Working Paper No. 336

December 2009

What Determines the Location Choice of Multinational Firms in the ICT Sector?

Iulia Siedschlag, Xiaoheng Zhang, Donal Smith

Subsequently published in "What Determines the Location Choice of Multinational Firms in the Information and Communication Technologies Sector?", Economics of Innovation and New Technology, Published online 18 April 2013

Abstract: We analyse the location decisions of 8,468 foreign affiliates in the Information and Communication Technologies (ICT) sector established in 224 regions in the European Union over the period 1998-2008. Our results suggest that on average, the location probability of foreign affiliates in ICT manufacturing and services increases with market size, market potential, the presence of other foreign-owned firms in the ICT sector, human capital, income tax, and decreases with the corporation tax rate. In addition, in the case of foreign affiliates in ICT services, the innovation intensity in the ICT sector has a positive effect on the location probability. We find that relevant geographical structures for the location decision are different for multinationals with a parent firm in the European Union and the United States.

Key words: Foreign direct investment; Information and Communication Technologies; Location choice; Conditional logit; Nested logit;

Corresponding author: iulia.siedschlag@esri.ie

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1 Introduction

Recent empirical analyses point to a positive effect of investment in Information and Communication Technologies (ICT) on productivity growth (Oliner and Sichel 2000; Bassanini and Scarpetta 2002; Timmer and van Ark 2005). In addition, it has been shown that ICT-producing sectors tend to promote technological change and innovation (Becchetti *et al.*, 2003; Carlsson, 2004).

There has been an increasing internationalisation of ICT activity in recent years which raises a number of questions which are of interest and relevance both for research and policy making: where are the ICT multinational enterprises located? Who are the main foreign investors in the ICT activity? What factors drive the location choice of multinational ICT activity?

To answer these questions, we analyse the location decisions of 8,468 foreign affiliates of multinational enterprises (MNEs) in the ICT sector established in 224 regions in the European Union (EU) over the period 1998-2008. We add to the empirical literature on the location of multinational enterprises in three ways. First, in contrast to most existing studies, we use a very rich micro data set which enables us to estimate more accurately the determinants of the location choice of a large number of foreign affiliates across a large number of alternative locations in the EU. Second, we use an improved econometric methodology to account for spatial correlation in the context of location choice. Third, we account for endogeneity arising from simultaneity and omitted variable bias. Our work is closest to Barrios and Cawood (2008). In comparison to Barrios and Cawood (2008), we estimate improved discrete-choice models and account for endogenity and spatial correlation. Furthermore we allow the probability of investing in a specific region to be different depending on the country of origin of foreign investors. These improvements enable us to estimate the determinants of the location choice of foreign affiliates in the ICT sector more accurately.

Our results suggest that on average, the location probability of foreign affiliates in the ICT manufacturing and services increases with market size, market potential, the presence of other foreign-owned firms in the ICT sector, and human capital. While the country level corporation tax rate has a negative effect on the location probability, the income tax rate has a positive effect. In addition, the location probability of foreign affiliates in the ICT services increases in the innovation intensity of the ICT sector. Finally, we find that relevant geographical structures for the location decision are different for multinationals with a parent firm in the European Union and the United States.

The remainder of this paper is organised as follows. Section 2 presents the empirical methodology and model specifications. Section 3 describes the data and summary statistics of the main variables. Section 4 discusses the empirical results. Finally, Section 5 concludes.

2 Empirical Methodology

2.1 Discrete-Choice Models

We employ two discrete-choice models to study the location choice of MNEs in the ICT sector. The first one is the conditional logit model (CLM), as proposed in McFadden (1974). Given the simple structure of the probability function of the CLM, it has been widely used to study consumer's choice, travel mode choice and location choice of FDI.

Suppose there are J alternative regions available to MNE i and the MNE needs to make a single choice amongst all alternative regions in order to maximise its profit U_{ij}. The profit of choosing region j can be expressed as a function of all observable characteristics of the region, X'_{ij}, with an unobservable part of profit. Therefore, we can write

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

ε_{ij} is the unobservable profit or simply the error term of the profit function. McFadden (1974) shows that, if (and only if) $\varepsilon_{ij}, \forall j = (1,...,J)$ follows a type I extreme value distribution IID across all MNEs and regions, the probability of region h being chosen by i has the logit form:

(2) $$\Pr(y = h \mid 1,...,J) = \frac{e^{X'_{ih}\beta}}{\sum_J e^{X'_{ij}\beta}}$$

The simple IID assumption over the error term gives the CLM a unique property called "Independence from Irrelevant Alternatives (IIA)". Simply put this means the choice made between any pair of two regions amongst J regions is independent of the rest of the regions. However, it is often found that IIA cannot hold in many discrete-choice cases. For instance, if the error term contains an unobservable individual preference towards some regions, which share common characteristics that are again unobservable to researchers, the error terms of these regions will correlate with each other and thus IIA is violated.

In order to account for the correlation among utilities generated from regions, a nesting structure can be imposed on the regions. The structure assumes that regions can be grouped into several nests according to similarity of those regions, therefore correlation of utilities is allowed within a nest, but not between nests. The nesting structure leads to a group of flexible models called nested logit models (NLM), where the error term follows one of generalised extreme value (GEV) distributions (see Ben-Akiva, 1973, Train, 1986, Train *et al*, 1987 and Forinash and Koppelman, 1993).

Let the error term in Eq. (1) follow a generalised extreme value distribution (Heiss (2002). Denote $\tau_k = \sqrt{1-\rho_k}$, where ρ_k is the correlation of regions in nest k. Thus τ_k measures the independence of alternatives in nest k. If $\tau_k = 1$, the regions are perfectly independent of each other (the NLM collapses into the CLM) and if $\tau_k = 0$, regions in a nest are perfect substitutes for each other (the nest itself becomes a valid alternative).

One can further write the log sum of profits generated from regions in nest k as

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

IV is the inclusive value of nest k (denoted by n_k). Therefore, τ_k is also called the IV parameter of n_k. The probability function of region 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 k is chosen [$\Pr(h \mid k)$]. The function can be expressed as follows

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

where τ_h and IV_h are the IV parameter and the inclusive value for the nest containing region h.

It can be shown that the probability ratio of any two alternatives from two different nests contains factors related to the profit of other regions in those two nests (through the presence of the inclusive value) but the probability ratio of any two regions within the same nest does not contain factors of other regions in that nest. [1] That is to say, IIA is allowed within nests, but not across nests.

Finally, the choice of nesting structures is multiple. Regions or countries can be partitioned depending on their geographic and economic similarity. However, Greene (2002) points out that there is no systematic way to identify a best structure amongst all possible nests. Fortunately, there exists a boundary for the NLM to be consistent with the Random Utility Maximisation (RUM) framework - the IV parameter τ_k has to be bounded between 0 and 1 (Heiss, 2002).

[1] See Train (2003)

2.2 Model Specifications and Econometric Issues

The dependent variable is the location choice of each foreign affiliate over all possible locations. It is equal to 1 if firm i located in region j over the period 1998 to 2008 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 explanatory variables that are used in the models are described in Table A1 in the Appendix A.

