strengthened if the analysis is re-run weighting by employees: the values obtained are of 95% and 90% respectively, not surprising because in these sectors the largest firms are those most involved in the development of new products with higher value added.
At sub-sector level, there are not very high differences with respect to the introduction of product innovations, only Optical Instruments and, to a lower extent, Spectacles and Lenses are less innovative. If the analysis is re-run weighting by employment for all sub-sectors but Optical Instruments, more than 90% of employment is in establishments that report to have introduced product innovations in the past two years.

The sources of innovation are more differentiated: Basic Pharmaceuticals and Medicaments are the more reliant on other branches of the same firm for their product innovations. In addition to this, all the three pharmaceutical sub-sectors are more reliant on external innovations than the photographic ones.
If the cases are weighted by employment, the differences become more evident: we begin the analysis, as in the rest of the paper, with the pharmaceutical sub-sectors: about 70% of employment in Basic Pharmaceuticals is in establishments that introduced product innovations coming from outside the establishment but within the firm. The same applies to 60% of the employment in Medicaments. The employment of Non-Medicaments, instead, is in large part in establishments that introduced innovations coming from within the establishment and only 10% in establishments that introduced external product innovations. This evidence excludes the possibility that the establishments in Non-Medicaments sector are localised because they need to cluster in order to acquire product innovations from outside. For the sub-sectors Basic Pharmaceuticals and Medicaments, instead, a slight majority of innovations come from outside the establishment, and this may be one of the causes of clustering.

In order to study more deeply the provenance of product innovations it is useful to test the effect of the headquarters, which may be a major source of innovations coming from outside the establishments.
A cross-tabulation of ownership, presence of the headquarters within the establishment and product innovative behaviour is computed for only Medicaments and Basic Pharmaceuticals in table 1: UK owned establishments have a behavior which is strongly dependent on the presence of the headquarters. In fact, when they are in the same place, product innovation are usually internal; when they are elsewhere, on the contrary, product innovations usually come from other branches of the firm, plausibly from the headquarters themselves. For foreign owned establishments, too few observations prevent from having robust results in this analysis.

No measure is available for the geographical distance of the headquarters but, the fact that the clustering of Basic Pharmaceuticals and Medicaments is around London, where most of the headquarters are located, is a signal that the establishments of these sub-sectors need to be close to the rest of their firm for innovative reasons.

Coming to the Optical sub-sectors, if the cases are not weighted, all the three sub-sectors exhibit the same strong reliance on product innovations coming from the establishment itself. If the cases are weighted, the reliance on the establishment is reinforced for Photographic Equipment and weakened for Spectacles and Lenses and Optical Instruments but remains very low.

Headquarters	Ownership	No product innovation in the past 2 years	Product innovation from the establishment	Product innovation from elsewhere in the firm	Product innovation from out of the firm	Absolute number
not at the establishment	UK	37.5%	12.5%	50.0%		8
	foreign	17.6%	35.3%	35.3%	11.8%	17
	Total	24.0%	28.0%	40.0%	8.0%	25
Within or besides the establishment	UK	23.1%	53.8%	7.7%	15.4%	13
	foreign	25.0%	25.0%	25.0%	25.0%	4
	Total	23.5%	47.1%	11.8%	17.6%	17

Table 1: Cross tabulation for Basic Pharmaceuticals and Medicaments sub-sectors only.

These results exclude that the pattern of location of the optical sub-sectors is due to the need to acquire external product innovations.

5.2.2 Process innovations

The establishments of the pharmaceutical sector are more often involved in process innovations with respect to those in the optical one (80% vs. 52%, compared with an average 46% in the London Employer Survey of 1988); however, this is due to a large extent to the larger size of establishments; in fact this difference becomes negligible (97% vs. 92%) when the data are weighted by employment. This confirms that in both sectors the innovation pace is fast, and again, as for product innovations, slightly faster for the Pharmaceutical one. If the sub-sectors are analysed, however, it emerges that process innovations are not a feature common to all: in fact only 22% of Photographic Equipment establishments reported process innovations, Spectacles and Lenses is at 62% and the others are between 73 and 85%. If the variable is analysed weighted by employment, again Photographic Equipment shows a significantly lower propensity to process innovations (50% when all the other are above 92%).

Concerning the sources of process innovations, in both the Pharmaceutical and the Optical sectors and in their respective sub-sectors, the establishments reported that the main source of these innovations was within the establishment. This result is confirmed when the analysis is re-run weighting by employment.
It is therefore very unlikely that these sectors are localised because they need to be close to external sources on which they rely for the introduction of process innovations.

5.2.3 Universities and R&D

Innovation is usually performed in structures specifically designed for this purpose. These can be internal to the firm, they can be external (the subcontracting of parts of research is more and more common in the pharmaceutical Industry, The Economist, 1998), or can be those of universities which collaborate in projects. The managing directors were asked to report the proximity of their establishments to three groups of R&D facilities corresponding to the tri-partition above and, then, to rate the importance for their business activities.

The importance attributed to R&D laboratories of the own firm is very important for both the Pharmaceutical and the Optical sectors, but more in the former in which, when data are weighted by employment, the score reaches 6.25 out of 7. External research laboratories and Universities are felt less important and have intermediate scores, i.e. they are not relevant in any of the directions; to both things, however, the Pharmaceutical sector tends to attribute slightly more importance.

We then look at the sub-sectors: within the Optical sector, Optical Instruments attributes more importance to external laboratories than Spectacles and Lenses and Photographic Equipment and also, less evidently, to universities. The sub-sector Spectacles and Lenses attributes very low importance to university research even weighting by employment, whereas Photographic Equipment does so only if the data are not weighted.
Within the Pharmaceutical sector, Medicaments is the sub-sector which attributes more importance to R&D in the own firm; Basic Pharmaceuticals, instead, is the one for which universities are more important, even if they remain less important than own R&D laboratories.

The analysis of closeness for the same three groups of R&D facilities makes evident that the Optical sector has, on average, closer establishments to these structures, this despite of the fact that, as seen above, it attributes lower importance to them. In both sectors, external R&D laboratories are felt further than the ones of the own firm, but not far in absolute terms. Own laboratories and universities are felt by the managing directors close to their establishments in both sectors.

Within the optical sub-sectors, Photographic Equipment, the one that has its (small) establishments close to each other, reports to be located closer than the others to universities. Within the pharmaceutical sub-sectors, Basic Pharmaceuticals, again the one with high non-randomness in the k-density function, behaves similarly since it feels further from own and external R&D laboratories, but not from universities.

5.3 Suppliers

The establishments of a localised sector, could be close each other because they all depend on specific suppliers, and they all wish to be located close to these suppliers in order to either reduce the transport costs or the transaction costs, as in the Moses (1958) model.
Since most sub-sectors, and in particular those which have non randomnesses in their k-density function (Basic Pharmaceuticals and Photographic Equipment) are more than total manufacture concentrated in the regions around London, the establishments were asked to rate the importance of suppliers divided into three main geographical provenances: "London and adjacent counties", "rest of the UK" and "rest of the World". The result is that both the Optical and the Pharmaceutical sectors report to attribute lower importance to suppliers located in the counties around London than elsewhere and this result remains valid when the data are weighted by employment.

