Functional fragmentation of the production process: A study of multinational firms location in the enlarged European Union*

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First preliminary Draft, Comments and suggestions are welcome
February, 2004.

Abstract

We propose to analyze the location of multinational firms value chain in the enlarged Europe. The theoretical framework focuses on the different type of integration strategies and organization of multinational firm network considering interaction between functions and countries characteristics. With a mixed logit test on individual firm data recently collected of almost 11000 location choices over five years and 23 countries, the paper analyzes the impact of co-agglomeration and verticals linkages on the location of multinational firms and of parent company's affiliates. We also show that vertical linkages between functions seem to have an centripetal effect only between the close functions on the value chain, which induce a possible functional cycle.

JEL classification: F23, L22, R3
Keywords: fragmentation; vertical integration ; Location Choice.

*The study of the quality of the EIM database has been realized at the Invest in France Agency (AFII). We thank Fabrice Hatem and Edouard Mathieu for their help on this job. We are also grateful to Matthieu Crozet and Thierry Mayer for helpful comments

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1 Introduction

Fragmentation of the production process is becoming one of the major issues for policy makers at the regional, national but also at the European level. In fact, the enlargement of the European Union induce an evolution in the geography of production. This phenomena and its link with the firm organization theory has recently became one of the major research area in international economics. Krugman (1995) considers that the international value-chain decomposition is one of the fourth major aspects of the modern international trade and called it "slicing the value chain". As reported by Grossman and Helpman (2004b), the World Trade Organization (1998) details, for example, the production of a particular American car:

Thirty percent of the cars value goes to Korea for assembly, 17.5 percent to Japan for components and advanced technology, 7.5 percent to Germany for design, 4 percent to Taiwan and Singapore for minor parts, 2.5 percent to he United Kingdom for advertising and marketing services, and 1.5 percent to Ireland and Barbados for data processing. This means that only 37 percent of the production value ... is generated in the United States. (p.36).

This recent literature gives a major place to the pre and post-production activities. In fact, service industries account for around 60% of the world FDI inflow in 2001 (World Investment Report (2003)). So, it is restrictive to only consider industrial aspect of the actual globalization. What's more, functions like headquarters or R&D centers include a strategic aspect of the multinational firms networks for the governments. That is why the economic specialization induced by multinational organization has to be performed in term of function and not only in term of production activities. However, The systematic functional fragmentation approach of the specialization has not yet been developed. In Fact, if it is a much more interesting way of research, it is also a more complex one, according to the lack of data and the difficulties to perform good links with theory. To our knowledge, the location of multinational firms' functions has never been econometricaly tested. The paper would fill this lack in the actual economics literature.

The theory related to the fragmentation phenomenon, firstly named by Jones and Kierzkowski (1990), has received different names [1]. Multinational firms play a important role on this pro-

[1] including de-location, disintegration of production, fragmentation, global production sharing, foreign outsourcing

cess thought the *vertical* separation of activities, in order to exploit international factor-cost's differences (Helpman (1984) and Helpman and Krugman (1985)) or through *horizontal* investments, where production plant are duplicated in several countries to get access to other market (Markusen (1984), Brainard (1997), and Markusen and Venables (1998, 2000)). Unfortunately, the empirical researches have difficulties to demonstrate the validity of this classification. In fact, as notice 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'.*

Recent papers have underline the organizational complexity of multinational firms. The first kind of literature use imperfect contract to explain why the internationalization of production increases by the way of outsourcing and contract partnership rather than by FDI (Grossman and Helpman (2003, 2004a,b)). The second kind of articles consider the classification into two types of investment as highly restrictive in comparison with the diversity of multinational location. Yeaple (2003) considers that actual models are not able to describe properly the diversity of multinationals firms strategies. Ekholm *et al.* (2003) put on light the importance of plat-form export. Hanson *et al.* (2002) argue that the distinctions have to be done between *production-oriented* investment and *distribution-oriented* one. This choice does not reflect the export-versus FDI decision common to standard models in the literature, as that decision is only about alternative production modes. The consideration of heterogeneity of firms, as developed by Melitz (2003); Helpman *et al.* (2003), is also an third and very way how to introduce the organization complexity of firms.