Demand related variables. Following other empirical studies of location choice (Crozet et al., 2004; Disdier and Mayer, 2004; Basile et al., 2008), we use the real GDP of a region to proxy the *market size* of the region. Further, we add a measure of *market potential* to proxy the accessibility of this region to all other EU regions' market. The market potential is defined following Harris (1954) as the sum of inverse distance-weighed GDP of all regions other than the host region, where the distance is proxied by lorry travelling time between the host region and all other regions[2]. We expect a positive effect from these two demand-side variables on the probability of location.

Supply related variables. We use region's GDP per capita to proxy *labour costs*. The potential complication is that GDP per capita also reflects regional development, in terms of labour skills and technological development. There may also exist "industry bias" or "skill bias" in the data. To account for these factors we use the percentage of manufacturing workers holding tertiary education degrees to control for *human capital*. The percentage of ICT related patent applications in total patent applications proxies the level of *regional innovation intensity*. We expect a negative effect of labour costs and positive effects of human capital and innovation intensity on the location probability. In

[2] We thank Matthieu Crozet from University Reims, Panthéon-Sorbonne Economie & CEPII for generously providing us with the travelling time data.

addition, we proxy *labour market conditions* with the unemployment rate. 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. Thus the effect of the *unemployment rate* on the location probability is ambiguous.

Agglomeration variables. We add to the model specification two measures of agglomeration. First, we use the *number of foreign-owned firms* in either the ICT manufacturing industries or service industries depending on which sectors we examine. Being close to other foreign-owned firms in the same sector allows MNEs to avail of the benefits from information sharing on the local business environment for foreign investment (Banerjee, 1992 and Head *et al*., 1995 and 1999 discuss such information spillovers), technology spillovers amongst MNEs and inter-firm linkage of intermediate input and output. The above-mentioned externalities generate a positive effect on MNEs' location choice. On the other hand, a substantial presence of foreign investment in a region may also lead to serious competition in the local markets. The price of local labour, land and infrastructure can be bid up and thus reduce MNEs' propensity to invest in such a region (as argued in Crozet *et al*., 2004). Thus, the overall effect of agglomeration of foreign-owned firms in the ICT sector depends on the trade-off between positive externalities and negative competition effects.

Further, we add the *number of domestic-owned ICT firms* (in either the ICT manufacturing or service industries) in a region to proxy local ICT business presence. By the same logic, the effect of this variable is ambiguous.

Policy variables. We use two policy variables at country level, namely the *corporation tax rate*, which was often found to be important in MNEs' location choice decisions across countries (Devereux and Griffith, 1998, Head and Mayer, 2004 and Mataloni, 2007 for example) and the *tax rate on personal income*, which is also related to the costs of doing business (Feld and Kirchgässner, 2003).

Model specifications also include a set of country dummies in order to control for unobserved time-invariant country specific effects shared by regions in the same country.[3]

All region-level and country-level explanatory variables are lagged by one year with respect to the year when an affiliate was established. This is to account for the fact that implementation of investment decisions are in practice lagged. Also, lagging the variables alleviates the issue of endogeneity in estimation.

All explanatory variables, other than the ones in percentage form are transformed into logarithms. Therefore, their coefficients can be interpreted as average probability elasticity (APE). In the case of the CLM, the APEs can be obtained by multiplying the point estimates by a parameter equal to $(1-\frac{1}{L})$. The APEs in the case of NLM can be computed by multiplying the point estimates by the parameter $\frac{1}{L}[\sum_K(\frac{J_{n_k}}{\tau_j}-\frac{1}{\tau_j})+K-1]$.

L is the number of regions in the choice set. Since there are 224 regions in the choice set, the first parameter is close to unity. [4] K is the number of nests at upper level of the choice set and J_{n_k} is the number of regions in nest k. The derivation of the APE for the NLM is explained in Appendix B. For the variables expressed in percentages, their APEs are evaluated at the mean values of those variables.

In our regressions we estimate the effect of region and country level variables on the decision of firms. Regions within each country are likely to share unobservable country specific characteristics. This implies that the error terms within countries might be correlated leading to downward biased standard errors and thus spurious statistical significance in the case of country variables. To account for this issue we follow Moulton (1986, 1990), Pepper (2002), and Cameron et al. (2006) and compute standard errors clustered at country level.

[3] Controlling for all regional fixed effects is not viable because there are up to 224 alternative regions in the sample. This large number of regions imposes a considerable computational burden upon estimations. We argue that by using country-level fixed effects at least the common part of the fixed effect that all regions belonging to the same country share can be taken away.
[4] See Head *et al*. (1995) and Head and Mayer (2004) for the derivation of the average probability elasticity.

2.3 Nesting Structures

In order to estimate nested logit models, regions need to be partitioned and grouped into different nests. Based on previous studies using the nested logit model, we explore several possible nesting structures. For instance, the EU15-EU10 nest takes into account the difference of the EU member states in institutions, economic development, as well as geographic structure (Disdier and Mayer, 2004). The UK and Ireland are grouped into one nest due to a common legal system and language, which may make these two countries particularly attractive to US MNEs. Other nests mainly take into account the geographic proximity, such as a broadly defined Northern Europe[5], Southern Europe and Eastern Europe. In addition to these institutions and geography - driven approaches, we also utilise a formal statistic approach – cluster analysis – to construct nesting structures. Cluster analysis applies to this specific spatial context in the way that, by conditioning on a vector of regional characteristics, it clusters regions into several nests so as to maximise the differences (measured by regional characteristics) of regions in different nests while minimizing such differences for regions within the same nest[6].

The decision of which nesting structure to use is based on two criteria: first the IV parameter of each nest needs to be in the 0-1 range and second, a model with smaller Bayesian Information Criterion (BIC)[7] is preferred.[8]

[5] It includes the UK, Ireland, Nordic and Western European countries.
[6] See Everitt *et al*. (2001) and Kaufman and Rousseeuw (2005)
[7] $BIC = -2\ln L + k\ln(n)$, where L is the log-likelihood of a model, k is the number of variables and n is the number of observations. BIC rewards large likelihood but penalises the loss of degree of freedom due to more variables in the model. See Schwarz (1978) for a discussion.
[8] Due to space constraints, the IV parameters and the BICs for various nesting structures are not reported. The results are available upon request from the authors.

3 Data

We identify 8,944 newly-established foreign affiliates of multinational enterprises in the ICT sector located in 246 NUTS2 regions[9] in the European Union[10] in the period from 1998 to 2008. The data is obtained from the *Amadeus* database, which is by far the most comprehensive database of European firm accounts[11]. A foreign affiliate is defined as a firm having a foreign shareholder with at least 10 per cent of voting share. This definition is in line with IMF and OECD's definitions of "foreign direct investment enterprise" (IMF, 1993). We consider the following ICT manufacturing and service industries classified at the NACE 2-digit level: ICT Manufacturing: Manufacture of office machinery and computers (30); Manufacture of radio, television and communication equipment and apparatus (32); Manufacture of medical, precision and optical instruments (33); ICT services: Post and telecommunications (64); Computer and related activities (72).

