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REGIONAL HIERARCHIES AND THE LOCATION OF HI TECH MNEs: THE CASE OF THE PHARMACEUTICAL INDUSTRY IN THE UK

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Abstract

In the "new age of capitalism", regions are emerging as important catalysts for innovation and production development. This paper investigates the location patterns of R&D-intensive MNEs at the geographical micro-level. Analysis refers to the pharmaceutical industry and their foreign activities established in British regions. We develop a hierarchy of UK regions both on a technological and skills basis but also on a broader basis covering the overall macroeconomic environment. Results point towards a combination of corporate location strategies. This pattern is consistent with MNEs' commitment to access and tap into the specific technological assets embedded in the local knowledge systems and at the same time exploit their corporate-specific advantages in large markets. JEL Classifications: F23, L65, R30.

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1. Introduction

It is nowadays well acknowledged that the creation and exploitation of knowledge plays a crucial role in the generation of wealth, leading to the development of concepts such as a "knowledge-driven" or "learning economy". It is argued that more attention should be devoted to the study of the dynamic mechanisms of knowledge generation and utilization. The firm and its geographical environment are two key players in this "knowledge arena". Globalization, far from eliminating the relevance of geography, brings to the surface the importance of location as a collector and repository of specialized knowledge. In this "new age of capitalism" (Dunning, 1995), regions are emerging as important catalysts for innovation and production development.

Renewed interest in regional economies has resulted in an extensive literature seeking to explain the regional factors contributing to the economic success of certain regions. The concept of a "learning" or "knowledge-creating" region within which firms operate has been defined to include inputs and related infrastructures that can facilitate knowledge flows and learning at the local level (Enright, 1998; Lawson, 1999; Maksell and Malberg, 1999).

Mapping Research and Development (R&D) - intensive Multinational Enterprises (MNEs) patterns is of particular relevance to local and national policy makers whose one of primary aims is to help the development of lagging behind regions and boost even further the growth of the developed ones. Public authorities design and provide particular incentives in order to influence investors' location decisions.

This paper investigates the location patterns of R&D-intensive MNEs at the geographical micro-level. Attention is restricted to the pharmaceutical industry and their foreign activities established in British regions. In this direction, this paper develops a hierarchy of UK regions both on a technological and skills basis but also on a broader basis covering market size, overall performance of the regions in terms of business climate, quality of life and infrastructure availability.

The pharmaceutical industry was chosen as one of the most active industries in Foreign Direct Investment (FDI) in R&D. Pearce (1989) observes that pharmaceuticals have a higher propensity to disperse R&D across borders than other industries and might therefore not be typical. Thus, understanding them may provide insights into the diffusion of other new technologies, particularly those characterized by large development costs, relatively low marginal or transportation costs, and that are susceptible to creative destruction by subsequent innovators.

This study makes four contributions to the relevant literature. First, the paper maps MNEs' activities of the pharmaceutical industry in UK regions and hence identifies potential regional clusters based on data available up to 2006. Second, the paper develops a multifaceted hierarchy of UK regions based on various regional aspects such as R&D intensity and skills as well as market size, overall business climate, availability of infrastructures and quality of life. Third, it explores R&D intensive foreign-owned operations based on corporate location strategies and agglomeration effects. Fourth, we link empirical results with the hierarchical order of regions.

Results point towards a combination of corporate location strategies. In particular, it turns out that foreign pharmaceutical affiliates locate in distinct UK regions driven by both *home-base-exploiting* (HBE)/*market seeking* (MS) and *home-base- augmenting* (HBA)/*strategic seeking* (SS) motives. Agglomeration forces are not in effect, though one may clearly identify already formed clusters in specific regions. Location of pharmaceuticals follows the regional hierarchical order developed here, which implies that besides particularly significant factors, other attributes reinforce regional attractiveness.

The rest of the paper is as follows: Section 2 reviews the relevant literature, Section 3 discusses the sample and regional hierarchies, whilst Section 4 presents the econometric methodology. Section 5 then presents obtained results and finally, some conclusions and implications for regional policy are drawn in Section 6.

2. Relevant literature

A considerable part of the existing literature on FDI claims that FDI takes place when firms seek to exploit existing corporate-specific capabilities in foreign environments[1] (Hakanson, 1990; Hymer, 1976; Vernon, 1966). This type of FDI is called *home-base-exploiting* (HBE). More recently, a growing number of researchers have argued that an alternative explanation for FDI is based on a firm's need to acquire and tap into new knowledge and capabilities, called *home-base-augmening*[2] (HBA) FDI (Cantwell, 1991; Dunning, 1998; Florida, 1997; Kuemmerle, 1998; Wesson, 1993).

