Functional Specialisation and the Location of Multinational Firms in the Enlarged Europe*

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Abstract

Despite the recent development of location theory, the role of services surrounding production activity has been largely understudied. We propose to analyze the location of multinational firms' value chain in the enlarged European Union. We develop a multi-stage model where downstream functions, i.e., *logistics* or *sales and marketing offices*, consider the size of the market in their location choice, while upstream activities, i.e., *headquarters* and *Research & Development centers*, focus on high skill abundant locations. *Production units* face a trade-off between production costs and high market potential. We then implement the model empirically, using recently collected individual firm data of almost 11.000 location choices over five years and 23 countries. We analyze the determinants of location for each activity, including sectoral and functional agglomeration variables. We find evidence that agglomeration effects arise at the sectoral level for production activities and at the functional level for service activities. This finding corroborates theories developed in urban economics. Finally, we illuminate the co-agglomeration of functions at the company level, specifically between R&D and production.

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Keywords: Functional specialisation; vertical integration ; location choice.

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1 Introduction

Fragmentation of the production process is becoming a major issue in International Economics. This research area has been widely related to the firm production organization change. However, it is restrictive to consider only manufacturing aspects of actual globalization. Krugman (1995) argues that the international value-chain decomposition is one of the four major aspects of modern international trade theory. He calls it "slicing the value chain" and includes in its definition a large number of service activities. In fact, the economic specialisation induced by multinational organizations has to be perceived in terms of functions and not only in terms of industrial activities. As described by the *World Investment Report* (UNCTAD, 2002, pages 121-123): *"[I]nternational production systems have emerged within which TNC's locate different parts of the production processes, including various services functions, across the globe [...] [T]he organization and distribution of production activities and other functions in what is commonly known as the global value chain. It extends from technology sourcing and development through production to distribution and marketing."*

However, Feenstra (2003) notes that this aspect of actual globalization has only been studied in economic sociology and in geography.[1] Despite the recent development of location theory,[2] current studies only consider production plant location choices and largely neglect all service functions surrounding production activity. More generally, very little theoretical or empirical papers analyzes directly the service function internationalization. One reason may be that while it is a very interesting research issue, it is also more complex to study due to the lack of data and the difficulties in linking it to theory. Thus, it is not surprising that, to our knowledge, the location of multinational firm functions has never been econometrically tested. This paper attempts to fill this gap in the current Economics literature.

The theory related to the fragmentation phenomenon, first introduced by Jones and Kierzkowski (1990), has been given number of different names[3]. Multinational firms play an important role in this process through the *vertical* separation of activities, in order to exploit international factor-

[1] See Gereffi and Korzeniewicz (1994) and Kenney and Florida (1994) in economic sociology and Dicken *et al.* (2001) and Yeung (2001) in geography.

[2] See Head *et al.* (1995), Head and Mayer (2004). See also Disdier and Mayer (2004) for an application to the enlarged Europe.

[3] Including de-location, disintegration of production, fragmentation, global production sharing, foreign outsourcing.

cost differences or through *horizontal* investments, where production plants are duplicated in several countries to get access to other markets.[4] Unfortunately, until now, empirical research has difficulties in demonstrating the validity of this classification. In fact, as noticed by Grossman *et al.* (2003) *"[W]ith more countries and more stages of production, some organizational forms do not fit neatly into either of these categories"*.

A few Recent papers have underlined the organizational complexity of multinational firms. Yeaple (2003) considers this classification into two types of investment as highly restrictive in comparison to the diversity of multinational location strategies. Ekholm *et al.* (2003) highlight the importance of platform export. Hanson *et al.* (2005) argue that a distinction has to be made between *production-oriented* and *distribution-oriented* investment, where this choice does not reflect the export-versus FDI decision common to standard models in the literature, since the latter is only about alternative production modes. Our contribution is to illuminate pre and post-production service activities widely neglected by the fragmentation theory. The only paper directly related to the functional specialisation is Duranton and Puga (2005). In an Urban Economics framework, they consider the transformation of urban structures from mainly sectoral to mainly functional specialisation. In fact, the separation of firms activities should generate a new form of cities specialisation based on function. Services are more likely to be located in big cities and production plants in small and low wage cities. The main implication of the Duranton and Puga (2005) studies is that agglomeration effects should be considered more within function activities than within sectors, when one is looking to the location of service activities.

Our aim is to provide and test a general analysis of function location choices. We aim to shed light on the determinants of the location of different parts of the firm value-chain. We develop a one firm theoretical model under monopolistic competition, with multi-stage production. Each stage differs in both transport costs and on the high skills/low skills ratio integrated in the intermediary production process. The most upstream stage is freely tradable and mostly integrates high skilled labor. The final downstream stages are non-tradable and integrate mostly low skilled labor. Production activity is somewhere between these two extremes. The model predicts that downstream functions, i.e. *logistics* and *sales offices*, will privilege the size of the market, while upstream activities, i.e. *headquarters* and *Research & Development centers*, will privilege high skill abundant location. *Production units* will face a trade-off between production costs and high market potential. To test the model, we use a unique dataset recently

[4] On the former, see Helpman (1984). On the latter, see Markusen (1984) and Brainard (1997).

collected by the consulting group Ernst & Young. Data of almost 11 000 location choices was collected at the individual firm level and covers the period 1997 to 2002. We consider both European Union countries and the new accession countries. In fact, the actual enlargement is a unique event in the process of studying the fragmentation of the production process across countries. Our econometric results corroborate our model except that the market size seems to be important in the headquarter location choice and human capital is an important variable for downstream functions.

Consistent with the Duranton and Puga (2005) model, we also find that service activities are sensitive to functional agglomeration but not to sectoral agglomeration (except for headquarters). For production plants, sectoral agglomeration remains very important. The demonstration of the "functional specialisation" phenomenon at a national level could have policy implications. In fact, in service economies, as in West Europe, it could be irrelevant to think of specialisation in terms of sectors instead of functions. Finally, we empirically analyze the co-location of the different stages of the value chain within-firm. We show that groups concentrated affiliate activities in a specific country due to vertical linkages between functions. This is the case between R&D and production plants, in that both activities seem to have a strong attraction for one and another. Surprisingly, headquarters do not appear to experiment any attraction effect on any other part of the value chain.

The remainder of the paper is organized as follows: In section 2, we develop our model describing the value-chain organization. Section 3 discusses the econometric model. Section 4 explains the database and variables used. Section 5 presents the econometrics results. Section 6 concludes.

2 The Model

We build a one firm model with a continuum of stages in monopolistic competition *à la* Dixit and Stiglitz (1977).[5] We consider a firm value chain composed of S stages comprised between 0 and 1, with stage s=0 representing the upstream activities and stage s=1 the direct sale to the consumer.[6] Each intermediate stage s+1[7] would integrate a certain amount of labor plus

[5]Krugman (1980, 1991) wrote the seminal papers in an international framework.

