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Where do MNEs Expand Production: Location Choices of the Pharmaceutical Industry in Europe after 1992*

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Abstract: Differences in regulations, technical standards and national medical cultures across EU member states created a highly segmented pharmaceutical market in Europe prior to the implementation of the Single Market Programme. The subsequent reduction in non-tariff barriers to trade would be expected to have an impact on where pharmaceutical multinationals locate production within the EU. Using discrete-choice models, we study the determinants of multinationals' location choices in terms of expanded production at existing facilities. Our results support the findings of New Economic Geography models that predict reduced rather than increased agglomeration in the face of trade-cost reductions.

JEL Classification: F15, F23, R12

Key words: economic geographic, location choice, discrete choice models, European integration, FDI

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1. Introduction

The New Economic Geography (NEG) literature (Krugman, 1991, Venables, 1996, and Puga, 1999) suggests that industrial location across countries is closely connected with inter-country trade-cost levels. Some NEG models predict that as trade costs decrease, increasing returns to scale (IRS) industries will agglomerate initially but then disperse across regions and countries. This prediction implies that earlier industrial agglomeration across countries may influence the locational trend of industries across those countries. In this paper, we test this prediction by studying the impact of country-level agglomeration on the location-choice decisions of multinational enterprises (MNEs) in the pharmaceutical industry in selected EU member states in the 1990's, following the implementation of the Single Market Programme (SMP). This programme resulted in the abolition of non-tariff barriers to trade between the member states of the European Union (EU) after 1992 and consequently led to a significant fall in trade-cost levels in the EU.

We focus on the pharmaceutical industry because it is a major industry in Europe[1] and one in which non-tariff barriers have been very significant in the past.[2] It also features substantial increasing returns to scale, as an R&D-intensive sector accounting for about 17 per cent of total EU business R&D expenditures in 2003 (EFPIA, 2005). We look at multinational enterprises (MNEs) in the pharmaceutical industry, since these

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[1] The pharmaceutical industry is the fifth largest industry in the European Union in terms of manufacturing value added (3.5 per cent, 2003 figure, EFPIA 2005). It is also important for European people as drugs and medicines play important roles in any national health service, which is one crucial indicator of national social welfare.

[2] See Cecchini et al., 1988.

enterprises have responded to trade costs in making location decisions and are in a position to respond the changing trade costs associated with the SMP (see Buckley and Artisien, 1988, Dunning, 1992, Dunning and Robson, 1988 and Young, 1992). We measure the response of pharmaceutical MNEs to trade-cost changes by looking at MNEs' location choices for expanding pharmaceutical output in the EU in the period between 1995 and 2003.[3]

Our analysis involves the estimation of a conditional logit model and a mixed logit model to study the impact of country-level agglomeration on where the expansion in pharmaceutical MNEs' production took place in the 1990s. Since MNEs' location-choice decisions are also driven by other country-level characteristics, e.g., market size, corporate-tax rates and labour market conditions etc., we also explore the impact of these factors on MNEs' location choices. Besides country-level factors, we include variables reflecting firm heterogeneity in terms of the nationality of ownership and size in the conditional logit model. The firm-level data for our analysis come from the *Amadeus* business database.

This research contributes uniquely to the location-choice literature because, to our knowledge, no studies on the location choice of output expansion have been published hitherto. Our results show that past agglomeration of the pharmaceutical industry in one EU country reduces the probability of this country being chosen for output expansion by MNEs. In addition, other country-level variables, such as the market size for drugs and medicines and corporate-tax rates are also important determinants of location. Moreover, we find that MNEs which differ in terms of having EU and Non-EU parents have heterogeneous responses to country-level characteristics.

The paper is organized as follows. Section 2 gives an account of NEG models and reviews related empirical research; Section 3 presents sector-level agglomeration trends in the European pharmaceutical industry and discusses NEG models' implications on this industry; Section 4 describes the data and the empirical methodologies to be used, while Section 5 presents and discusses our results. Section 6 summarizes our main findings and concludes.

[3] Our choice of 1995 as a starting date is dictated by data availability – see Section 4 below.

2. Theoretical Background and Related Empirics

New Economic Geography (NEG) models aim to explain the geographic distribution of economic activities, starting from the assumption that manufacturing industry exhibits increasing returns to scale (IRS), which generate benefits if manufacturing firms agglomerate. While the IRS assumption is common to all models, the models differ in the assumptions they make about the degree of factor mobility (inter-sectoral and inter-regional), which has an impact on the extent of the net benefits generated from agglomeration.

For example, Krugman (1991) uses a two-region framework to demonstrate that, under the assumption of free movement of capital and workers between two regions, market size-production linkages will cause all manufacturing firms and workers to agglomerate in one region (called "core") at the expense of the other region, which becomes a "periphery".[4] Venables (1996) suggests that the input-output linkage in manufacturing can explain why manufacturing firms agglomerate together, even without invoking the assumption of inter-regional mobility of labour.[5] Puga (1999) presents a model based on Krugman's Core-Periphery model, into which he incorporates input-output linkages. This model demonstrates the agglomeration processes of manufacturing sector across two regions under assumptions that manufacturing workers are either inter-regionally mobile or immobile.

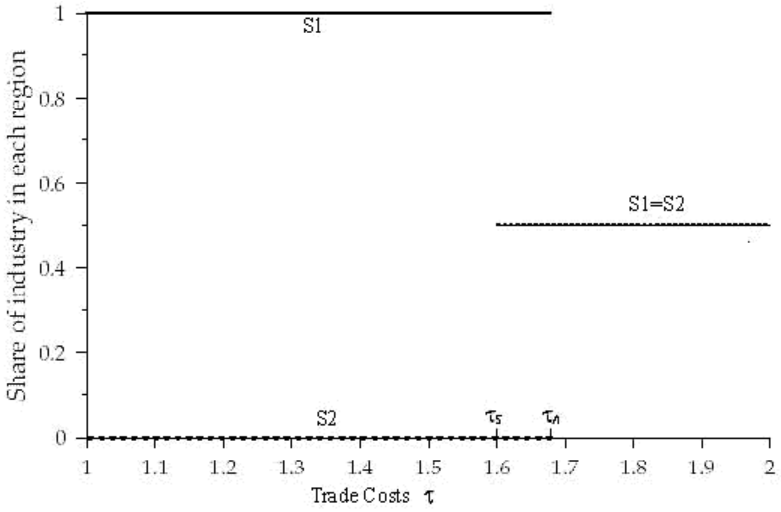
Despite differences in the mechanisms employed to explain industrial agglomeration, all NEG models imply that industrial agglomeration in one or more regions is closely connected with trade costs between regions (e.g., transportation costs, tariffs, non-tariff barriers, customs efficiency, etc.), and is influenced by the balance between agglomeration forces (market-production or input-output linkages) and dispersion forces (high land rental, severe competition in the intermediate and final goods markets, etc.). Generally, these models generate two different patterns of relationship

[4] Manufacturing firms go to the region that has the larger market size and workforce, thus reducing the regional price index (trade costs are saved because more products are produced locally) and raising its real wage rate. More workers are encouraged to move into that region, resulting in an expansion in local market and workforce. In turn more firms go to that region and a 'circular causality' is created.