From another point of view, though within the same rationale, the eclectic paradigm (Dunning, 1994) identifies a tripartite motive for FDI. *Market seeking* (MS) involves producing within a country or a region in this particular case to supply the market of that region. A second motive involves *efficiency seeking* (ES) with the objective of sharpening the cost-efficiency of their manufacture in order to enhance (or defend) their competitiveness in those (usually higher-income) markets where they are already well established. The third strategic motivation regards *strategic assset-seeking* R&D (SS) (Dunning and Narula, 1995). This third strategy aims at targeting technologies in which the firm has a relative advantage at home and the host country is also relatively strong. Such R&D activities are aimed at monitoring or acquiring competitive advantages which are complementary to those already possessed by the firm so as to augment a firm's existing stock of knowledge.

Within the above two frameworks, one may clearly identify the match between HBE and MS strategies and HBA and SS strategies.

Parallel to the above lines of research, New Economic Geography (NEG) (Krugman, 1991; Venables, 1996; Puga, 1999) models aim to explain the geographic distribution of economic activities based on the assumption of increasing returns to scale (IRS), which generate benefits if firms agglomerate. Despite differences in the mechanisms employed to explain industrial agglomeration, all NEG models imply that industrial agglomeration in one or more regions is closely connected with trade costs between regions (e.g. transportation costs, tarrifs, non-tarrif barriers, etc.) and is influenced by the balance between centripetal forces (market-production or input-output linkages) and centrifugal forces (high land rental, severe competition in the intermediate and final goods markets, etc.).

Most of the relevant empirical literature analyzes the determinants of MNE industrial activity, with a particular emphasis on firms' clustering, at a national level, particularly with location choices in Europe (Wheeler and Mody, 1992, Devereux and Griffith, 1998; Barrell and Pain, 1999; Mucchielli and Puech, 2003) or within US states (Carlton, 1983, Friedman *et al.*, 1992; Nachum, 2000). Head *et al.* (1995) examine Japanese manufacturing investments in the US and provide at the same time a map of their geographical distribution among the states.

There are a few exemptions that deal with thinner geographical analyses within countries. Head and Ries (1996) investigated foreign investment decisions for 54 cities in China and a similar work belongs to Cheng and Kwan (2000) who estimated 29 Chinese regions confirming the self-reinforcing effect on FDI on itself. He (2002) also has addressed the role of information costs and agglomeration economies in the location of FDI in Chinese regions. Guimaraes *et al.* (2000) presents a spatial distribution of FDI start-ups in Portuguese concelhos. Crozet *et al.* (2002) maps location choices by foreign investors in France focusing especially on agglomeration effects and on the impact of French and European regional policies. More recent work by Driffield and Hughes (2003) examines the impact of FDI and domestic investment on regional development in the UK. Boudier-Bensebaa (2005) examines the determinants of FDI at a regional level in Hungary and concludes that labor availability, demand conditions and agglomeration economies influence positively and significantly inward FDI in Hungarian counties.

Regarding location of R&D, Kuemmerle (1999) examines motives, location characteristics, inter-temporal characteristics and modes of entry for FDI in R&D based on a survey of laboratory sites of the pharmaceutical and electronics industries in 5 countries. He concludes that firms invest in R&D sites abroad to augment their knowledge base or to exploit it, thus, they establish facilities primarily close to universities and existing manufacturing facilities and markets.

Empirical research at the sub-national level focusing on R&D activities by MNEs belongs to Carrincazeaux et al. 2001; Frost, 2001 and Cantwell and Iammarino, 2003. Cantwell and Piscitello (2005) examine corporate research activity in European regions by foreign-owned firms and provide evidence for the role of regional technological competence as significant factor for attracting foreign-owned research, thus, confirming that intra- and inter-industry spillovers are highly region specific (Keller, 2002). Howells (1984) investigates the location of R&D in the UK both on aggregate scale and micro scale placing emphasis on the pharmaceutical industry. Janne (2002) examines the regional aspects of the MNEs' R&D activities in the electronics and pharmaceutical industries in German, Belgian and British regions. She develops regional hierarchies based on the technological advantage of each in the underlying industries based on patents granted.

3. Data and Methods

3.1 Data

Our analysis is based on Corporate Database Affiliations (Who owns Whom), a wide database that Lexis-Nexis prepares with all foreign subsidiaries of US firms operating all over the world as well as the foreign subsidiaries of the world's largest MNEs. The total numbers of foreign pharmaceutical subsidiaries that operate in the UK are 128. We focused on subsidiaries that were established after 1980, thus we excluded observations that were established back in the 19th or early 20th century (e.g. 1860, 1912, etc.). The final number of usable observations was 119 firms.

The regional breakdown of the UK was based on the standard classification of UK National Statistics. UK National Statistics distinguishes among twelve regions, namely, North East, North West, England, Yorkshire and the Humber, West Midlands, East Midlands, East of England, South East, London, South West, Wales, Scotland and Northern Ireland. Data on regional characteristics were obtained from UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform.

Table 1 provides a description of all available variables. By combining these different datasets we are able to cover a spectrum of variables capturing the size of the region, its labour costs, skills and knowledge intensity, infrastructure availability, overall business climate/institutional quality and quality of life.

