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What Determines the Attractiveness of the European Union to the Location of R&D Multinational Firms?

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Abstract

We analyse 446 location decisions of R&D activities by multinational firms incorporated in the European Union over 1999-2006. Our results suggest that on average, the location probability of a representative R&D foreign affiliate increases with agglomeration economies from foreign R&D activities, human capital, proximity to centres of research excellence and the research and innovation capacity of the region. We find evidence of geographical structures relevant for the location choice of R&D activities by multinational firms across the European Union. Further, our evidence suggests that while R&D government expenditure intensity increases the probability of location of European foreign-owned firms in the region, it does not have a significant effect on the probability of location of North American firms.

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What Determines the Location Choice of R&D Activities by Multinational Firms?

1 Introduction

There has been a growing internationalisation of enterprise R&D activities over the last two decades. Multinational enterprises (MNEs) are the main drivers of this growing internationalisation of enterprise R&D and in many countries foreign affiliates carry out more R&D than domestic firms (OECD, 2007; Abramovsky et al., 2008). While traditional cross-border R&D enterprise activities have tended to locate in developed economies, an increasing amount of R&D outward investment in recent years has gone to emerging economies (OECD, 2007; European Commission, 2008; Sachwald, 2008).

In recent years, the speed and extent of the internationalisation of R&D have increased (von Zedtwitz and Gassmann, 2002; UNCTAD, 2005; Abramovsky et al., 2008). This increased mobility of R&D and innovation activities has been linked to increased global competition, technological change, in particular the use of information and communication technologies (ICT) and the availability and costs of skills (Abramovsky et al., 2008, OECD, 2008). In addition to the traditional role of R&D foreign investment in diffusing technology (demand-driven) related to adapting products and services to local market conditions and supporting MNEs local manufacturing operations, R&D foreign investment is being increasingly motivated by tapping into worldwide centres of knowledge (supply-driven) as part of firms strategies to source innovation globally (Wortmann, 1990; Hakanson and Nobel, 1993; Florida and Kenny, 1994; Florida, 1997; Patel and Vega, 1999; Le Bas and Sierra, 2002; Iwasa and Odagiri, 2004; von Zedwitz and Gassmann, 2002; Ambos, 2005; Abramovsky et al. 2008; OECD, 2008).

Over the period 1995-2005, the share of foreign affiliates in total business R&D expenditure has increased substantially in almost all European Union's countries (European Commission, 2008). In 2005, this share was over 70 per cent in Ireland, over 50 per cent in Belgium and the Czech Republic, over 40 per cent in Austria and Sweden. In contrast, the share of R&D expenditure by foreign affiliates was lower, less than 25 per cent in Slovakia and Finland. The European Union (EU) is the largest recipient of R&D investment by US multinationals. In 2005, the EU accounted for 62.5 per cent of the R&D expenditure of affiliates of US parent companies abroad. Abramovsky et al. (2008) show that in comparison to 1990, over the period 2000-2004, the average level of innovative activity of multinational firms from EU countries located abroad grew faster than their innovative activity conducted in the home country. This dynamics has lead to a growing share of the innovative activity located abroad in the total innovative activity of multinational firms.

This increasing internationalisation of R&D activity in the EU raises a number of questions which are interesting and relevant for both research and policy making: Where are the R&D activities of multinational enterprises located? Who are the main foreign investors in R&D activity? What factors drive the location choice of multinational R&D activity?

To answer these questions, we analyse the determinants of the location choice of R&D activities by multinational firms across regions in the European Union. By considering regions as location choices we account for heterogeneity of locations within countries and avoid the aggregation bias which might arise when using country averages in cross-country analyses. We use a large firm-level data set[1] which enables us to consider a wide range of location choices of R&D activities by multinational

[1] The *Amadeus* data set provided by Bureau van Dijk contains information on over 18 million firms located in 43 countries in Europe. We discuss in more detail our data in Section 3.

firms. Specifically, we analyse the location choice of R&D activities of 446 new foreign affiliates incorporated in the European Union over the 1999-2006 period. The large number of location choices (233 regions) enables us to obtain robust estimates of determinants of the attractiveness of regions to foreign investment in R&D activity[2].

There has been a renewed interest in recent years in the empirical analysis of the location choice of multinational enterprises which is linked to theoretical advances in international trade and investment to account for increasing returns to scale, imperfect competition and product differentiation[3] (Head et al., 1995; Belderbos and Carree, 2002; Barry et al., 2003; Crozet et al., 2004; Disdier and Mayer, 2004; Barrios et al., 2006; Pusterla and Resmini, 2007; Basile et al., 2008). The traditional theory of multinational firms has modelled the location decision of multinational firms assuming that R&D activity is located where production takes place and it has not addressed specifically the case of the location choice of R&D activities by multinational firms. Notable exceptions are Markusen (2002) and Ekholm and Hakkala (2007). These latter theoretical contributions allow the geographical separation of knowledge-based (R&D) activities and production facilities in a two-country general equilibrium setup. The theoretical model proposed by Markusen (2002) known as the "knowledge capital model" of multinationals firms predicts that when trade costs are low, international production is likely to locate in large economies while knowledge-intensive activities will concentrate in small skills-intensive economies. The model developed by Ekholm and Hakkala (2007) allows agglomeration forces to arise in both production and R&D activities and predicts that

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[2] Data on regions is taken from the Regio data set of the Eurostat and the European Regional Dtabase provided by Cambridge Econometrics. We discuss in more detail these data in Section 3.
[3] For reviews of this literature see Fujita et al. (1999) and Markusen (2002)

international production will locate in a larger economy while R&D activities by multinationals will locate in a smaller economy to benefit from R&D spillovers.

In contrast to the slow development of the theoretical literature on the location choice of R&D activities by multinational firms, a growing number of empirical studies have analysed the internationalisation of R&D and the development of R&D global networks (Kenny and Florida, 1994; Patel and Vega, 1999; Frost, 2001; Ambos, 2005; Abramosvsky et al. 2008; Sachwald, 2008).

Given that multinational enterprises are concentrated in R&D intensive industries, many factors driving the location choice of foreign affiliates are also relevant and important in the case of R&D activities of multinationals. However, as documented in a number of recent studies in international business, in addition to demand-side factors, such as market access, factors specific to the R&D sector such as knowledge-sourcing have become increasingly important as a motivation for establishing R&D units abroad (Florida, 1997; Patel and Vega, 1999; Frost, 2001; Le Bas and Sierra, 2002; von Zedtwitz and Gassmann, 2002; Ambos, 2005; Ito and Wakasugi, 2007; Belderbos et al. 2008). Most existing studies analyse determinants of the location choice of foreign R&D in a single country setup. Cantwell and Iammarino (2000) analyse the location patterns of multinational networks for innovation in the UK regions. Frost (2001) examines the origin of external sources of innovation of US greenfield subsidiaries. Ito and Wakasugi (2007) and Shimizutani and Todo (2008) investigate determinants of Japanese R&D investments abroad and Iwasa and Odagiri (2004) anlayse determinnats of Japanese R&D investment in the US. Ambos (2005) analyses motivations of German-owned multinational enterprises with international R&D activities.

This paper builds on and extends these two strands of literature, namely the existing theoretical and empirical literatures, on international trade and investment on one hand, and on the internationalisation of R&D and global R&D networks on the other hand. We add to the empirical literature on the location choice of multinational enterprises in three ways. First, in contrast with most existing empirical studies mentioned above which consider both demand-driven (market access) and supply-driven (knowledge sourcing) motivations for foreign direct investment in R&D in a single country setup, we estimate location choice models in a multi-country setup. Second, in contrast to existing cross-country analyses, we account for heterogeneity of locations within countries and avoid aggregation bias in the estimates of the location choice determinants. Third, in contrast to previous studies, we use an improved econometric methodology to account for spatial correlation among location alternatives and firms due to unobserved location-specific characteristics.

Our results suggest that on average, the probability to locate in an EU region (NUTS 2) increases with agglomeration economies from foreign R&D activities, human capital, proximity to centres of research excellence and the research and innovation capacity of regions. There is also evidence of a geographical structure in the location choice of R&D multinational firms across the European Union. Further, we find that R&D government expenditure intensity increased the probability of location of R&D activities by European-owned multinational firms but it had no significant effect on the location of R&D activities by North American multinational firms.