[6]The latter would sell final goods to consumer. Results would be like in Head and Mayer (2004) framework. We do not consider this case in the following presentation and focus on all other intermediate stages.

[7]s+1 refers to the stage following s and s-1 the one preceding s.

intermediate inputs from stage s. The price of the latter would be equal of the sum of the value added (va) incorporated at each previous stage:

$$p_s = \int_0^s va_s. \tag{1}$$

Each stage of a multinational would be composed of different plants located in different country r. Each unit can be considered to be independent, maximizing its own profit function and directed by an independent manager. Each intermediate stage manager is both consumer (of previous stage goods) and producer (selling to the following stage).

From the point of view of a manager of stage s, E_{rs+1} represents the total expenditure of the representative stage s+1 in country r. Managers of the latter, act as consumers, and allocate their expenditures across differentiated varieties of intermediate inputs of stage s.[8] In addition of their expenditure, the maximization of their sub-utility function is also subject to the delivered prices from all R possible input origins. So, we obtain the demand curve for the representative stage s+1 in the representative firm as

$$q_{ijs+1} = \frac{p_{ijs}^{-\sigma}}{\sum_{r=1}^{R} n_{rs} p_{rjs}^{1-\sigma}} E_{js+1}, \tag{2}$$

The product of the mill price p_{js} and of the trade cost factor, τ_{ijs}, corresponds to the delivered price p_{ijs}. It is faced by the s+1 managers in region j (destination) for inputs from region i (origin). In fact, each stage of the value chain can be produced apart from the other stages, but if so, the superior stage input must be shipped to the place of the next stage before it can be used. Transportation costs would differ between stages following an assumption described in section 2.2.

2.1 The Profit Equation of each stage

Each manager chooses its price and as it is usual in monopolistic competition, profit maximization implies to sets mill prices as a simple mark-up over marginal costs c_{rs}:

$$p_{rs} = c_{rs}(\sigma/(\sigma - 1)). \tag{3}$$

[8]We consider that managers have constant elasticity of substitution.

where σ represents the elasticity of both substitution and demand. Substituting into (2), we obtain the quantity that manager of the representative stage s producing in region i will deliver to each destination j to stage s+1:

$$q_{ijs+1} = \frac{(\sigma-1)}{\sigma}\frac{(c_{is}\tau_{ijs})^{-\sigma}}{G_{js}}E_{js+1}, \tag{4}$$

where

$$G_{js} \equiv \sum_r n_{rs}(c_{rs}\tau_{rjs})^{1-\sigma}.$$

The gross profit of a manager of the stage s producing in region i and selling in region j is

$$\pi_{ijs} = (p_{is} - c_{is})\tau_{ijs}q_{ijs+1} = \frac{(c_{is}\tau_{ijs})^{1-\sigma}}{\sigma G_{js}}E_{js+1}. \tag{5}$$

The aggregate net profit, Π_{rs} to be earned by stage s in each potential location r is obtained by summing the gross profits earned in each market and subtracting the fixed costs F_r necessary to establish an activity in region r:

$$\Pi_{rs} = \frac{c_{rs}^{1-\sigma}}{\sigma}\sum_{j=1}^{R}\tau_{rjs}^{1-\sigma}\frac{E_{js+1}}{G_{js}} - F_r, \tag{6}$$

where

$$M_{rs+1} \equiv \sum_j \frac{\tau_{rjs}^{1-\sigma}E_{js+1}}{G_{js}}.$$

We will refer to M_{rs+1} as the "market potential" for s+1=1 and to the "affiliate market potential of stage s+1" for all other stages.

2.2 Characterization of each stage

Our goal in this section is to characterize the different stages of the value chain. To do this, we introduce two types of labor : H representing high skilled labor and L low skilled labor.

Iceberg transportation costs[9] between any two successive stages are paid on the basis of the low wage incorporated in the goods shifted, which corresponds to the sum of low skilled labor input and trade cost which have been paid on precedent stages of production. High skilled labor

[9]In order to move one unit of a good to another location, $1 + \tau$ units must be shipped, so τ units get lost in transit.

integrated into the goods is considered to be freely transportable. In fact, we do not consider any trade barrier or tariff, but we only take into account cost of transporting goods, which could be related to the weight of input but not to its value added. High skilled labor introduced in the production process is viewed as information, which is easily transportable. An extreme case could be a product only composed of high skilled labor as an idea, which would be freely transportable.[10]

Each stage adds to the input both low skilled labor l, with a price ω_r^l and high skilled labor h, with wage equal to ω_r^h, the quantity of the whole depends on a Cobb-Douglas function ${\omega_r^h}^{\beta_s} {\omega_r^l}^{(1-\beta_s)}$, in which β_s represents the part of high skilled in the total amount of labor incorporated. We consider that β is a decreasing function in S. Upstream activities, such as research & development or headquarter services are considered as very intensive in high skilled labor and so, would be easily transportable. At the opposite, downstream stages, for example, logistics or sales office are viewed as very intensive in low skilled labor and so, hardly transportable.

2.3 Testable implications

At each stage level, we consider that fixed costs are invariant across locations and thus, it would be omitted on the following computation. Multiplying equation (6) by σ and take natural logs leave the profit ordering between location unchanged and allow us to obtain a simple expression for profitability, noted U_{rs}.

$$U_{rs} = -(\sigma - 1)\ ln\ c_{rs} + ln\ M_{rs+1}. \tag{7}$$

Manager chooses the location which maximizes its profit. Equation (7) expresses the profitability for a stage s activity locating in region r as a decreasing function in production costs and a increasing one in the market potential term. Let us suppose that the variable cost function is assumed to be Cobb-Douglas with constant returns, using labors (as previously described) and adding input of stage s-1 at cost p_{rs-1}. Labors share is α and A_r represents total factor productivity. Thus, log marginal costs are given by

$$ln\ c_{rs} = \alpha\beta_s\ ln\ \omega_r^h + \alpha(1-\beta_s)\ ln\ \omega_r^l + (1-\alpha) ln\ \ p_{rs-1} - ln\ \ A_{rs}. \tag{8}$$

[10]To simplify the model as much as possible, we will not consider two distinct costs (one representing high skilled labor and the other one based on low skilled labor, in which transport cost is applied). We will simply consider that τ_{ij} increases when one adds low skilled labor into the intermediate input.