Despite all, this literature gives a specific place to service functions of the firm, no one referred directly to the concept of value-chain developed by Porter (1990)[2]. As mentioned by Feenstra and Hanson (2001) referring to the "Global Commodity Chain" note that *"[I]t is already used in economic sociology Gereffi and Korzeniewicz (1994); Kenney and Florida (1994)) Geography (Dicken* et al. *(2001); Yeung (2001)) and other sciences".* This expression referred to the international fragmentation of sequence of activities involved by the manufacture of a product, from the initial development through to the final production of an assembled good, marketing and sales

Econometric tests on the determinants of production plants's location have also considered as essential both agglomeration effects and vertical links between or within firms as essential.

[2]In a different literature, Duranton and Puga (2001) have provided a theoretical framework of the functional fragmentation of multinational firms between cities with different size.

Smith and Florida (1994) study the investment of Japanese auto-related parts suppliers and show that they tend to locate near Japanese assembly plants and prefer areas with greater aggregate manufacturing activity. Head *et al.* (1995), using Japanese investments in the United States, test agglomeration variables in the location choice model. They also consider possible supply relationships or technological spillovers between members of a same industrial *Kieretsu*[3].

Without referring directly to the location theory, Midelfart-Knarvik and Steen (2002) consider that vertical industry linkages may work as channels for externalities in geographic clusters. They consider output growth and output level of industrial and services sector of Norwegian maritime transport to analyze the impact of upstream activity on productivity growth of downstream firms due to externalities.

Gross *et al.* (2001), have studied the location choices of Japanese manufacturing and service firms in Europe between 1970 and 1995. They examine whether the presence of Japanese manufacturing (service) firms attracts other Japanese manufacturers (service providers). They find existence of inter-industry linkages between the manufactured and service sectors, and show how such intra-and inter-industry agglomeration effects have evolved over time. Ryan (2002) shows that a non-manufacturing location, as wholesale/retail affiliate implantation tends to push off investment into manufacturing. Thus, it appears a sequential investment strategy: first into wholesale/retail and then later into manufacturing.

Our concerns in this paper is to provide and to test a general analysis of function location choices. we aim to shed light on the determinants of the location the different part of firm value-chain, by the formalization of a *functional cycle*, as described by Mucchielli (1982). Our model is somewhat similar to those of Grossman *et al.* (2003), Yeaple (2003) and Ekholm *et al.* (2003).

We empirically analyze the location and co-location of the different stages of the value chain between affiliates of multinational firms established in the enlarged Europe. We show that groups implant closely associated activities of the value chain in a specific country due to vertical relationship between activities.

We also show that countries factor endowment and function characteristics interact on the location choice decisions. We also find that agglomeration variables are strongly significant for

[3]Upstream and downstream linkages have also started to be a key agglomeration force in recent models of New economic Geography (Venables (1996), Krugman and Venables (1995)). Estimation of structural location choice models have recently been developed by Head and Mayer (2004), but vertical linkages have not been yet considered.

all the functions.

The remainder of the paper is organized as follow: Section 2 we develop our model of functional organization where firms must choose to duplicate or to re-locate in a second country the different stages of their value-chain. Section 3 describes the econometric model, the database and variables used. Section 4 presents econometrics results. Section 5 presents the implication for policy maker and concludes.

2 The Model

We seek a simple setting in which firms face a choice between performing activities only at home, to duplicate or to re-localize part of their value-chain in foreign direct investment (FDI) to conserve on trading costs. We also need to distinguish between -*distribution services*- using finished product ready for sale to consumers and necessary to get access to a market -*production activities*- those that can be performed in any location so long as the output later is transported to the place of distribution and -*headquarters activities*- which also need to pay a communication cost to be used in the production location in a other country . The introduction of three stages of the value chain, which can be moved internationally, including headquarters is motivated by the necessity to consider corporate globalization, which imply the (re)location of strategic activities, as direction or R&D center in the different part of the world.