We examine the location choices at the region level rather than at country level because one would expect that the spatial correlation of market size and agglomeration across different regions may manifest themselves more significantly at region level. Hence using the finer geographic definition may bring out more information.

We analyse the manufacturing and service industries separately because the location choice of MNEs in these two groups may be affected by different country-level and region-level characteristics, or the same characteristic may affect the MNEs differently. For instance, we expect that manufacturing MNEs are more likely to be attracted by agglomeration while market potential may be more important for the service MNEs but less relevant for the manufacturing MNEs, given that their products are tradable.

[9] The Nomenclature of Territorial Units for Statistics, is a three-level hierarchical classification used by EUROSTAT, the statistical office of the European Union. A complete list of NUTS regions at the three levels is available from: http://ec.europa.eu/eurostat/ramon/nuts/codelist_en.cfm?list=nuts.

[10] 25 EU countries including the 15 EU countries before the enlargements of 2004 and 2007 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, UK) and 10 new EU countries (Bulgaria, Cyprus, Czech, Estonia, Hungary, Latvian, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia). We do not include Cyprus and Malta in this study because *Amadeus* shows there is no ICT firm established during the period under investigation in Cyprus and nine ICT firms established during this period in Malta are not foreign-owned.

[11] *Amadeus* is a firm-level database published by electronic publisher Bureau van Dijk. It contains data for over 11 million firms located in 45 European countries. The data cover basic profile, the balance sheet, profit and loss account, financial ratios and ownership structure of a firm.

The ICT manufacturing industries include 1,342 foreign affiliates. As shown in Table A3, the geographic distribution of these firms across countries is highly uneven. For all three 2-digit sectors, Germany received the largest number of new firms in EU25 countries, while among the EU10 countries, Romania received the largest number of new firms. If the firms are broken down by country of investment, looking at all three industries, the UK received the largest number of MNEs from the US, and Germany received the largest number of MNEs from the EU and other countries (except for Manufacture of office machinery and computers). Furthermore, it is worth noting, that the pattern of foreign ownership is consistent across the three industries. For instance, the firms owned by US account for about 24 to 29 per cent of all firms in each industry. That share varies from 47 to 53 per cent for EU owned firms and 23 to 27 per cent for other nationalities of MNEs.

Table A4 presents the shares of these new firms in each country across industries. The cumulative shares for the EU15 and EU10 countries reveal that the new firms created in the EU10 account for 16 (Manufacture of medical, precision and optical instruments) to 24 per cent (Manufacture of office machinery and computers) of all firms created in the EU25.

In comparison with the manufacturing industries, the ICT service industries contain a much larger number of foreign affiliates - 7,602. Table A5 reports the geographic distribution of newly-established foreign-owned ICT service firms across the EU25 countries. Among them, the UK received the largest number of firms in both NACE 64 and 72 industries in terms of total firms or by ownership, while Romania received the largest number of firms among the EU10 countries. Again we can see that the pattern of foreign ownership is consistent for the two service industries.

Table A6 reports the shares of the firms in each country. The sums of the shares for the EU15 and EU10 countries reveal that the new firms created in the EU10 accounted for 13.4 (Computer and related activities) to 18.9 per cent (Post and telecommunications) of all firms created in EU25.

The top 10 receiving NUTS 2 regions are reported in Table A7. Inner London received the largest share of the new investments in the ICT manufacturing and services industries.

Other top destinations include Darmstadt (an industrial technology center), regions containing the capital city and some highly-developed regions. Cumulative shares of the two industries for these ten regions reveal that the ICT service sector is more concentrated at region level than the ICT manufacturing sector is. This finding implies that agglomeration forces are stronger than competition forces in the ICT services.

The highly-skewed geographic distribution of the ICT industries at country level is also documented in Barrios and Cawood (2008).

Due to the fact that 22 regions have missing values for some regional characteristics, 224 out of 246 NUTS 2 regions are included in the choice set.[12] Therefore, the number of firms in the sample of the ICT manufacturing industries is reduced to 1,232 and the number for the ICT service industries is 7,236. A list of all NUTS 2 regions involved in estimations is presented in Table A8 in Appendix 2.

Table A2 in the Appendix A shows the descriptive statistics of the region and country-level variables. For most of the variables, the regions in EU15 have higher means than regions in the EU10. On average, regions in the EU10 have higher unemployment rates and higher income tax rates.

[12] The dropped regions are located in Bulgaria (BG31, BG32, BG33, BG34, BG41 and BG42, that is to say all Bulgaria regions), Denmark (DK01, DK02 and DK03, that is to say, all Danish regions), Germany (DE41, DE42, DEE2 and DEE3), Greece (GR11 and GR42), Portugal (PT20 and PT30), Slovenia (SI01 and SI02, that is to say, all Slovenia regions), Spain (ES70), and the UK (UKM5 and UKM6).

4 Results

4.1 The Location Choice of Multinational Enterprises in the ICT Manufacturing

Table 1 reports the results for determinants of the location choice of MNEs in the ICT manufacturing industries. Column 1 presents the results of the conditional logit model. These results serve as benchmark for the NLM estimates, which are reported in Column 2. All standard errors shown in the table are clustered at country level[13]. Given that the average probability elasticities (APEs) have a straightforward economic meaning, Table 1 reports APEs rather than point estimates.

The estimates obtained with the CLM model suggest that other things equal, the attractiveness of an average region to foreign investment in the ICT manufacturing is positively associated with market size, market potential, the presence of other foreign-owned firms in the ICT manufacturing and human capital. While the corporation tax rate has a negative effect on the location probability, we find that regions in countries with a higher income tax rate are likely to receive more foreign investment in the ICT manufacturing.

An one per cent increase in market size, would lead to an increase in the location probability of a representative ICT manufacturing MNE by 0.60 per cent. Further, an increase of the market potential by one per cent would result in a higher probability of location by 0.72 per cent. These findings can be interpreted as being consistent with the deepening integration of European markets.

Further, GDP per capita which proxies labour costs has a positive effect but the corresponding coefficient is not statistically significant. The average probability elasticity of location with respect to human capital is about 0.55 per cent, suggesting that regions with highly skilled labour force are attractive locations to foreign affiliates in the ICT manufacturing. It appears that neither labour market rigidity nor the potential labour force matters in MNEs' decision making.

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[13] The clustered standard errors are larger than the unadjusted errors for most of the explanatory variables. This indicates the downward bias caused by uncontrolled clustering in the data. Unadjusted standard errors are not shown because of space limitation but are available upon request from the authors.

We find a positive effect of the agglomeration of foreign-owned ICT manufacturing firms on the location probability but no significant effect of agglomeration of domestic-owned ICT manufacturing firms. This result suggests that the agglomeration benefits of being close to other foreign firms in the same industry outweigh the agglomeration costs generated by competition. Agglomeration benefits may arise from information sharing, technology spillovers and inter-industry linkages of intermediate products from clustering. Such evidence is in line with findings in many previous studies on location choice of MNEs (see for example Disdier and Mayer, 2004; Crozet et al. 2004). In addition, the agglomeration effect appears to be confined within the clustering of foreign firms and not of domestic firms, possibly because the competition effects are stronger than agglomeration effects in the case of domestic firms.