The remainder of this paper is organised as follows. Section 2 describes the empirical methodology and testable hypotheses. Section 3 presents our data and summary statistics. The results of our econometric analysis are presented in Section 4. Finally Section 5 summarises our results and concludes.

2 Empirical Methodology

2.1 Modelling Location Choice

The background for our analytical framework is the literature on the behaviour of multinational firms (Dunning, 1977, 1981; Cantwell, 1994; Krugman, 1991; Horstmann and Markusen, 1992; Markusen, 1995). This literature models a multinational firm's location decision as part of a three-step decision-making process which starts with the firm's decision to serve a foreign market and follows with the choice to undertake foreign direct investment and the location choice. This analytical convention is discussed in more details by Devereux and Griffith (1998), Head and Mayer (2004) and Basile et al. (2008). In the first stage, a firm decides whether to enter a foreign market. Following the decision to enter foreign markets, the next step is the choice on whether to enter foreign markets by exporting or by foreign direct investment. If foreign direct investment is the chosen option to enter foreign markets, the firm decides where to locate. Devereux and Griffith (1998) models the location choice of multinational firms as well the options of not serving the foreign markets and of exporting as a mode to enter a foreign market. Head and Mayer (2004) and Basile et al. (2008) focus on the determinants of the location choice of international production by multinational firms.

In this paper, we focus on the last step of this process and use two discrete choice models to analyse the determinants of the location choice of R&D activities by multinational firms. First, we estimate a conditional logit model following McFadden (1974) which we use as a benchmark for our analysis. This model has been widely used for spatial choice analysis as it allows the modelling of a decision with more than two discrete outcomes (Haynes and Fotheingham 1990). This random utility maximization model assigns a utility level U_{ij} to each alternative $j = 1,.....,N$ for each decision maker $i = 1,.....I$ for vectors of observed attributes (McFadden 1974). For each firm (i) the utility from locating in a given region j depends on a deterministic component X_{ij} which is a function of the observed characteristics and some unobservable factors which are captured by a stochastic term ε_{ij} :

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

The probability that a firm i chooses to start up a plant in a region j as opposed to any other region k is then equal to the probability of U_{ij} being the largest of all $U_{i1},.....,U_{iJ}$ (Heiss 2002).

To estimate equation (1) an assumption must be made about the joint probability distribution of the unknown stochastic utilities ε_{ij}. As shown by McFadden (1974) under the assumptions of independently and identically distributed (IID) error terms with type 1 extreme value (Gumbel) distribution the probability of choosing a location h is:

(2) $$P(y = h \mid 1,..., J) = \frac{e^{\beta X_{ih}}}{\sum_{j=1}^{J} e^{\beta X_{ij}}}$$

The IID assumption on the error terms implies a statistical property in the conditional logit model, the independence of irrelevant alternatives (IIA). This property states that the relative probability ratio (the odds ratio) of any alternative being chosen over another alternative is independent of the size and composition of the choice set of alternatives. With IID, the error terms cannot contain any alternative-specific information and so adding a new alternative cannot alter existing relationships between pairs of alternatives. The assumption thus constrains the ratios to be constant over all possible choice sets. This imposes a rigid substitution pattern across all alternatives as for the odds ratio to remain constant as alternatives are added and removed from the choice set, the individual choice probability of the remaining alternatives will have to change by the same amount (Hunt 2004). If the model's IIA property is violated this will lead to biased parameter estimates. As discussed in Haynes and Fotheingham (1990), the equal substitution pattern implied by the IIA property is unlikely to hold in a spatial choice framework due to location-specific characteristics of size, aggregation, dimensionality, continuity and variation. These characteristics may yield alternatives spatially correlated in unobservable factors and so estimates will be biased.

To account for this, a generalised extreme value model within the framework of random utility maximization is used (McFadden 1984). These models allow a more complex pattern of substitution while maintaining a simple closed form structure for the choice probabilities (Sener et al 2008). Thus, the nested logit model takes into account the correlation among alternatives and it alleviates the omitted variables bias due to unobserved location-specific characteristics. The nested structure is created by grouping the alternative locations choices into nests chosen according to the degree of similarity and so correlation between the alternatives (Basile et al 2003). Therefore in the location choice model, the nests consist of regions with similar characteristics, hence correlation is allowed within but not across nests. The structure allows the independence of irrelevant alternatives (IIA) property to hold within nests but not across nests.

Following Heiss (2002), let the error term to follow a generalised extreme value distribution. Denote $\tau_k = \sqrt{1-\rho_k}$, where ρ_k is the correlation of alternatives in nest k, thus τ_k, the inclusive value (IV) parameter, measures the independence of alternatives in nest k. If $\tau_k = 1$, the alternatives are perfectly independent of each other and so there the nested structure is not required. At this value of the IV parameter the nested model collapses into the conditional logit model. If $\tau_k = 0$, perfect dependence exists and as the alternatives are perfect substitutes, the nest then becomes the alternative. One can further write the log sum of utilities generated from alternatives in nest k as follows:

(3) $$IV_k = \ln \sum_{j \in n_k} \exp(U_{ih} / \tau_k),$$

IV_k is the inclusive value of nest k (denoted by n_k). Therefore, τ_k is the IV parameter of n_k. The probability function of alternative h in nest k being chosen is the product of the probability of choosing nest k ($\Pr(k)$) and the conditional probability of choosing h given that k is chosen ($\Pr(h \mid k)$). The function can be expressed as follows:

(4) $$\Pr(y = h \mid 1,...,J) = \Pr(h \mid k)\Pr(k) = \frac{\exp(U_h / \tau_h)}{\exp(IV_h)} \frac{\exp(\tau_h IV_h)}{\sum_K \exp(\tau_k IV_k)},$$

where τ_h and IV_h are the IV parameter and the inclusive value for the nest where alternative h is in.

The choice of possible nested structures is multiple and there is no systematic way to identify a best structure amongst all possible nests (Greene and Hensher 2002). However, for the nested model to be consistent with the Random Utility Maximisation (RUM) framework - the IV parameter τ_k s has to be bounded between 0 and 1 (Heiss 2002).

2.2 Testable Hypotheses and Model Specifications

The dependent variable (y_{ij}) is the location choice of each R&D activity of a new foreign affiliate over 233 possible locations[4]. Specifically, the dependent variable is a binary variable equal to one if firm i located in region j over the period 1999 to 2006 and zero for all regions different from j.

$$y_{ij} = \begin{cases} 1 & if\, \pi_{ij} > \pi_{ik}, \forall j \neq k \\ 0 & otherwise \end{cases}$$

π_{ij} is the expected profit for firm i in region j. Since π_{ij} is not observed we estimate it as a function of variables that are likely to influence it.

Each firm's location decision is explained as being a function of regional characteristics as well as policy variables at national level. The empirical analysis of the location choice of multinational enterprise activity distinguishes between horizontal and vertical motivations of foreign direct investment (Mayer et al. 2007). Horizontal motivations are driven by market access and market potential of an area and affect the revenue component of the profit function. Vertical motivations are concerned with the firms' cost, locating the firm and its affiliates in regions that will minimize the cost element of the profit function. The literature on the internationalisation of R&D suggest that knowledge-sourcing has become an important motivation for establishing R&D activities abroad (Florida, 1997; Frost, 2001; von Zedtwitz and Gassmann, 2002; Ambos, 2005; Ito and Wakasugi, 2007; Belderbos et al., 2008).

[4] 233 NUTS 2 regions in the European Union (EU-27) countries having at least one R&D foreign affiliate and for which data on regional characteristics are available.

For horizontal motivations, the location and demand of the final consumer market are important. Using a model with increasing returns, Krugman (1980) shows that firms will locate in larger markets and use these as a base to export to smaller markets in the region. This occurs as by concentrating production in one place the firm can simultaneously realise economies of scale (EOS) and also minimize transportation costs. This is important in the case of R&D firms as by far the most common form of overseas R&D facility is the support laboratory. The purpose of these facilities is to adapt technologies and products to local markets and also provide technical backup for local manufacturing and sales (Dicken 2004; Shimitzutani and Todo, 2008). However, as shown by Motta (1992) and Neary (2002) this relationship between market size and foreign direct investment is not monotonic as market size also affects the number and so competition between firms.