Figure 1 sheds light on the information obtained from the Corporate Affiliations Database (Lexis-Nexis). It represents in absolute and relative terms the allocation of firms established and operating in each of the UK regions. It is evident that South East and East of England host by far the majority of them whilst Wales hosts none. Northern Ireland and West Midlands host the least firms. The corresponding shares indicate that South East and East of England host 33.61% and 24.37% respectively of total foreign pharmaceutical subsidiaries[3].

A classification of regions based on concentration of pharmaceuticals in respective regions may be found in Table 2[4].

To further examine the background of the firms included in our sample we provide in Table 3 a break down with respect to their origin. The first column represents the non-US international firms included in the Corporate Affiliations Database. These firms represent two thirds of our full sample. It is noteworthy that more than 50% of the US firms are located in South East whilst almost half of all non-US firms are spread between South East and East of England with 16.81% in East of England and 14.29% in South East. This indicates a strong home-based agglomeration effect especially for the US affiliates that seem to cluster in the South East region. Furthermore, it is evident that the overall effect of South East dominance is driven by US firms.

It would also be interesting to see the corresponding allocation of the entire chemical sector. Figure 2 is illustrative of the pattern. North West enters dynamically into the picture now, holding the same share as East of England which is lower than the one for the pharmaceuticals (17%) and it is also evident that the relative share of the South East region is also lower having fallen from 33.61% for the pharmaceuticals to 24%. It is now Northern Ireland that hosts the least number of chemical subsidiaries. The above pattern of the chemical industry reveals a more idiosyncratic nature of the pharmaceutical firms.

3.2 Constructing Hierarchies

Starting from regional hierarchies, we have classified the corresponding UK regions according to their status relating to R&D and skills, market size, overall business climate, quality of life and infrastructure. To construct hierarchies, we have calculated the average value for each of the regional aspects and then calculated the ratio indicating how much above or beyond the average value each region stands. This enables a better understanding of the dynamism of regions on the attributes under consideration.

In particular, the hierarchies are constructed as follows

$$h_j = \frac{x_j}{\overline{X}} \quad \text{where} \quad \overline{X} = \frac{1}{N}\sum_{j=1}^{N} x_j \qquad (1)[5]$$

For the combined measures, we have taken averages of previous ordering.

3.3 Econometric Methodology

In this paper we adopt the econometric methodology used by Crozet et al., (2002), Head et al., (1999) Friedman et al., (1992), Filippaios and Kottaridi (2004). The model assumes that foreign investors, once they have already decided to build a manufacturing plant in the U.K., maximize an intertemporal profit function subject to uncertainty with respect to location selection. The profit function consists of a deterministic part typically called the attributes of the choices and a random component arising from maximization errors, other unobserved characteristics of choices or measurement errors in the exogenous variables. Hence, the profit function of an investor *i*, locating in region *j* may be written in the following form

$$\pi_{ij} = U_{ij} + \varepsilon_{ij} \tag{2}$$

where $U_{ij} = U(\ln X_{ij1}, \ln X_{ij2}, ..., \ln X_{ijk})$ with X_{ijm} representing a set of *m* observable characteristics of alternative locations *j,* and ε_{ij} is a random variable associated with unobserved location attributes potentially influential to investor's choice. Investor *i* will choose to locate in region *j* (and continue to operate there afterwards), rather than choosing location *l*, if the following expression holds

$$\pi_{ij} > \pi_{il}, \forall l, l \neq j \tag{3}$$

Since the profit function contains a stochastic part, the probability that location *j* is selected among alternative choices by investor *i* may be then defined as

$$P_{ij} = \Pr ob(\pi_{ij} > \pi_{il}), \forall l, l \neq j \tag{4}$$

Under the assumption that the disturbances are independent and identically distributed with Weibull distribution, the probability takes the following form (McFadden, 1984)

$$P_{ij} = \frac{e^{U_{ij}}}{\sum_{l=1}^{L} e^{U_{il}}} \tag{5}$$

This is the conditional logit model or McFadden's choice model. Using equation (5) and assuming that U_{ij} is a linear combination of the explanatory variables, estimation of the relevant coefficients is obtained using maximum likelihood. To further test the validity of our results, we performed a test for controlling the Independence of Irrelevant Alternatives (IIA) property. This property states that the ratio of probabilities of choosing two locations, P_j/P_l, is independent of the characteristics of any third location, or, in other words, the choices must be equally substitutable to investors. From the aforementioned analysis, it is evident that we model the probability of a plant's location and prolongation of operations in any given region at period t as a function of a set of explanatory variables related to the choice variable. In this case the choice reflects one of the 12 UK regions.[6]

3.4 Explanatory Variables and Empirical Model

3.4.1 Corporate Strategies

Regional Market: A well-founded hypothesis in the relevant literature relates to the market potential of the respective location. In this regard, we use here the population of the respective regions and we expect a positive sign. This variable corresponds to the HBE or MS motives.