[5] Input-output linkages matter because the final good producers prefer to cluster close to the producers of intermediate products in order to reduce production costs and vice versa for the producers of intermediate products.

between industrial agglomeration and trade costs: a monotonic relationship or a non-monotonic (bell-shaped) relationship, depending on their assumption of labour mobility. The monotonic outcome in Krugman (1991) is linked to the assumption of inter-regional labour mobility, which is illustrated in Figure 1. The x-axis shows the trade-cost level, ranging from $\tau = 2$ (maximum trade costs) to $\tau = 1$ (zero trade costs) and the y-axis shows the shares of industry in two regions.[6] At the right end of the figure, when trade costs between two regions are extremely high, manufacturing firms prefer to stay and serve the region where they were incorporated. As trade costs fall, industrial agglomeration stays unchanged until trade costs cross the critical value of τ_s. As one moves through this critical value, industry begins to agglomerate in one region and which region receives all industry depends on the exogenous shock or so called "historical event"[7]. At these low trade costs manufacturing firms can locate anywhere and serve other regions without incurring any additional costs. While the excess demand for labour in the receiving region generates a wage gap between two regions, as long as labour mobility can eliminate the inter-regional wage gap, then other firms follow and eventually, complete industrial agglomeration in one region is reached.

Figure 1: Monotonic Relationship between Agglomeration Process and Trade Costs in Krugman (1991)



Fugure 1.

Source: Modified version of figure in Ottaviano and Puga (1997).

[6] τ denotes a Samuelson-type iceberg cost. If one wants to import one unit of a good from region A into region B, then one needs to ship τ ($\geq$1) units of that good, since τ-1 melts down during the trip, i.e., τ-1 is the trade cost. Therefore, τ =1 implies no trade costs.

[7] For example, suppose the authority in one region introduces a tax incentive for firms that can increase their net profits, this will be the region into which the firms move.

By contrast, the assumption that labour is not inter-regionally mobile in Venables (1996) and Puga (1999)'s models creates a dispersion force to counteract the IRS agglomeration advantages, so the industry-agglomeration process goes through five stages under different levels of trade costs and shows a non-monotonic (or bell-shaped) relationship. This is illustrated in Figure 2. In Stage 1, when trade costs are very high, serving one region from another is not economically profitable and hence firms in the manufacturing industries distribute evenly across two regions. As trade costs reduce, the industry begins to agglomerate (Stage 2) in one region and if the costs continue to fall, then complete agglomeration is reached between two critical values of trade costs (Stage 3). However, as trade costs reduce further, agglomeration begins to decline (Stage 4). In this stage, because of inter-regional labour immobility, the wage gap between the agglomerated and un-agglomerated regions causes more losses for firms than the agglomeration advantages they receive. Consequently, it drives previously agglomerated industry back to the less agglomerated periphery region. When trade costs reduce enough (Stage 5), industries distribute evenly in two regions again.

Figure 2: Bell-shaped Relationship between Agglomeration Process and Trade Costs in Puga (1999)

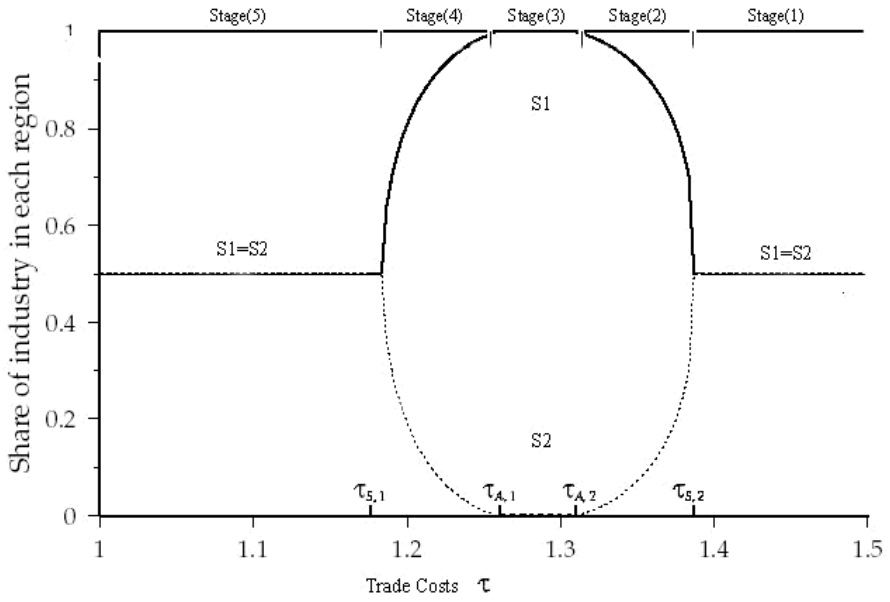


Figure 2.

Source: Modified version of original figure in Puga (1999).

The differences in predictions of different NEG models are also reflected in the mixed evidence of industrial agglomeration found in related empirical research at sector level in the EU in the period prior to the Single Market. Using data on 11 European countries and 18 industries (including the chemical industry) between 1980 and 1990, Brülhart and Torstensson (1996) found that indices of IRS are positively correlated with the locational Gini coefficients, which suggests that industries with higher levels of IRS are more concentrated in selected European countries. Noting the significant non-tariff barriers between the EU countries, they suggest that IRS industries will become more concentrated after 1990 if non-tariff barriers cease to hinder free trade. Amiti (1998, 1999) found similar results - during the period between 1968 and 1990, industries (including the pharmaceutical industry) characterized by high-scale economies and high proportions of intermediate goods in production showed an increase in geographical concentration across EU-12 countries. In contrast, using the Gini coefficient of concentration, Midelfart-Knarvik et al. (2002) found diverse trends of concentration across industries, with a very slow process of dispersion in geographic distribution for manufacturing sectors overall from the 1970s to the 1990s.[8]

Turning to the more recent period, Aiginger and Davies (2004) and Aiginger and Pfaffermayr (2004) examined the geographic concentration of industries in the EU for the period up to 1998. They found, for the post 1992 period, industrial concentration declined across 14 EU countries. They suggest this evidence is consistent with a non-monotonic relationship, i.e., the left part of arc in the bell-shaped curve in Figure 2, where decreasing transport costs lead to dispersion.[9]

The somewhat conflicting evidence on the direction of the relationship between industrial agglomeration and trade-cost levels in the EU suggests that further research is warranted. In the rest of this paper we use data at firm level for the pharmaceutical industry to test further the predictions of the different NEG models using the natural experiment of the fall in trade costs for this industry during the 1990s.

[8] Specifically, in the case of the medium and high IRS industries (including the drugs and medicines industry), they find a diminishing trend in the geographic concentration in central European countries before 1990.

[9] Combes and Overman (2004) provide a comprehensive survey of studies in this area.

3. The European Pharmaceutical Industry: Theoretical Implications and Real Trends

Trade costs within the EU fell dramatically following the introduction of the Single Market Programme, which effectively abolished non-tariff barriers (NTBs) within the EU with effect from 1993. In the context of decreasing trade costs, NEG models predict that the agglomeration level of industries in the European Union can either be strengthened (see Figure 1 and Stage 2 in Figure 2) or be weakened (see Stage 4 in Figure 2). Because the NTBs were particularly important elements in the trade costs for the pharmaceutical industry, and this industry features high increasing returns to scale, we suggest that it is a natural case study for exploring the agglomeration predictions of NEG models. Clearly, the question of whether the agglomeration of the European pharmaceutical industry was strengthened or weakened in the past decade depends on the level of trade costs prior to and after 1993. Unfortunately, because there is no benchmark by which to judge how high the level of trade costs was, one cannot tell the precise stage of agglomeration in pharmaceuticals in Figure 1 or Figure 2 before the fall in trade costs.