When looking at the sub-sectors the same result arise and all attribute less importance to the suppliers around London than elsewhere. The importance of foreign suppliers, instead, is for all quite high, but it is lower for the sectors Basic Pharmaceuticals and Photographic Equipment; the sub-sectors whose establishments have more concentrated k-densities are therefore not only closer to each other but also slightly less internationally open with regard to suppliers.

The establishments were also asked to assess the importance of four factors in their choice of suppliers: price; quality of products; reliability; closeness. The averages are very high for the first three in both the Pharmaceutical and the Optical sectors. The score attributed to the closeness, instead, is appreciably lower; closeness, therefore, is not perceived as a factor directly affecting the choice of suppliers, even if it may have an indirect effect, for example through th reliability.
It is interesting to notice, however, that the importance attributed to closeness by the sub-sectors where the establishments are close to each other (Basic Pharmaceuticals and Photographic Equipment) is slightly larger than for the others.

To complete the analysis of the suppliers, the quota in value terms of supply provided by other establishments of the same firm were investigated. The result is that, in general, only a minor part of the inputs come from other establishments of the same firm. At sub-sectoral level, it is interesting to observe that this quota is higher for the establishments in Basic Pharmaceuticals with respect to the other pharmaceutical sub-sectors.

In summary, the location of suppliers is not the main factor of localisation, but its effect is not equal among sub-sectors: Basic Pharmaceuticals

and Photographic Equipment have less international suppliers and attribute slightly more importance to the closeness of suppliers. In particular Basic Pharmaceuticals establishments are also more strictly linked to the other establishments of the same firm, so that, in this sub-sector, intra-firm relations are an important factor of localisation.

5.4 Customers

The closeness of customers can also be a very important factor of localisation, either directly because of specific advantages in terms of transport costs, either indirectly through the easiness of relations and the possibility to better tune the products with their demand.

The analysis made for the suppliers war repeated for the customers: the establishments were asked to rate the importance of the same four factors (price, quality of products, reliability in delivery, closeness) this time in selling their output.
Here again, closeness is not felt as an important factor, neither in the Optical nor in the Pharmaceutical sectors. The other three factors, instead, are considered very important, especially the quality of products, and this is not surprising in technologically advanced sectors.

When looking at sub-sectors, here too Basic Pharmaceuticals attributes (both weighted by employment and not weighted) more importance to the closeness of suppliers than the rest of its sector. The establishments of Basic Pharmaceuticals are therefore willing to locate close to their customers; since, as we will show below, the customers are likely to be other establishments of the same firm, and since Pharmaceutical firms and Medicaments establishments are in the regions around London, intra-firm supply relations are an influential location factor for Basic Pharmaceuticals sub-sector.

The establishments were in fact also asked to rate the importance of their customers classified with respect to their geographical location, ownership and type. Eight different groups were proposed: "other establishments of the same firm inside the UK" and "outside the UK"; "UK public sector"; "consumer market in the UK", "consumer market abroad"; "firms in London and adjacent counties"; "firms in the rest of the UK"; "firms abroad".
Other establishments of the same firm, both inside and outside the UK are more important in the Pharmaceutical than in the Optical sector. So is the UK public sector and this is not surprising in a sector that sells extensively to the NHS (79% of the total value in 1995, according to MSI). Firms in London, firms elsewhere in the UK and firms abroad are more important for the Optical than for the Pharmaceutical sector. For the consumer market, instead, the evidence is mixed.

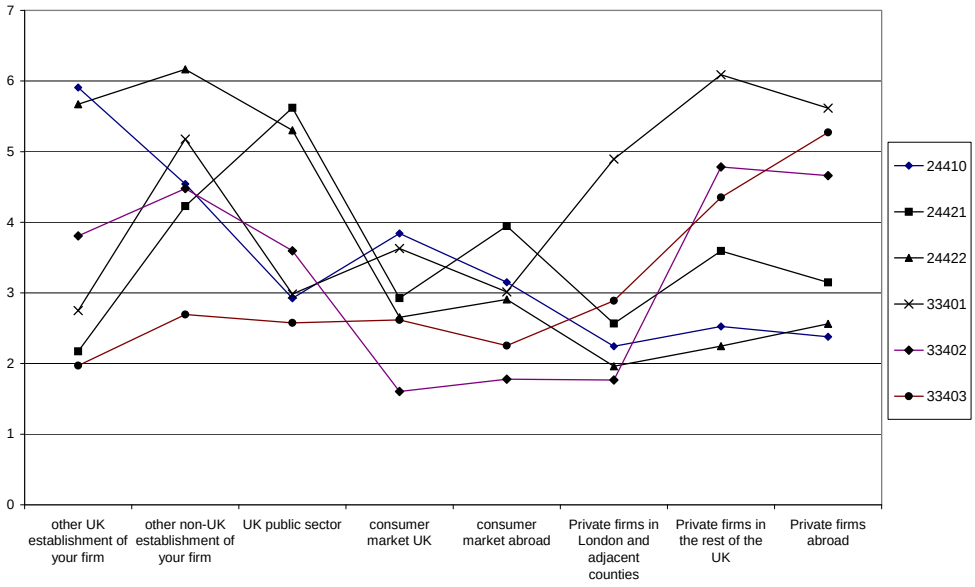

Figure 2: Importance of customers weighted by employment

Within the pharmaceutical sub-sectors (Fig. 2), the establishments of Basic Pharmaceuticals are likely to sell their products to other establishments of the same firm in the UK and (as second option) abroad; the establishments of Medicaments are characterised by the large importance they attribute to the UK public sector; the establishments of Non-Medicaments attribute greater importance to other establishments of their firm (both in the UK and abroad), and to the public sector. Within the optical sector: Spectacles and Lenses tends to sell to firms (in London, the UK and elsewhere) and to other non-UK establishments of the same firm; Optical Instruments is likely to sell to other establishments of the same firm and to other firms; Photographic Equipment sells to private firms in the rest of the UK and, most of all, abroad.

The analysis of customers' importance has not signalled meaninglful differences between the Optical sub-sectors. For the Pharmaceutical sector, on the contrary, it is possible to draw interesting conclusions. In fact, the sub-sector Medicaments has an important concentration in the counties around London and it attributes higher importance to the UK public sector. The hypothesis of the need to be close to the market in order to be receptive to its movements is corroborated. This is also consistent with the findings of Simmie (1998) for the innovative firms of the Hertfordshire.

The sub-sector Basic Pharmaceuticals is also clustered in the London area, but the direct importance of London as the capital city is lower than for

Medicaments; for Basic Pharmaceuticals, large part of the importance of London is instead indirect: this sub-sector is the most likely to sell to other establishments of the same firm, and most of them belong to the sub-sector Medicaments.
The sub-sector Non-Medicaments, which attributes the lowest importance to the consumer market and, if weighted by employment, very high importance to other establishments outside the UK, has its positive coefficients of variation relatively far from London and this could be explained by the fact that it does not need to locate in the congested and expensive south East.

5.5 Social Network

The hypothesis of the existence of some sort of social network is at the core of the explanation for localisation in cases of industrial districts or innovative milieux. The firms could in fact be located in the same place because they maintain important relations the one with the other, in the form of various types of collaborations, some of which are formal and traded and some other informal and untraded. The questionnaire contained a large set of questions to investigate the existence of collaborations and interdependendencies.