With regard to the two policy variables, we find that they had different effects on the ICT manufacturing MNEs' location choice. An one per cent increase in the corporation tax rate of an average country reduces the location probability being chosen by approximately one per cent. This is a rather sizable effect compared with the APE of other determinants discussed before. This confirms the usual pattern of FDI decision – MNEs are looking for locations where the cost of doing business is lower. In contrast, the income tax rate has a strong positive impact on the location probability of MNEs, amounting to 3.27 per cent. We interpret this finding in the following way: first, the income tax rate may have less an impact on MNEs' costs than the corporation tax rate does, depending on the share of labour costs in total costs; second, a higher income tax rate may also imply a better provision of public goods, such as infrastructure and public administration and so attract MNEs. Finally, we find that ICT patent application intensity does not have a statistically significant effect on the location probability of foreign affiliates.

Column 2 of Table 1 shows the NLM estimates. The North-South-East nesting structure is chosen to estimate the NLM because the two criteria (IV parameters and BIC) discussed in Section 3 show that the NSE structure is the best one among all candidate structures. We also test the validity of IIA using a likelihood-ratio (LR) test that all τ s of the model are jointly equal to unity. Chi2 statistics of the LR test are reported at the bottom of Table 1. The H_0 of IIA is rejected at the 1 per cent level, hence the geographic structure upon the choice set is justified.

The results of the NLM are broadly similar with those obtained with the CLM in terms of sign and magnitude of the effect of explanatory variables. However, the interpretation of the effects estimated by the NLM is slightly different from that of the CLM, as the former indicates how the regional determinants work in each nest and the latter applies to the whole choice set. The major difference is that for some variables the significance levels are lower. In particular, the effects of agglomeration of foreign ICT firms and the income tax rate are only marginally significant at the 10 per cent level. Since the geographic correlation between regions is taken into account in the NLM, we deem the estimated effects and significance levels from this model as more accurate.

Motivated by Basile *et al*. (2008) and Hogenbirk and Narula (2004) [14], we also explore the possibility of different responsiveness of MNEs to local conditions which might occur due to the country of origin of MNEs. The location choice model is estimated separately by the NLM for EU MNEs and US MNEs using the same model specifications. The results are reported in Columns 3 and 4 in Table 1. The nesting structure used in the case of the EU MNEs is North-South-East. In the case of US MNEs we use a different nesting structure, namely the UK/Ireland - the rest of regions. This choice is motivated by the fact that in the case of US MNEs the North-South-East structure leads to IV parameters being out of the 0 - 1 range. In contrast, the IV parameters of the UK/IE-rest regions structure are much closer to zero, compared with the IV parameters of North-South-East in the EU MNE sample. Low IV parameters suggest that US MNEs indeed treat regions in the UK/Ireland and the rest of the EU respectively as close substitutes in each nest. Therefore, the choice of such a nesting structure is justified. However, none of the explanatory variables have statistically significant coefficients, neither do the IV parameters.

[14] Basile *et al*. (2008) find that demand, labour market conditions and taxation have different impacts on EU and non-EU MNEs' location choices. Hogenbirk and Narula (2004) find that US and Japanese MNEs prefer the Randstad region in the Netherlands, while EU MNEs prefer the regions which border other EU countries.

4.2 The Location Choice of Multinational Enterprises in the ICT Services

Table 2 reports the results for MNEs in the ICT service industries. The CLM estimates are shown in column 1 and column 2 shows the NLM estimates. The CLM estimates indicate that on average, other things equal, the location probability of a representative foreign affiliate is positively associated with market size, market potential, GDP per capita, the presence of other foreign owned firms in the ICT service industries, human capital, the unemployment rate and innovation intensity. As in the case of the foreign affiliates in the ICT manufacturing, we find that the location probability of foreign affiliates in the ICT service industries increases in income tax and decreases in the corporation tax rate.

The nesting structure applied in the case of foreign affiliates in the ICT service industries is the EU15 versus EU10 which produces valid IV parameters. The LR test of the NLM rejects the IIA hypothesis at the 1 per cent level. This structure implies that the MNEs in these particular industries see regions as substitutable with each other in the EU15 nest and EU10 nest but not cross the nests. A similar geographical pattern is also confirmed in Disdier and Mayer (2004). They find that the institutional differences are the major cause of the “East-West divide”.

The NLM estimates shown in column 2 suggest that the location probability of ICT foreign affiliates in the service industries within EU15 and EU10 is driven broadly by similar factors as suggested by the CLM with the exception of the effect of the unemployment rate which appears to play no role in this case. It is noteworthy that the effect of market potential is less sizable. Also the effects of income tax, human capital and innovation intensity on the location probability within the two nests appear weaker in comparison to the CLM estimates.

The results of separate estimations for the EU MNEs and US MNEs in the ICT service industries are shown in Columns 3 and 4, respectively. While the EU15-EU10 nesting structure is validated in the case of EU MNEs, it is not valid in the case of the US MNEs. To identify an alternative nesting structure for the US sub-sample we use cluster analysis. The resulting structure produces IV parameters which are mostly within the 0-1

range[15], [16]. The LR test rejects the IIA hypothesis at the 10 per cent level. The major differences between the EU and US owned MNEs is that while market size has no effect on EU MNEs, it has a significantly positive effect on the location probability of US MNEs. A similar pattern is also found for GDP per capita and human capital. It appears that the corporation tax rate does not have any significant effect on the US MNEs. According to the international taxation literature (Slemrod, 1990; Goodspeed and Witte, 2000; Gordon and Hines, 2002), this result could be explained by the tax credit system adopted by the US tax authority on foreign income of US multinationals. Under this system, when US MNEs repatriate their incomes from foreign affiliates back home, foreign tax that has been paid to host countries' authority can be deducted from US tax calculated with the US corporation tax rate and the MNEs only pay the remaining part of the US tax.[17] This implies that the tax credit system may give US MNEs no additional incentive to invest in
low-tax rate countries.

[15] This nesting structure consists of six nests. The first nest contains 36 regions in the UK and Ireland, the second one contains the Irish region Southern and Eastern (IE02), the third one contains 140 regions in Western and Northern Europe, the fourth one contains the Italian region Molise (ITF2), the fifth one contains 45 regions in Eastern Europe and the last one contains the polish region Warminsko-Mazurskie (PL62).

[16] One additional point to be noted is that for the nests 2, 4 and 6, the τ s are unity because they consist of only one NUTS2 region, hence regional correlation does not exist (so $\tau = 1$) . Such nest is called "degenerate" (Heiss, 2002).

[17] Another tax system is the exemption system where MNEs' foreign incomes are exempted from home country taxation. Countries adopting this system include Germany, France, the Netherlands and Canada.

5 Summary and Conclusions

We identify the determinants of the location choice of multinational firms in the ICT manufacturing and services using data on 8,468 foreign affiliates established in the European Union over the period 1998-2008. Our results can be summarized as follows.