However, we can measure the actual agglomeration trend of the whole European pharmaceutical industry over the past decade. The Theil Index [10] and the Gini coefficient of concentration [11] are used to measure the geographic concentration (agglomeration)[12] of production of the pharmaceutical industry in 14 European Union countries from 1993 to 2002. [13] Two concentration measures of pharmaceutical

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[10] The Theil Index is defined as $\frac{1}{N}\sum_{i}^{N}\frac{x_i}{\bar{x}}\ln(\frac{x_i}{\bar{x}})$, where x_i is pharmaceutical production in country *i*, $\bar{x}=\frac{1}{N}\sum_{1}^{N}x_i$, and N is the number of countries. This index is bounded between $\ln N$ (highly concentrated) and 0 (evenly distributed).

[11] The Gini coefficient of concentration is defined as the area between the Lorenz curve and 45 degree line in a space where S_i, the pharmaceutical production share of country *i* in the data set that under investigation, is cumulated on the Y-axis and the number of countries cumulated on the X-axis with equal interval of width 1/N. Countries are ranked by S_i.

[12] The terms concentration and agglomeration are used interchangeably in this paper and both refer to the distribution pattern of industry production in given geographic area (countries in this paper) in the absolute term.

[13] Due to data availability, we can only calculate cross-country Theil Indices and the Gini coefficients of concentration for 14 European countries from 1993 to 2002. These countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the UK.

production are based on the employment level and gross output, using data from the OECD STructural ANalysis (STAN) database. Figure 3 presents changes in the Theil Indices for pharmaceutical production over the 10-year period, with the Theil Index of deflated GDP for comparison. The figure clearly shows a decreasing trend in agglomeration of pharmaceutical production, especially when measured in terms of gross output. During the same period, the geographic concentration of GDP is virtually unchanged, which suggests that the decreasing trend in agglomeration of pharmaceutical production is not simply a mirror of changing trends in economic agglomeration. Figure 4 presents changes in the Gini coefficients, which also confirm the dispersion trends of the pharmaceutical industry. This finding is in line with that in Midelfart-Knarvik et al. (2002), who use the same concentration measure (the Gini coefficient of concentration) and database (OECD) to measure dispersion trends in the same industry before 1990's.

Figure 3: Theil Indices of Geographic Concentration of Pharmaceutical Production in Selected European Countries

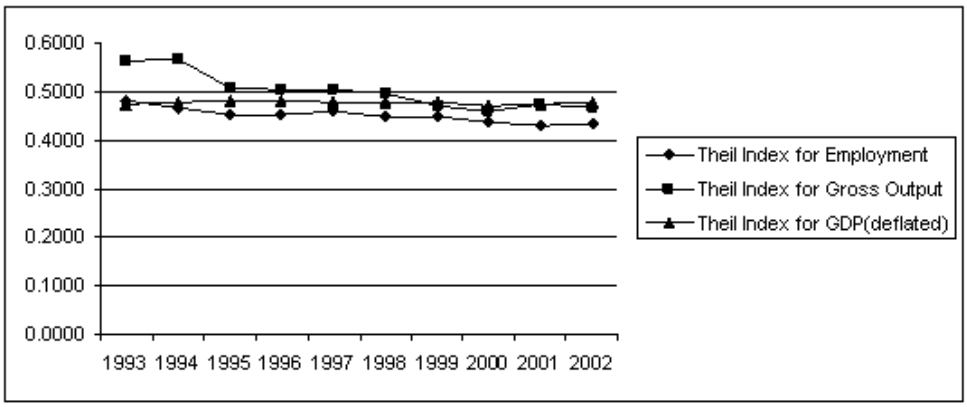

Figure 3.

Source: OECD STAN Database, EU15, excl. Luxembourg.

Figure 4: The Gini Coefficients of Concentration for Pharmaceutical Production in Selected European Countries

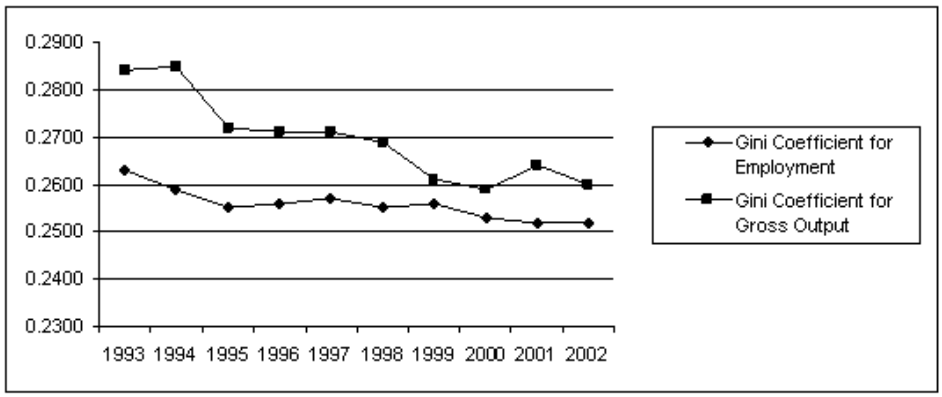

Figure 4.

Source: OECD STAN Database, EU15, excl. Luxembourg.

Given the lowering of trade costs, the decreasing agglomeration trend of the pharmaceutical industry suggests that this industry has been moving down along the left part of the arc (Stage 4) in Figure 2. This movement is consistent with Puga's model but not with Krugman's model, thus implying that either the wage gap between Member States or congestion costs in the agglomerated regions are driving this industry to the less agglomerated regions.

In terms of pharmaceutical MNEs' location-choice decisions, this downward trend implies that the previous agglomeration of pharmaceutical production at country level may reduce the probability of an MNE choosing a plant or plants in a particular country as a base for output expansion. However, previous agglomeration is not the only driving force of MNEs' location-choice decisions but operates alongside other economic and policy influences at play. Consequently, in the discrete-choice model, we isolate the agglomeration effect by controlling for these other effects. We focus particularly on market (product and labour) effects and tax-policy (corporate-tax rates) effects.

4. Data and Empirical Approach

4.1 Data

In this study, we focus on the location choices of expansion in their subsidiaries by MNEs taking place in the pharmaceutical industry[14] in the EU-15 countries.[15] Our choice of changing output expansion in existing subsidiaries is a key difference between our study and studies of location choices that involve only new subsidiaries.[16] The data we use show that output expansion at existing plants accounted for roughly six times more of the output change than did the production by new subsidiaries during the period from 1993 to 2003. [17] Thus changes in production at existing plants were the major channel of potential geographic production relocation over the period. We use the commercial *Amadeus* database to identify the European subsidiaries of MNEs, whose parent company could be from any country in the world, which existed in the period from 1995 to 2003.[18] After applying certain size criteria[19], we find 725 such subsidiaries initially. Further investigation allows us to identify 448 subsidiaries out of 725 that having complete production data in both 1995 and 2003, which are necessary for one to calculate the scale of production change. A brief description of the *Amadeus* database and details about how we identify MNEs and their subsidiaries is set in Appendix 1.

Since majority of the identified subsidiaries expanded their turnover at different growth rates during the last decade, it is to be expected that subsidiaries would expand at higher growth rates in the more attractive country locations, and thus to identify

[14] The pharmaceutical industry is defined according to NACE Rev.1.1 industry code at 3-digit level. The 3-digit NACE code for the pharmaceutical industry is 244 and two 4-digit codes are assigned to its sub-industries: 2441 (manufacture of basic pharmaceutical products) or 2442 (manufacture of pharmaceutical preparation).

[15] They are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden, and United Kingdom.

[16] Those studies consider all subsidiaries established within an arbitrarily- chosen time period.

[17] A new subsidiary is defined as a firm being established after 1993 and its production value in 2003 is used for comparison.