5.5.1 Collaboration with suppliers

The first group of questions concerned the collaborations with suppliers in the past two years: all the sub-sectors but Spectacles and Lenses reported to be collaborative with the suppliers in the development of new products with percentages of positive answers of at least 63% and, if weighted by employment, of at least 83%.
The collaborations in the achievement of quality levels are also widespread, especially among large plants, in all the sub-sectors; the collaboration aimed at quality levels is more common than the one in the development of new products in all sub-sectors but Photographic Equipment. The exchange of human resources is by far less practised, with a peak close to 50% (in employment terms) in Optical Instruments and Photographic Equipment.

To test the existence of "trust" with suppliers, we created a new proxi variable: we investigated the existence of the habit of putting in practice non written agreements before having signed written contracts[5]. In the specific

[5]A contract is an agreement between two or more parties intended to be enforceable by law. It can be written or spoken, except for some contracts which need a written form. In any case the written form is a guarantee for the parts that the contract will actually be enforceable.

case of customers, the results are not significant, since implementing agreements before having signed a written agreement is a practice which, in most establishments, only happens occasionally ("seldom" or "sometimes"); in a smaller number of cases it takes place "never" or "often", with no difference among sub-sectors. Since collaborations are diffuse, but trust is not, we conclude that vertical inter-firm relations are indeed important but these relations don't take place through a real "social network".

5.5.2 Collaborations with customers

The presence of collaborative behaviours in the past two years was also investigated with respect to customers. In all the sub-sectors, with the exception of Spectacles and Lenses, the majority of establishments reported to have collaborated with customers in the development of new products; the collaboration in the achievement of quality levels is also diffuse in all sub-sectors, this time also including Spectacles and Lenses.
The exchange of human resources is less diffuse in both sectors but with sub-sectoral differences; in fact, differently from the others, it takes place in the majority of the establishments belonging to Basic Pharmaceuticals and Optical Instruments.

We then analysed the "trust" in customers by using as proxi the tendency to implement agreements before a written contract is signed: the trust level with customers, both non-weighted and weighted by employment, is not an important feature of any sub-sector, apart from Photographic Equipment which instead sees a large use of non written contracts: this is normally a symptom of the existence of a social network.

5.5.3 Horizontal collaborations

After having investigated the collaborations with suppliers and customers, a complete analysis of the social network hypothesis would not omit the collaborations with other firms in the same sector. The evidence is that the Pharmaceutical sector is more collaborative horizontally than the Optical one, as we might expect from the larger relevance of business associations and the larger need to act unitary in negotiations.
Nearly half of the Pharmaceutical establishments reported to have participated in joint ventures in the past two years, instead of one third in the Optical. Two thirds of the Pharmaceutical, again in the last two years, collaborated with exchanges of knowledge (about 30% in the Optical). Nearly half of the Pharmaceutical establishments (but more than 70% in employment terms, signalling that the larger establishments are more active in this

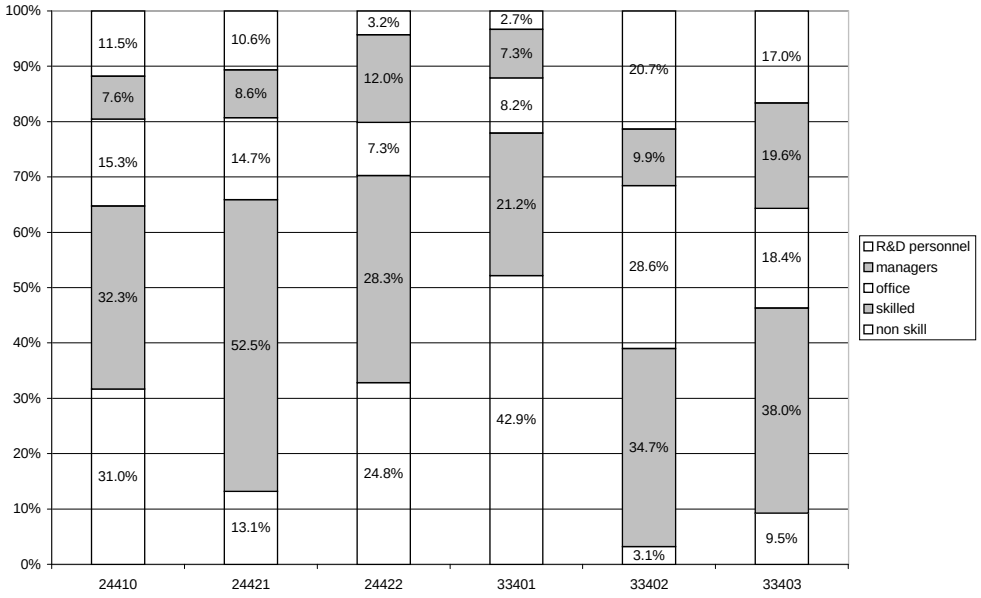

Figure 3: Reported workforce breakdown

sense) reported to be involved in lobbying activities, whereas in the Optical sector only 20% (which increases to around 50% if weighted by employment) reported to have done the same. The only exception to this pattern, which sees the Pharmaceutical more horizontally collaborative, is for the exchanges of human resources with other establishments of the same sector in the past two years, which involved only a minority of establishments in both sectors.

When looking at the sub-sectors, the main difference arising is in the stronger participation in lobbying activities by Basic Pharmaceuticals and Medicaments with respect to Non-Medicaments: as seen in section 4 the first two are concentrated around London, the last one is instead very far. The lobbying activities are therefore relevant to the localisation of the first two.

5.6 Labour force

With the analysis of collaborations, we illustrated that the exchange of human resources is not a practice diffuse among the establishments of the sub-sectors of this analysis, neither with suppliers, nor with customers, nor with competitors.

The human resources, however, constitute an important asset for firms in innovative sectors as these. In some cases, the presence of a skilled workforce is directly an important factor in firms location; in other cases, it is the possibility to attract in the place of the plant skilled workers from elsewhere

that matters, since workers have to be compensated for their moving costs. For this reason, the study of the characteristics of employment and of its movements between establishments and firms can give precious insights on the reasons of localisation.

The establishments were first asked to declare the importance of the presence of qualified workforce for their business. The average answers were very high (close to 6 on a scale of 7) in all the sub-sectors, signalling that the importance of employees' skills is not only theoretical but also directly felt by the establishments.

The establishments were also asked to report if they encountered difficulties in finding this skilled personnel in the past two years: in all the sub-sectors the majority reported to have experienced difficulties, with the exception of Photographic Equipment. The difficulties of finding personnel can be interpreted in a number of different ways: first of all it is possible that the areas of location are not endowed enough, but it may also be the case that, despite of the fact that the areas of location are the more endowed of the country, the needs of a sector are too large to be fully satisfied. It must be noted, however, that a variable like this one is affected by the economic cycles and the establishments are more likely to experience difficulties in hiring during the expansion periods; since the survey was conducted for all sub-sectors at the same time, in any case, the cycle is the same for all, and the differences among sub-sectors are not biased. For this reason, the fact that, differently from the others, Photographic Equipment does not experience these difficulties is, as we will further evidence in section 6, a relevant component of the location pattern of this sub-sector.