Following Harris (1954), we measure *market potential* of each host region by GDP in that region and a distance weighted sum of GDP in all other regions[5]. Our theoretical prior is a positive effect of market potential on the probability to locate in a region.

Agglomeration economies from foreign R&D activities are likely to be of particular importance as R&D activities are characterised by the need to assemble a diverse and skilled network of workers, sophisticated infrastructure and also uncertainty surrounding outcomes. This leads to a need to concentrate activities (Dicken 2004). This effect can be negative as agglomeration diseconomies, due to resources such as labour being bid up in the region (Head et al. 1999). Firm specific agglomeration occurs as it reduces the uncertainty of operating in a region and so reduces the risk of

[5] The argument made by Harris (1954) is that, in a multicounty set up, the actual demand which firms face in a given location is determined in addition to the size of local market by the sum of the market sizes of the neighbouring regions weighted by a measure of accessibility to all regions. For a discussion of measuring market potential in modelling the location choice of multinational firms see Crozet et al (2004) and Altomonte (2007).

new investments[6]. To account for this spatial dependence, we measure agglomeration by the number of R&D foreign affiliates in the same region plus a distance- weighted[7] measure taking into account foreign-owned R&D firms located in all other regions. Firms are counted at the beginning of the period to mitigate endogeneity problems. As pointed out by Head and Mayer (2004), counts of multinational firms also proxy the unobserved attractiveness of regions to foreign direct investment and thus alleviate the omitted variable bias.

As for vertical motivations, a number of factors are considered important in determining the costs of production such as labour costs, unemployment rates (a proxy for labour market flexibility), and taxation.

We proxy labour costs with *compensation per employee* in each region. The expected effect can be positive or negative. While regions with a high labour costs can indicate the presence of highly skilled workers, regions with low labour cost would be associated with low cost locations.

The effect of the *unemployment rate* on the location probability is ambiguous. On one hand, as shown in efficiency wage models, unemployment reduces workers bargaining power and increases worker effort as it increases the cost of being fired. On the other hand, high unemployment can indicate a pool of available labour but may also be related to labour market rigidities in a region.

Tax directly reduces the profits of firms. Devereux and Griffith (1998) show that corporate profit taxes significantly influence US multinational firms' decision on

[6] Barry et al (2003) provide empirical evidence showing that the presence of multinational firms in Ireland has acted as a "demonstration effect" for the attraction of new foreign direct investment.

[7] Distance is measured by estimated road - freight travel time in hours between capital cities of regions. We thank Matthieu Crozet for providing us with these estimates. The data used and estimation methodology are described in Brülhart et al (2004).

which European country to locate in. Griffith (2002) shows that R&D tax credits have a significant effect on the level of R&D investment[8]. Tax can also indicate a stock of public goods and so the sign may be positive. Benassy - Quéré et al (2000) show that firms may be willing to pay higher taxes in exchange for more public goods. To control for the effect of taxation on the location probability of R&D activities of multinational firms we use data on the top corporate tax at country level[9] .

The literature on the internationalisation of R&D (Wortmann, 1990; Hakanson and Nobel, 1993; Almeida, 1996; Daniels and Lever 1996; Florida 1997; Patel and Vega, 1999; Cantwell and Iammarino, 2000; Kumar, 2001; Le Bas and Sierra, 2002; von Zedtwitz and Gassmann 2002; Dicken 2004; Iwasa and Odagiri, 2004; Ambos, 2005; Ito and Wakasugi, 2007; OECD 2008) points to access to a strong knowledge base as a factor driving foreign investment in the R&D sector. To test this effect on the location choice of R&D activities by multinational firms, we proxy the knowledge base of regions by *patent intensity*, calculated for each region as the number of patent applications to the European Patent Office per GDP[10]. Patents have been extensively used to measure innovation output and the technology capacity of regions and countries (Jaffe et al., 1993; Almeida, 1996; Cantwell and Iammarino, 2000; Frost, 2001; Iwasa and Odagiri, 2004; Abramovsky et al., 2008). However, not all firms use patents in their innovation strategy. In addition, patents measure inventions while innovation activity is broader than inventions. Therefore, alternatively we use R&D

[8] While controlling for the tax treatment of R&D is desirable, data on R&D tax credits is not available for a sufficient number of countries and time periods.

[9] We use data on corporate tax rates available from the World Tax database available from the Michigan Business School, http://www.bus.umich.edu/otpr/otpr/default.asp

[10] We also consider the following additional measures of patent intensity at regional level available from the Regiopnal Statistics database of the Eurostat : the number of patent applications to the European Patent Office (EPO) per labour force; the number of patent applications to the EPO per employees; the number of patent applications per inhabitants. Each of these measures are highly correlated with the market potential measure (pair-wise correlations were around 0.67) and we do not use them in regressions.

expenditure intensity, which has been also extensively used to proxy innovation activity and the level of technological development (Kumar, 2001; Shimituzani and Todo, 2008). Specifically, we use three measures of R&D expenditure intensity: total R&D expenditure, business R&D expenditure and government R&D expenditure as a percentage of regional GDP. As pointed out by Our theoretical prior is a positive link between the innovation and technological capacity of the region measured alternatively by patent intensity and R&D expenditure intensity and the location probability of R&D activities by multinational firms.

Florida and Kenny (1994) have shown that an important number of Japanese R&D subsidiaries in the US are located near major research centres to access new sources of scientific and technological excellence. Abramovsky et al (2007) finds that foreign-owned R&D labs are located in the proximity of centres of university research excellence in the UK. Universities provide firms with access to high quality researchers for basic scientific research. Location close to universities indicates that R&D firms are engaging in a higher level of research than a basic production support function and are engaging in global market orientated R&D (Dicken 2004). Thursby and Thursby (2006) document the growing role of universities in global innovation systems. This result comes out from a survey of over 200 multinational firms on the factors that influence the decisions on the location of R&D. Proximity to universities ranks higher than costs factors in developed countries and it is as important as cost factors in emerging economies. To capture the effect of proximity to centres of research excellence, we include a dummy variable which is equal to one if a region has a university ranked in the t*op 500 ranked universities*[11]. We test the hypothesis

[11] We use the QS World University Ranking published annually available from http://www.topuniversities.com/university-rankings/world-university-rankings

that the presence of a top ranked university in the region is positively associated with the location choice of R&D foreign affiliates.

In this paper we focus on long-term determinants of the location choice of new R&D foreign affiliates and we do not consider firms decisions to exit markets. In the latter case, an analysis using panel data would be more suitable[12].

Explanatory variables are lagged with respect to the dependent variable to account for the fact that investment decisions are lagged in time and to avoid possible endogeneity. Detailed variables definitions and data sources are given in Table A1 in the Appendix A.

3 Data and Summary Statistics

The firm level data used in this analysis is taken from the *Amadeus* database provided by Bureau van Dijk[13], which contains information on over 18 million firms located in 43 European countries. By using data over the period 1999-2006 on ownership, location, incorporation date and industry affiliation, we identify 446 newly established R&D activities by multinational firms the EU regions. A firm is defined as foreign-owned if it had one foreign shareholder with at least 10 per cent of voting share in it. This definition is in line with the IMF and OECD's definition of "foreign direct investment enterprise" (IMF 1993). Thus, we identify 3,5 million foreign affiliates which fulfil this definition. We extract data on R&D activities by multinational firms from the database according to NACE Rev. 1.1 codes[14]. R&D activities are classified as K73.

[12] Becker et al (2005) discuss this point.
[13] Information about the Amadeus database is available from http://bvdinfo.com/Products/Company-Information/International/AMADEUS.aspx
[14] NACE is the European Communities statistical classification system for economic activities.