Substituting (8) into (7), we have

$$U_{rs} = -(\sigma - 1)\left(\alpha\beta_s \; ln \; \omega_r^h + \alpha(1-\beta_s) \; ln \; \omega_r^l + (1-\alpha) ln \; p_{rs-1} - ln \; A_{rs}\right) + ln \; M_{rs+1}. \quad (9)$$

We consider a three stages production process in which upstream and downstream stages can be analyzed as extreme cases. More precisely, we assume that the upstream activities, as headquarters or R&D center, are principally composed of high skilled labor (β is high), so that transporting the goods to the next stage can be done at a negligible cost. We would expect that this stage would be located in a region with high skill level and does not value other location aspects as the market potential. If transport cost are not equal to zero, it would have advantage to be located close to the middle stage.

At the other extreme, location of downstream activities, such as logistics or sales & marketing activities, would be fully determined by the size of the market when transport cost are prohibitive (β is low). If transport cost is not too high, market linked functions, which are essentially composed of low skilled labor would focus on low skill wages. Be located close to the middle stage would also decrease input price.

Production can be viewed as an intermediate case incorporating both high and low skilled labor, and facing an intermediate transport cost. The profit equation suggests that this function faces a trade-off between variable cost[11] and high market potential[12].

Our model does not incorporate trade-off between in-house versus arms-length offshoring.[13] This lack of distinction is a result of shortcomings of our data. When implemented with data, a problem will appear. Only a small number of firms have located all stages of the value-chain in the enlarged EU (see section 4.1 for descriptive statistics). It is also possible that some activities are located outside Europe. Hence, it is not possible to calculate an affiliate market potential for each firm. As a consequence, we would only consider within-firm co-agglomeration between functions at the country level. We would also be able to study market variable coefficients. Magnitude should be decreasing when moving to upstream activities.

[11]High education level, low production costs and input price.
[12]Market potential of final consumer and of downstream stage.
[13]See Antrás (2003) or Grossman and Helpman (2002) for theoretical model with two types of organization: outsourcing versus FDI.

We observe wages of each location choice, and will calculate M_r using a simply Harris (1954) market potential, i.e. the inverse-distance weighted sum of incomes.[14]

2.4 Sectoral and functional externalities

We now consider the total factor productivity A_{rs}, viewed by Head and Mayer (2004) as *"firm-specific variation in regional productivity"* and implemented with an "agglomeration variable". In fact, much evidence suggests that related firms tend to cluster in the same regions. By following Duranton and Puga (2005), we consider two forms of agglomeration. The former is sectoral: when activities belonging to the same sector are agglomerated in a specific country. More precisely, we consider the agglomeration around production plants in the same sector. The latter is the functional: activities belonging to the same function but not to the same sector are taking place in the same location. The Duranton and Puga (2005) model predicts that production plants would be more likely to be affected by sectoral externalities and service functions by the functional one.

3 Econometric Model

3.1 Basic methodology

In order to test the model, we use individual firm location choices over a set of 23 European Union and Eastern European Countries.[15] The most commonly used econometric modelling technique for this type of problem is the conditional logit model (CLM) proposed by McFadden (1984). Each location decision is a discrete choice made among several alternatives.

While the real underlying profit yielded by alternative locations cannot be observed, one does observe the actual choice of each firm and the characteristics of the alternative locations. Suppose $R = (1, ..., r, ...o)$ is the set of possible location countries. Each location offers a profit of π_r such that

$$\pi_r = U_r + \varepsilon_r, \tag{10}$$

[14] Head and Mayer (2004) estimate a more complex market potential variable derived rigorously from theory using information from international trade flows to estimate these parameters. However, they do not find much difference in this relative to Harris market potential.

[15] These are EU countries and new accessing countries excluding Malta and Cyprus. Generally, we exclude all specific locations such as islands.

with

$$U_r = \beta X_r,$$

where U_r is a function of observable characteristics (X_r) of each location choice r, β a vector of coefficients to be estimated by maximum likelihood procedures and ε_r the unobservable advantage of the location r. The firm will choose r if the profit at this location is higher than the ones obtained in any other alternative location. Hence, the probability of choosing r is

$$P_r \equiv Prob(\pi_r > \pi_k) = Prob(\varepsilon_k < \varepsilon_r + \beta(X_r - X_k)), \forall k \neq r. \tag{11}$$

3.2 Limitations of the conditional logit

The crucial assumption of the CLM is that the error terms are independently and identically distributed according to a type I extreme value distribution. It leads to the simple probability of choosing location r

$$P_r = \frac{e^{\beta X_r}}{\sum_{i=1}^{o} e^{\beta X_r}}. \tag{12}$$

One of the main assumptions of CLM is to do with the Independence of Irrelevant Alternatives (IIA), which implies that choosing one country is independent of the destination choice set: working on a sub-sample or on the whole enlarged European Union should produce the same results (except of course the loss of information in the omitted decision). But unobserved characteristics of the choosers and unobserved correlations across element choices can generate a form of IIA assumption violation (Train, 2003). In such a case, estimations of logit models are inconsistent. The use of the specification test proposed by Hausman and McFadden (1984) show that IIA assumption is violated, certainly due to individual heterogeneity which can lead to disturbance of the distribution of the errors and then to the inconsistency of the estimators.

3.3 Mixed logit

One way to relax the IIA assumption is to introduce individual random effects and to estimate a mixed logit model (Brownstone and Train, 1999).[16]

The utility function of person l from alternative r is specified as: $\pi_{lr} = \beta_l' X_{lr} + \varepsilon_{lr}$ where X_{lr} are observed variables that, in our case, relate to the decision-maker, β_l is a random vector

[16] An other way to relax IIA is to use a nested logit model as Head and Mayer (2004). Unfortunately, no geographical structure seems to be relevant simultaneously for all part of the value-chain.

of coefficients which vary over decision-makers in the population with density $f(\beta)$ and ε_{lr} is a random term with same properties as in the CLM. Thus, we can write the utility function as:

$$\pi_{lr} = \beta_l^{\prime m} X_{lr} + \beta^{\prime s} X_{lr} + \varepsilon_{lr}, \tag{13}$$

where β^m and β_l^s characterize the distribution of β, i.e., its mean and deviations. Following Train (2003), the unconditional choice probability is:

$$P_{lr} = \int \left(\frac{e^{\beta' X_{lr}}}{\sum_{i=1}^{o} e^{\beta' X_{lk}}} \right) f(\beta) d\beta. \tag{14}$$

We estimate β^m and β^s with simulation methods, assuming that $f(\beta)$ is normal. Variables directly linked to firms would be considered as fixed coefficients.[17] This methodology will allow us to eliminate the perception differences on location choices of the multinational firms due to their heterogeneity. In fact, we do not want this aspect to affect variable coefficients directly linked to country characteristics.