First, both market size and market potential of an average region increase its attractiveness to new investment in the ICT industries. This result is consistent with predictions of trade models assuming increasing returns to scale and trade costs (Krugman, 1991). It appears that the effect of market potential is stronger than that of market size. Such evidence is consistent with the fact that the EU market is highly integrated.

With respect to supply conditions, MNEs in the ICT manufacturing and service industries appear to be attracted by the availability of highly-skilled labour. While the presence of other foreign-owned firms has a positive effect on the location choice of ICT MNEs, clustering of domestic-owned firms in the ICT sector has no effect. While the corporation tax rate has a negative effect on the location probability, the income tax rate has a positive effect. Further, while the innovation intensity is positively associated with the location probability of foreign affilates in the ICT service industries, it does not matter for the location choice of foreign affiliates in the ICT manufacturing industries.

The geographical patterns which are relevant for the location choice are different for EU and US MNEs. In the case of ICT manufacturing, while the relevant geographical structure for EU MNEs appears to be North-South-East, the location choice of US MNEs seem to distinguish between regions in the UK and Ireland and the rest of possible locations. In the case of ICT foreign affiliates in the service industries we find that the location choice of EU MNEs follows a geographical divide between EU15 and EU10. In case of the location choice of US MNEs in the service industries, the geographical structure is less clear.

Our results are to some extent similar with findings reported by Barrios and Cawood (2008). For example, they also show that for all five industries of the ICT sector, MNEs' location choices of new investment are positively affected by regional market size, agglomeration and the education level of the work force. In comparison to Barrios and Cawood (2008), we estimate improved discrete-choice models and account for endogeneity and spatial correlation. In addition, we allow the probability of location to vary depending on the country of origin of the parent firm.

Our research results suggest a number of policy implications. First, policy aiming to enhance the knowledge-base of regions such as human capital and innovation intensity are likely to foster the attractiveness of regions to foreign investment in the ICT industries. Second, positive externalities from clustering of foreign affiliates in the ICT industries outweigh competition effects. Third, there is a need of co-ordination of policies across various areas that affect the attractiveness of regions to foreign investment in the ICT sector such as education, innovation, competition, employment and fiscal policies.

Acknowledgements

We thank Marius Brülhart, Esther Kalkbrenner, Mina Kim, Marc Schiffbauer, and participants at research presentations at the Institute for International Economics in Vienna, and the Annual Congress of the European Association for Research in Industrial Economics in Ljubljana, for useful comments and suggestions. Financial support from the European Union's RTD 6th Framework Programme (Contract no. CIT5-028818) is gratefully acknowledged.

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Table 1. Determinants of the Location Choice of Multinational Enterprises in the ICT Manufacturing Industries

	CLM (1) Full sample	NLM (2) Full sample	NLM (3) EU	NLM (4) US
Regional GDP	0.600***	0.512**	0.703	0.514
	(0.103)	(0.152)	(0.643)	(0.226)
Market potential	0.718***	0.761**	0.631	0.447
	(0.191)	(0.241)	(0.396)	(0.230)
GDP per capita	0.118	0.458	-0.004	0.655
	(0.290)	(0.265)	(0.347)	(0.233)
Number of foreign firms	0.565***	0.518*	0.609	0.551
	(0.105)	(0.214)	(0.704)	(0.256)
Number of domestic firms	-0.049	0.051	0.012	0.045
	(0.047)	(0.080)	(0.151)	(0.024)
Corporation tax rate	-0.937***	-1.107**	-0.736	-1.034
	(0.009)	(0.009)	(0.012)	(0.012)
Income tax rate	3.268***	3.383*	4.696	1.448
	(0.028)	(0.032)	(0.125)	(0.017)
Third level education	0.552**	0.582**	0.266	0.561
	(0.010)	(0.008)	(0.008)	(0.011)
Unemployment rate	0.191	0.202	0.081	0.130
	(0.021)	(0.021)	(0.035)	(0.007)
Patent applications	0.065	0.062	0.000	0.160
	(0.002)	(0.002)	(0.004)	(0.002)
Country fixed effects	yes	yes	yes	yes
IV parameters				
North	-	0.723**	0.829	
		(0.317)	(0.944)	
South	-	0.527*	0.539	
		(0.275)	(0.692)	
East	-	0.904***	0.940	
		(0.339)	(1.023)	
UK/Ireland	-			0.134
				(0.431)
Rest regions	-			0.133
				(0.417)
Number of firms	1,232	1,232	584	337
Number of regions	224	224	224	224
Number of observations	272,774	272,774	129,295	74,632
Log likelihood	-5,841.8	-5,830.7	-2,769.9	-1,507.1
Chi2 for H0: IIA	-	29.67***	13.69***	4.61*

Notes: The dependent variable is equal to 1 if affiliate i is located in region j and zero for all other regions. All explanatory variables are lagged by one year to the year when an affiliate was established. Coefficients of explanatory variables are converted into average probability elasticities (APEs). Coefficients of IV parameters are point estimates. Clustered standard errors at country level are shown in parentheses. ***, ** and * stand for the 1 per cent, 5 per cent and 10 per cent significance level, respectively. Chi2 is the statistics of the likelihood-ratio test on H0: IIA holds. Chi2 is based on estimations without clustering.

Table 2. Determinants of the Location Choice of Multinational Enterprises in the ICT Service Industries

	CLM (1) Full sample	NLM (2) Full sample	NLM (3) EU	NLM (4) US
Regional GDP	0.486*	0.801**	0.660	0.859***
	(0.290)	(0.172)	(0.160)	(0.121)
Market potential	1.271***	0.808**	0.560*	0.641***
	(0.268)	(0.168)	(0.133)	(0.127)
GDP per capita	1.040**	1.072*	1.126	0.861*
	(0.495)	(0.266)	(0.281)	(0.257)
Number of foreign firms	0.576***	0.543***	0.479**	0.608***
	(0.168)	(0.090)	(0.079)	(0.077)
Number of domestic firms	-0.077	-0.116	0.015	-0.125
	(0.114)	(0.061)	(0.046)	(0.072)
Corporation tax rate	-0.798***	-0.970**	-1.154**	-0.645
	(0.008)	(0.006)	(0.006)	(0.007)
Income tax rate	3.734***	2.991*	3.684*	2.603
	(0.032)	(0.020)	(0.022)	(0.037)
Third level education	1.104***	0.760*	0.450	1.400***
	(0.016)	(0.007)	(0.005)	(0.010)
Unemployment rate	0.539***	0.284	0.312	0.032
	(0.023)	(0.014)	(0.016)	(0.017)
Patent applications	0.108***	0.100*	0.055	0.080
	(0.002)	(0.001)	(0.001)	(0.001)
Country fixed effects	yes	yes	yes	yes
IV parameters				
EU15	-	0.426***	0.384**	
		(0.165)	(0.184)	
EU10	-	0.447***	0.424**	
		(0.161)	(0.189)	
Nesting structure 1	-			0.488***
				(0.086)
Nesting structure 2	-			1.000
				(1.188)
Nesting structure 3	-			0.507***
				(0.085)
Nesting structure 4	-			1.000
				not estimated
Nesting structure 5	-			0.672***
				(0.134)
Nesting structure 6	-			1.000
				(58.070)
Number of firms	7,236	7,236	3,700	1,837
Number of regions	224	224	224	224
Number of observations	1,604,073	1,604,073	819,947	403,472
Log likelihood	-29,828.9	-29,668.2	-16,049.3	-6,667.0
Chi2 for H0: IIA	-	464.85***	242.98***	111.62***