[18] Due to the data availability in the *Amadeus*, we are only able to obtain adequate data of subsidiaries' size (measured by turnover) from 1995 to 2003, which are necessary for us to calculate the growth rate of each subsidiary. However, we exclude those subsidiaries were established between 1993 and 1995; this step takes into account the fact that a newly-born subsidiary can not achieve its full production capacity within the first few years after establishment. We think subsidiaries established in and before 1992 should be mature by 1995.

[19] Because data for small firms are generally poor in the *Amadeus*, we only choose those firms can meet at least one of the three size criteria: turnover greater than 12 million USD, or number of employees greater than 150, or total assets greater than 12 million USD.

those countries one needs to choose high-performance subsidiaries. We use the median of growth rate of all existing pharmaceutical subsidiaries as the criterion to determine high-performance subsidiaries – those subsidiaries should have above median growth rate. After applying on the whole set of identified subsidiaries, we end up with 224 high-performance subsidiaries in the sample that were established before 1993 and operated between 1995 and 2003 in EU-15.[20]

In Appendix 2, Tables A1 and A2 summarize the descriptive statistics and location distribution by parent nationality[21] of the high-performance subsidiaries. Comparing mean and median values for these subsidiaries, we can see that the distribution of employees, turnover and fixed assets is skewed towards larger subsidiaries; the distribution of age is skewed toward older subsidiaries; and the distribution of growth rates is skewed towards fast-growing subsidiaries.

Turning to the geographic distribution of subsidiaries, we see that France, Italy, Spain and UK account for the majority of high-performance subsidiaries during the period between 1995 and 2003. The relatively low representation of Germany amongst high-performance subsidiaries may in part be due to the fact that German firms are under-represented in the *Amadeus* (as explained in its Help File).

4.2 The Conditional Logit Model and the Mixed Logit Model

The first discrete-choice model we use is McFadden's conditional logit model. McFadden (1974) models discrete choices in terms of an individual *i (i=1,...., I)* making a choice j among J alternatives to maximize his/her perceived utility (U_{ij}) conditional on the characteristics (X_{ij}) of each alternative. The perceived utility generated by individual *i* from choosing alternative *j* can be expressed as

(1) $$U_{ij} = X'_{ij}\beta + \varepsilon_{ij},$$

where X_{ij} is a vector of alternative *j*'s characteristics, which are observable to the individual as well as to the researcher; β is a vector of coefficients measuring the

[20] While our data cover EU-15, in practice we only find high-performance subsidiaries locating in 11 of the EU-15 countries: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden, and UK.
[21] The MNE parent's nationality is decided by headquarter's location.

influence of these characteristics on the individual's utility and ε_{ij} is the unobservable random element of the individual's utility.[22]

McFadden proposed that, if (and only if) the random element $\varepsilon_{ij}, \forall j = (1,...,J)$ follows a type I extreme value distribution, independently and identically (IID) across *J* alternatives and *I* individuals, the probability of alternative *k* being chosen over other alternatives can be expressed as

$$(2) \qquad \Pr(y = k \mid 1,...,J) = \frac{\exp(X'_{ik}\beta)}{\sum_{j=1}^{J} \exp(X'_{ij}\beta)}.$$

Independent and identical distribution of the random element ε_{ij} means that there is no correlation between any two alternatives in terms of utility, which gives the CLM a strong property that the ratio of probabilities of any two alternatives being chosen is independent on any other alternatives. This *Independence from Irrelevant Alternatives* (IIA) property can be easily tested because it implies that if any one of the alternatives is irrelevant to the rest in the choice set, dropping it will not result in inconsistent estimates. Based on this implication, Hausman and McFadden (1984) proposed a specification test for the validity of IIA, which can shed light on the assumption of IID of random element ε_{ij}.[23]

It is often found that the IID assumption of the random element in the utility function (1) cannot hold in some empirical research because of the unobserved utility due to variation in individuals' tastes towards some characteristics of alternatives may enter the random element and this unobserved utility causes cross-alternative correlation. We use a recently-developed *Mixed logit model* (MXL) to tackle this problem (See Train, 2003 for an extensive discussion of this model). The MXL specifies the utility function as follows,

$$(3) \qquad U_{ij} = X'_{ij}\beta_i + \varepsilon_{ij},$$

[22] ε_{ij} captures the unique taste of individual *i* to the alternative's characteristics and the contribution of any unobservable alternative characteristics to the individual's utility.

[23] In terms of the location-choice model, to perform the Hausman test for one country, one needs to exclude this country from the choice set and run the conditional logit model for the remaining countries, and then compare the estimates with estimates for the full set of countries using chi-square test. One can exclude one country at a time in turn to perform Hausman tests for every country.

where β_i is a vector of coefficients for the alternative-specific characteristics X_{ij} associated with individual *i,* and ε_{ij} is a unobserved error term following IID extreme value distribution. β_i is assumed to distribute randomly across all individuals and has a density function of $f(\beta)$. Consequently, the variation in individual's tastes towards alternatives' characteristics is accommodated in the utility function. [24] The probability of alternative *k* being chosen by individual *i* over *J* alternatives is an integral of the ratio of utility derived from alternative *k* to the sum of utilities derived from all alternatives over the density function of β_i:

$$(4) \qquad \Pr_i(y = k \mid 1,...,J) = \int \frac{\exp(X_{ik}'\beta_i)}{\sum_{j=1}^{J}\exp(X_{ij}'\beta_i)} f(\beta)\, d\beta .$$

Since β_i reflects idiosyncratic tastes of individuals towards each alternative and is usually assumed to have a normal distribution form (see Revelt and Train, 1998 and Ben-Akiva and Bolduc, 1996), the density function can be expressed as $f(\beta \mid \mu, \sigma)$, where μ is the mean of the normal distribution and σ is the standard deviation. These two parameters have to be estimated to evaluate the effect of an alternative-specific characteristic on individuals' utilities.

In this paper we will estimate the mean β and the variance σ^2 for the explanatory variables that are set to follow random distribution, and this estimation is done by using a STATA add-in programme "GLLAMM" (see Rabe-Hesketh et al., 2004).

4.3 Explanatory Variables and Empirical Model

Based on the implications of the NEG models and related empirical research, a set of explanatory variables to account for country-level differences and firm heterogeneity is constructed for the tests of their effects on MNEs' location choices.

Country-level Variables

Agglomeration Variables: Agglomeration of the pharmaceutical industry at country-level is the primary focus of this paper. Following other studies[25], sets of absolute and

[24] In effect, the CLM is a special case of the MXL where β_i is assumed to be fixed for every individual.

[25] Agglomeration forces are seen as playing an important role in location-choice studies by Bartik (1985), Head et al. (1995), Hogenbirk and Narula (2004) and Disdier and Mayer (2004).

relative measures are constructed. We use the number of employees in the pharmaceutical industry [*PHAR* in the model] in each country to measure the absolute agglomeration of the pharmaceutical industry. Since this measure is likely to be biased due to productivity differences across countries, we use gross output of pharmaceuticals [*PHAR2*] as a robustness check, but it may also be biased due to price difference across countries. The NEG models predict different agglomeration trends as trade costs decrease; therefore we have no *a priori* sign for these variables. Because input-output linkages in various NEG models imply that the pharmaceutical industry may co-locate with the chemical industry, we include two corresponding chemical-industry agglomeration variables, namely, employment level [*CHEM*] and gross output [*CHEM2*] (with a positive sign expected). As for the relative measures, we consider the shares of one country's pharmaceutical production and chemical production to its total manufacturing production (in terms of the employment level and the gross output respectively). Hence, for the corresponding absolute variables, we have [*PHARSHARE*], [*PHAR2SHARE*], [*CHEMSHAR*] and [*CHEM2SHARE*].