To see if the importance of skills was reflected by the actual composition of the workforce, we built a complete breakdown of the employment in five categories, mutually excluding each other and adding up to the total employment of the establishment: unskilled workers, skilled workers, office workers, managers and R&D personnel. As from Fig. 3, all the sub-sectors but Spectacles and Lenses use more skilled than unskilled workforce. Moreover the R&D personnel is an important part of the total in all the sub-sectors but Spectacles and Lenses and Non-Medicaments.

The presence of university graduates was then investigated[6]: they are reported to constitute about 1/4 of the employees in the pharmaceutical sector and 1/8 of the employees in the optical one. Within the pharmaceutical sec-

[6]It has to be remembered that these are not real values but instead reflect the feelings of the managing directors about their employees; however, it is more important for production to have people able to run "graduate" tasks than formal graduates; moreover, it is legitimate to assume that the answers are at least ordinally coherent with those that would be obtained in a much more expensive census of the actual educational attainments.

tor the maximum percentage is in Medicaments, then Basic Pharmaceuticals and finally Non-Medicaments. Within the optical sector it is Optical Instruments which has the largest percentage, followed by Photographic Equipment and Spectacles and Lenses. The sub-sectors analysis shows that the qualification of the workforce and the presence of graduates are consistent, since the establishment giving more importance to the skills of their personnel also report to have a larger presence of graduates.

The attendance of training in the past two years was also investigated for each category of employment: training is a diffuse practice in all sub-sectors, especially belonging to the pharmaceutical sector. In the Optical one it is less diffuse, especially in Optical Instruments and, less evidently, in Photographic Equipment. In these two sub-sectors, the same that less frequently experienced difficulties in finding skilled personnel, the establishments are more reliant (and with greater success) on the external to find the workers they require and therefore need to spend less in training.

It is also important to study the stability of the employment in the firms and the turnover; in this way in fact we can test whether the abilities necessary to the firms are internal to the firm, if the skills belong to the local economy or, finally, if skills are sector-specific: in this last case the localisation economies would be greater.

The average number of years the employees had been working in the establishment was therefore investigated (their "fidelity"), with the usual 5-category breakdown. In all 5 categories the workers are felt by their respective general managers as stably employed in the establishment: the average period they have been working in the same establishment is in fact usually above 10 years. However, differences among sub-sectors arise: within the optical sector, Photographic Equipment has a smaller average lenght for all the five employment categories. Since this evidence could also be due to the smaller age of the establishments surveyed, we investigated the same aspect by computing the ratio between the reported years and the age of the establishment. Sub-sector Photographic Equipment still has the minimum value of its sector in four out of five categories of workers, and its low fidelity/high turnover pattern is therefore robust with respect to this test.

In the Pharmaceutical sector, the sub-sectors are less clearly differentiated: Basic Pharmaceuticals tend to have the less stable unskilled workers and office workers (the two groups which could more easily move between completely different sectors) and by far the maximum stability of workers in all the three positions which are less inter-sectorally substitutable (skilled workers, managers and R&D personnel). These findings don't depend on the different average ages of the establishments surveyed in the different sub-sectors; in fact, these ages are about the same among the Pharmaceutical

sub-sectors.

To explore the characteristics of the mobility of workers we finally investigated the presence, among the employees of the surveyed establishments, of people that previously worked for other firms, but in the same sector, to see if the labour force pool is sector specific or not. We asked the general managers to report the percentages, again using the same five mutually exclusive categories breakdown. The analysis is conducted weighting each obtained percentage by the respective absolute number of employees (e.g. weighting the percentage of office workers that previously worked for another firm in the sector by the absolute number of office workers in the establishment) in order to get all the quotas of α-type workers in sub-sector X that previously worked in another firm of the X sector. The result is interesting: the percentages reported by the managing directors are always considerably higher for Basic Pharmaceuticals and Medicaments than for all the remaining sub-sectors and, apart for managers, Medicaments is above Basic Pharmaceuticals. These sub-sectors, therefore, appear to need a workforce with sector specific skills, and this contributes to explain the observed localisation.

In Non-Medicaments and all the Optical sub-sectors the managing directors think that a large majority of their workforce does not have as provenance another firm of the same sector. The mobility of workers of Photographic Equipment, which is higher than in the other sub-sectors of the Optical sector, takes therefore place prevalently outside the sector and within the area of location.

6 Main findings of the empirical analysis

Section 4 analysed the localisation patterns observed in two 3-digit UK manufacturing sectors and their respective sub-sectors. Section 5, using an original data set, investigated the possible explanations for the observed patterns. This needed pieces of different theories and the analysis of a comprehensive number of aspects.

It is now possible to join the relevant pieces and build an organic economic explanation of the observed localisation for five out of six sub-sectors. The most appealing observation, from a theoretical point of view, is the fact that the explanations are generally different even among sub-sectors belonging to the same sector, showing that the hypothesis of page 16 is verified since the economic processes behind localisation take place at 5-digit level.

6.1 Pharmaceutical sector

The pharmaceutical sector is highly innovative and R&D facilities, as well as a skilled workforce play an important role in localisation. Moreover, the public sector as a customer is an important shared feature, which reflects into diffuse horizontal collaborations.

Within the sector, sub-sectors Basic Pharmaceuticals and Medicaments share a number of characteristics: first of all they both are localised in the regions around London. In addition to this both have horizontal collaborations and are involved in lobbying activities. Both tend to acquire from outside the establishment most of their product innovations, in particular (especially Basic Pharmaceuticals) from other plants of the same firm. The headquarters are an important source of product innovations for both. Very important is the presence of a qualified workforce, as evidenced by this survey and also by others (e.g. DTZ Pieda Consulting, 1998) and so is the presence of academic and research institutions, which is in fact denser in the area in which they concentrate. In particular this survey showed, in both Basic Pharmaceuticals and Medicaments, an important presence of workers that previously worked for other firms of the same sector, signalling that they need to localise in order to use sector specific labour skills.

However, they also present differences: first of all concerning the location pattern, since Basic Pharmaceuticals is constituted of smaller plants with non random closeness the one to the other (according to the k-density function); Medicaments, instead, is made of larger plants in which the k-density signals less remarkable non-randomness. Basic Pharmaceuticals attributes more importance to the closeness of Universities, Medicaments to other R&D of the firm. For Basic Pharmaceuticals it is relatively more important the closeness to suppliers, which also tend to be more often other establishments of the firm. The most interesting difference, however, resides in output destination: Medicaments sells a considerable quota of output directly to the public sector, whereas for Basic Pharmaceuticals the most important customer is represented by other establishments of the same firm in the UK. Both are therefore localised around London for innovation, sectorially skilled workforce availability and horizontal relations, but the localisation of Medicaments is also due to the role of the capital city for a sector that has the NHS as the main customer. Basic Pharmaceuticals, instead, is clustered around London because its output goes generally to other establishments and a large part of these belongs to Medicaments.

Sub-sector Non-Medicaments has many differences from the other two: first of all it is concentrated relatively far from London and its establishments are not non-randomly close to each other. It tends to use product

innovations coming from inside the establishments and gives relatively more importance to foreign plants of the same firm as customers and less to the public sector. It is less than the others involved in lobbying and employs both less R&D personnel and less graduates than the other pharmaceutical sub-sectors. Moreover it more rarely employs workers coming from other firms of the sector. The establishments of this sub sector are therefore localised, but away from London in order to avoid the costs of the South East, since they would not take advantage from its services.