4 Data

4.1 Description of the database

The theory will be evaluated by econometric tests based on our database of multinational firms' new location in Europe over the period 1997-2002 computing more than 11000 projects.[18]

This database EIM (European Investment Monitor) which has been developed by the consulting group Ernst & Young, identifies the project-based foreign inward investment announcements that are new, expanding, or co-located realized in an international context. The main sources of information are newspapers, financial information providers (such as Reuters), and national investment agencies (such as Invest in France Agency). When the consulting group discovers a new project, they track it in order to determine the exact location, at the city level. Projects included in the database have to comply with several criteria to be considered as investments with an international mobility character. The database excludes acquisitions, licence agreements, and joint ventures (except in the case where these operations lead to an extension or a new plant creation). It also excludes retail, hotel and leisure facilities, fixed infrastruc-

[17] In fact, introducing heterogeneity among firms around firm's specific variables would not make sense.

[18] The complete database is composed of 13109 projects when one is considering all countries and functions available. To simplify our presentation, we will limit our descriptive statistics to the 23 countries of the enlarged Europe and to the five functions. This restrictions would be detailed in section 4.2.

tures, extraction facilities, and portfolio investments. There are no minimum of investment size criteria, but the number of investments with less than 10 job creation projects is very low.

The investment projects data is at an individual level and includes the name of the firm, the parent company name, the name and the origin country of the parent company, the sector and both the country and the city of location. It also includes the function of each investment (unit of production and different service activities, such as headquarters, research & development centers, logistics, or sale & marketing offices).

At the country level, table 1 shows that the number of investments in the production function is less than one third of the total number of investments realized by multinational firms. One would expect that the fragmentation of the production process drives the different part of the value chain to be located in accordance with countries' characteristics. From the same table, we can observe that production investments in Central and Eastern Europe (CCE8) countries represent 72% compared to 42% in the EU 15.[19]

Table 1: Structure of the investments by function in UE15 and CCE8

Function	European Union	Accession (CCE8) countries	Total
Headquarters	840	19	859
Research & Development	946	56	1002
Production	3912	1304	5216
Logistics	816	142	958
Sales & Marketing	2849	299	3148
Total	9362	1820	11182

Notes: New creations and extensions in the 23 countries of the Enlarged European Union (EU15 and CCE8) on the five functions during the period 1997-2002. Manufacturing and non-manufacturing sectors. European and non-European firms.

Figure 1 represents maps of the geographical distribution of the five functions (headquarters, R&D, production, logistics and sales & marketing office) during the period 1997 to 2002. We consider the number of investments for each function divided by the countries population. Some countries such as the UK, Ireland or Belgium seem to attract a number of investments 30% above the European average for all the functions relative to the population. At the opposite end, Portugal, Spain, Italy and Greece have attracted investment 30% below the European average with equal population for five activities.

[19]CCE8: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia.

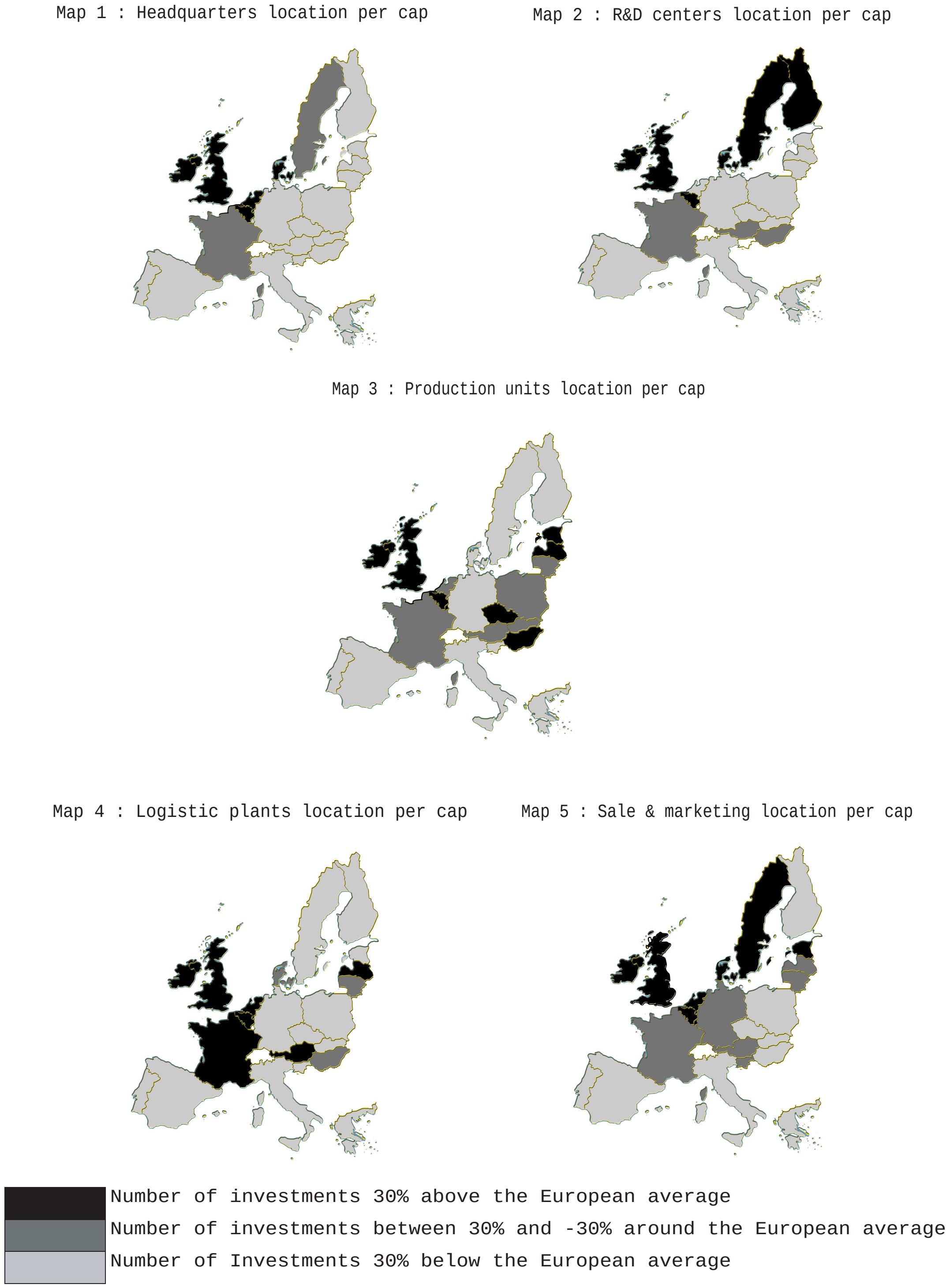

Figure 1: Number of investments by function related to the countries population in the Enlarged Europe.

Notes: New creations and extensions of European and non-European firms in the manufacturing sector in the 23 countries of the Enlarged European Union (EU15 and CCE8) during the period 1997-2002.