For this, we develop a simple model with three stages of production. We also consider two types of country : one with low production costs and a relatively small market ('South'), and the others (East and West, together comprising the North) with larger markets, higher wages, and fully symmetric. We consider $J + 1$ sector, in which one industry supplies a homogeneous good under competitive conditions (used as numeraire) and J sectors producing differentiated products. Consumers share similar preferences that can be represented by a utility function containing a part of homogeneous good and an index of consumption of the differentieted outputs of industry $j \in 1, ..., J$. The consumption index for industry j is a CES aggregate of the amounts consumed of the different varieties.

If the basic story follow directly Grossman *et al.* (2003), our consumption index differs from them on several way. We introduce in it the notion of market share ϕ. In fact, households need to be informed (by advertising) of the possibilities to consume differentiated product from multinational firms (potential market share of national firm in their own country are considered

as equal to one). We consider two distinct way to increase the market share ϕ in a specific country.

Firstly, we introduce an other determinant on the firm organization choice : *the time*. In fact, the probability of location in a specific country could strongly differ depending of the knowledge and the market share of the firm in each of them. Much more, this different aspects, which would change with the time that the firm has already been in this country, will affect the type of function that the multinationals would implant. So, if a multinational firm M localize a distribution plant in a country, its market share will automatically increase with *time*

$$\phi^M = \gamma * time \qquad with \qquad 0 < \phi^M < 1$$

Secondly, we consider positive externalities between multinational firms already engage in export and national firm. In fact, previous setting-up of firm in a country increase potential market share of firm which are not already implanted due to the advertisement on the specific home-characteristic products. So, as *time*, externalities between firms, is also related to the share market of the firm. So, the potential market share in country l of a national firm N will also been increased with advertising realized by other multinational firms M due to positive externalities.

$$\phi^N = \lambda * \phi^M \qquad with \qquad 0 < \phi^N < 1$$

To simply the model as much as possible, we will considered that $\phi^N = \phi^M = \gamma * time$.

Let $c_j(p_h, p_p, p_d)$ denote the unit cost function[4], where p_i is the effective price of input i in the place of assembly (without including delivery costs). Each stages of the value chain can be produced apart from each other, but if so, the superior stage must be shipped to the place of the next stage before a final good can be produced. Iceberg transportation costs between any two successive stages is paid on the basis of the value added of the good shifted. va_k correspond to the value added at the stages k[5].

A firm in industry j that separates any stages from the location of its initial country bears an extra (fixed) cost of F_j units of home labor for the initialization of this new activity. fixed

[4]production function is considered as an increasing and concave production function with constant returns to scale.

[5]The value added a the stage h compute only headquarters service activities ($va_h = ph$), the second stage, p, addition production to the first stage ($va_p = ph + pp$), and the third step include distribution cost to the second stage ($va_d = ph + pp + pd$).

cost are identical between countries, and have to be payed for every part of the three sequences of the value chain which is removed.

We do also consider heterogeneity between firms leading to different productivity levels Θ. Productivity levels in industry j are independent draws from a centred normal law function, $G_j(.)$, for which we only consider positive value. Then $C_j(p_h, p_d, p_d)/\Theta$ is the per-unit variable cost of production in this location for a firm with productivity Θ.

Each producer treats the aggregate consumption indexes as given. Therefore, it maximizes profits by charging a price in each market that is a multiple $1/a$ of its per-unit variable cost of serving that market. We do consider exactly the same type of demand and production than Helpman *et al.* (2003) and Grossman *et al.* (2003). It follows from the demand function, for any strategy with an extra fixed cost of F and a per-unit variable cost of c/θ, the maximum attainable operating profits are

$$\pi = (1-\alpha)Y\Theta C - F$$

where Θ is a measure of the firms productivity, Y is a measure of the size of market (as the sum of the different potential market M^l in countries l) and $C(p_h, p_p, p_d)$ correspond to the unit cost.

2.1 North to North value chain duplication

We consider in this section that the sizes of the two north markets for differentiated products are considered as identical ($M^E = M^W$). We assume that one unit of labor is needed to produce one unit of the homogenous good in East or West, so wages are identical.

Consider for example a firm with headquarter and production in West with productivity θ that wishes to deliver final goods to consumers in East need to implant a distribution cost by paying a fixed cost F. Still another possibility would be to realized both production and distribution in the Eastern country (fixed cost equal 2F) to pay the communication cost ($t * va_h$) rather than to pay transport cost of produced good ($t * va_p$). It is also possible to locate all the three sequences of the value chain for a fixed cost equal to 3F and not paying any transport cost.