Notes: The dependent variable is equal to 1 if affiliate i is located in region j and zero for all other regions. All explanatory variables are lagged by one year to the year when an affiliate was established. Coefficients of explanatory variables are converted into average probability elasticities (APEs). Coefficients of IV parameters are point estimates. Clustered standard errors at country level are shown in parentheses. ***, ** and * stand for the 1 per cent, 5 per cent and 10 per cent significance level, respectively. Chi2 is the statistics of the likelihood-ratio test on H0: IIA holds. Chi2 is based on estimations without clustering.

Appendix A. Descriptive Statistics of Explanatory Variables and Firm Data

Table A1. Explanatory Variables

Variable	Description	Source
Region level		
Market size	Real GDP of the host region, in Euros, 1995 prices.	Cambridge Econometrics
Market potential	The sum of inverse distance-weighed real GDP of all regions other than the host region. Distance is measured as the lorry travelling time between the host region and all other regions.	Cambridge Econometrics and own calculation
GDP per capita	Real GDP per capita, in Euros, 1995 prices.	Cambridge Econometrics
Agglomeration	Number of ICT manufacturing firms (ICT service firms) in the host region. The firms are distinguished as foreign-owned or domestic-owned, where foreign owner has at least 10 per cent share in the firm.	*Amadeus*
Human capital	The proportion of workers in the labour force holding a tertiary degree or above, per cent.	Eurostat
Unemployment rate	Regional unemployment rate, per cent	Cambridge Econometrics
Innovation intensity	Share of patent applications in the ICT sector in total patent applications to the European Patent Office, per cent.	Eurostat
Country level		
Corporation tax rate	Corporation tax rate, per cent	KPMG Annual Report
Income tax rate	Personal income tax rate, per cent	Eurostat

Table A2. Descriptive Statistics of Explanatory Variables (1997 values)

All regions	Regional GDP (million euro)	Market potential	GDP per capita (euro per ca.)	Number of ICT manufacturing firms (foreign owned)	Number of ICT manufacturing firms (domestic owned)	Number of ICT service firms (foreign owned)	Number of ICT service firms (domestic owned)	Third level education attainment (%, 2000 value)	The unemployment Rate (%, 2000 value)	Patent applications (%)	Corporation tax rate	Income tax rate
Mean	28,899.8	74.0	15,377.9	25.5	102.0	100.9	241.7	24.8	8.7	22.3	34.3	40.1
Standard deviation	34,795.3	36.3	8,470.5	48.1	159.8	279.5	438.8	10.0	5.4	15.9	8.6	6.6
Maximum	342,209.6	155.1	49,500.2	435.0	1,193.0	2,432.0	4,322.0	52.0	26.0	100.0	57.5	49.5
Minimum	41.1	13.8	1,827.6	0.0	0.0	0.0	0.0	4.9	2.2	0.0	18.0	24.9
EU15												
Mean	34,454.2	79.4	18,363.7	28.0	110.1	115.2	249.7	26.1	8.0	23.3	37.2	39.1
Standard deviation	36,625.9	36.1	6,476.7	52.1	158.9	306.5	380.3	9.5	4.9	16.5	8.4	8.2
Maximum	342,209.6	155.1	49,500.2	435.0	1,193.0	2,432.0	2,617.0	52.0	26.0	100.0	57.5	49.5
Minimum	662.8	13.9	7,139.2	0.0	0.0	0.0	0.0	4.9	2.2	1.2	28.0	24.9
EU10												
Mean	5,645.0	53.7	3,723.5	14.4	66.5	38.7	206.9	20.5	11.0	17.7	30.0	41.6
Standard deviation	5,042.7	29.8	3,098.2	21.7	160.5	70.4	638.2	10.4	6.1	12.6	7.5	2.7
Maximum	23,417.0	142.5	23,291.5	103.0	1,070.0	318.0	4,322.0	52.0	24.0	50.0	40.0	47.8
Minimum	41.1	13.8	1,827.6	0.0	0.0	0.0	0.0	8.3	2.3	0.0	18.0	37.8

Table A3. Geographic Distribution of New Foreign Affiliates in ICT Manufacturing Industries (number of firms, by ownership and industry)

Industry	NACE 30				NACE 32				NACE 33			
Ownership	**Total**	US	EU	Other	**Total**	US	EU	Other	**Total**	US	EU	Other
AT	**4**	0	3	1	**13**	1	11	1	**26**	1	20	5
BE	**3**	0	2	1	**12**	4	6	2	**8**	5	2	1
BG	**1**	0	0	1	**18**	2	15	1	**7**	0	6	1
CZ	**4**	0	2	2	**9**	0	6	3	**9**	2	7	0
DK	**4**	1	2	1	**11**	0	10	1	**16**	0	9	7
EE	**0**	0	0	0	**10**	1	9	0	**2**	0	1	1
FI	**0**	0	0	0	**2**	1	1	0	**9**	1	5	3
FR	**5**	1	2	2	**44**	18	14	12	**52**	20	21	11
DE	**45**	10	25	10	**127**	26	53	48	**210**	56	84	70
GR	**0**	0	0	0	**3**	0	3	0	**2**	1	1	0
HU	**1**	0	1	0	**10**	2	6	2	**2**	0	2	0
IE	**11**	6	4	1	**5**	2	2	1	**23**	9	12	2
IT	**11**	2	8	1	**20**	5	13	2	**31**	12	16	3
LV	**1**	0	1	0	**0**	0	0	0	**1**	0	0	1
LT	**0**	0	0	0	**1**	0	1	0	**0**	0	0	0
LU	**0**	0	0	0	**0**	0	0	0	**1**	1	0	0
NL	**8**	1	3	4	**16**	3	7	6	**27**	10	8	9
PL	**16**	2	14	0	**12**	0	9	3	**33**	6	23	4
PT	**2**	0	2	0	**2**	0	1	1	**7**	1	3	3
RO	**24**	4	12	8	**32**	2	23	7	**57**	0	46	11
SK	**0**	0	0	0	**1**	0	1	0	**0**	0	0	0
SI	**0**	0	0	0	**0**	0	0	0	**1**	0	1	0
ES	**7**	2	4	1	**8**	0	6	2	**7**	2	3	2
SE	**2**	0	2	0	**8**	4	2	2	**7**	1	5	1
GB	**45**	18	16	11	**84**	35	24	25	**162**	72	55	35
Total	**194**	47	103	44	**448**	106	223	119	**700**	200	330	170

Notes: 30: manufacture of office machinery and computers. 32: manufacture of radio, television and communications equipment and apparatus. 33: manufacture of medical, precision and optical instruments and clocks. Ownership: US - owned by US MNE parent; EU - owned by EU parent; Other - owned by MNE parent from the rest of the world.