The identified 446 new R&D activities by multinational firms over the period 1999-2006 are located in 233 NUTS 2 regions in 21 EU countries[15]. The location choice is analysed at regional level as multinational firms consider both country and region characteristics in their decision. Regions are defined according to the NUTS 2 classification system[16]. Details of the location choices are given in Table A2 in the Appendix A. Regional data are taken from the Eurostat and the European Regional Database provided by Cambridge Econometrics[17].

Table 1 about here

Table 1 presents descriptive statistics of the locations of new R&D activities by multinational firms over the analysed period, 1999-2006. Columns one and two show the top ten countries chosen as location of the new R&D foreign affiliates. Regions in the United Kingdom and Germany attracted the bulk of foreign investment in R&D, approximately 72 per cent of the total number of R&D foreign investments. Six per cent of the new firms chose regions in the new EU countries. Column three shows the top ten countries after the number of new R&D foreign investments per GDP. Romania attracted the largest number of R&D foreign affiliates relative to its economic size. Column four shows that Inner London attracted the largest number of new R&D foreign affiliates.

[15] Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Spain, Sweden, the United Kingdom.

[16] NUTS stands for "the Nomenclature of Territorial Units for Statistics", which is a geographic coding system developed by the EU to reference administrative regions within its countries. There are three levels of NUTS codes which break countries down to finer regions one after another. Namely, they are NUTS 1, NUTS 2 and NUTS 3.

[17] Eurostat's database containing regional statistics is available from http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database
Information about Cambridge Econometrics is available from http://www.camecon.com

Table 2 provides summary statistics of the origins of the firms in our sample by broad geographical classification. 50.9 per cent of the firms in the sample originate from one of the EU-15 countries[18], Switzerland or Norway. As for individual countries the top origin country is the United States accounting for 30.7 per cent followed by Switzerland with 9.6 per cent of the number of new R&D foreign affiliates.

Table 3 presents summary statistics of the explanatory variables used in our empirical analysis.

Table 3 about here

Regional characteristics vary in particular with respect to agglomeration economies from foreign R&D activities, human capital and compensation per employee. Table 4 shows pair-wise correlations among all explanatory variables.

Table 4 about here

Total R&D expenditure intensity is highly correlated with business R&D expenditure intensity (0.9678) which indicates a high share of business R&D expenditure in total R&D expenditure. Patents intensity appears correlated with business R&D expenditure intensity (0.6585) and with total R&D expenditure intensity (0.6447). To account for these high correlations we will use Patents intensity and R&D expenditure intensity in separate regressions.

4 Econometric Results

4.1 Conditional Logit Models

Table 5 shows the estimates of the conditional logit model. The first three columns show the results obtained for newly established R&D activities by all multinational

[18] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

firms over all regions. The first column shows the model with patent intensity as a proxy for the knowledge base (innovation capacity) of regions, while in columns two and three we use R&D expenditure intensity to proxy the knowledge base of regions. The figures reported are the average probability elasticities (APE)[19] of each variable aside from the dummy variable for the presence of a top university in the region. For the variables in percentage form, the APE is evaluated at the mean value of the variable. The reported standard errors are clustered at country-level [20].

Table 5 about here

It appears that on average, other things equal, the probability to locate R&D foreign affiliates across regions in the EU was associated positively with agglomeration economies from foreign R&D activities, the presence of a top university in the region, as well as the R&D expenditure intensity. The effect of business R&D expenditure intensity appears stronger in comparison to the effect of government R&D expenditure intensity. This result indicates that the benefits of clustering R&D activity outweigh any local competition effects. This variable is also an indicator of positive unobserved characteristics in a region as when multinational firms locate in a region it can be taken as a signal by other firms of favourable characteristics. Furthermore, this result suggests that agglomeration effects are important over and above the spatial concentration of R&D activity generated by demand-linkages (Head and Mayer, 2004) and are in line with the theoretical predictions of the model developed by Eckholm and Hakkala (2007). The effect of the regional unemployment rate is negative but insignificant indicating that the availability of labour or the presence of

[19] The APEs in the conditional logit models are obtained by using the following formula: $\beta\,(1-\frac{1}{J})$ where J is the number of regions in the choice set and β is the estimated parameter.

[20] Following Moulton (1990) and Pepper (2002), in the estimated models we cluster standard errors at country level to account for possible correlation of error terms across regions within each country due to unobserved country characteristics.

labour market rigidities do not affect the attractiveness of regions to R&D foreign affiliates.

The tax variable is not significant across all specifications. This result suggests that the corporate tax rate in a country has no affect on the location of R&D activities by multinationals in regions of that country over and above other determinants of the location choice. Basile et al. (2008) and Spies (2010) also find an insignificant effect of the corporate tax on the location choice of multinational firms. Regional compensation per employee and human capital appear also insignificant.

In column two and three two measures of regional R&D expenditure intensity are used to proxy the technological development of regions. The estimates for both measures are positive and significant. This indicates that foreign R&D firms locate in regions with a high research capacity and that business R&D expenditure had a greater impact on the location choice of R&D activities by multinationals than government R&D expenditure intensity.

Further, we find that the presence in the region of a top 500 ranked university was positively linked to the probability of the location of R&D activity by multinational firms. This variable's significance shows that R&D foreign affiliates were attracted to centres of research excellence. This result along with the significant result for government and business R&D expenditure intensity suggest the importance of the regions' knowledge base in attracting foreign investment in R&D activities.

The baseline model was estimated across all regions and firms. However it is possible that heterogeneity among firms in the treatment of regional characteristics exists and so firms may weigh regional characteristics differently. This difference in firm behaviour will not be seen when they are grouped together. To examine this possibility the sample of foreign affiliates is divided by country of origin and we estimate the models 1-3 for European and North American multinational firms separately[21]. Columns 4-6 contain the estimates for European multinational firms while columns 7-9 show the estimates for North American firms[22].

The only difference uncovered with these separate regressions is with respect to the role of R&D expenditure intensity. While European multinational firms are responsive to both the business and the government R&D expenditure intensities, in the case of North American multinational firms only business R&D expenditure intensity was significantly associated with the location probability while the government R&D expenditure intensity did not seem to play a significant role.

4.2 Nested Logit Models

As discussed in Section 2, estimating unbiased parameters with the conditional logit model assumes that the IIA property holds. However, given potential spatial correlation in unobservable factors, the alternative locations are unlikely to be independent in a spatial choice framework. This implies that the IIA assumption may not hold which would lead to biased estimates. We therefore test a number of geographical structures to estimate nested logit models. We find that a country-based structure was inconsistent with random utility maximization. Further, we identify a model with a four group nesting structure to be the most successful: South, Anglo-Saxon, East and Central North. The composition of this nesting structure is as follows: South: all NUTS 2 regions in Italy, Greece, Portugal and Spain; Anglo-

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[21] European multinational firms are those with a parent in the following countries: Austria, Belgium, Bulgaria, Cyprus, Czech-Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Gibraltar, Greece, Ireland, Israel, Isle of Man, Italy, Liechtenstein, Luxembourg, Switzerland, Monaco, Netherlands, Norway, Poland, Portugal, Sweden. North American multinational firms are those with a parent in the US and Canada.

[22] Data on industrial sectors and technology fields of the R&D activities is not available to us. Also, another limitation of our data is that we cannot distinguish between research for development and fundamental research activities.

Saxon: all NUTS 2 regions in the United Kingdom and Ireland; East: all NUTS 2 regions in the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, and Romania, the Slovak Republic; Central and North: all NUTS 2 regions in Austria, Belgium, Denmark, Finland, France, Germany, the Netherlands and Sweden. The results from the nested logit model using this four-group geographical structure are presented in Table 6.

Table 6 about here

The IV parameters are all between zero and one, which indicates that the chosen geographical structure is valid and that choices are geographically nested. Across all specifications, the IV parameters for "South" are lower in comparison to the other three nests suggesting that the regions in "South" are perceived as more closely substitutable than the regions within the other three nests.