Market Variables: We choose the national consumption of drugs and medicines, [*CDRUG*], as a variable to proxy national market size with data coming from OECD Health Data. We expect the coefficient of this variable to be positive as many empirical research show the market size has a positive effect on the location choice.

Corporate-tax Rate: We use the effective average tax rate [*EATR*] generated by Devereux and Griffith (2003) to measure corporate tax rates. EATR is superior to the statutory tax rate as it takes account of various financial factors that a hypothetical investment project will face in a discrete location-choice context.[26] We expect a negative effect on output expansion, as shown in Devereux and Griffith (1998) for US MNEs' location choices in three European countries.

Geographic Variables: In the NEG models, trade costs are conceived as a mixture of various factors that hinder the free movement of goods between countries, e.g., tariffs and quotas, non-tariff barriers, customs inefficiency, transportation costs, etc. We focus here on distance only, on the grounds that the SMP has reduced other trade costs.

[26] These financial factors include: the statutory tax rate, the fixed asset-deprecation rate, the interest rate and the inflation rate.

Following other studies, we use the Euclidean distance to proxy transportation costs, where the distance measure [*DIST*] is that from each country's capital city to Brussels.[27] We expect that the larger is the distance from one country to Brussels, the higher are the costs of accessing European market for a manufacturer from this country and thus the lower the probability of this country being chosen as a base for expanded production.[28]

Labour-market Conditions: To take account of national differences in labour markets, labour compensation per employee [*LCOST*] in the pharmaceutical industry is derived from the OECD STAN database. To control for national labour quality we include the percentage of workers having completed tertiary education in the total manufacturing workforce [*EDU3*]. Previous empirical studies[29] lead us to believe that if EDU3 captures the skills component fully, we expect a negative sign of LCOST and a positive sign of EDU3.

Institutional Efficiency: To capture differences in institutional efficiency across countries, we use the World Bank's Aggregate Governance Indicator [*GOV*]. The precise variable used is an average of scores for six sub-indicators across seven years, where higher scores mean better governance. Although none of the literature on location choice cited above uses institutional efficiency variables, other empirical studies have found evidence that institutional efficiency (or inefficiency) is associated with FDI inflow and investment patterns for many countries (see Aizenman and Spiegel, 2002, Globerman and Shapiro, 2002 and Bénassy-Quéré et al., 2005 for the studies on large cross-section of countries; Smarzynska and Wei, 2000 for CEEC).

[27] Brussels is chosen because, according to an industry specialist consulted in the IBEC, it is seen by many leading pharmaceutical MNEs as the key distribution centre in Europe.

[28] A limitation of this variable is that its accuracy depends on the assumption that pharmaceutical production clusters within a country near its capital city. A close look at the firm-level data used here reveals that this is true for most of the countries under investigation but less true for Austria, Germany, Italy, and Spain.

[29] See Bartik (1985), Friedman et al. (1992), Devereux and Griffith (1998), Head et al. (1999), Barrios et al. (2002) and Békés (2005), which use labour market variables in the location choices of MNEs..

Firm-Heterogeneity Variables

Because firm heterogeneity is found being important in MNEs' location-choice decisions[30], we construct four firm-heterogeneity variables and interact them with country-level variables to isolate the responses of different firms to various country-level characteristics. These firm-heterogeneity variables include three dummy variables and a continuous variable.

Firm Ownership: Two dummy variables, [*EU*] and [*US*], are created to capture the nationality of the MNE parent as being an EU MNE parent and a US MNE parent respectively. In addition, a dummy variable [*TOP*] is created for those firms belonging to the top 50 global pharmaceutical MNEs (rank comes from SCRIP 100, 2005/2006), to capture the dominance of these particular MNEs in the development of the European market. Among them, 17 out of the 50 top pharmaceutical MNEs in the world are US MNEs, while another 17 MNEs are European MNEs.

Firm Production Size: An MNE's decision to expand production in a subsidiary may be influenced by the scale of increase proposed - for example, an MNE planning for a large scale expansion might more likely to be attracted by some country-level characteristics than others. If the scale of the production increase does matter in MNEs' location-choice decisions, by interacting production size with a country-level characteristic, we can identify the effect of this characteristic associated with different levels of production size. We construct a production-size variable [*SIZE*] using firms' account data from the *Amadeus*. This variable equals the difference in a firm's turnover between 2003 and 1995.

All country-level variables and firm-heterogeneity variables are listed along with their sources and expected signs in Appendix 3.

Specification of Variables

All explanatory variables enter the CLM and the MXL in logarithm form except those variables that are in percentage form, such as PHARSHARE, CHEMSHARE, EATR

[30] Basile et al. (2003) and Hogenbirk and Narula (2004) examine the firm heterogeneity among the US, Japanese and EU MNEs.

and EDU3, etc. We use the average values of country-level variables for as many previous years as are available over the period 1994 and 2003.[31]

Due to the computational load, PHAR/PHAR2, CHEM/CHEM2, PHARSHARE/PHAR2SHARE, CHEMSHARE/CHEM2SHARE, CDRUG and EATR are set to follow random distributions in the MXL specifications, while other explanatory variables are set as fixed effects.[32]

Finally, we present the complete discrete-choice model for the CLM and MXL

$$\begin{aligned}(5)\quad &\Pr(y = k \mid 1, \ldots, J) \\ &= \Lambda(\beta_1 \ln PHAR + \beta_2 \ln CDRUG + \beta_3 EATR + \beta_4 \ln DIST \\ &\quad + \beta_5 \ln LCOST + \beta_6 EDU3 + \beta_7 \ln GOV),\end{aligned}$$

where $\ln PHAR$ will be replaced by other absolute and relative agglomeration variables in different specifications. To study cross-firm variations in the response to country-level characteristics, four firm-heterogeneity variables are interacted with each of seven explanatory variables at a time, and twenty-eight regressions are run.

5. Location-Choice Results

Before describing empirical results, we first discuss how estimated coefficients can be interpreted so as to have straightforward economic meanings. Head et al. (1995) and Head and Mayer (2004) show how to derive the average probability elasticity (APE) of an explanatory variable in logarithm form by differentiating Equation (5). We follow their way to calculate the APE of a variable as

$$b_k(1-Pr),$$

where b_k is the coefficient of the variable and Pr equals to $1/L$ with L being the number of alternative countries in the choice set. In this study, there are eleven countries in the alternative set and one need to multiply the coefficients of logarithm-

[31] Expansion took place over the period from 1995 to 2003 and it was continuously influenced by the country-level variables and their changes in every year; therefore variables in any single year cannot capture their aggregated effects on expansion.

[32] GLLAMM utilizes numerical simulation technology to maximize the log-likelihood in the MXL, which implies a heavy computation load. Generally the computation load is proportional to the sample size and increases exponentially to the number of the random effects involved in the estimation. Technical issues on the estimation and simulation methods are discussed in Train (2003) and Rabe-Hesketh et al. (2004). Further information about GLLAMM is on www.gllamm.org.

form variables by a parameter of 0.91 to get APE. The coefficients of percentage-form variables can also be roughly interpreted as elasticities as well (see Bartik, 1985, pp. 18-19).