Since these two countries are fully symmetric a firm has no reason to undertake a given activity in two locations, as this would impose extra fixed costs without conserving on any wage cost. So, the only raison for north to north FDI is to get an access to the other market. Thus,

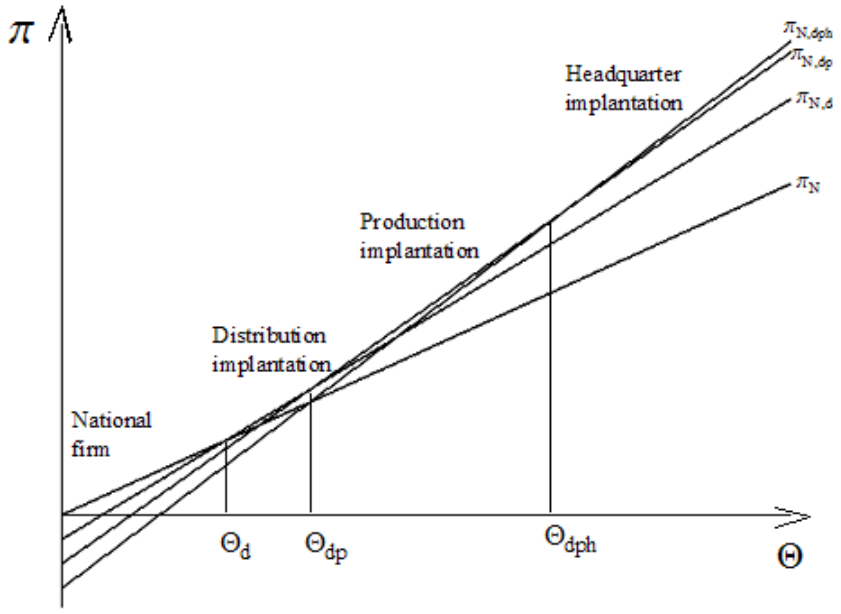

Figure 1: The different profit function for the different type of organization

with our hypothesis that an distribution plant is needed to sale in a market, four integration strategies remain for consideration: the firm can stay national, duplicate the distribution or duplicate both production and distribution activity and finally, the firm can also duplicate all the three sequences of the value chain.

In Figure 1, we depict the operating profits attainable for the four north to north strategies for different level of Θ. These profit which are denoted π_N for national firms[6], $\pi_{N,d}$ for multinational firms with the implantatio setting-up of an distribution center, $\pi_{N,dp}$, when both production and distribution have been duplicated, and $\pi_{N,dph}$ for firms which have duplicate all parts of their value-chain.

$$\pi_N = \frac{(1-\alpha)Y^W\Theta}{C_N} \tag{1}$$

$$\pi_{N,d} = \frac{(1-\alpha)(Y^E C_d + Y^W C_N)\Theta}{C_d C_N} - F \tag{2}$$

$$\pi_{N,dp} = \frac{(1-\alpha)(Y^E C_{dp} + Y^W C_N)\Theta}{C_{dp} C_N} - 2F \tag{3}$$

[6]it could also have been possible to consider the possibility to export for national firm. That would have changed the π_N equation but not our basic story

and

$$\pi_{N,dph} = \frac{(1-\alpha)(Y^E C_{dph} + Y^W C_N)\Theta}{C_{dph} C_N} - 3F \tag{4}$$

The figure shows that firms with low productivity prefer national strategies whereas firms with highest productivity would duplicate in the East all the sequences of the value chain, in keeping with the findings of Helpman *et al.* (2003). The reason, of course, is that FDI offers the prospect of lower per-unit costs and higher fixed costs, and the potential to save on variable cost is most valuable to highly productive firms that anticipate producing high volumes of output. Firms with intermediate level of productivity would only engage FDI on distribution activities, or both production and distribution if there productivity level allow them to cover two fixed costs.