The Likelihood Ratio (LR) test rejects the null hypothesis of the IIA. Columns 1-3 show the results for all multinational firms, columns 4-6 for European multinational firms and columns 7-9 for North American multinational firms. Figures shown are marginal effects (average probability elasticities)[23]. We find that the regions' market potential was not significantly associated with the probability of the location choice of R&D activities by multinationals within the considered geographical nests. Further, agglomeration economies from foreign R&D activities appear to be important within the four geographical structures for all multinational firms as well as European and North American multinationals. The effect is stronger in the case of North American multinationals in comparison to European multinationals. These results are in line with the theoretical predictions of the models proposed by Markusen (2002) and

[23] The derivation of average probability elasticities in the nested logit models is explained in Appendix B.

Eckholm and Hakkala (2007). While international production is likely to locate in large markets, R&D activities are attracted to small skills-intensive regions where they can benefit from R&D spillovers. Furthermore, the location choice of R&D activities by multinationals was positively associated with the knowledge base captured by human capital[24], proximity to centres of excellence, patents intensity as well as total R&D expenditure intensity. Business R&D expenditure intensity was positively associated with the location probability of R&D activities by multinationals while government R&D expenditure intensity mattered less: we uncover only a marginally significant link in the case of European multinationals and no significant effect in the case of North-American multinationals. It appears that on average, regional characteristics such as labour costs[25], unemployment rates[26] and the country corporate tax rate do not play a significant role in the location choice of R&D activities by multinational firms over and above other determinants. These results are in line with the findings of Thursby and Thursby (2006).

[24] In the case of the North American multinationals, human capital was positive but insignificant in the models with R&D expenditure intensity.

[25] The estimated parameter for compensation per employee is positive and significant at ten per cent in the model with patent intensity for all firms

[26] The estimated parameters for unemployment rates appear negative and significant at ten per cent in three models (all firms, the mode; with total R&D expenditure intensity; European multinationals, models with R&D expenditure intensity); the estimated parameter for unemployment rates is positive and significant at ten per cent in the case of North American multinationals in the model with patent intensity

5 Summary and Conclusions

In this paper we estimated the determinants of the location choice of new R&D activities by multinational firms across regions in the European Union over the period 1999-2006. With respect to methodology improvements, in addition to conditional logit models we estimated nested logit models to account for the fact that in relation to many alternative location choices, conditional logit models might lead to biased estimates if the location choices are not independent. In contrast to most existing cross-country analyses, we consider regions within countries as location choices and thus avoid aggregation bias in the estimates of the location choice determinants.

We find that in our spatial choice framework the independence of the location choices does not hold. Consequently we base our conclusions on the estimates of determinants of the location choice of R&D activities by multinationals obtained with the nested logit models. Our results suggest that on average, the probability of the location of a representative R&D foreign affiliate in an EU region increases with agglomeration economies from foreign R&D activities, and the knowledge base measured by human capital, proximity to centres of research excellence, patents intensity as well as R&D expenditure intensity. It appears that, over the analysed period, regional characteristics such as market potential and compensation per employee had no effect on the attractiveness of regions to R&D foreign investment over and above other determinants. These results are in line with theoretical predictions of the models of the location of multinational firms developed by Markusen (2002) and Eckholm and Hakkala (2007). In the case of European multinationals, unemployment rates were negatively associated with the location probability of R&D activities when we use R&D expenditure intensity to measure the knowledge base of regions. Our evidence also suggests that country level corporate tax rates had no significant effect in fostering the attractiveness of regions to R&D foreign investment over and above other determinants. This result might be explained by the fact that the sensitivity of the probability to location to taxation in a country/region is higher in the case of a small number of location options (Barrios et al., 2008). Also, multinationals locate foreign affiliates in more than one country and they optimize the tax on a global base. We find evidence of a geographical structure in firm's location choice across the European Union.

The determinants of the location choice of R&D foreign affiliates vary depending on the country of origin of the foreign investor. Thus, agglomeration externalities from foreign R&D activities and business R&D expenditure intensity had a higher positive effect on the propensity to locate in an EU region in the case of multinationals from North America in comparison to European based multinationals. While government R&D expenditure intensity appear to matter for the location choice of R&D activities by European multinationals, it does not play a significant role in the case of the location decisions for R&D activities by North American multinationals.

Our research results suggest a number of policy implications. First, policy aiming to increase the knowledge base of regions are likely to foster the attractiveness of regions to R&D foreign investment. Second, positive externalities from clustering of R&D foreign affiliates outweigh competition effects. Third, given the heterogeneous behaviour of foreign investors, differentiated policy depending on target partner countries can increase the success of such policies.

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Table 1: The location of new R&D foreign affiliates incorporated in the EU, 1999-2006

Top ten countries after the share in the total number of R&D foreign affiliates	Country share in total R&D foreign affiliates (%)	Ranking of countries after the number of R&D foreign affiliates per GDP	Top ten NUTS 2 Regions after the number of R&D foreign affiliates
United Kingdom	35.9	Romania	Inner London
Germany	35.9	Estonia	Oberbayern
Austria	4.9	Ireland	Berkshire, Buckinghamshire and Oxfordshire
France	4.3	United Kingdom	East Anglia
Romania	4.0	Austria	Bucuresti – Ilfov
Ireland	2.7	Bulgaria	Darmstadt
Sweden	2.5	Germany	Dusseldorf
Italy	2.0	Denmark	Koln
Denmark	1.8	Sweden	Freiburg
Netherlands	1.8	Poland	Hamburg

Data source: *Amadeus* database, Bureau van Dijk

Table 2: Country origin of new R&D foreign affiliates incorporated in the EU, 1999-2006

Origin of Firms by Area	% of total number of R&D foreign affiliates
EU 15 + Switzerland & Norway	50.9
North America	33.1
Asia & Australia	8.1
Rest of Europe	3.4
South & Central America	1.6
Middle East	1.6
Africa	1.3

Data source: *Amadeus* database, Bureau van Dijk

Table 3: Summary Statistics					
Variable	Number of NUTS2 regions	Mean	Std. Dev.	Min.	Max.
Market Potential	233	4.3	0.5	3.0	5.1
Compensation Per Employee	233	21.3	10.1	1.5	43.9
Agglomeration	233	14.0	34.7	0.0	371.1
Unemployment Rate	233	9.3	5.0	2.5	28.0
Corporate Tax Rate	233	33.3	3.7	18.0	39.0
Human Capital	233	23.0	10.2	2.8	53.0
Top University	233	0.5	0.5	0	1
Patents Intensity	233	3.9	3.9	0.1	26.5
Total R&D Intensity	216	1.0	1.0	0.0	4.8
Business R&D Intensity	216	0.8	0.9	0.0	4.2
Government R&D Intensity	216	0.2	0.2	0.0	1.9

Table 4: Correlations of explanatory variables						
	Market Potential	Compensation Per Employee	Agglomeration	Unemployment Rate	Corporate Tax Rate	Human Capital
Market Potential	1					
Compensation Per Employee	0.5910	1				
Agglomeration	0.1635	0.1534	1			
Unemployment Rate	-0.3346	-0.0994	-0.1220	1		
Corporate Tax Rate	0.0111	0.0606	-0.0828	0.1684	1	
Human Capital	0.2866	0.4380	0.3046	-0.0553	-0.2853	1
Top University	0.1907	0.3669	0.1997	-0.1950	-0.0243	0.3218
Patents Intensity	0.5931	0.5128	0.1277	-0.1758	-0.2119	0.3280
Total R&D Intensity	0.3065	0.4374	0.1272	-0.2338	-0.1641	0.4150
Business R&D Intensity	0.2939	0.4396	0.1154	-0.2570	-0.1801	0.3823
Government R&D Intensity	0.1668	0.1693	0.0914	0.0150	0.0115	0.2791
	Top University	Patents Intensity	Total R&D Intensity	Business R&D Intensity	Government R&D Intensity	
Top University	1					
Patents Intensity	0.3576	1				
Total R&D Intensity	0.3500	0.6447	1			
Business R&D Intensity	0.3026	0.6584	0.9678	1		
Government R&D Intensity	0.3028	0.2137	0.5134	0.2807	1	