At the firm level, of the 5166 parent company names which have created new plants in the enlarged EU during the period 1997-2002, 4008 have created new plants for only one function. Of the rest of the sample, 636 firms have realized investments in two types of activities, 225 in three, 90 in four and 207 have invested in all the five functions studied. Some firms have realized an impressive number of investments. For example Ford Motor Co, had 37 new plant creations in the enlarged EU during the period 1997-2002.[20]

4.2 Construction of the dependent variable

We allowed some restriction on the data in order to obtain a coherent and homogeneous subset. Notably, we are able to distinguish projects between real creations (also known as *greenfield*) and extensions (e.g. *brownfield*).[21] This last category is not directly linked to the location choice determinants so we only utilize real creations for the construction of the dependent variable.

Delimitation of the functional area: We only consider five functions : production plant, headquarters, R&D centers, logistics, sales and marketing office. Other functions were available[22] but we could not use them due to the limited number of investments.

1. Headquarters : This function corresponds to all the administration, management and accounting activities localized internationally. It includes decision centers, but our data does not allow us to know exactly their importance in the global decision process and none correspond to the principal decision center. In fact, investments realized in the home country are excluded. And so, most of these centers correspond to European or regional headquarters (e.g. North of Europe) or are only intended for the network organization at a national level.

2. Research & Development centers : They can be fundamental scientific research, but also to applied development directly linked to the production process.

3. Production plants : They correspond to the whole entity related to the physical production of goods.

4. Logistics : This function refers to all the entities linked to goods transport, including warehouse (e.g. regional good distribution). They can be internal to the firm or external logistics, destined to distribute to customers or suppliers. The position of this function on the

[20] 2 headquarters, 5 R&D centers, 22 production plants, 1 logistics center and 7 sales & marketing offices.

[21] The database computes 7892 new plants and 3290 extensions during the period 1997-2002 in the 23 countries of the enlarged Europe and the five functions.

[22] Contact center ; education & training ; internet data center ; testing & servicing ; service center. This functions represent 770 projects.

value chain is not completely clear and can be viewed as acting as an intermediary between component production and assembly.

5. Sales & marketing offices : They include both wholesale trade and business representative offices. Despite the fact that they are not limited by size, it seems that the database only covers the biggest investments.

We group functions under three headings : upstream activities, i.e., headquarters and research & development, production plants and downstream functions, i.e, marketing, sales and distribution services.

Delimitation of the sectoral area: Each project can be defined by sector or by function. There are 49 sectors classified by NACE classification, with sub-sectors in the automotive, electric-electronic, and the chemical sectors. We only consider the manufacturing sector and exclude other sectors (essentially service sectors) (see table 2). Indeed, it would have been difficult to know the domination between service functions and service sectors.[23]

Table 2: Structure of the investments by function and by sector type

	Headquarters	R&D	Production	Logistics	Sale office	Total
Manufacturing	395	727	5104	541	845	7612
Non-manufacturing	464	275	112	417	2303	3570
Total	859	1002	5216	958	3148	11182

Notes: New creations and extensions in the 23 countries of the Enlarged European Union (EU15 and CCE8) on the five functions during the period 1997-2002. European and non-European firms.

Delimitation of the geographical area : The database indicates the home country name of each project. We only consider investments realized by non-European firms (mostly American and Japanese firms) and exclude all European firm projects (see table 3). In fact, we would like to study location choices, independently of the home country characteristics.[24] The database includes west and east European countries, including Russia and Turkey, that is to say 36 countries. Unfortunately, due to the lack of homogeneous and comparable data at the national level, we only consider, as location choice, 23 countries including future EU members which entered the union in 2004.[25]

[23]It means that we consider service function of a manufacturing sector, for example, the R&D center of an automotive company. But we don't consider any project of the financial sector.

[24]As for example, the distance between the home country and the choice of location.

[25]We don't include Malta and Cyprus. Generally we don't take into account particular geographical areas. The country limitation reduces the sample by 1189 projects (13109 to 11920 investments).

Table 3: Structure of the investments by function and origin region

Origin region	Headquarters	R&D	Production	Logistics	Sale office	Total
EEA^a	211	354	2883	562	1144	5154
$NAFTA^b$	515	525	1646	273	1708	4667
Japan	58	99	451	64	123	794
Other	76	24	236	59	173	566
Total	859	1002	5216	958	3148	11182

Notes: [a] The European Economic Area. [b] The North American Free Trade Agreement.
New creations and extensions in the 23 countries of the Enlarged European Union (EU15 and CCE8) on the five functions during the period 1997-2002. Manufacturing and non-manufacturing sectors.

4.3 The independent variables

Testing the theoretical model implies the consideration of three types of variables. Firstly, we will study host country characteristics. More precisely, we consider high skilled and low skilled labor input (in term of endowment and price respectively) in addition to market size variables. Secondly, we also consider functional and sectoral agglomeration according to Duranton and Puga (2005) model. Finally, we introduce co-agglomeration variables between functions, in order to consider national vertical linkages between stages of the value-chain.

Country characteristics variables: Real Wage: This variable corresponds to the wage (hour cost) divided by the productivity (value added per head) both provided by Eurostat.[26] We calculate real wages for each host country and for the five different functions. To do that, we need to consider correspondence between function and the NACE Rev.1 classification using specific data only available for the year 2000 (see table 4).

Table 4: Relationship between function and NACE classification

function	nace classification	code
Headquarters	Financial activities	J
Research and development center	financial activities	J
Production	manufacturing	D
Logistics	transport services	I
Sales & marketing center	sales sector	G

[26]This implies that we assume identical within function hour worked per year among countries. To our knowledge, no data of annual hour worked per capita are available at NACE rev.1 desegregation.

The model predicts that the coefficient associated with this variable should be non-significant for upstream functions and negative and significant for production plant. It is more ambiguous in the downstream stage, because on the one hand, they should be the most low skill intensive and so should have an very negative and significant coefficient. But on the other hand, due to high transport costs, the location could also be completely endogenously determined by the market size.

Education: As a proxy for high skilled labor, we consider the percentage of labor force with more than tertiary education (ISCED 5 and 6) in mathematics, sciences or technologies for the period 1997 to 2002. In considering the model, upstream stages should take into account this variable on their location choice. Downstream is viewed at the other extreme, and production plant location as intermediate.

Governance : In the way to consider political specificities, which could be important in the CEE countries, we use a public "governance effectiveness" indicator computed by Kaufmann *et al.* (2004) for the year 1997 to 2002. The variable is established on the basis of polls of experts or surveys of businessmen/citizens: government effectiveness is related to the ability of the government to formulate and implement sound policies.