6.2 Optical sector

The optical sector is also very innovative, but the cause of its localisation cannot be found in the need to get process innovations from outside the establishments, since this rarely happens. For product innovation the evidence is more varied, since Optical Instruments is likely to take them from outside whilst Photographic Equipment is not. The supplier analysis reveals, as expected, that the public sector has not for the Optical sector the same important role it has for the Pharmaceutical. Instead, the establishments demonstrate a tendency to sell their products to firms.
For the Optical sector, similarly to the Pharmaceutical one, the empirical analysis evidenced that the reasons for the observed patterns of localisation are different among sub-sectors.

Optical Instruments is characterised by a comparably larger exchange of human resources with customers and suppliers; it is also very likely to sell to other firms or other establishments of the firm, and this would lead to an explanation based on a mix of input-output and collaborative relations. In addition to this, there are strong linkages through innovation, which is relatively more likely to come from external laboratories, and the presence of urbanisation economies: the percentage of graduates in the workforce is in fact higher and so is the importance of external laboratories and universities, so that this sub-sector needs to locate in particular areas.

For the sub-sector Photographic Equipment, a number of signals support that localisation is mainly due to the externalization of the human resources: in fact this sub-sector is characterised by small establishments particularly close to each other. These establishments are the less likely to experience difficulties in finding the skilled personnel they need. Moreover they tend to train less their employees and have a significantly higher turnover, characterised by a small number of years of presence of workers in the establishment, even when compared with the establishment age. However, the fact that these employees are not reported to have previously worked for other firms in the same sector, indicates that the skills needed in Photographic Equip-

ment are in general non specific to this sub-sector, instead they belong to the area of location, which is roughly situated in the surroundings of London. The larger importance attributed to universities reinforces this view. The presence of collaborative behaviours is a less evident but important factor to be taken into account for the location pattern in this sub-sector.

For the last sub-sector, Spectacles and Lenses, a number of differences with the other sub-sectors has emerged: it is slightly less keen to introduce product innovations and it is more likely to use process innovations from within the establishment; it is relatively less collaborative with suppliers and customers in the development of new products, it has a less qualified workforce and both less graduates and less R&D personnel. However, the empirical analysis, which was conducted with a survey equal for all sectors, is not able to identify the reasons of localisation for this sector. Its spatial pattern, in fact, is peculiar, with very strong concentration in Hampshire and some in adjacent regions; for this reason, a standard survey might not be the most adequate instrument, whereas a dedicated study, also including the history of the industry, would give better results.

7 Conclusions

This article has shed light on a number of aspects on the measurement and the explanation of manufacturing localisation.

Concerning the measurement, it evidenced that no perfect and comprehensive methodology still exists to empirically observe and measure the localisation of industrial sectors. In addition to this, there still is a problem of definition, since different authors sometimes use different terms, nor employment and establishment concentrations in space should be confused.
Despite this, the indexes analysed in section 3 are a consistent advancement in the measurement, since they take into account both geographic and sectorial concentration, and are usually robust to the subtraction of an establishment, even the largest, except when this represents a relevant part of total employment. Unfortunately, all indexes are sensible to the spatial scale in which they are measured and, more important, they all fail to take into account the proximity relations between geographical units.

A possible solution could be represented by distance-based methods as the Duranton and Overman (2002) methodology; this one has the advantages of using "real" space but loses two important features of the indexes: the easiness to compute and the comparability, since coordinates are not available in all countries. Moreover, as evidenced in section 3, it is not still clear if treating every industrial plant as equal sized can lead to biases. For these

reasons a good empirical analysis of the observed patterns of localisation still needs the simultaneous use of more than one methodology, including an easy to compute map of the coefficients of variation, which gives precious insights on where the sector is localised.

The application in section 5 of the new methodologies to two British manufacturing sectors has evidenced that, if used at a sectorial scale different from those of the underlying economic processes, the measures have no real economic meaning; for instance, in our case, the 3-digit patterns were just the sum of highly differentiated 5-digit patterns.

Concerning the reasons of the observed patterns of localisation in manufacturing, the survey conducted for this article provides additional support to the fact that real world explanations are in general rather complex, and require the use of features from more than one theoretical model.

The observation that sub-sectors often differ the one from the other with respect to their spatial localisation pattern, is confirmed when investigating the explanations of localisation: we submitted an identical questionnaire to six 5-digit sub-sectors belonging to two 3-digit sectors, and the answers evidenced a large set of relevant differences among them. For five sub-sectors, a theoretical explanation for the localisation pattern arose, each different from the other; in our specific case, therefore, the sectorial scale of economic phenomenona proved to be very small.

The choice of the sectorial scale in which to measure and explain localisation is therefore a complicated issue, different from one case to the other, which makes not really meaningful to count the ratio of localised on non-localised sectors at a given digit level.
Moreover, extra care should be used by scholars and policy makers before trying to extend and apply the results of an enquiry about localisation economies from a sector to another, even adjacent.

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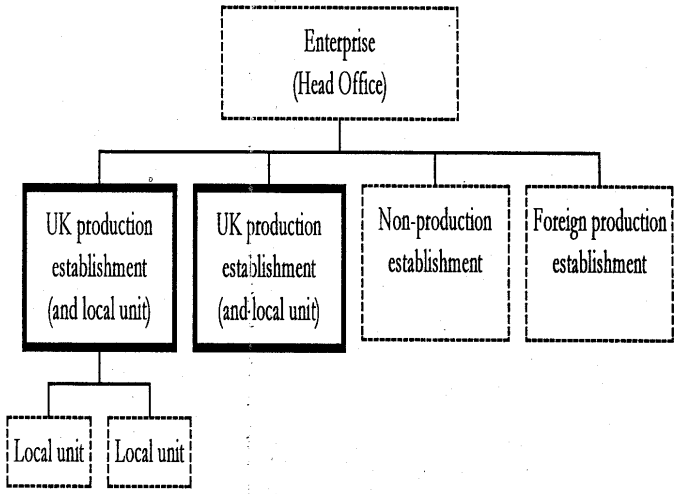


Fig. 1. *Example of Reporting for UK-based Multinational*

Figure 4: Establishments, firms and local units. (from Griffith, 1999, p.F421)

Appendix A: Methodology and description of data

The data on establishment location and size come from the ARD database for 1997. ARD is an acronym for ABI (annual business inquiry) Respondent Database and comes from the annual census of production of ONS. The "establishment" is defined as "the smallest unit for which a firm possesses the data necessary to answer the question of the census form" (Oulton, 1997, p.48) and may comprise one or more local productive units. In the same way, firms can be composed of one or more establishments (Fig. 4). Not all the UK establishments and units are annually asked to answer the questions of the ARD but all employment data are available.
Through the postcodes it is also possible to have the location in space for most of them (Raper et al. 1992; Duranton and Overman, 2002).

The data on the location behaviour of the industrial sectors come from an original database obtained through a survey in a sample of establishments in the two sectors of interest.