Table 5: Determinants of the Location Choice of R&D Foreign Affiliates: Conditional Logit Models									
	All multinationals			European multinationals			North American multinationals		
Variable	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Market Potential	0.051	0.354	0.302	-0.105	0.224	0.151	0.034	0.280	0.248
	(0.783)	(0.880)	(0.862)	(0.787)	(0.863)	(0.844)	(0.781)	(0.880)	(0.867)
Compensation Per Employee	-0.101	0.100	0.184	-0.114	0.115	0.212	0.173	0.301	0.364
	(0.603)	(0.598)	(0.598)	(0.629)	(0.642)	(0.632)	(0.586)	(0.530)	(0.538)
Agglomeration	0.011***	0.009**	0.009**	0.010***	0.007*	0.007*	0.012***	0.011***	0.011***
	(0.002)	(0.004)	(0.004)	(0.002)	(0.004)	(0.004)	(0.002)	(0.004)	(0.004)
Unemployment Rate	-0.047	-0.326	-0.410	0.121	-0.224	-0.335	-0.410	-0.475	-0.531
	(0.102)	(0.065)	(0.060)	(0.094)	(0.062)	(0.059)	(0.116)	(0.075)	(0.068)
Corporate Tax Rate	-0.132	0.760	0.364	0.430	1.553	1.024	-1.124	-0.727	-0.958
	(0.075)	(0.083)	(0.080)	(0.071)	(0.079)	(0.077)	(0.081)	(0.083)	(0.078)
Human Capital	0.393	0.485	0.439	0.485	0.647	0.577	0.162	0.069	0.023
	(0.017)	(0.020)	(0.020)	(0.016)	(0.017)	(0.017)	(0.028)	(0.034)	(0.033)
Top University	0.554***	0.526***	0.508***	0.448**	0.413**	0.392**	0.694***	0.659***	0.646***
	(0.281)	(0.288)	(0.278)	(0.412)	(0.396)	(0.391)	(0.227)	(0.276)	(0.265)
Patents Intensity	0.783			0.821			0.634		
	(0.575)			(0.537)			(0.622)		
Total R&D Intensity		0.346***			0.374***			0.346**	
		(0.123)			(0.136)			(0.142)	
Business R&D Intensity			0.220***			0.227**			0.242***
			(0.106)			(0.137)			(0.116)
Government R&D Intensity			0.142***			0.167***			0.114
			(0.244)			(0.173)			(0.407)
Observations	99,957	92,232	92,232	56,386	52,056	52,056	32,853	30,240	30,240
Multinational firms	429	427	427	242	241	241	141	140	140
NUTS2 regions	233	216	216	233	216	216	233	216	216
Log-likelihood	-1,930.3	-1,922.3	-1,919.7	-1,151.8	-1,147.1	-1,144.3	-591.9	-584.2	-583.9
Pseud-R2	0.175	0.162	0.164	0.131	0.119	0.121	0.230	0.224	0.224

Notes: Figures given are average probability elasticities. *** significant at the 1 per cent level, ** significant at the 5 per cent level, * significant at the 10 per cent level. Explanatory variables are lagged with respect to the dependent variable by one period. Market potential, compensation per employee, agglomeration and patents intensity are in logs. Top university is a dummy variable. Unemployment rate, corporate tax rate, human capital and R&D intensities are in percentage form and are evaluated at their mean value. European multinational firms are those with a parent in the following countries: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Gibraltar, Greece, Ireland, Israel, Isle of Man, Italy, Liechtenstein, Luxembourg, Switzerland, Monaco, the Netherlands, Norway, Poland, Portugal and Sweden. North American multinational firms are those with a parent in the US or Canada.

Table 6: Determinants of the Location Choice of R&D Foreign Affiliates: Nested Logit Models

	All multinationals			European multinationals			North American multinationals		
Variable	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Market Potential	-0.072	0.524	0.524	-0.287	0.130	0.126	0.204	1.264	1.259
	(0.089)	(0.082)	(0.082)	(0.125)	(0.105)	(0.107)	(0.154)	(0.151)	(0.151)
Compensation Per Employee	0.741*	-0.000	-0.000	0.577	0.161	0.154	1.997	0.336	0.481
	(0.139)	(0.118)	(0.118)	(0.196)	(0.153)	(0.156)	(0.233)	(0.225)	(0.226)
Agglomeration	0.017***	0.025***	0.025***	0.011***	0.018***	0.017***	0.033***	0.040***	0.041***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Unemployment Rate	0.432	-0.471*	-0.471	0.083	-0.557*	-0.575*	1.808*	-0.493	-0.317
	(0.010)	(0.007)	(0.007)	(0.015)	(0.010)	(0.011)	(0.019)	(0.012)	(0.013)
Corporate Tax Rate	1.148	1.948	1.948	1.257	2.674	2.606	1.466	-0.874	-0.450
	(0.011)	(0.013)	(0.013)	(0.017)	(0.018)	(0.018)	(0.021)	(0.019)	(0.020)
Human Capital	0.602***	0.389**	0.389**	0.568**	0.487**	0.475**	0.896**	0.153	0.157
	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Top University	0.764***	0.858***	0.858***	0.578***	0.609***	0.593***	1.635***	1.905**	1.976***
	(0.123)	(0.102)	(0.102)	(0.177)	(0.129)	(0.131)	(0.222)	(0.226)	(0.224)
Patents Intensity	1.280***			1.011***			2.803***		
	(0.075)			(0.116)			(0.129)		
Total R&D Intensity		0.762***			0.686***			1.204***	
		(0.029)			(0.041)			(0.047)	
Business R&D Intensity			0.611***			0.522***			1.037***
			(0.031)			(0.043)			(0.049)
Government R&D Intensity			0.142**			0.151*			0.142
			(0.085)			(0.129)			(0.135)
IV Parameters									
South	0.147***	0.092***	0.092***	0.228*	0.123***	0.128**	0.055*	0.050**	0.048**
	(0.054)	(0.025)	(0.025)	(0.123)	(0.046)	(0.051)	(0.033)	(0.022)	(0.022)
UK and Ireland	0.621***	0.556***	0.556***	0.573***	0.471***	0.475***	0.694***	0.633***	0.629***
	(0.065)	(0.050)	(0.050)	(0.104)	(0.065)	(0.067)	(0.101)	(0.089)	(0.089)
East	0.562***	0.593***	0.593***	0.628***	0.616***	0.621***	0.452***	0.507***	0.503***
	(0.063)	(0.054)	(0.055)	(0.102)	(0.071)	(0.073)	(0.086)	(0.098)	(0.098)
Central and North	0.443***	0.233***	0.233***	0.548***	0.272***	0.277***	0.343***	0.163**	0.162**
	(0.081)	(0.045)	(0.045)	(0.153)	(0.074)	(0.079)	(0.119)	(0.072)	(0.072)
Observations	99,957	92,232	92,232	53,357	49,248	49,248	32,853	30,240	30,240
Multinational firms	429	427	427	229	228	228	141	140	140
NUTS2 regions	233	216	216	233	216	216	233	216	216
Log-likelihood	-1,916.6	-1,889.8	-1,889.8	-1,067.8	-1,048.5	-1,048.4	-575.3	-568.5	-568.3
Chi2 for H0: IIA	27.49***	65.05***	59.82***	8.50*	43.51***	39.95***	33.18***	31.35***	31.14***

Notes: Figures shown are average probability elasticities. Standard error in parentheses are clustered at country level. *** significant at the 1 per cent level, ** significant at the 5 per cent level, * significant at the 10 per cent level. Coefficients of IV parameters are point estimates. Explanatory variables are lagged with respect to the dependent variable by one period. Market potential, compensation per employee, agglomeration and patents intensity are in logs. Top university is a dummy variable. Unemployment rate, corporate tax rate, human capital and R&D intensities are in percentage form and are evaluated at their mean value. European multinational firms are those with a parent in the following countries: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Gibraltar, Greece, Ireland, Israel, Isle of Man, Italy, Liechtenstein, Luxembourg, Switzerland, Monaco, the Netherlands, Norway, Poland, Portugal and Sweden. North American multinational firms are those with a parent in the US or Canada.Chi2 is the statistics of the likelihood-ratio test on H0: IIA holds.