Demand : We divided the demand variable between the internal market assess, using GDP in constant US$ 1995, provided by Eurostat for the year 1997-2002, and the "external market potential". The latter, inspired by Harris (1954), is the sum of the GDPs of all other countries weighted by their distance D_{ij} to the chosen location. We use distance between capitals provided by the Cepii.

$$External\ Market\ Potential_i = \sum_{i \neq j} \left(\frac{GDP_j}{D_{ij}} \right).$$

The model predicts that demand variable coefficients should be positive and significant for downstream stages and non-significant for upstream activities. Production plant case is viewed as an intermediate case. Theoretically, this interpretation is valid for both demand variables, but in practice the interpretation of GDP coefficient is more ambiguous. In fact this variable is highly correlated to the country population[27] and could also be viewed as a size variable, with

[27] GDP and population are correlated at 81 percent.

which number of plant locations would mechanically increase.

Functional versus sectoral Agglomeration effects: We define agglomeration[28] as the sum plus one of the number of multinational firms located in the country the year before the location decision of a new firm as first proposed by Head *et al.* (1995). This method assumes that the firm taking the decision takes its own investment into account in the anticipated level of agglomeration/dispersion forces in the country. Because we need a time-lag of one year, we exclude of the dependent variable projects realized in the first year (1997). Following Duranton and Puga (2005), we divided this effect and created two variables. The first is sectoral, i.e., when activities belonging to the same sector agglomerate in a specific country. Thus, the sectoral production count variable is defined as the agglomeration around production plants of establishments in the same sector. The second is functional: the function count variable is the agglomeration of establishments in the same function (including manufacturing and non-manufacturing sectors) but not in the same sector. We expect that a production plant would be affected by sectoral externalities, while service functions should be more likely to focus on functional agglomeration.

Vertical linkages variables: Vertical linkages between the different stages of the value chain are likely to encourage multinational firms to co-agglomerate functions to save in transport and communication costs. In this study, we only consider national co-agglomeration. To do this, we build five "co-agglomeration with f" variables, one for each function. The variable takes the value 1 if the function f has already been implanted in the country by one of the affiliates of the parent company and 0 otherwise. For building this variable, we consider all the projects of the sample (greenfield and brownfield). Thus, we also consider extension plants during the period 1997-2002 (which represent about one third of the database projects) and new creations realized during the years before the specific investment studied.[29] Thus, the number of past investments is naturally growing with time.

[28]The total factor productivity A_{rs} of our model.

[29]it could also have been possible to take into account the same project several times (for example, a creation and different extensions of the plant operated during the next year). Thus, we count as just one all the projects in a particular function realized by an affiliate in a particular city.

Table 5: Dependent and independent variable descriptions

Variables	Definition	year
Y	Location choices among 23 countries (*greenfield* only)	1998-2002
country variables		
Wages	Labor cost per hour differing by function (Eurostat).	2000
Productivity	Value added per head differing by function (Eurostat).	2000
Real Wages	Wage divided by productivity differing by function.	2000
Education	% of labor force with tertiary school level: ISCED 5-6	1998-2002
	in mathematics, sciences or technologies. (Eurostat).	
Governance	Governance effectiveness Index (percent)	1998-2002
	(Kaufmann *et al.*, 2004).	
GDP	Constant Gross Domestic Product: US$ 1995	1998-2002
	(Cepii: Chelem).	1998-2002
Distance	Distance between home and host country capitals	
	(Cepii).	
External Market Potential	Add of the GDPs of all countries weighted	1998-2002
	by their distance to the location choice.	
Functional and sectoral agglomeration variables		
Function Count	count+1 of firms location in the same function	N-1
	(*greenfield* only - all sectors).	
Sectoral Production Count	count+1 of production plant in the same sector	N-1
	(*greenfield* only).	
Co-agglomeration variables		
Function "f" Co-agglomeration	1 is function f have been located in the past and	1997-2001
	0 otherwise (*greenfield* and *brownfield*)	

Sources are in parentheses.

5 Econometric test

Tables 6 to 8 summarize results of non-European firm location choices during the period 1998-2002 in the 23 countries of the enlarged European Union. Each table contains 5 independent regressions; one for each of the five functions. We implement the theoretical model using both conditional logit (tables 6 and 8) and mixed logit (tables 7 and 9). We begin with the study of country determinants as well as functional and sectoral agglomeration effects (tables 6 and 7). We then introduce vertical co-agglomeration between functions. Variables are taken in log,[30] which enables us to consider the coefficients to be a relatively precise approximation of the elasticity of the probability of choosing a particular country with respect to the considered variable for the average investor.

5.1 Characteristics of the countries

We start by considering Conditional Logit Model (CLM) results of non-European firm investments (table 6). The comparison of country determinant coefficients across the different sequences of the value chain will enable us to draw insights from the possibility of different effects depending on the function.

In line with the model, real wages have a negative and significant coefficient on production plant and a non significant one for upstream activities, which evidences the priority give to the level of education in a location. Production plants have the lowest coefficient of all the five functions on this variable. But contrary to our model, downstream stages seem to focus on level of education rather than level of wages. In addition, these coefficients are highly significant with high magnitudes, which refute the hypothesis of endogenous location choices of market linked activities. In fact, downstream stages' location choices are not fully determined by the size of the market and their locations can be influenced by higher education levels.

Turning to the demand variable, coefficients of GDP are positive and significant at the 1 percent level for all five of the activities. This finding is difficult to interpret. In fact, this variable can be viewed as representing the demand size as well as a proxy for country size. A more accurate market size variable such as the External Market Potential is able to eliminate this aspect. The coefficient structure of the latter is globally in line with our model: For location of downstream functions this demand variable is of great importance in accordance with our theoretical framework. In contrast, decisions on R&D centers and production plants disregard

[30]Except the "Governance" variable which is given as a percentage.

this variable. The only function that acts differently than our prediction is the headquarters function. The latter obtains the highest coefficient of all functions, significant.

The Mixed Logit Model (MLM) mostly provides the same results as the CLM on the country characteristic variables. The only notable change is the significance level of Governance in the R&D activity location choices. In the CLM, "governance" only influences the location of upstream and production functions. In MLM, this variable is no longer significant in the R&D location choices. None of the heterogeneous terms associated with country characteristics are significant.

5.2 Functional versus sectoral agglomeration

We turn now to the functional and sectoral agglomeration effects in the CLM. In line with the Duranton and Puga (2005) model, the sectoral agglomeration variable is significantly positive with high magnitude in the production plant location choices, and non- or weakly significant with low magnitude for all other service functions. The only service function with a significant coefficient is the R&D location (respectively at 5% with CLM and 10% with MLM). We will see below that the introduction of co-agglomeration variables would eliminate it. Functional agglomeration seems to be an important variable for both service and production functions in line with our expectations. Headquarters location choices are a notable exception. In fact, contrary to our first intuition, this function does not give importance to any agglomeration effect.