The choice of the establishment as the unit for the analysis is not perfect. In fact some processes take place at the firm level, and other at the local unit level. In particular, for the purposes of this analysis, it is remarkable that it is not the establishment itself which decides its location, which is instead

determined at firm level.
Despite of these difficulties, the establishment remains the best feasible scale to conduct the analysis. There is first a need for coherence with the ARD database from which the data of the employment and localisation are taken; concerning this aspect, it has to be remarked that an analysis of the localisation as measured from the employment would be very biased if the employment sizes would be accounted at the headquarters of the firm (or at the registered office). At the same time the establishment, defined as above, is, differently from a local unit, endowed with some degree of autonomy of administration.
The second important consideration that makes the establishment the more reliable feasible scale for this analysis, is due to the structure of the questionnaires we used. In fact, instead of asking direct subjective questions on why the establishment is there[7], we used more direct and objective questions on what the business is and on the conditions in which the business is run in the place where the production is located. To answer these questions, we strongly believe that the highest person in charge of an establishment (in general the managing director), is better informed than managers at firm level, who probably were not in charge when the location choice of the establishment was made. These complications do not exist, as obvious, for all the cases in which the firm is composed of only one establishment.

Bearing in mind the considerations above, a total of 350 addresses of establishments in the Optical and Photographic and Pharmaceutical sectors (150 and 200 respectively) have been randomly chosen to receive the questionnaire that was sent to the managing directors (or person with different nominal qualification but having the maximum responsibility inside the establishment). The follow up questionnaire was sent to those that did not answer 6 weeks after the first mailing. Because in many postcodes more than one establishment was present and, there, some mistakes were possible, especially when trying to distinguish among establishments of different subsectors of the same sector, the managing directors were requested to indicate the sub-sector their plant belong to; this shortcut also allows to detect the plants that are no longer in the sector or that are not manufacturing. A small number of questionnaires, therefore, came back as non-applicable to the survey and were for this reason deleted from the enquiry. A minor number of addresses had changed so that the respective questionnaires did not reach the target. This number was small compared to the sample size, and non biased geographically or with respect to establishment size, therefore it

[7]We would expect the answers to be very unreliable since, as we already mentioned, the location choice is made at firm level.

did not affect the reliability of the sample. The net answer rate was 39%.

Each questionnaire contained 96 questions relative to the location and the business behaviour of the establishment, a scale that was specifically asked to respect by the respondents. The questions were designed in order to test predictions from different theories. All the questions were in closed form or asking for numbers and, for the analysis, were manually entered into a spreadsheet; this allowed to observe the possible misunderstandings between the enquiry and the respondents. These misunderstandings proved to be very rare.

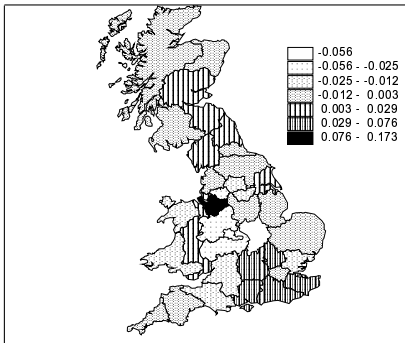
The data on employment in the different UK Nuts II regions have their primary source in the data of employment in manufacturing in 1997-98 (same year than the data available from the ARD database) published by the ONS in Regional Trends, but a re-elaboration, through de-composing at a smaller scale and re-aggregating the data when the boundaries were not the same of the ARD database, was necessary; in this way comparable data were made available.

Appendix B: Details of localisation patterns and description of sectors

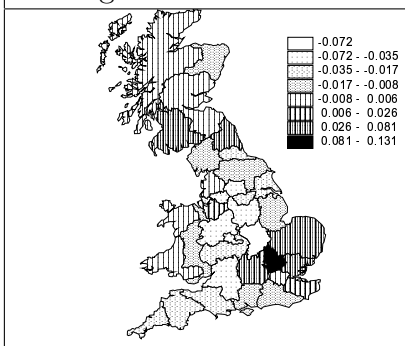
Using sectorial data from the ARD database and aggregate data of ONS for manufacturing employment in the same year, it is possible to calculate the indexes and measure the localisation of the two sectors chosen and respective sub-sectors (see the appendix A for a more detailed description of the ARD database). The geographical scale used to compute the indexes is the UK NUTS II regions; this scale is both smaller than the UK statistical regions and, compared with the counties, it makes possible to compare data from the two sources. In addition to this, Nuts II regions are fairly homogeneous in terms of total employment as indicated by the Herfindhal of total manufacturing employment, which is 0.0384.

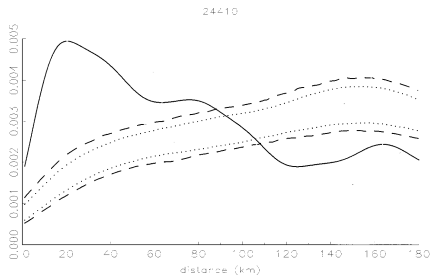
Pharmaceutical Sector (SIC 244)

The "Manufacture of pharmaceuticals, medicinal chemicals and botanical products" (SIC 244) is an important sector for the UK economy, with more than 68000 employees in 1997.
According to McCormick (1998), there exist five main types of pharmaceutical companies: R&D based multinationals, local companies with a single factory, new multinationals in regions like Latin America which are based on generics but spreading their sales, contract manufacturers providing an outsourcing service, and virtual companies which specialise in a single core competence (as research) and contract out everything else. Since the companies can be so differentiated, we added to the survey a number of questions concerning the firm structure, even though maintaining the establishment level.
This is a sector in which the UK has a comparative advantage (the trade surplus was estimated at £ 2.067 billion in 1999), which is highly dependent on innovation (20% of the turnover is spent in R&D according to the BIPA) and which has the NHS as the main customer. It is also important to remember that the manufacturing plants of this sector have to attend a number of regulations which also affect the location of plants (Department of the Environment, 1995).
Since it is a large sector, even if it involves a number of large establishments, it is not overall very concentrated (H=0.0137). All the indexes depict it as not really localised, since all of them are positive but small, not differently from the largest part of UK sectors (appendix B of Devereux at al., 1999). Also the locational Gini coefficient is not particularly high.

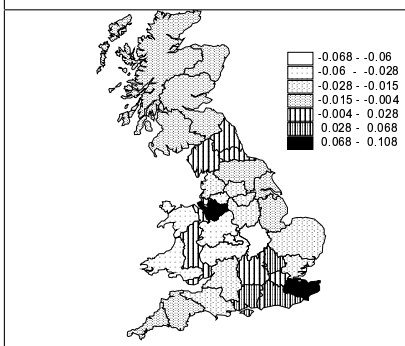


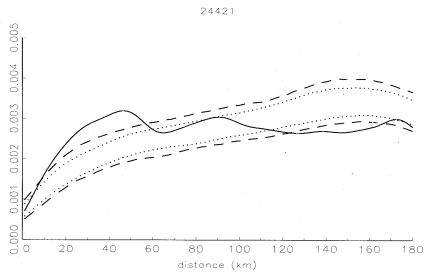
3-digit Pharmaceutical sector (SIC 244)



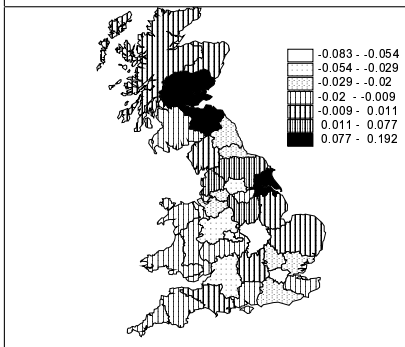


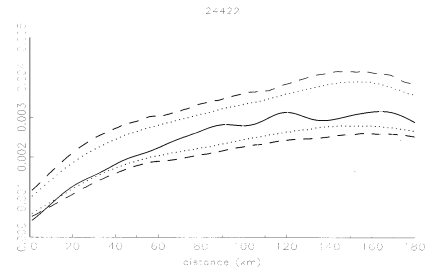
Basic Pharmaceuticals sub-sector (SIC 2441)