Cost-efficiency: To take account of labour costs, we include labour compensation per employee in the respective region and we expect a negative coefficient. This variable captures the ES motive.

Knowledge: Based on the arguments above for the factors that determine a "learning" or "knowledge" economy, we have incorporated two variables: first, we have used one variable that captures skills and education of the working-age population and second, we have used one variable that manifests the technological intensity of regions. Regarding the first, we use employment in the high-tech sectors as a share of the working-age population. With reference to the second, we use the R&D expenditures of the region per capita. Both variables are expected to yield positive coefficients. These variables fall within the HBA or SS strategies of MNEs.

3.4.2 Locational Characteristics

Business Climate: The overall business climate of a region has been argued to be a reinforcing factor for investments. We include here the business survival ratio as this may capture institutional efficiency of a region that facilitates business development. The coefficient is expected to be positive.

Infrastructure: Infrastructure is considered a key aspect of locational attractiveness as it facilitates production and thus promotes efficiency. We include here the motor vehicle flows in motorways per person and we expect a positive effect.

Quality of life: We incorporate here two measures to capture quality of life: first, the registered crime ratio and second, the mortality ratio. We expect negative signs for both.

3.4.3 NEG

Agglomeration: Following other studies, we have constructed relative measures of agglomeration. In particular, we use the share of pharmaceutical firms to the region's total manufacturing firms. Also, because input-output linkages imply that the pharmaceutical industry may co-locate with the chemical industry, we include the corresponding relative variable of that industry as well. The coefficients may be positive or negative based on the centripetal or centrifugal forces that prevail in the region. Agglomeration variables are in line with NEG models.

Based on the above-described variables our baseline empirical model takes the following form

$$\Pr(choice_i = j \mid 1,\ldots,l) = \Lambda(\beta_1 MS + \beta_2 EC + \beta_3 SK + \beta_4 RD + \varepsilon_{ij}) \quad (6)$$

where we examine corporate location strategies.

Next, we augment the baseline model with variables capturing attractive locational attributes and agglomeration. The augmented model in its full form is the following

$$\Pr(choice_i = j \mid 1,\ldots,l) =$$
$$= \Lambda(\beta_1 MS + \beta_2 EC + \beta_3 SK + \beta_4 RD + \beta_5 BC + \beta_6 QLC + \beta_7 QLM + \beta_8 IN + \beta_9 AGGLO + \varepsilon_{ij}) \quad (7)$$[7]

4. Results and discussion

4.1 Regional Hierarchies

The first two columns of Table 4 present the hierarchy of regions according to their R&D intensity and the next two columns orders them based on their human capital or skills of their employment as discussed in the previous section. Table 5 orders regions on their market size basis. Table 6 uses the overall business climate to categorise them. Table 7 uses quality of life and Table 8 infrastructure availability. Finally, we have constructed average measures that relate to knowledge, thus, combine both employment skills and R&D intensity and the rest of environment, and thus combine business climate, infrastructure and quality of life. Table 9 presents hierarchies of regions as to knowledge intensity, quality of environment and market size. Last column presents the overall hierarchical order of regions.

As displayed, South East and East of England are the most skills and R&D intensive regions. It is interesting to note the high value of East of England referring to R&D intensity. Northern Ireland and West Midlands are found at the bottom of the knowledge hierarchy. With reference to market size, South East is the most populated one, followed by London, North West and East of England. Regarding the overall business climate[8], South East is ordered first followed by East of England. It is noteworthy here that London is found at the bottom of this hierarchy. This might be explained by the fact that there might be more intense competition in the region which is reflected in the business survival ratio. Turning to quality of life[9], there is a differentiated picture; London appears with the best score followed by Yorkshire and the Humber whilst South East is found in the fourth place and East of England indicating a value above the average. In terms of infrastructure availability, the picture is significantly altered; South East is now found down in the hierarchy whilst East Midlands and East of England hold the first two positions respectively. Finally, turning to the combined hierarchies, we find East of England and South East on the first two positions with regards to skills and R&D, South East at the top with reference to market size, while both South East and East of England are lower in the hierarchy of environmental quality. In this category, East Midlands, South West, North West and North East hold the positions at the top with this ordering.

Table 10 displays the hierarchical order of regions as turned out in the last column of Table 9 for better illustration. The overall hierarchy portrays South East, East of England, London, North West and South West at the top 5 positions with ratios above the average value.

4.2 Econometric Results

Table 11 presents obtained econometric results. Column 1 includes the baseline model (6) with standard variables relating to corporate location strategies, i.e., market size, employment costs, human capital and R&D intensity. It turns out that market size and R&D intensity are as expected and both highly significant at the 1% level. Human capital pool is also positive and marginally significant at the 10% level. Labour costs exert a positive sign contrary to our expectations though they are non-significant. This outcome may be explained on the basis that it is very likely that labour costs capture quality of employment.