Implementation of the MLM leads to the same results with the exception of the case of the logistic activities. For the latter, the introduction of heterogeneity serves to increase the External Market Potential variable coefficient and to eliminate the functional agglomeration significativity. In all the coefficients of table 7, only the functional agglomeration variable of sales & marketing and R&D have a significant heterogeneous term associated with their coefficient. Despite the fact we are not really interested in interpreting these heterogeneous terms, one of the variables of interest would be in the evolution of the heterogeneous perception among firms when one introduces within-firm co-agglomeration variables.

Table 6: Non-European firm country location choices: Conditional Logit Model

Variables	Headquarters	Research & Development	Production	Logistics	Sales & Marketing
Ln Real Wages	-0.49	-0.18	-1.52[a]	-0.99	0.02
	(0.66)	(0.35)	(0.31)	(0.61)	(0.23)
Ln Education	0.66[b]	0.40[b]	0.23[b]	0.72[a]	0.55[a]
	(0.27)	(0.19)	(0.10)	(0.25)	(0.12)
Governance (%)	0.07[b]	0.03[b]	0.04[a]	0.01	0.01
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Ln GDP	0.89[a]	0.40[a]	0.21[a]	0.56[a]	0.49[a]
	(0.16)	(0.08)	(0.07)	(0.17)	(0.07)
Ln External Market Potential	1.81[a]	-0.09	0.14	1.75[a]	0.66[a]
	(0.54)	(0.25)	(0.13)	(0.39)	(0.18)
Ln+1 Function Count	0.04	0.43[a]	0.41[a]	0.34[b]	0.30[a]
	(0.17)	(0.13)	(0.08)	(0.18)	(0.09)
Ln+1 Sectoral Production Count	0.07	0.23[b]	0.64[a]	-0.02	0.06
	(0.15)	(0.12)	(0.07)	(0.15)	(0.10)
Number of observations	166	287	729	137	447
Log Likelihood	-326	-670	-1852	-317	-1064

Notes: Standard errors are in parentheses with a, b, c respectively denoting significant at 1%, 5% and 10% levels. Dependent variable: Location choice in the 23 countries of the Enlarged European Union (EU15 and CCE8) on the five functions during the period 1998-2002. New creations of Non-European firms in the manufacturing sector.

Table 7: Non-European firm country location choices: Mixed Logit Model

Variables	Headquarters	Research & Development	Production	Logistics	Sales & Marketing
Ln Real Wages	-0.41	-0.15	-1.52[a]	-1.17	0.05
	(0.94)	(0.38)	(0.34)	(0.83)	(0.22)
Heterogeneity term					
Ln Education	0.66[b]	0.39[c]	0.23[b]	0.77[b]	0.53[a]
	(0.31)	(0.23)	(0.11)	(0.32)	(0.14)
Heterogeneity term					
Governance (%)	0.07[c]	0.03	0.04[a]	0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.02)	(0.01)
Heterogeneity term					
Ln GDP	0.92[a]	0.42[a]	0.21[b]	0.59[a]	0.52[a]
	(0.19)	(0.11)	(0.08)	(0.22)	(0.08)
Heterogeneity term					
Ln External Market Potential	1.82[a]	-0.20	0.14	1.93[a]	0.62[a]
	(0.54)	(0.28)	(0.14)	(0.53)	(0.20)
Heterogeneity term					
Ln+1 Function Count	0.04	0.48[a]	0.41[a]	0.34	0.37[a]
	(0.19)	(0.15)	(0.08)	(0.24)	(0.10)
Heterogeneity term		0.38[c]			0.41[a]
		(0.23)			(0.13)
Ln+1 Sectoral Production Count	0.07	0.24[c]	0.64[a]	-0.00	0.04
	(0.18)	(0.13)	(0.06)	(0.16)	(0.11)
Heterogeneity term					
Number of observations	166	287	729	137	447
Log Likelihood	-326	-670	-1852	-317	-1061

Notes: Standard errors are in parentheses with a, b, c respectively denoting significant at 1%, 5% and 10% levels.
Mixed logit methodology with 250 simulations. Heterogeneity terms only reported if significant.
Dependent variable: Location choice in the 23 countries of the enlarged European Union (EU15 and CCE8) on the five functions during the period 1998-2002. New creations of non-European firms in the manufacturing sector.

5.3 Functional co-agglomeration and the networks' firms

Previous econometric studies of the determinants of production plants' location have already been found to be essential for both agglomeration effects and vertical links between or within firms. Head *et al.* (1995), using Japanese investments in the United States also consider possible supply relationships or technological spillovers between members of a the same industrial *Kieretsu*. Nevertheless, Smith and Florida (1994) is the only one paper which explicitly considers relationships between two distinct parts of the production process. More precisely, they study the investment of Japanese auto-related parts suppliers and show that they tend to locate near Japanese assembly plants.

The particular contribution of this section is the introduction of co-agglomeration between functions within the same parent company in a specific country. Tables 6 and 7 add these variables to our previous empirical framework. We do not include the diagonal of the subdivided network variables (for which setting up a function f would have been explained by the presence of the same function by other affiliates). In fact, the diagonal would have incorporated agglomeration effects rather than vertical linkages.

Table 8 presents CLM results and Table 9 MLM. In the latter case, as mentioned in the econometric model, we estimate β^m and β^s with simulation methods, assuming $f(\beta)$ is normal for all variables which are not firm level characteristics. This doesn't include our co-agglomeration variables, which would be considered as fixed coefficients. Both CLM and MLM agree with the two main results of this section: (i) within-firm vertical linkages tend to agglomerate services activities and production plant in the same country. (ii) R&D centers and production plants seem to be strongly attracted by each other.

The four service functions surrounding production are all attracted by the production co-agglomeration variable. R&D and logistics have high and significant coefficients while headquarters and sales & marketing are only weakly significant. It is very surprising to see that service functions are attracted by the production unit when one is looking at vertical linkages inside the firm. In fact, the sectoral agglomeration variable (count of production plants within the same sector) do not seem to have any impact on the location of service activities. These results could lead to the hypothesis that functional agglomeration effects arise when activities are outsourced, and sectoral agglomeration when within-firm vertical linkages are strong.