Medicaments sub-sector (SIC 24421)





Non-Medicaments sub-sector (SIC 24422)

Figure 5: Localisation coefficients and K-densities of the Pharmaceutical Sector

The observation of the graphical distribution of employment across regions (Fig. 5) shows that the Pharmaceutical sector tend to be present more heavily in the regions around London, in northern England and in Cheshire. The fact that the regions with more SIC 244 employment tend to cluster, signals that the sector is more spatially localised than it is indicated by the indexes, which are not able to take into account the proximity relations between regions. To confirm more rigorously the observation of the map, we use the simplest version of the Moran's I index, which uses the contiguities among regions to detect spatial autocorrelation[8]. The Moran's index is positive and confirms that the localisation indexes under-estimate the localisation of the pharmaceutical sector.

The pharmaceutical sector is composed by three sub-sectors, whose localisation patterns will in turn be described below.

Basic Pharmaceuticals sub-sector (SIC 2441 or 24410)

The first one is SIC 24410, "Manufacture of Basic Pharmaceuticals products". This sub-sector encompasses the productions of a number of chemical products; the most important products in terms of value for this and the other sub-sectors are listed in Appendix C.
This sub-sector represents slightly less than 12% of the sector employment and is quite concentrated (Herfindhal at 0.061). The average establishment size is also smaller than the average in the sector. According to the three indexes of localisation this is the less spatially concentrated sub-sector and γ_{ms} is even negative; on the contrary the locational Gini coefficients are high and this is due to a small number of large plants.
According to the k-density function (Fig. 5) the establishments in this sector are very close the one to the other, with very high excess localisation for distances between 10 and 50 kilometres. The map of the coefficients of variation supports the fact that this sub-sector is not a dispersed one. In fact, there is a remarkable concentration in regions around London as Bedfordshire and Hertfordshire, as confirmed by the relatively high Moran's I. This is clearly a case in which the indexes alone fail to describe all the features of the localisation pattern.

[8]This index is calculated as: $I = \frac{N \sum_{i=1}^{N} \sum_{j=1}^{N, i \neq j} (cv_i cv_j C_{ij})}{(\sum_{i=1}^{N} \sum_{j=1}^{N, i \neq j} C_{ij})(\sum_i {cv_i}^2)}$, where cv_i are the coefficients of variation and C_{ij} is 1 if the two regions i and j share a boundary, 0 otherwise. The index ranges from -1 to 1, with positive values signalling positive spatial autocorrelation and negative values signalling negative spatial autocorrelation.

Medicaments sub-sector (SIC 24421)

SIC 24421, "manufacture of medicaments", is the largest sub-sector of the pharmaceutical sector, accounting for more than 77% of the total employment. This sub-sector is also by far the largest in terms of turnover.
According to the Herfindhal index, this sub-sector is the less concentrated. This is due to the contemporary presence of a large number of big plants. All the three indexes of localisation are larger than for Basic Pharmaceuticals and also than for the whole pharmaceutical sector. The Gini coefficient is instead smaller than for Basic Pharmaceuticals and the k-density function shows departures from randomness, but smaller is size and for a smaller section of the curve, for distances from 30 to 50 kilometers.

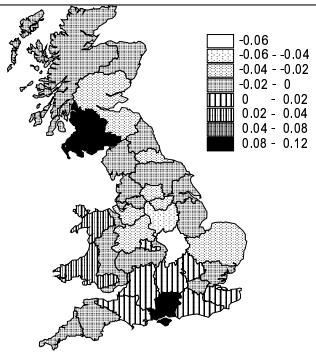
The analysis of the regions in which the employment locates shows that this sub-sector is more than average represented in regions around London (like Bedfordshire and Hertfordshire and Kent) and in Cheshire. The clustering of the regions with positive coefficients of variation (Moran's I = 0.12) depicts the sector as more concentrated than indicated by the indexes.

Non-Medicaments sub-sector (SIC 24422)

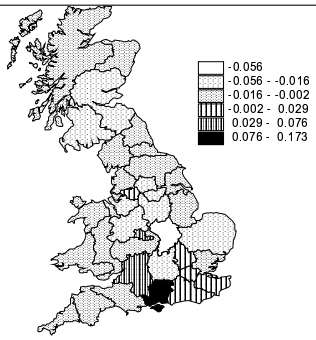
The last 5-digit sub-sector of the pharmaceutical sector is the SIC 24422: "manufacture of non-medicaments".
According to the Herfindhal index of establishment size, it is as concentrated as Basic Pharmaceuticals and of comparable total size. According to the three indexes of localisation used and to the Gini coefficients, this sector is the most localised in terms of employment. In terms of plants, on the contrary, the k-density function maintains that its plants are not non-randomly close to each other. The map of the regional distribution of the sector shows a low clustering of the regions in which it is over-represented in Centre-Northern England plus Eastern Scotland, not really important as implied by a positive but small Moran's I.

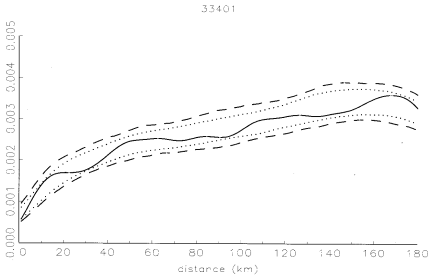
Optical and Photographic sector (SIC 334)

The 3-digit sector SIC 334, "Manufacture of optical instruments and photographic equipment" (referred as "Optical sector" for simplicity), is composed of three 5-digit sub-sectors and is much smaller than the Pharmaceutical sector in terms of employment and turnover. In fact it employed in 1997 about 15000 people with a total value of manufacturing estimated at £ 989 billion in 1999. Despite this, the number of establishments is larger than for the Pharmaceutical sector, since there are as much as 751 of them, with average

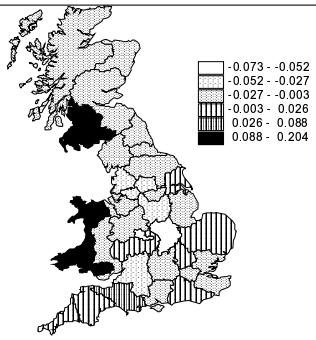


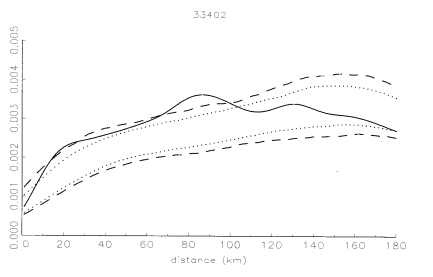
Optical and Photographic sector (SIC 334)



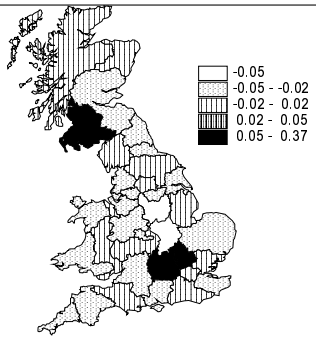


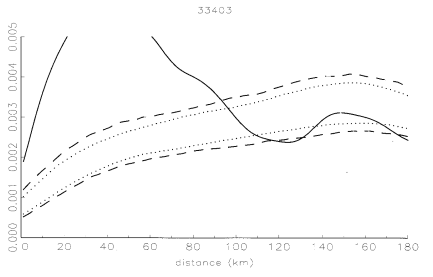
Spectacles and Lenses sub-sector (SIC 33401)





Optical Instruments sub-sector (SIC 33402)





Photographic Equipment sub-sector (SIC 33403)

(the map is plotted excluding the largest establishment)

Figure 6: Localisation coefficients and K-densities of the Optical Sector

size relatively small.