Table A4. Geographic Distribution of New Foreign Affiliates in ICT Manufacturing Industries (share, by industry)

Industry Ownership	% 30 Total	% 32 Total	% 33 Total	% 30+32+33 Total
AT	2.1	2.9	3.7	2.9
BE	1.5	2.7	1.1	1.8
BG	0.5	4.0	1.0	1.8
CZ	2.1	2.0	1.3	1.8
DK	2.1	2.5	2.3	2.3
EE	0.0	2.2	0.3	0.8
FI	0.0	0.4	1.3	0.6
FR	2.6	9.8	7.4	6.6
DE	23.2	28.3	30.0	27.2
GR	0.0	0.7	0.3	0.3
HU	0.5	2.2	0.3	1.0
IE	5.7	1.1	3.3	3.4
IT	5.7	4.5	4.4	4.9
LV	0.5	0.0	0.1	0.2
LT	0.0	0.2	0.0	0.1
LU	0.0	0.0	0.1	0.0
NL	4.1	3.6	3.9	3.9
PL	8.2	2.7	4.7	5.2
PT	1.0	0.4	1.0	0.8
RO	12.4	7.1	8.1	9.2
SK	0.0	0.2	0.0	0.1
SI	0.0	0.0	0.1	0.0
ES	3.6	1.8	1.0	2.1
SE	1.0	1.8	1.0	1.3
GB	23.2	18.8	23.1	21.7
Total	100.0	100.0	100.0	100.0

Table A5. Geographic Distribution of New Foreign Affiliates in ICT Services (number of firms, by ownership and industry)

Industry	NACE 64				NACE 72			
Ownership	**Total**	US	EU	Other	**Total**	US	EU	Other
AT	**21**	5	15	1	**171**	17	123	31
BE	**20**	5	15	0	**105**	20	76	9
BG	**19**	2	15	2	**71**	4	58	9
CZ	**16**	2	14	0	**61**	7	49	5
DK	**39**	6	20	13	**160**	33	95	32
EE	**6**	0	4	2	**30**	3	20	7
FI	**7**	2	5	0	**45**	7	31	7
FR	**44**	13	21	10	**287**	90	166	31
DE	**192**	27	108	57	**1049**	198	551	300
GR	**12**	1	9	2	**25**	6	19	0
HU	**3**	1	2	0	**7**	2	5	0
IE	**42**	10	26	6	**190**	76	96	18
IT	**26**	6	14	6	**112**	31	68	13
LV	**2**	0	2	0	**0**	0	0	0
LT	**3**	0	3	0	**8**	1	4	3
LU	**2**	0	2	0	**29**	1	16	12
NL	**42**	10	26	6	**173**	46	84	43
PL	**26**	2	21	3	**80**	13	64	3
PT	**8**	2	6	0	**41**	5	32	4
RO	**154**	31	79	44	**593**	90	420	83
SK	**1**	1	0	0	**0**	0	0	0
SI	**0**	0	0	0	**1**	1	0	0
ES	**66**	18	41	7	**219**	38	151	30
SE	**13**	4	3	6	**108**	21	44	43
GB	**447**	134	160	153	**2826**	906	1148	772
Total	**1211**	282	611	318	**6391**	1616	3320	1455

Notes: 64: post and telecommunications; 72: computer and related activities. Ownership: US - owned by US MNE parent; EU - owned by EU parent; Other - owned MNE parent from the rest of the world.

Table A6. Geographic Distribution of New Foreign Affiliates in ICT Services (share, by industry)

Industry Ownership	% 64 Total	% 72 Total	% 64+72 Total
AT	1.7	2.7	2.2
BE	1.7	1.6	1.6
BG	1.6	1.1	1.3
CZ	1.3	1.0	1.1
DK	3.2	2.5	2.9
EE	0.5	0.5	0.5
FI	0.6	0.7	0.6
FR	3.6	4.5	4.1
DE	15.9	16.4	16.1
GR	1.0	0.4	0.7
HU	0.2	0.1	0.2
IE	3.5	3.0	3.2
IT	2.1	1.8	1.9
LV	0.2	0.0	0.1
LT	0.2	0.1	0.2
LU	0.2	0.5	0.3
NL	3.5	2.7	3.1
PL	2.1	1.3	1.7
PT	0.7	0.6	0.7
RO	12.7	9.3	11.0
SK	0.1	0.0	0.0
SI	0.0	0.0	0.0
ES	5.5	3.4	4.4
SE	1.1	1.7	1.4
GB	36.9	44.2	40.6
Total	100.0	100.00	100.0

Table A7. Top 10 Receiving NUTS 2 Regions of New Foreign Affiliates

ICT manufacturing (%)		ICT service (%)	
Inner London (UKI1)	4.35	Inner London (UKI1)	14.93
Darmstadt (DE71)	3.17	Berkshire (South east UK) (UKJ1)	5.07
Bucuresti (RO32)	3.17	Bucuresti (RO32)	4.93
Berkshire (South east UK) (UKJ1)	3.10	Ile de France (FR10)	3.38
Upper Bavaria (DE21)	2.88	Surrey (UKJ2)	3.23
Ile de France (FR10)	2.80	Upper Bavaria (DE21)	2.94
Southern and Eastern Ireland (IE02)	2.51	Southern and Eastern Ireland(IE02)	2.87
Lombardia (ITC4)	2.51	Outer London (UKI2)	2.86
Dusseldorf (DEA1)	2.29	Darmstadt (DE71)	2.60
Tübingen (DE14)	1.92	Madrid (ES30)	2.36
Sum	28.7	Sum	45.17