This aspect can be observed more precisely in the case of R&D location. In fact, the introduction of the co-agglomeration variables leads to the insignificance of the sectoral agglomeration

Table 8: Location choices and functional Co-agglomeration: Conditional Logit Model

Variables	Headquarters	Research & Development	Production	Logistics	Sales & Marketing
Ln Real Wages	-0.46	-0.11	-1.55^{a}	-0.92	0.05
	(0.66)	(0.35)	(0.31)	(0.62)	(0.23)
Ln Education	0.62^{b}	0.35^{c}	0.22^{b}	0.62^{b}	0.51^{a}
	(0.27)	(0.19)	(0.10)	(0.25)	(0.13)
Governance (%)	0.07^{b}	0.03^{c}	0.04^{a}	0.01	0.01
	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)
Ln GDP	0.86^{a}	0.39^{a}	0.19^{a}	0.51^{a}	0.47^{a}
	(0.17)	(0.08)	(0.07)	(0.17)	(0.07)
Ln External Market	1.73^{a}	-0.16	0.13	1.73^{a}	0.63^{a}
Potential	(0.55)	(0.25)	(0.13)	(0.40)	(0.18)
Ln+1 Function Count	0.05	0.41^{a}	0.42^{a}	0.37^{b}	0.31^{a}
	(0.17)	(0.13)	(0.08)	(0.19)	(0.09)
Ln+1 Sectoral Production	0.05	0.19	0.62^{a}	-0.13	0.05
Count	(0.15)	(0.12)	(0.07)	(0.16)	(0.10)
Headquarter Co-agglomeration		0.04	-0.49^{c}	-1.21^{c}	-0.06
		(0.29)	(0.26)	(0.63)	(0.31)
R&D Co-agglomeration	-0.59		1.30^{a}	0.49	0.05
	(0.45)		(0.19)	(0.41)	(0.25)
Production Co-agglomeration	0.54^{c}	0.57^{a}		0.87^{a}	0.37^{c}
	(0.32)	(0.18)		(0.29)	(0.20)
Logistics Co-agglomeration	0.25	-0.37	0.26		0.14
	(0.53)	(0.45)	(0.24)		(0.29)
Sale & Marketing	0.30	0.06	-0.19	-0.68	
Co-agglomeration	(0.45)	(0.27)	(0.25)	(0.52)	
Number of observations	166	287	729	137	447
Log Likelihood	-324	-665	-1829	-308	-1061

Notes: Standard errors are in parentheses with a, b, c respectively denoting significant at 1%, 5% and 10% levels. Dependent variable: Location choice in the 23 countries of the enlarged European Union (EU15 and CCE8) on the five functions during the period 1998-2002. New creations of non-European firms in the manufacturing sector.

Table 9: Location choices and functional Co-agglomeration: Mixed Logit Model

variables	Headquarters	Research & Development	Production	Logistics	Sales & Marketing
Ln Real Wages	-0.33	-0.08	-1.56^a	-1.08	0.09
	(0.87)	(0.40)	(0.37)	(0.92)	(0.23)
Heterogeneity term			1.11^a		
			(0.38)		
Ln Education	0.64^c	0.34	0.27^b	0.67^c	0.48^a
	(0.37)	(0.24)	(0.12)	(0.36)	(0.14)
Heterogeneity term					
Governance (%)	0.06^c	0.03	0.04^a	0.01	0.01
	(0.04)	(0.02)	(0.01)	(0.03)	(0.01)
Heterogeneity term					
Ln GDP	0.94^a	0.40^a	0.20^b	0.54^b	0.50^a
	(0.19)	(0.11)	(0.08)	(0.22)	(0.09)
Heterogeneity term					
Ln External Market Potential	1.89^a	-0.26	0.07	1.92^a	0.58^a
	(0.66)	(0.29)	(0.14)	(0.55)	(0.20)
Heterogeneity term					
Ln+1 Function Count	0.10	0.46^a	0.39^a	0.37	0.39^a
	(0;20)	(0.15)	(0.08)	(0.26)	(0.10)
Heterogeneity term					0.44^a
					(0.00)
Ln+1 Sectoral Production Count	0.02	0.19	0.62^a	-0.11	0.03
	(0;19)	(0.13)	(0.07)	(0.17)	(0.11)
Heterogeneity term					
Headquarter Co-agglomeration		0.06	-0.47^b	-1.31^c	-0.12
		(0.33)	(0.24)	(0.68)	(0.34)
R&D Co-agglomeration	-0.64		1.35^a	0.51	0.09
	(0.47)		(0.18)	(0.45)	(0.24)
Production Co-agglomeration	0.61^c	0.58^a		0.88^a	0.44^b
	(0.33)	(0.20)		(0.31)	(0.20)
Logistics Co-agglomeration	0.24	-0.37	0.30		0.16
	(0.59)	(0.49)	(0.24)		(0.29)
Sale & Marketing Co-agglomeration	0.39	0.02	-0.20	-0.67	
	(0.43)	(0.33)	(0.23)	(0.54)	
Number of observations	166	287	729	137	447
Log Likelihood	-323	-664	-1828	-307	-1058

Notes: Standard errors are in parentheses with a, b, c respectively denoting significant at 1%, 5% and 10% levels.
Mixed logit methodology with 250 simulations. Heterogeneity terms only reported if significant.
Dependent variable: Location choice in the 23 countries of the enlarged European Union (EU15 and CCE8) on the five functions during the period 1998-2002. New creations of non-European firms in the manufacturing sector.

variable. So, the sectoral aspect on R&D location (table 6 and 7) was only due to vertical linkages within groups. It is also interesting to notice that the introduction of the vertical linkage variables have also led to the insignificance of the heterogeneous term associated with the functional agglomeration variable in the R&D location choices model.

The second important result of the introduction of vertical linkage variables is the co-agglomeration between R&D and Production plants. In fact, those functions are highly attracted to each other and the strong vertical linkages between activities are likely to lead to a cumulative effect such as those described in the New Economic Geography (Krugman and Venables, 1995). More surprisingly, within groups, the location of headquarters have a weak significant negative effect on the production plant location choice. One would have expected that management and production would be linked together. Our results show the opposite effect. But how to explain that, on the one hand, headquarters are attracted by production (even if weak) when at the same time, production is negatively affected by the presence of affiliate headquarters? This could be explained by a sequence of investments, in which firms locate headquarters only when having completely established their productive structure.

6 Conclusion

We focus in this paper on location choices of non-European multinational firms in countries of the enlarged European Union during the period 1997-2002. More specifically, we extend the actual location theory literature by considering upstream and downstream service activities in addition to production units. We present a one-firm model with multi-stage and compared its prediction with empirical results. In addition to the country characteristic determinants for each part of the value chain, we show that, apart from the headquarter case, service activities are more affected by functional rather than by sectoral agglomeration. This finding corroborate theories developed by Duranton and Puga (2005).

We also empirically analyze the co-location of the different stages of the value chain between affiliates of multinational firms established in the enlarged European Union. We show that both R&D and production activities seem to have a strong attractions for one and another. Surprisingly headquarters do not appear to have any attraction effect on any other part of the value chain. Our work highlights some strategic aspects of location for policy makers. In fact, some functions, such as headquarters or R&D centers have a strategic aspect for both multinational firms and host countries. But the latter results seem to demonstrate that, contrary to R&D centers, headquarters don't have any attractive effect, which could revise policy orientation through privilege subsidies to R&D.

An possible extension of this work would be in the consideration of the regional level. In fact, the new political activism seems to be on the rise at local level, and would be probably at a more relevant geographical level for some functions, such as headquarters or R&D.

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