The optical sector, taken as a whole, is not very concentrated (Herfindhal of 0.0179) and is only slightly localised according to the three indexes and the Gini coefficients. The map of coefficients of variation (Fig. 6) depicts that, apart from two very strong concentrations in Hampshire and South Western Scotland, the regions in which the sector is more represented than the average tend to cluster in Southern England, with a sensibly positive Moran's I. For this reason the sector has to be considered more localised than the indexes say.

The components of this sector are differentiated, and some prefer to classify the Optical and the Photographic sectors (including in this the SIC 2464 "manufacture of photographic chemical material") as two different entities (e.g. Schrober, 2000). This makes the study of the aggregate Optical and Photographic sector not very meaningful and reinforces our choice of the sub-sector as the level of the survey; also from an empirical point of view, the three sub-sectors are very different, as it emerges from the respective analyses below.

Spectacles and Lenses sub-sector (SIC 33401)

The first 5-digit sub-sector of the optical sector is SIC 33401, "manufacture of spectacles and unmounted lenses"; it is the largest, accounting in 1997 for a total employment of about 8000 (more than half of the total) and 58% of plants.

It is not concentrated (Herfindhal of 0.0164) but it is localised according to all the three available indexes. The Gini coefficients, which do not correct for the sectorial concentration, are instead very low. The spatial distribution of the coefficients of variation presents a significant cluster in southern England. Finally (Fig. 6) the k-density function does not signal any non-randomness of the plant distribution as points in space.

Optical Instruments sub-sector (SIC 33402)

The second 5-digit sub-sector is SIC 33402, "manufacture of optical precision Instruments". It is a small sector (total employment of less than 4000 workers in about 150 plants).

According to the available indexes, this sub-sector is localised, even if not as much as the previous one, the Gini coefficient, instead, is considerably higher; this depends on the fact that it is more concentrated (Herfindhal of establishments distribution of 0.0733). The k-density function (Fig. 6) signals only slight departures from the randomness at distances of 20 and 90

kilometres. The map of the coefficients of variation presents two very strong concentrations but no particular clustering of the other over-represented regions, as is confirmed by a very close to 0 Moran's I; in these cases, the fact that the indexes don't take into account the spatial proximity, does not affect the reliability of results.

Photographic Equipment sub-sector (SIC 33403)

The last 5-digit sub-sector involved in this analysis is SIC 33403 "Manufacture of Photographic and Cinematographic Equipment". It is the smallest sub-sector of all (3364 employees in 160 plants) and it is also the most concentrated, since the Herfindhal is as high as 0.1774.
Because of the high employment concentration, the geographic concentration is also high (and this is reflected in a very high Gini coefficient) but, once a measure is corrected for plant size distribution as in the three more recent indexes, the result is of no localisation in the sector (two out of three indexes are even slightly negative).
This sub-sector represents another case in which the use of the indexes is not able to represent all the reality. The reason is that in this already small sector, the largest establishment accounts for as much as 40% of total employment. For this reason we re-calculated the indexes of localisation without this large plant (creating the virtual 5 digit sub-sector M33403), and the modified sub-sector proves to be instead very localised in all the three indexes. Moreover, the regions with positive coefficient of variation (Fig. 6) cluster around London (also attested by a large Moran's I).
In order to check how much this correction (which is somewhat arbitrary) can affect the results, we applied it also to all the other sub-sectors: the result is that for only Medicaments (SIC 24421), whose largest plant accounts for 20% of total employment, the change in the indexes is perceivable; even in this case, however, the modification remains considerably smaller than for photographic equipment. The general conclusion that we can draw from this analysis, is that the indexes of localisation are quite robust to sectorial structure modifications (and the closure of the largest establishment is a major one), unless the largest establishment has, alone, a size comparable to the aggregate size of the others, as it happens in this analysis only for the photographic equipment sub-sector.

The un-weighted k-density function we use to detect establishment proximity is by definition almost unaffected by the subtraction of just one establishment; when plotted (Fig. 6) it displays that the plants are very close to each other, with an important departure from randomness between 0 and 80 kilometres. This sector is therefore probably the most localised one, and for

this reason the empirical analysis concentrates on all the small establishments leaving apart the largest one.

Appendix C: main products of the sub-sectors

Main products classified in the different 5-digit sub-sectors:

- SIC 24410, Basic Pharmaceuticals: esters of salicylic acid, ammonium salts and hydroxides, acylic amides and derivatives, cyclic amides and derivatives, lactones, concentrates of vitamins, pennicillins and derivatives, blood and cultires of micro-organisms.

- SIC 24421, Medicaments: medicaments containing antibiotics not put up in measured doses or for retail sale, medicaments containing penicillins put in measured doses or for retail sale, medicaments containing antibiotics put up in measured doses or for retail sale excluding penicillins, medicaments containing adrenal cortical hormones, medicaments containing hormones; other medicaments for therapeutic use not put up in measured doses or for retail sale; medicaments containing alkaloids; medicaments containing vitamins; other medicaments for therapeutic use put up in measured doses or for retail sale.

- SIC 24421, Non-Medicaments: vaccines for human medicine, vaccines for veterinary medicine, chemical contraceptive preparation, opacifying preparations for x-ray examinations, adhesive dressings impregnated or coated with pharmaceutical substances, wadding, gauze, bandages and dressings impregnated with pharmaceutical substances, sterile surgical catgut and other suture materials.

- SIC 33401, Spectacles and Lenses: contact lenses, unmounted single focal spectacle lenses with both sides finished, lenses with both sides finished other than single focal, unmounted spectacle lenses other than those with both sides finished, sunglasses, spectacles, goggles and the like excluding sunglasses.

- SIC 33402, Optical Instruments: unmounted optical elements including prisms, lenses, plates, discs, ophthalmic lenses, colour filters, etc.; mounted optical elements of any material; telescopes and periscopes; lasers excluding laser diodes; liquid crystal devices; optical devices appliances and instruments including hand magnifying glasses and magnifiers, stereoscopes, kaleidoscopes, etc.; parts and accessories of telescopes designed to form part of optical, photographic, cinematographic, [...], appliances.

- SIC 33403, Photographic Equipment: cabinet or instant type instant print cameras; cameras for roll film 35mm wide; electronic flashlight

apparatus; still image projectors excluding for cinematography; photographic enlargers; apparatus and equipment for automatically developing photographic film and paper; projection screens; parts and accessories for photographic cameras excluding flashing apparatus; parts and accessories of slide projectors, microfilm, microfiche, etc. excluding for cinematography; parts and accessories of apparatus and equipment for automatically developing photographic film or paper including for cinematography.

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