Table A8. List of NUTS2 Regions Included in the Regressions

#	NUTS2 Code	Name	#	NUTS2 Code	Name	#	NUTS2 Code	Name
	Austria			**Greece**			**Spain**	
1	AT11	Burgenland	89	GR23	Dytiki Ellada	169	ES11	Galicia
2	AT12	Niederosterreich	90	GR30	Attiki	170	ES12	Asturias
3	AT13	Wien	91	GR43	Kriti	171	ES21	Pais Vasco
4	AT21	Karnten		**Hungary**		172	ES23	Rioja
5	AT22	Steiermark	92	HU10	Közép-Magyarország	173	ES24	Aragon
6	AT31	Oberosterreich	93	HU21	Közép-Dunántúl	174	ES30	Madrid
7	AT32	Salzburg	94	HU22	Nyugat-Dunántúl	175	ES41	Castilla-Leon
8	AT33	Tirol	95	HU23	Dél-Dunántúl	176	ES42	Castilla-la Mancha
9	AT34	Vorarlberg	96	HU31	Észak-Magyarország	177	ES51	Cataluna
	Belgium		97	HU32	Észak-Alföld	178	ES52	Com. Valenciana
10	BE10	Bruxelles	98	HU33	Dél-Alföld	179	ES53	Baleares
11	BE21	Antwerpen		**Ireland**		180	ES61	Andalucia
12	BE22	Limburg	99	IE01	Border, Midlands, Western	181	ES62	Murcia
13	BE23	Oost-Vlaanderen	100	IE02	Southern and Eastern		**Sweden**	
14	BE24	Vlaams Brabant		**Italy**		182	SE11	Stockholm
15	BE25	West-Vlaanderen	101	ITC1	Piemonte	183	SE12	Ostra Mellansverige
16	BE31	Brabant Wallon	102	ITC2	Valle d'Aosta	184	SE21	Smaland med oarna
17	BE32	Hainaut	103	ITC3	Liguria	185	SE22	Sydsverige
18	BE33	Liege	104	ITC4	Lombardia	186	SE23	Vastsverige
19	BE34	Luxembourg	105	ITD2	Trentino-Alto Adige	187	SE31	Norra Mellansverige
	Czech Republic		106	ITD3	Veneto	188	SE32	Mellersta Norrland
20	CZ01	Praha	107	ITD4	Fr.-Venezia Giulia	189	SE33	Ovre Norrland
21	CZ02	Strední Cechy	108	ITD5	Emilia-Romagna		**UK**	
22	CZ03	Jihozápad	109	ITE1	Toscana	190	UKC1	Tees Valley and Durham
23	CZ04	Severozápad	110	ITE2	Umbria	191	UKC2	Northumb. et al.
24	CZ05	Severovýchod	111	ITE3	Marche	192	UKD1	Cumbria
25	CZ06	Jihovýchod	112	ITE4	Lazio	193	UKD2	Cheshire
26	CZ07	Strední Morava	113	ITF1	Abruzzo	194	UKD3	Greater Manchester
27	CZ08	Moravskoslezko	114	ITF2	Molise	195	UKD4	Lancashire
	Estonia		115	ITF3	Campania	196	UKD5	Merseyside
28	EE00	Eesti	116	ITF4	Puglia	197	UKE1	East Riding
	Finland		11	ITF5	Basilicata	19	UKE2	North Yorkshire

			7			8		
29	FI18	Etelä-Suomi	118	ITF6	Calabria	199	UKE3	South Yorkshire
30	FI19	Länsi-Suomi	119	ITG1	Sicilia	200	UKE4	West Yorkshire
31	FI1A	Pohjois-Suomi	120	ITG2	Sardegna	201	UKF1	Derbyshire
	France			**Latvia**		202	UKF2	Leics.
32	FR10	Ile de France	121	LV00	Latvia	203	UKF3	Lincolnshire
33	FR21	Champagne-Ard.		**Lithuania**		204	UKG1	Hereford et al.
34	FR22	Picardie	122	LT00	Lithuania	205	UKG2	Shrops.
35	FR23	Haute-Normandie		**Luxembourg**		206	UKG3	West Midlands (county)
36	FR24	Centre	123	LU00	Luxembourg (Grand-Duché)	207	UKH1	East Anglia
37	FR25	Basse-Normandie		**The Netherlands**		208	UKH2	Bedfordshire
38	FR26	Bourgogne	124	NL11	Groningen	209	UKH3	Essex
39	FR30	Nord-Pas de Calais	125	NL12	Friesland	210	UKI1	Inner London
40	FR41	Lorraine	126	NL13	Drenthe	211	UKI2	Outer London
41	FR42	Alsace	127	NL21	Overijssel	212	UKJ1	Berkshire et al.
42	FR43	Franche-Comte	128	NL22	Gelderland	213	UKJ2	Surrey
43	FR51	Pays de la Loire	129	NL23	Flevoland	214	UKJ3	Hants.
44	FR52	Bretagne	130	NL31	Utrecht	215	UKJ4	Kent
45	FR53	Poitou-Charentes	131	NL32	Noord-Holland	216	UKK1	Gloucester et al.
46	FR61	Aquitaine	132	NL33	Zuid-Holland	217	UKK2	Dorset
47	FR62	Midi-Pyrenees	133	NL34	Zeeland	218	UKK3	Cornwall
48	FR63	Limousin	134	NL41	Noord-Brabant	219	UKK4	Devon
49	FR71	Rhone-Alpes	135	NL42	Limburg	220	UKL1	West Wales
50	FR72	Auvergne		**Poland**		221	UKL2	East Wales
51	FR81	Languedoc-Rouss.	136	PL11	Lódzkie	222	UKM2	Eastern Scotland
52	FR82	Prov-Alpes-Cote d'Azur	137	PL12	Mazowieckie	223	UKM3	South West Scot.
	Germany		138	PL21	Malopolskie	224	UKN0	Northern Ireland
53	DE11	Stuttgart	139	PL22	Slaskie			
54	DE12	Karlsruhe	140	PL31	Lubelskie			
55	DE13	Freiburg	141	PL32	Podkarpackie			
56	DE14	Tubingen	142	PL33	Swietokrzyskie			
57	DE21	Oberbayern	143	PL34	Podlaskie			
58	DE22	Niederbayern	144	PL41	Wielkopolskie			
59	DE23	Oberpfalz	145	PL42	Zachodniopomorskie			
60	DE24	Oberfranken	146	PL43	Lubuskie			
6	DE25	Mittelfranken	14	PL51	Dolnoslaskie			

1			7		
62	DE26	Unterfranken	148	PL52	Opolskie
63	DE27	Schwaben	149	PL61	Kujawsko-Pomorskie
64	DE30	Berlin	150	PL62	Warminsko-Mazurskie
65	DE50	Bremen	151	PL63	Pomorskie
66	DE60	Hamburg		**Portugal**	
67	DE71	Darmstadt	152	PT11	Norte
68	DE72	Giessen	153	PT15	Algarve
69	DE73	Kassel	154	PT16	Centro
70	DE80	Mecklenburg-Vorpomm.	155	PT17	Lisboa e V.do Tejo
71	DE91	Braunschweig	156	PT18	Alentejo
72	DE92	Hannover		**Romania**	
73	DE93	Luneburg	157	RO11	Nord-Vest
74	DE94	Weser-Ems	158	RO12	Centru
75	DEA1	Dusseldorf	159	RO21	Nord-Est
76	DEA2	Koln	160	RO22	Sud-Est
77	DEA3	Munster	161	RO31	Sud - Muntenia
78	DEA4	Detmold	162	RO32	Bucuresti - Ilfov
79	DEA5	Arnsberg	163	RO41	Sud-Vest Oltenia
80	DEB1	Koblenz	164	RO42	Vest
81	DEB2	Trier		**Slovak**	
82	DEB3	Rheinhessen-Pfalz	165	SK01	Bratislavský
83	DEC0	Saarland	166	SK02	Západné Slovensko
84	DED1	Chemnitz	167	SK03	Stredné Slovensko
85	DED2	Dresden	168	SK04	Východné Slovensko
86	DED3	Leipzig			
87	DEF0	Schleswig-Holstein			
88	DEG0	Thuringen			

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

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

The probability elasticity w.r.t. x_h is

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

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

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

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