Column 2 adds the overall regional business climate, which though with a positive sign as expected is far from significant. The rest of the model is stable and as described above. Column 3 adds quality of life to the baseline model as captured by the crime ratio. Contrary to our expectations, crime exerts a positive sign albeit insignificant. R&D intensity is significantly positive at the 5% level and market size at the 1% level. Personnel skills are again significant at the 10% level. In column 4 we incorporate another quality of life measure, that of the mortality ratio. Mortality ratio appears with the correct sign however it is non-significant. R&D intensity and market size are both highly significant, whilst human capital is marginally significant around 12%. Next, (column 5) we include infrastructure availability to the baseline model; contrary to our expectations, the coefficient emerges with a negative sign albeit non-significant. R&D intensity maintains its high statistical significance and employment skills are again marginally significant at the 12% level. Market size has lost significance in this specification.

Columns 6, 7 and 8 include alternative combinations of variables. In particular, column 6 incorporates the two quality of life measures at the same time. Those variables turn out as before. In this specification, R&D intensity is significant at the 10% level and is the coefficient of the personnel skills. Market size is highly significant. Column 7 shows results of the baseline model plus quality of life measures and business climate. Market size is again significant albeit at the 5% level and employment qualifications at the 10% level. It's remarkable that R&D intensity has lost significance in this specification. Column 8 presents another combination of variables, quality of life measures and infrastructure availability. Those variables are as before. R&D and human capital are now significant at the 10% level and marginally significant at the 12% level respectively, while it is noteworthy that market size is insignificant.

Next column (column 9) includes all variables except agglomeration. The R&D intensity is highly significant, skills are insignificant and the market size switches sign from positive to negative. However, we should point here that this might be due to the fact that market size and infrastructure are somewhat highly correlated nevertheless we believe it' s worthwhile to present them for illustrative purposes. The rest of the variables are as usually.

Next, it would be interesting to check for agglomeration effects. We use here relative measures of agglomeration both for pharmaceuticals and for chemical firms. We observe, that pharmaceutical agglomeration is quite highly correlated with R&D intensity, thus, we excluded R&D intensity from the model. Indeed, it is now agglomeration that demonstrates high and positive significance[10]. Market size is marginally significant. In this specification, employment costs switch signs and they now emerge negative and marginally significant at the 12% level. Regarding the chemical industry, there is no correlation issue hence we include both R&D intensity and agglomeration. Nevertheless, agglomeration of chemical industry does not emerge with a significant coefficient whilst R&D and market size are both positive and significant at the 1% level[11] and again skills are significant at the 10% level.

Overall, we observe that two are the dominant environmental characteristics that affect regional location choice of pharmaceuticals; market size and R&D intensity. Employment skills also turn out to affect regional location though these appear to be less significant the first two.

The above results point to a combination of corporate location strategies; it appears that foreign affiliates locate in distinct UK regions driven by both HBE or MS and HBA or SS motives. This is not surprising though; the shift towards internationally integrated strategies within MNEs is partly grounded on a 'life cycle' effect within what have become mature firms. These MNEs have now created a sufficient international spread in their operations that they have the facility to establish an internal network of specialized subsidiaries, which each evolve a specific regional or global contribution to the overall firm beyond the concerns of their own most immediate market (Cantwell and Piscitello, 2000). While some of the subsidiaries within such a network may have essentially just a competence-exploiting or an 'assembly' role, others take on a more technologically creative function and the level and complexity of their operations rises accordingly (Cantwell, 1987).

Looking closer at our analysis and hierarchies of regions, one may easily identify the correspondence of regional hierarchies and concentration of foreign affiliates in distinctive regions. In particular, cross checking Tables 2 and 10, it is evident that the pattern of pharmaceutical MNEs' location follows regional hierarchies as discussed in this study. South East, East of England, London, North West, South West are the first 5 hosts of pharmaceutical MNEs and they are also classified in the 5 first positions of regional hierarchies. The above implies that although environmental factors like quality of life, infrastructure and business climate are not significant on their own as evidenced in our econometric results, they act as secondary attributes that reinforce the overall attractiveness of regions.

5. Concluding Remarks

This paper investigates the location patterns of R&D-intensive MNEs at the geographical micro-level. Attention is restricted to the pharmaceutical industry, as one of the most active industries in FDI in R&D, and their foreign activities established in British regions. In this route, the present study develops a hierarchy of UK regions both on a technological and skills basis but also on a broader basis covering market size, overall performance of the regions in terms of business climate, quality of life and infrastructure availability. At the same time it explores R&D intensive foreign-owned operations based on corporate location strategies and agglomeration effects.

Results point towards a combination of corporate location strategies. High-technology firms are more likely to operate abroad in technology specialised large regions in accordance with hierarchies developed here. This pattern is consistent with MNEs' commitment to access and tap into the specific technological assets embedded in the local knowledge systems and at the same time exploit their corporate-specific advantages in large markets.