Appendix A: Data and Descriptive Statistics

Table A1: Variables Definitions and Data Sources

Variables	**Description**	**Source**
Market Potential	Log of real GDP of the host region plus the sum of inverse distance-weighted real GDP of all other regions. Distance is measured as the lorry travelling time between the host region and all other regions. Average over 1995-2002.	Cambridge Econometrics and own calculations
Compensation per Employee	Log of compensation per employee in constant prices, average over 1995-2002.	Eurostat, Regional Statistics database
R&D Agglomeration	Log of the total number of foreign R&D firms located in each host region plus a distance-weighted count of the foreign R&D firms in all other regions up to 2002.	Bureau van Dijk, *Amadeus* database and own calculation
Unemployment Rate	Regional rate of unemployment, per cent. Average over 1995-2002	Cambridge Econometrics
Corporate Tax Rate	National top corporate tax rate, per cent. Average over 1995-2002	World Tax Database, Michigan Business School
Human Capital	Percentage of the regional economically active population which have attained tertiary education level (International Standard Classification of Education). Average over 1998-2002.	Eurostat, Regional Statistics database
Top University	Dummy variable which is equal to one for the presence of a world top 500 ranked university in each region. Equal to 1 if a ranked university is present.	The QS World University Rankings
Patents Intensity	Log of patent applications to the European Patent Office to real GDP ratio. Average over 1999-2002.	Eurostat, Regional Statistics database and own calculation
Business R&D Intensity	R&D expenditure in the business enterprise sector as a percentage of real GDP in each region. Average over 1995-2002.	Eurostat, Regional Statistics database
Government R&D intensity	R&D expenditure in the government sector as a percentage of real GDP in each region. Average over 1995-2002.	Eurostat, Regional Statistics database
Total R&D Intensity	Business R&D and government R&D expenditure as a percentage of real GDP in each region. Average over 1995-2002.	Eurostat, Regional Statistics database and own calculation

Table A2: Location Choices (NUTS 2 Regions)					
No.	Country and NUTS 2 Code	Region Name	No.	Country and NUTS 2 Code	Region Name
	Austria			**Germany (cont.)**	
1	AT11	Burgenland	44	DE72	Giessen
2	AT12	Niederosterreich	45	DE73	Kassel
3	AT13	Wien	46	DE80	Mecklenburg-Vorpomm.
4	AT21	Karnten	47	DE91	Braunschweig
5	AT22	Steiermark	48	DE92	Hannover
6	AT31	Oberosterreich	49	DE93	Luneburg
7	AT32	Salzburg	50	DE94	Weser-Ems
8	AT33	Tirol	51	DEA1	Dusseldorf
9	AT34	Vorarlberg	52	DEA2	Koln
	Belgium		53	DEA3	Munster
10	BE10	Bruxelles	54	DEA4	Detmold
11	BE21	Antwerpen	55	DEB1	Koblenz
12	BE22	Limburg	56	DEB2	Trier
13	BE23	Oost-Vlaanderen	57	DEB3	Rheinhessen-Pfalz
14	BE24	Vlaams Brabant	58	DEC0	Saarland
15	BE25	West-Vlaanderen	59	DED1	Chemnitz
16	BE31	Brabant Wallon	60	DED2	Dresden
17	BE32	Hainaut	61	DED3	Leipzig
18	BE33	Liege	62	DEF0	Schleswig-Holstein
19	BE34	Luxembourg	63	DEG0	Thuringen
20	BE35	Namur		**Spain**	
	Czech Republic		64	ES11	Galicia
21	CZ01	Praha	65	ES12	Asturias
22	CZ02	Strední Cechy	66	ES13	Cantabria
23	CZ03	Jihozápad	67	ES21	Pais Vasco
24	CZ04	Severozápad	68	ES22	Navarre
25	CZ05	Severovýchod	69	ES23	Rioja
26	CZ06	Jihovýchod	70	ES24	Aragon
27	CZ07	Strední Morava	71	ES30	Madrid
28	CZ08	Moravskoslezko	72	ES41	Castilla-Leon
	Germany		73	ES42	Castilla-la Mancha
29	DE11	Stuttgart	74	ES43	Extremadura
30	DE12	Karlsruhe	75	ES51	Cataluna
31	DE13	Freiburg	76	ES52	Com. Valenciana
32	DE14	Tubingen	77	ES53	Baleares
33	DE21	Oberbayern	78	ES61	Andalucia
34	DE22	Niederbayern	79	ES62	Murcia
35	DE23	Oberpfalz		**Finland**	
36	DE24	Oberfranken	80	FI13	Itä-Suomi
37	DE25	Mittelfranken	81	FI18	Etelä-Suomi
38	DE26	Unterfranken	82	FI19	Länsi-Suomi
39	DE27	Schwaben	83	FI1A	Pohjois-Suomi
40	DE30	Berlin		**France**	
41	DE50	Bremen	84	FR10	Ile de France
42	DE60	Hamburg	85	FR21	Champagne-Ard.
43	DE71	Darmstadt	86	FR22	Picardie

No.	Country and NUTS 2 Code	Region Name	No.	Country and NUTS 2 Code	Region Name
	France (cont.)			**Italy (cont.)**	
87	FR23	Haute-Normandie	130	ITD3	Veneto
88	FR24	Centre	131	ITD4	Fr.-Venezia Giulia
89	FR25	Basse-Normandie	132	ITD5	Emilia-Romagna
90	FR26	Bourgogne	133	ITE1	Toscana
91	FR30	Nord-Pas de Calais	134	ITE2	Umbria
92	FR41	Lorraine	135	ITE3	Marche
93	FR42	Alsace	136	ITE4	Lazio
94	FR43	Franche-Comte	137	ITF1	Abruzzo
95	FR51	Pays de la Loire	138	ITF2	Molise
96	FR52	Bretagne	139	ITF3	Campania
97	FR53	Poitou-Charentes	140	ITF4	Puglia
98	FR61	Aquitaine	141	ITF5	Basilicata
99	FR62	Midi-Pyrenees	142	ITF6	Calabria
100	FR63	Limousin	143	ITG1	Sicilia
101	FR71	Rhone-Alpes	144	ITG2	Sardegna
102	FR72	Auvergne		**Lithuania**	
103	FR81	Languedoc-Rouss.	145	LT00	Lithuania
104	FR82	Prov-Alpes-Cote d'Azur		**Latvia**	
105	FR83	Corse	146	LV00	Latvia
	Greece			**The Netherlands**	
106	GR11	Anatoliki Makedonia, Thraki	147	NL11	Groningen
107	GR12	Kentriki Makedonia	148	NL12	Friesland
108	GR13	Dytiki Makedonia	149	NL13	Drenthe
109	GR14	Thessalia	150	NL21	Overijssel
110	GR21	Ipeiros	151	NL22	Gelderland
111	GR23	Dytiki Ellada	152	NL23	Flevoland
112	GR24	Sterea Ellada	153	NL31	Utrecht
113	GR25	Peloponnisos	154	NL32	Noord-Holland
114	GR30	Attiki	155	NL33	Zuid-Holland
115	GR42	Notio Aigaio	156	NL34	Zeeland
116	GR43	Kriti	157	NL41	Noord-Brabant
	Hungary		158	NL42	Limburg
117	HU10	Közép-Magyarország		**Poland**	
118	HU21	Közép-Dunántúl	159	PL11	Lódzkie
119	HU22	Nyugat-Dunántúl	160	PL12	Mazowieckie
120	HU23	Dél-Dunántúl	161	PL21	Malopolskie
121	HU31	Észak-Magyarország	162	PL22	Slaskie
122	HU32	Észak-Alföld	163	PL31	Lubelskie
123	HU33	Dél-Alföld	164	PL32	Podkarpackie
	Ireland		165	PL33	Swietokrzyskie
124	IE01	Border, Midlands, Western	166	PL34	Podlaskie
125	IE02	Southern and Eastern	167	PL41	Wielkopolskie
	Italy		168	PL42	Zachodniopomorskie
126	ITC1	Piemonte	169	PL43	Lubuskie
127	ITC3	Liguria	170	PL51	Dolnoslaskie
128	ITC4	Lombardia	171	PL52	Opolskie
129	ITD2	Trentino-Alto Adige	172	PL62	Warminsko-Mazurskie