Results of the CLM and the MXL

In Table 1 we report the results of the CLM with four alternative agglomeration variables. [33] In Column 2 the absolute agglomeration in the pharmaceutical industry (lnPHAR) shows a statistically significant and negative effect, with an APE of -1.1 per cent, supporting from a firm's perspective the prediction of Puga's model on the industrial agglomeration in the EU. In effect, trade costs are at such a low level that the geographic distribution of the pharmaceutical industry become dispersing, with output expansion of MNEs being more likely to take place where the pharmaceutical agglomeration level is lower. This result is consistent with the actual dispersing trend of the whole pharmaceutical industry shown in Figure 3 in Section 3, but is contrast to most of the studies on the MNEs' location choice, which find that agglomeration has a positive impact on MNEs' location choices.

The effect of the pharmaceutical market size (lnCDRUG) is significantly positive with an APE of 1.5 per cent. This is consistent with what we expect and with results found in other studies: market size still matters in the Single Market despite the fact that the rigidities of national borders are supposed to be negligible. The elasticity of the effective average tax rate (EATR) is statistically significant and negative, at approximately -0.1 per cent.

The geographic variable, lnDIST shows a statistically significant positive effect, implying that pharmaceutical production was leaving core countries in Europe to move to periphery countries. The fact that MNEs are relocating their production away from the European geographic centre is consistent with there being a negative agglomeration effect because pharmaceutical production was traditionally concentrated in those core countries. Midelfart-Knarvik et al. (2002) noted that "*12% of Drugs &*

[33] Various combinations of explanatory variables are tried to select the "best specification" in terms of goodness of fit. The Pseudo R^2 and Bayesian information criterion (BIC), as well as economic rationale are used to judge different specifications, which found that the employment is better than the gross output to proxy the agglomeration in two industries in both absolute and relative terms. The results of specification selection are available in our working paper in SSRN. The link is http://papers.ssrn.com/sol3/papers.cfm?abstract_id=980942.

Medicines production moved out of Germany and Italy and this production was primarily absorbed by Denmark, the UK, Ireland and Sweden.(pp.235)" for the period prior to 1990. Our results confirm that their observed dispersion trend has continued since the implementation of the Single Market Programme. In combination these results suggest that the reduction of trade costs as a consequence of the SMP does not lead to more agglomeration, as Krugman's model predicts, but instead to further dispersion as predicted in Puga's model.

The labour costs variable (lnLCOST) is found having a significantly positive impact (APE is about 1.3 per cent) on location choice, even after controlling for labour quality (EDU3), which has an expected positive effect. This strong positive effect, while opposite to what one would generally expect, can be explained by the signal theory of labour costs that labour costs work as an indicator of labour quality. Hence, pharmaceutical MNEs, which are usually knowledge-intensive, are willing to pay high wages on the understanding that the higher pay secures better quality workers (See Békés, 2005).

The institutional efficiency (lnGOV) has a strong and unexpected negative effect with APE at level of -1.3 per cent, suggesting that something hindering pharmaceutical MNEs' development is being captured by this variable. For example, better governance in a country may be associated with a higher level of development, which in turn may be connected with higher congestion and regulatory costs, and may drive production to a lower cost country. Therefore, this result helps to explain the dispersion trend in the European pharmaceutical industry and is also in line with the effect of agglomeration (lnPHAR) on location choice.

In Column 3, the replacement of lnCHEM with lnPHAR indicates that both agglomeration variables affect location choice in a similar way, except that the effect of chemical agglomeration is not statistically significant. This result runs contrary to the implications of input-output linkages in the Venables (1996) and Puga (1999) models, which predict that pharmaceutical production should be attracted to the location where the chemical industry agglomerates. One possible explanation could be that if the Single European Market means that the European chemical industry has begun to move out of the previously agglomerated countries during the last decade,

then this might be expected to happen in any component of this industry (including the pharmaceuticals). This issue merits further investigation. Coefficients of all other country-level variables have similar magnitude and signs to those in Column 2, except that the coefficients of lnDIST and lnLCOST lose their significance.

Columns 4 and 5 present the specifications using relative measures of agglomeration in both the pharmaceutical and chemical industries taken separately. We find that the relative agglomeration variables also have negative effects on MNEs' location choices and this evidence supports the robustness of our claim of a dispersion trend in the European pharmaceutical industry after 1992. In these two specifications lnDIST is dropped because it is highly correlated with PHARSHARE and CHEMSHARE. [34] The remaining explanatory variables show similar effects as those found in Columns 2 and 3 and the changes in their magnitudes and significance levels appear to be due to removal of lnDIST.

To test if the IIA property holds in our sample, Hausman tests are performed for the specifications using the absolute and relative measures of industrial agglomeration and the result for one specification is reported in Table 2 for every country (excluded), while Hausman tests on other specifications produce similar results. Chi-Squared Statistics show that when Germany, Portugal, Spain and Sweden are excluded respectively from the country set, the estimates are significantly different from the estimates using complete county set. Since the IIA property (as well as the assumption of IID) cannot hold, we estimate the MXL using the same specifications. The results of the MXL are reported in Table 3. For the six variables that are set as random effects (lnPHAR, lnCHEM, PHARSHARE, CHEMSHARE, lnCDRUG and EATR), the MXL estimates has very similar effects to those estimated by the CLM. [35] Log-likelihoods generated in the four MXLs are only marginally larger than those generated by the corresponding CLMs, which suggest that the MXL's performance in this sample is not much better than that of the CLM. In terms of the CLM's performance, Train (2003) explains that if the model is correctly specified so that the sources of cross-alternative

[34] Coefficients of correlation for lnDIST/PHARSHARE and lnDIST/CHEMSHARE are all close to 0.8. We find that high correlation makes the coefficients of either relative agglomeration variables or distance variable statistically insignificant. The results are available upon request.

[35] The cross-firm variations of six random-effect variables are estimated by the MXL as variances, which are reported in Table 3 following the coefficients with their standard errors.

correlation are controlled explicitly in the utility function, the random element of the utility function should be independent and the estimates of the CLM should be reliable. Hence, we can conclude that by comparing two discrete-choice models, the application of the CLM and its specification is justified.

Results for Firm Heterogeneity

We introduce firm ownership and size effects into the CLM by interacting the ownership dummies or the size with each of explanatory variables, in order to identify the heterogeneous responses of MNEs to various country-level characteristics. Because the interaction terms are highly correlated with each other, they enter the model separately.[36] Since there are four firm heterogeneity variables and seven country-level variables (for the specification using lnPHAR), total twenty-eight estimations are made. [37] Only the statistically significant coefficients of the interaction terms are reported in Table 4, along with the major effects of corresponding country-level variables. [38]

Looking at the major and interaction effects in Table 4 in the context of EU MNEs (Regression 1 and 2), we find that, in their output-relocation decisions, they respond relatively more negatively to industrial agglomeration. However, the interaction effect of labour costs to EU MNEs is negative. This finding can be understood as suggesting that since EU players should be comparatively more familiar with local labour market than their foreign counterparts, they are less likely to rely on the signalling function of labour costs.

US dummy does not reveal any statistically significant heterogeneity among US MNEs compared with other MNEs and those results are not reported in Table 4. The result of Regression 3 suggest that the top 50 global pharmaceutical MNEs are less likely to expand in countries with high labour quality, which is often associated with high labour costs, while last three rows show how MNEs' location choices of expansion are

[36] Usually the coefficient of correlation for any pair of interaction terms is higher than 0.8.
[37] The MXL takes into account firm heterogeneity in the estimation of effects of the explanatory variables, and thus it is less useful for estimating the marginal effects using interaction terms. Another concern of using the MXL is computational load, which is very heavy.
[38] We repeat the same analysis for the specifications using lnCHEM, PHARSHARE and CHEMSHARE. The results show very similar heterogeneous effects of country-level variables as those reported in Table 4. Therefore we do not report them here and they are available upon request.

related to size, with significant but very weak interaction effects which reinforce the major effect in the cases of labour costs, but offset them in the case of the distance from Brussels and institutional efficiency.