Regions have increasingly become complexes of MNEs to which they provide a series of infrastructures, which can support and facilitate (or block) the flow of knowledge, ideas and learning. The local environment and more particularly its position in a geographical hierarchy may play an important role in the ability of subsidiaries to develop their own technological competences. At the same time, high-tech MNE activities have a fundamental role to play to the local development and may unevenly benefit the higher-order regions to the detriment of the lower ones. Under this perspective, R&D-intensive MNE locational patterns are of particular relevance to local and national policy makers whose one of primary aims is to help the development of lagging behind regions and boost even further the growth of the developed ones. Public authorities design and provide particular incentives in order to influence investors' location decisions.

Appendix

TABLE 1

Available Variables and Description

Variable	Description
MS	Market size, population of the region in millions
EC	Employment costs, total employments costs per person employed, (£)
SK	Employment skills, employment in high-tech sectors as a % of working age population
RD	R&D expenditures, as a share of the regional GDP
BC	Business climate, 36 month survival rate for businesses registered in 1999
QLC	Quality of life, recorded detected crimes in percentages
QLM	Quality of life, standardised mortality ratio (UK=100)
IN	Infrastructure, average daily motor vehicle flows in motorways per person

Source: UK online national statistics, UK Invest and the Department for Business, Enterprise and Regulatory Reform and Author's Calculations

TABLE 2

Concentration Index of Firms in Distinctive Regions

NUTS II	Concentration Index
South East	3.780
East of England	2.929
London	1.228
North West	1.134
South West	1.134
Yorkshire and the Humber	0.661
East Midlands	0.378
North East	0.283
Scotland	0.283
Northern Ireland	0.094
West Midlands	0.094
Wales	0.000

Source: Lexis-Nexis Database and Authors' Calculations

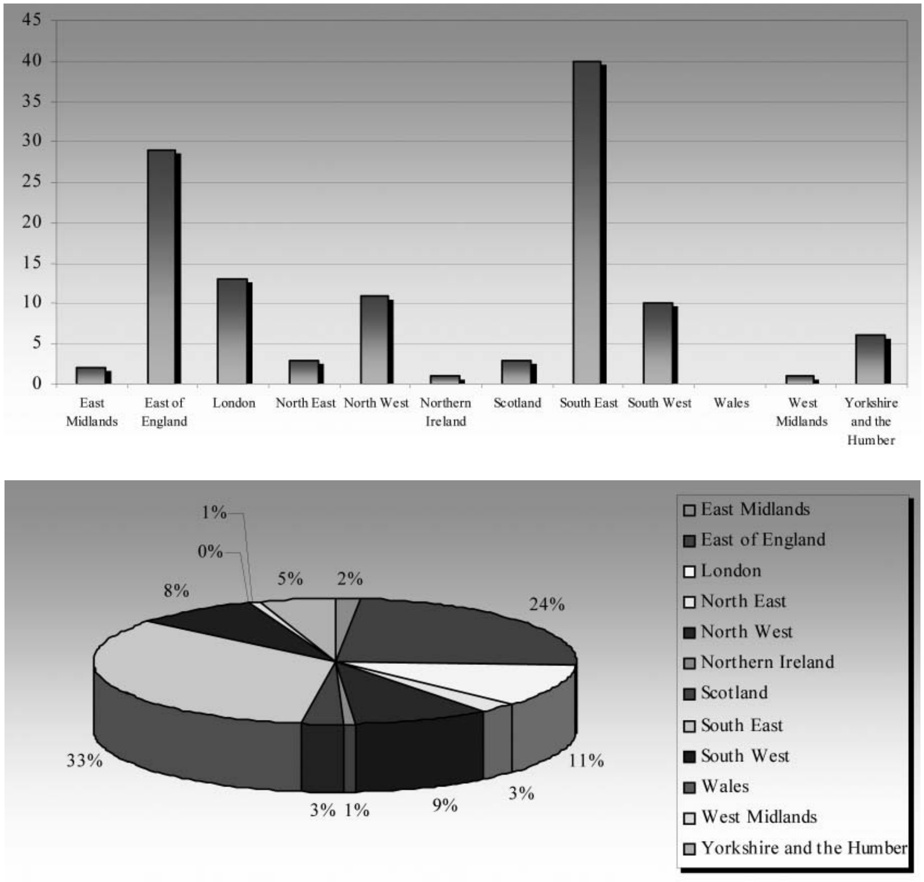

Figure 1. Allocation of pharmaceuticals in the UK regions, absolute numbers and percentages
Source: Lexis-Nexis Corporate Affiliations Database and Authors' Calculations

TABLE 3

Percentage of Firms by NUTS II Region and Region of Origin

NUTS II	International Firms	US	Total
East Midlands	1.68%	0.00%	1.68%
East of England	16.81%	7.56%	24.37%
London	9.24%	1.68%	10.92%
North East	2.52%	0.00%	2.52%
North West	7.56%	1.68%	9.24%
Northern Ireland	0.84%	0.00%	0.84%
Scotland	2.52%	0.00%	2.52%
South East	14.29%	19.33%	33.61%
South West	5.04%	3.36%	8.40%
Wales	0.00%	0.00%	0.00%
West Midlands	0.84%	0.00%	0.84%
Yorkshire and the Humber	3.36%	1.68%	5.04%
Grand Total	64.71%	35.29%	100.0%