No.	Country and NUTS 2 Code	Region Name	No.	Country and NUTS 2 Code	Region Name
	Poland (cont.)			**UK (cont.)**	
173	PL63	Pomorskie	203	UKD3	Greater Manchester
	Portugal		204	UKD4	Lancashire
174	PT11	Norte	205	UKD5	Merseyside
175	PT15	Algarve	206	UKE1	East Riding and North Lincolnshire
176	PT16	Centro	207	UKE2	North Yorkshire
177	PT17	Lisboa e V.do Tejo	208	UKE3	South Yorkshire
178	PT18	Alentejo	209	UKE4	West Yorkshire
	Romania		210	UKF1	Derbyshire and Nottinghamshire
179	RO11	Nord-Vest	211	UKF2	Leicestershire, Rutland and Northamptonshire
180	RO12	Centru	212	UKF3	Lincolnshire
181	RO21	Nord-Est	213	UKG1	Herefordshire, Worcestershire and Warwickshire
182	RO22	Sud-Est	214	UKG2	Shropshire and Staffordshire
183	RO31	Sud - Muntenia	215	UKG3	West Midlands (county)
184	RO32	Bucuresti - Ilfov	216	UKH1	East Anglia
185	RO41	Sud-Vest Oltenia	217	UKH2	Bedfordshire and Hertfordshire
186	RO42	Vest	218	UKH3	Essex
	Sweden		219	UKI1	Inner London
187	SE11	Stockholm	220	UKI2	Outer London
188	SE12	Ostra Mellansverige	221	UKJ1	Berkshire, Buckinghamshire, and Oxfordshire
189	SE21	Smaland med oarna	222	UKJ2	Surrey, East and West Sussex
190	SE22	Sydsverige	223	UKJ3	Hampshire and Isle of Wight
191	SE23	Vastsverige	224	UKJ4	Kent
192	SE31	Norra Mellansverige	225	UKK1	Gloucestershire, Wiltshire and Bristol/Bath area
193	SE32	Mellersta Norrland	226	UKK2	Dorset and Somerset
194	SE33	Ovre Norrland	227	UKK3	Cornwall and Isles of Scilly
	Slovak Republic		228	UKK4	Devon
195	SK01	Bratislavský	229	UKL1	West Wales and The Valleys
196	SK02	Západné Slovensko	230	UKL2	East Wales
197	SK03	Stredné Slovensko	231	UKM2	Eastern Scotland
198	SK04	Východné Slovensko	232	UKM3	South West Scotland
	UK		233	UKN0	Northern Ireland
199	UKC1	Tees Valley and Durham			
200	UKC2	Northumberland and Tyne and Wear			
201	UKD1	Cumbria			
202	UKD2	Cheshire			

Appendix B: The Derivation of Average Probability Elasticity in the Nested Logit Models

Rewrite the profit function of MNE i choosing region $h \in n_k$ be $U_h = X_h'\beta + \varepsilon_h$ (subscript i is dropped to keep the formula concise). Let x_h be one variable of interest and it enters X_h' in its logarithm. The corresponding coefficient of $\ln x_h$ is β_x. Denote τ_h the inclusive value parameter for the nest where alternative h lies in. Rewrite and simplify Equation (4) by inserting Equation (3) into (4) where is applicable and denote $e^{U_h/\tau_h} = e^{\bullet}$ and $e^{\tau_h \ln \sum_J e^{U_h/\tau_h}} = e^{\bullet\bullet}$, we have

(A1)
$$\begin{aligned}\Pr_h = \Pr_{h|k}\Pr_k &= \frac{e^{U_h/\tau_h}}{\sum_J e^{U_h/\tau_h}} \frac{e^{\tau_h \ln \sum_J e^{U_h/\tau_h}}}{\sum_K e^{\tau_j \ln \sum_J e^{U_j/\tau_j}}} \\ &= \frac{e^{\bullet}}{\sum_J e^{\bullet}} \frac{e^{\bullet\bullet}}{\sum_K e^{\bullet\bullet}}.\end{aligned}$$

The probability elasticity w.r.t. x_h is

(A2)
$$\begin{aligned} e_{x_h} &= (\Pr_h)'_{x_h} \frac{x_h}{\Pr_h} = (\Pr_{h|k}\Pr_k)'_{x_h} \frac{x_h}{\Pr_{h|k}\Pr_k} \\ &= (\frac{\Pr'_{h|k}}{\Pr_{h|k}} + \frac{\Pr'_k}{\Pr_k}) x_h \end{aligned}.$$

Straightforward derivation leads to following two results,

$$\begin{aligned}\frac{\Pr'_{h|k}}{\Pr_{h|k}} &= \frac{e^{\bullet}\frac{1}{\tau_h}\frac{\beta_x}{x_h}\sum e^{\bullet} - e^{\bullet}\frac{1}{\tau_h}\frac{\beta_x}{x_h}e^{\bullet}}{[\sum e^{\bullet}]^2} \cdot \frac{\sum e^{\bullet}}{e^{\bullet}} \\ &= \frac{\beta_x}{\tau_h x_h}\frac{\sum e^{\bullet} - e^{\bullet}}{\sum e^{\bullet}} = \frac{\beta_x}{\tau_h x_h}(1-\Pr_{h|k})\end{aligned}$$

and

$$\begin{aligned}\frac{\Pr'_k}{\Pr_k} &= \frac{e^{\bullet\bullet}\tau_h \frac{1}{\sum e^{\bullet}} e^{\bullet}\frac{\beta_x}{\tau_h x_h}\sum e^{\bullet\bullet} - e^{\bullet\bullet}e^{\bullet\bullet}\tau_h \frac{1}{\sum e^{\bullet}} e^{\bullet}\frac{\beta_x}{\tau_h x_h}}{[\sum e^{\bullet\bullet}]^2} \cdot \frac{\sum e^{\bullet\bullet}}{e^{\bullet\bullet}} \\ &= \frac{\beta_x}{x_h}\frac{e^{\bullet}}{\sum e^{\bullet}}\frac{\sum e^{\bullet\bullet} - e^{\bullet\bullet}}{\sum e^{\bullet\bullet}} = \frac{\beta_x}{x_h}\Pr_{h|k}(1-\Pr_k)\end{aligned}.$$

Substituting $\frac{\Pr'_{h|k}}{\Pr_{h|k}}$ and $\frac{\Pr'_k}{\Pr_k}$ into Equation (A2), we have

$$e_{x_h} = \frac{\beta_x}{\tau_h}(1-\Pr_{h|k}) + \beta_x \Pr_{h|k}(1-\Pr_k).$$

The subscript h can be replaced with j to represent any alternative region $j \in n_k, \forall j = (1,..., J)$.

To obtain the sum of e_{x_j} over any alternative region $l \in L$, we firstly sum up e_{x_j} within each nest to get

$$\begin{aligned}\sum_{J\in n_k} e_{x_j} &= \frac{\beta_x}{\tau_j}\sum_{J\in n_k}(1-\Pr_{j|k}) + \beta_x(1-\Pr_k)\sum_{J\in n_k}(\Pr_{j|k}) \\ &= \frac{\beta_x}{\tau_j}(J_{n_k}-1) + \beta_x(1-\Pr_k) \\ &= \beta_x(\frac{J_{n_k}}{\tau_j} - \frac{1}{\tau_j} + 1 - \Pr_k)\end{aligned},$$

where J_{n_k} is the number of regions in nest n_k. Then sum up $\sum_{J\in n_k} e_{x_j}$ over nest $k \in K$ to get

$$\begin{aligned}\sum_K \sum_{J\in n_k} e_{x_j} &= \beta_x[\sum_K(\frac{J_{n_k}}{\tau_j} - \frac{1}{\tau_j}) + \sum_K(1-\Pr_k)] \\ &= \beta_x[\sum_K(\frac{J_{n_k}}{\tau_j} - \frac{1}{\tau_j}) + K - 1]\end{aligned}.$$

Finally, the average probability elasticity for L regions w.r.t. x is

$$\overline{e}_x = \frac{\beta_x}{L}[\sum_K(\frac{J_{n_k}}{\tau_j} - \frac{1}{\tau_j}) + K - 1].$$