6. Summary and Conclusions

The New Economic Geography models in Puga (1999) and Venables (1996) predict that industrial agglomeration between two regions will firstly strengthen and then disperse as trade costs decrease from a high level to a low level. Their models predict that there are stages when, as trade costs decrease, industries in one region may move between regions in such a way that the overall distribution of industries becomes more or less dispersed.

Examining the European pharmaceutical industry using the Theil Index and the Gini coefficient of concentration, we observe increased geographic dispersion of production across EU member states since 1993, when the Single Market Programme effectively reduced the level of trade costs among those countries. This outcome is consistent with the Puga-Venables' prediction. It suggests that we should test the hypothesis that, during the past decade, the agglomeration of pharmaceutical production at country level in the EU may have negatively impacted on the location choices of pharmaceutical MNEs that were expanding production in existing subsidiaries.

We test this hypothesis and at the same time examine the effects of a set of other country-level characteristics on pharmaceutical MNEs' location choices, using discrete-choice models. Estimations are made based on a sample of subsidiary firms that experienced high levels of output expansion in the period between 1995 and 2003. Firm heterogeneity is also introduced in the conditional logit model by interacting firm characteristics with explanatory variables.

The results show that, for MNEs wishing to expand production in their existing firms, the agglomeration of the pharmaceutical industry or the chemical industry, the corporate tax rate and institutional efficiency have negative impacts on a country's attractiveness, while market size for medicines, distance from Brussels, labour costs

and labour quality show positive impacts. This evidence supports the Puga-Venables prediction about of the relationship between industrial agglomeration and trade costs. We also found evidence of cross-firm variation in MNE's responses to various country-level characteristics.

These results can be understood in terms of the segmentation of the European pharmaceutical markets prior to 1993, which was due to tough national regulations and price controls imposed on pharmaceutical products. As pointed out in the Cecchini Report (Cecchini et al., 1988), "…, *the sector (Pharmaceuticals) is highly regulated, with two areas of regulation (market registration and price controls) …Admission of new products to national markets is subject to registration procedures to … All EC countries have measures to control public expenditure on pharmaceuticals*. (pp.66-67)" In effect, European pharmaceutical markets were so segmented in the early years that MNEs had to set up production facilities in each country in order to access local markets, no matter what the business environment was like.[39] Since the implementation of the Single Market Programme, MNEs can be more footloose than before in determining where to locate additional production in response to more/less favourable local business climates.

Our results show that in an integrating European market, corporate tax policy, in the form of low tax rates, and investment in human capital, in the form of labour quality, can increase a country's attractiveness to MNEs.

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[39] For a further discussion of the regulation of the European pharmaceutical industry, see Burstall (1990), Burstall et al. (1999), Gambardella et al. (2000), Danzon and Chao (2000) and Abraham and Smith (2003).

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Table 1. CML: Determinants of the Location Choice of Output Expansion

Explanatory Variables	Column 2	Column 3	Column 4	Column 5
lnPHAR	-1.225** *(0.572)*	-	-	-
lnCHEM	-	-0.508 *(0.309)*	-	-
PHARSHARE	-	-	-0.645* *(0.355)*	-
CHEMSHARE	-	-	-	-0.132* *(0.078)*
lnCDRUG	1.638*** *(0.376)*	1.254*** *(0.272)*	0.659*** *(0.234)*	0.778*** *(0.186)*
EATR	-0.083*** *(0.027)*	-0.077*** *(0.026)*	-0.093*** *(0.023)*	-0.075*** *(0.025)*
lnDIST	0.296* *(0.177)*	0.179 *(0.155)*	-	-
lnLCOST	1.444* *(0.836)*	0.769 *(0.697)*	1.175 *(0.749)*	0.796 *(0.605)*
EDU3	0.041** *(0.020)*	0.063*** *(0.017)*	0.066*** *(0.015)*	0.073*** *(0.015)*
lnGOV	-1.406** *(0.601)*	-1.667*** *(0.603)*	-2.239*** *(0.550)*	-2.057*** *(0.524)*
# of Obs.	224	224	224	224
Log-likelihood	-437.0826	-438.1050	-438.0743	-438.3462

Note: *** significant at 1 per cent, ** significant at 5 per cent level, * significant at 10 per cent level; standard error in parentheses; the coefficients can be interpreted as average partial elasticity (APE) after being multiplied by 0.91. See Section 5 for details about the calculation of APEs.

Table 2. Hausman Test for the CLM

#	Country excluded	Chi-Squared Statistics	Conclusion
1	Belgium	1.42	IIA cannot be rejected
2	Denmark	3.95	IIA cannot be rejected
3	France	2.02	IIA cannot be rejected
4	Germany	17.81***	IIA rejected
5	Greece	5.50	IIA cannot be rejected
6	Ireland	0.32	IIA cannot be rejected
7	Italy	0.56	IIA cannot be rejected
8	Portugal	14.35**	IIA rejected
9	Spain	12.85*	IIA rejected
10	Sweden	18.74***	IIA rejected
11	UK	0.02	IIA cannot be rejected

Note: The specification used in this test is that in Column 2 in Table 1, where the agglomeration variable is lnPHAR. Hausman tests on other specifications also produce similar results.
*** significant at 1 per cent level, ** significant at 5 per cent level and * significant at 10 per cent level.

Table 3. MXL: Determinants of the Location Choice of Output Expansion

Explanatory Variables	Column 2	Column 3	Column 4	Column 5
lnPHAR	-1.306** *(0.602)*	-	-	-
Variance	0.113 *(0.387)*	-	-	-
lnCHEM	-	-0.506 *(0.321)*	-	-
Variance	-	0.040 *(0.195)*	-	-
PHARSHARE	-	-	-0.895** *(0.446)*	-
Variance	-	-	1.913 *(1.704)*	-
CHEMSHARE	-	-	-	-0.149 *(0.104)*
Variance	-	-	-	0.008 *(0.034)*
lnCDRUG	1.757*** *(0.427)*	1.281*** *(0.283)*	1.109*** *(0.351)*	0.817*** *(0.219)*
Variance	0.243 *(0.517)*	0.002 *(0.037)*	0.035 *(0.101)*	0.021 *(0.072)*
EATR	-0.099*** *(0.037)*	-0.080*** *(0.030)*	-0.157*** *(0.048)*	-0.081** *(0.032)*
Variance	0.004 *(0.007)*	0.003 *(0.005)*	0.011 *(0.011)*	0.001 *(0.004)*
lnDIST	0.301* *(0.180)*	0.205 *(0.166)*	-	-
lnLCOST	1.372 *(0.862)*	0.845 *(0.748)*	0.237 *(0.934)*	0.754 *(0.658)*
EDU3	0.040** *(0.020)*	0.065*** *(0.017)*	0.067*** *(0.015)*	0.074*** *(0.016)*
lnGOV	-1.355** *(0.609)*	-1.677*** *(0.620)*	-1.615** *(0.637)*	-1.988*** *(0.579)*
# of Obs.	224	224	224	224
Log-likelihood	-436.7510	-437.9173	-435.8020	-438.2529

Note: *** significant at 1 per cent, ** significant at 5 per cent level, * significant at 10 per cent level; standard error in parentheses; lnPHAR, lnCHEM, PHARSHARE, CHEMSHAR, lnCDRUG and EATR are set as random effects in the mixed logit model; their variances are reported following the coefficients. The coefficients can be interpreted as average partial elasticity (APE) after being multiplied by 0.91. See Section 5 for details about the calculation of APEs.