Source: Lexis-Nexis Database and Authors' Calculations

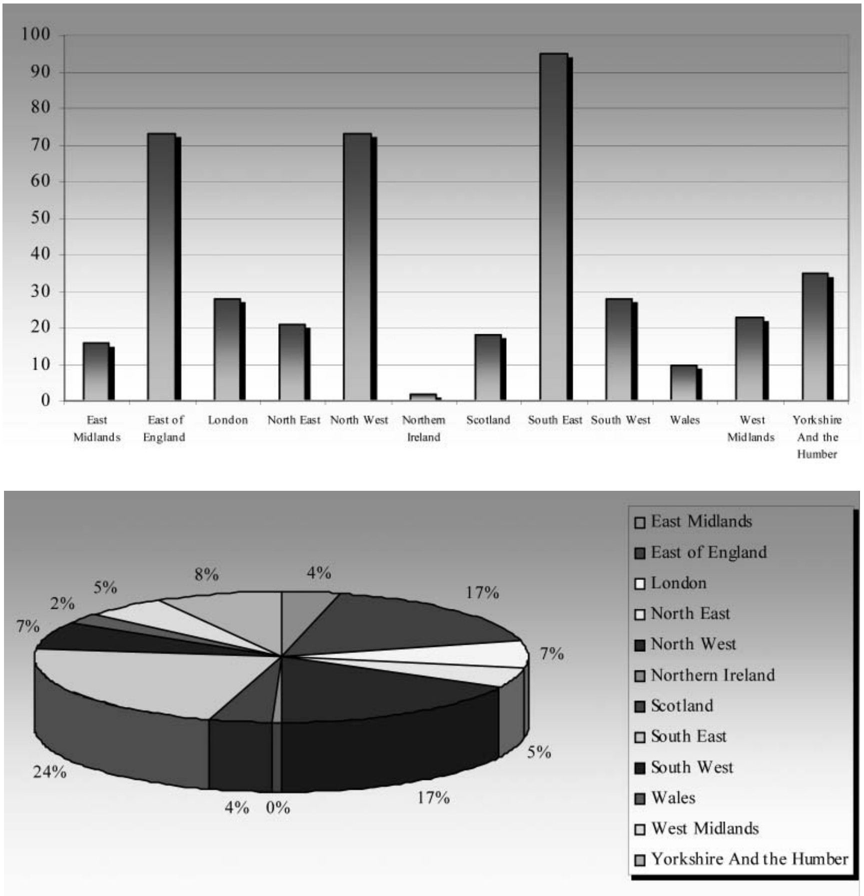

Figure 2. Allocation of the chemical sector in the UK regions, absolute numbers and percentages

Source: Lexis-Nexis Database and Authors' Calculations

TABLE 4

Hierarchical Order of Regions based on Local Characteristics – Skills and R&D

Part A		Part B	
NUTS II	**RD**	**NUTS II**	**SK**
East of England	2.5311	South East	1.1252
South East	1.9068	East of England	1.1182
South West	1.1810	South West	1.0937
North West	0.9629	East Midlands	1.0754
London	0.9489	Scotland	1.0661
East Midlands	0.9047	London	1.0556
Scotland	0.8882	Yorkshire and the Humber	1.0519
North East	0.5845	North West	1.0252
Yorkshire and the Humber	0.5719	Wales	0.9903
West Midlands	0.5333	North East	0.9771
Wales	0.5324	Northern Ireland	0.9483
Northern Ireland	0.4542	West Midlands	0.4729

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 5

Hierarchical Order of Regions based on Market Size

NUTSII	MS
South East	1.6281
London	1.4874
North West	1.3668
East of England	1.1055
West Midlands	1.0653
Scotland	1.0251
South West	1.005
Yorkshire and the Humber	1.005
East Midlands	0.8643
Wales	0.603
North East	0.5025
Northern Ireland	0.3417

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 6

Hierarchical Order of Regions based on Local Characteristics –
Business Climate

NUTS II	BC
South East	1.0467
East of England	1.0227
South West	1.0212
East Midlands	1.0167
West Midlands	0.9987
Yorkshire and the Humber	0.9927
North East	0.9836
North West	0.9746
London	0.9431

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 7

Hierarchical Order of Regions based on Local Characteristics –
Quality of Life

NUTSII	QL
London	0.8242
Yorkshire and the Humber	0.9541
South west	0.9564
South East	0.9614
East Midlands	0.9808
East of England	1.0134
North West	1.0731
West Midlands	1.0905
North East	1.1460

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 8

Hierarchical Order of Regions based on Local Characteristics – Infrastructure

NUTS II	INF
East Midlands	1.4598
East of England	1.0205
London	0.8831
North East	1.3585
North West	0.7118
South East	0.7616
South West	0.8961
West Midlands	1.0194
Yorkshire and the Humber	0.8894

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 9

Hierarchical Order of Regions based on Local Characteristics

NUTS II	TECH	ENV	MS	ALL
East Midlands	0.9901	1.1291	0.8643	0.9945
East of England	1.8246	0.8878	1.1055	1.2727
London	1.0022	1.0069	1.4874	1.1655
North East	0.7808	1.0220	0.5025	0.7685
North West	0.9941	1.0287	1.3668	1.1299
South East	1.5160	0.9732	1.6281	1.3725
South West	1.1374	1.0852	1.0050	1.0759
West Midlands	0.5031	1.0035	1.0653	0.8573
Yorkshire and the Humber	0.8119	0.9316	1.0050	0.9162

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 10

Overall Hierarchy of Regions

NUTS II	ALL
South East	1.3725
East of England	1.2727
London	1.1655
North West	1.1299
South West	1.0759
East Midlands	0.9945
Yorkshire and the Humber	0.9162
West Midlands	0.8573
North East	0.7685

Source: UK online national statistics, UK Invest, and the Department for Business, Enterprise and Regulatory Reform and Authors' Calculations.

TABLE 11

Determinants of Location Choice of Large Pharmaceutical Firms

	(1) (baseline)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
MS	0.308***	0.308***	0.275***	0.307***	0.128	0.266***	0.304**	0.081	-0.217	0.159*	0.284***
	3.29	3.29	2.73	3.24	0.77	2.55	2.05	0.46	-0.61	1.69	2.82
EC	0.004	0.004	0.009	0.004	0.007	0.009	0.007	0.001	0.021	-0.008+	0.004
	0.73	0.73	1.01	0.7	1.2	1.04	0.74	1.26	1.58+	-1.57	0.83
SK	0.006*	0.006*	0.007*	0.006+	0.006+	0.007*	0.008*	0.006+	0.003	0.003	0.006+
	1.6	1.6	1.69	1.53	1.52	1.68	1.6	1.53	0.46	0.86	1.53
RD	0.633***	0.633***	0.499**	0.626***	0.673***	0.459*	0.398	0.502*	0.756**		0.612***
	4.33	4.33	2.11	3.87	4.33	1.71	1.26	1.84	2.04		3.99
BC		0.023					-0.066		0.253		
		0.29					-0.37		0.99		
QLC			0.053			0.060	0.096	0.056	-0.077		
			0.71			0.77	0.76	0.69	-0.51		
QLM				-0.002		-0.007	-0.029	-0.011	0.046		
				-0.1		-0.31	-0.47	-0.52	0.75		
INF					-0.098			-0.102	-0.184+		
					-1.3			-1.3	-1.53		
AGG										36.314***	
										4.24	
AGGCH											1.437
											0.57
Obs.	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035	1035
LR	97.24***	97.33***	97.72***	97.25***	99.17***	97.82***	97.95***	99.74***	100.71***	97.40***	97.56***
Pseudo R2	0.1925	0.1926	0.1934	0.1925	0.1963	0.1936	0.1939	0.1974	0.1993	0.1928	0.1931

Note: significance at: ***1% level, **5% level, *10% level; z-statistics in parentheses.

Notes

1. This type of investment corresponds to what Patel and Pavitt (1990) refer to as 'short-sighted learning' (or myopic learning): firms exploit their knowledge base in order to make their technological capital profitable in the short-term, without trying to improve it through external investment operations.

2. This type of conduct corresponds to 'dynamic learning' (following the taxonomy of Patel and Pavitt, 1990).

3. South East has been found in earlier studies to host the majority of R&D activity by MNEs (Howells, 1984; Janne, 2002).

4. As a measure of concentration in each region, we have calculated ratios that indicate how much above or below the average number of firms that regions host each region is found, $c_j = \frac{m_j}{\bar{M}}$ where $\bar{M} = \frac{1}{N}\sum_{j=1}^{N} m_j$ where m denotes number of firms hosted and N is the number of regions.

5. x_j is region's j respective value of the variable of interest and N is the total number of regions.

6. The specification of the McFadden technique does not allow the usage of attributes that are not associated with the dependent variable. Thus, incorporation of subsidiary characteristics would make the model unspecified.

7. Descriptive statistics of variables and correlation matrices are available upon request.

8. Local characteristics other than knowledge variables and market size, were not available for Northern Ireland, Wales and Scotland, hence the hierarchies do not include them.

9. The corresponding ratios are ordered here ascending as the lower the crime and mortality ratios, the better the quality of life.

10. We run the model including both, but obviously due to correlation, none of the two turned out to be significant and only the market size shows a significant coefficient at the 10% level.

11. We have tested alternative specifications including all other regional characteristics with agglomeration variables following the rationale of models 2 through 9. The pattern is the same as already discussed; therefore we choose not to present them for space economy. These results are available upon request.

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