Table 4. CLM: Selected Interactions of Firm Heterogeneity with Country-level Variables from Multiple Regressions

		Major Effect		Interaction Effect
Regression 1 EU (dummy) interacts with lnPHAR	lnPHAR	-0.915 *(0.593)*	EU*lnPHAR	-0.463** *(0.230)*
Regression 2 EU (dummy) interacts with lnLCOST	lnLCOST	2.156** *(0.951)*	EU*lnLCOST	-0.930* *(0.529)*
Regression 3 TOP (dummy) interacts with EDU3	EDU3	0.063*** *(0.023)*	TOP*EDU3	-0.044** *(0.021)*
Regression 4 SIZE interacts with lnDIST	lnDIST	0.400** *(0.183)*	SIZE*lnDIST	-2.95e-07*** *(1.14e-07)*
Regression 5 SIZE interacts with lnLCOST	lnLCOST	1.182 *(0.845)*	SIZE*lnLCOST	1.89e-06*** *(6.70e-07)*
Regression 6 SIZE interacts with lnGOV	lnGOV	-1.738*** *(0.623)*	SIZE*lnGOV	1.09e-06** *(5.08e-07)*

Note: Each of four firm heterogeneity variables, EU, US, TOP and SIZE is interacted with one of seven explanatory variables at a time. EU dummy equals one for a firm having a European MNE parent; US dummy equals one for a firm having a US MNE parent; Top dummy equals one if a firm's parent is one of the top 50 global pharmaceutical MNEs; Size is the difference of turnover between 2003 and 1995. Twenty-eight regressions with interaction term are estimated.

Only six regressions have statistically significant interaction effects and they are reported in the table along with major effect of explanatory variable; US dummy does not result in statistically significant effects when interacting with each explanatory variable; agglomeration is measured by lnPHAR.

*** significant at 1 per cent level, ** significant at 5 per cent level, * significant at 10 per cent level; standard error in parentheses.

Appendix 1. The Amadeus Database and Identification of Subsidiaries

Compiled by the Bureau Van Dijk, the *Amadeus* collects both public and private firm accounts for 38 European countries. It is able to provide researchers with comprehensive information on increasing numbers of firms from 1992. This information covers the balance sheet, the profit and loss account, various financial ratios, the ownership data, the industry classification code, address details and the year of incorporation. Therefore, it allows one to trace a firm's birth and evolution over time.

In the build-in ownership database in the *Amadeus*, each firm is linked to its shareholders and the value of each shareholder's share in that firm is available. We mainly rely on this ownership database to identify a subsidiary firm's parent. Sometimes, a firm may have more than one MNE shareholder, and its MNE shareholders may be inter-linked. Usually the *Amadeus* marks one of the MNE shareholders as the ultimate owner of the subsidiary firm. In the event that it does not, we define, from among all MNE shareholders a subsidiary has, the MNE shareholder that has the largest share (directly, or indirectly through other subsidiaries) as its ultimate owner. By doing so, each subsidiary is linked to only one MNE shareholder as its MNE parent, and all ultimate MNE parents defined by this way are independent of each other. Therefore, these clean "parent - subsidiary links" allow us to study ownership effect on MNEs' location choices (through subsidiaries).[40]

[40] By defining an ultimate owner as having the largest share in a firm, we avoid the complication of joint ventures. According to the ownership database in the *Amadeus*, only one joint-venture case where two parents have exactly 50 per cent shares each in a subsidiary is found, which is Bracco Spa, an Italian company owned equally by E.MERCK (Germany) and Brafin Finanziaria Spa (Italy). We somewhat arbitrarily treat Bracco Spa as the subsidiary of E.MERCK because E.MERCK is a leading European pharmaceutical multinational.

Appendix 2. Description of the High-Performance Subsidiaries

A1: Summary Statistics

Variable	Mean	Median	Std.Dev.	Min	Max
No. of Employees	736.2	281	1,275.7	11	10,076
Turnover (thousand USD)	465,977.4	98,443	948,096.3	2,523	6,669,416
Fixed Assets (thousand USD)	295,857.9	25,834	1,581,229.4	8	18,724,261
Age (until 1993)	30.8	26	21.8	3	122
Growth Rate of Turnover (Ratio of Turnover in 2003 to Turnover in 1995)	23.1	3.2	180.7	2.1	2601

Note: High-Performance subsidiaries are those subsidiaries experiencing above-median growth (among all existing subsidiaries) in terms of turnover between 1995 and 2003. Reported value in the table is for 2003 (except Age). Number=224.

A2: Geographic Distribution of the Output-Expansion Sample (by Nationality of Ownership)

Nationality \ Location	Belgium	Denmark	France	Germany	Greece	Ireland	Italy	Portugal	Spain	Sweden	Great Britain	Sum (Share, per cent)
EU MNE Parent	6	4	46	5	4	2	23	7	40	2	12	151 (67)
US MNE Parent	3	0	10	2	1	0	9	1	8	0	13	47 (21)
Other Non-EU MNE Parent	1	0	8	1	0	1	9	0	3	0	3	26 (12)
Sum (Share, per cent)	10 (4.5)	4 (1.8)	64 (28.6)	8 (3.6)	5 (2.2)	3 (1.3)	41 (18.3)	8 (3.6)	51 (22.8)	2 (0.9)	28 (12.5)	224 (100)

Appendix 3. List of Country-Level Variables and Firm-Heterogeneity Variables

Variable	Description	Expected sign	Source
Country-level Variables			
PHAR/ PHAR2	Number of employees in the pharmaceutical industry (100 person) / Gross output in the pharmaceutical industry (million euros, deflated to base year 1994).	?	OECD STAN industry
PHARSHARE/PHAR2 SHARE	The shares of one country's pharmaceutical production to its total manufacturing production (in terms of the employment level and the gross output respectively).	?	OECD STAN industry data
CHEM/ CHEM2	Number of employees in the chemical industry (100 persons) / Gross output in the chemical industry (million euros, deflated to base year 1994).	+	OECD STAN industry data
CHEMSHARE/CHEM2 SHARE	The shares of one country's chemical production to its total manufacturing production (in terms of the employment level and the gross output respectively).	+	OECD STAN industry data
CDRUG	National consumption of drugs and medicines (millions USD, deflated to base year 1994).	+	OECD Health Data
EATR	National effective average tax rate (per cent) created by Devereux and Griffith (2003).	-	The Institute for Fiscal Studies
DIST	Geographic distance from capital city to Brussels (km).	-	CEPII's dyadic
LCOST	National labour compensation per worker in the pharmaceutical industry (euros). Labour compensation is defined as "wages as well as the costs of supplements such as employer's compulsory pension or medical payments."	-	OECD STAN industry data
EDU3	National share of workers with a tertiary level education in manufacturing workforce (per cent).	+	Eurostat
GOV	The Governance indicator, which contains six sub-indicators of different institutional aspects of a country for seven years from 1996. They are voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control for corruption. The higher the score is, the better governance is.	+	World Bank
Firm Heterogeneity Variables			
EU	Dummy variable=1 if EU MNE parent.		The *Amadeus*
US	Dummy variable= if US MNE parent.		The *Amadeus*
TOP	Dummy variable=1 if the top 50 global pharmaceutical MNEs (2004 rank by sales).		SCRIP 100 (2005/2006), compiled by KPMG
SIZE	Turnover change between 1995 and 2003.		The *Amadeus*

Year	Number	Title/Author(s) ESRI Authors/Co-authors Italicised
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