We can now consider the three different value of Θ for which the different kind of organization of the value chain are equivalents[7]. As we previously mentioned, in a north to north reorganization, each element of the value chain would be duplicated, starting with the distribution activities. So we just need to consider three frontiers between the four possible type of strategic integration. In fact, if a national firm is to be viable at any productivity level, this strategy must be at least as profitable as duplicating activities in both country.

Finally, we can consider the number of firms for which each type of integration strategy are the most profitable, depending of their market share. The most productive firm are able to duplicate all parts of their value-chain, when in the same time, the less productive firms can stay national firm or just export without duplication of production plant, depending of the parameters.

So, we are able to identify in the figure 3 a *functional cycle*, in which there are a succession of the different type of organization, when ϕ the market share of firms increase with time . Mucchielli (1982) identifies two axes in functional location's choice : first an interaction between functions and countries characteristics and secondly a "spacio-functional cycle", in which the nature of the location depends on the activities which have already been implanted in the country. The succession of location goes from downstream to upstream sequences. So, such downstream service location could be a sign of further manufacturing implantation.

[7]When Θ equate π_N and $\pi_{N,d}$; $\pi_{N,d}$ and $\pi_{N,dp}$; $\pi_{N,dp}$ and $\pi_{N,dph}$

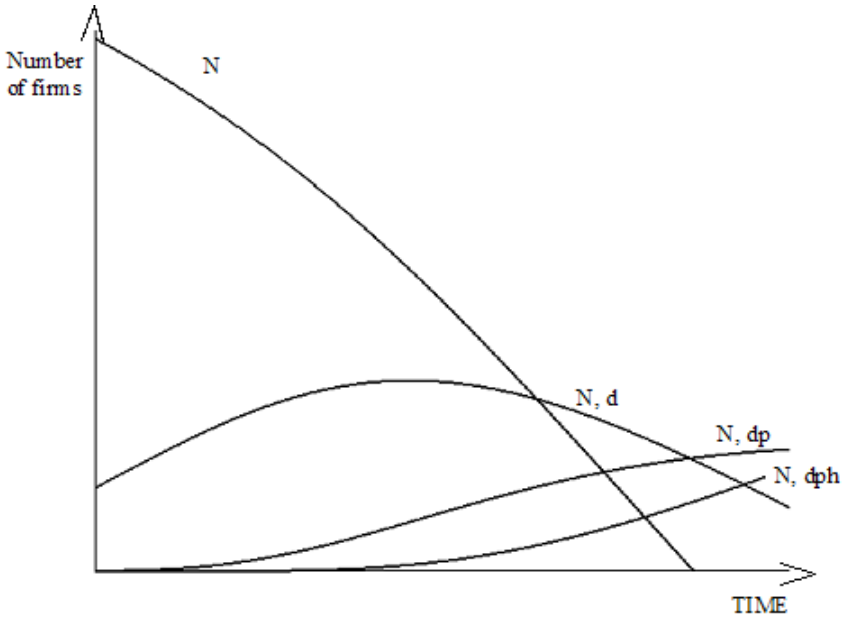

Figure 2: The functional cycle

The functional fragmentation cycle can also been considered has an timing sequential choice suggesting that past investment history plays an important role in the understanding the limitations in generalizing the effect of FDI determinants over firms entire investment histories.

2.2 North to South value chain reorganization

We now consider the possible relocation of part of the value chain in south country. So, we distinguish the countries in several ways.

First, we consider that wages in the North are higher than in the South[8] Then $w^E = w^W = 1 > w^S = w$, where w^l is the wage in country l. In one hand, by considering these assumptions, the South enjoys a comparative advantage in production for all the part of the value chain. In another hand, the different function of the value chain differ in their characteristics, and won't have the same incitive to be removed. As we previously mentioned, fixed cost due to relocation (which could be considered as human capital or R&D expenditure) are equal for any country and any function. What is change is the relative value added of each stages in the total cost[9]. It

[8]Grossman *et al.* (2003) consider the hypothesis that firms in the North are more productive than those in the South in producing the homogeneous good. This creates a gap between Northern and Southern equilibrium wages.

[9]We normalize the total variable cost to a final and distributed good to one. We also consider that the share of headquarter activity equal those of distribution services. Manufacturing activities represent the rest.

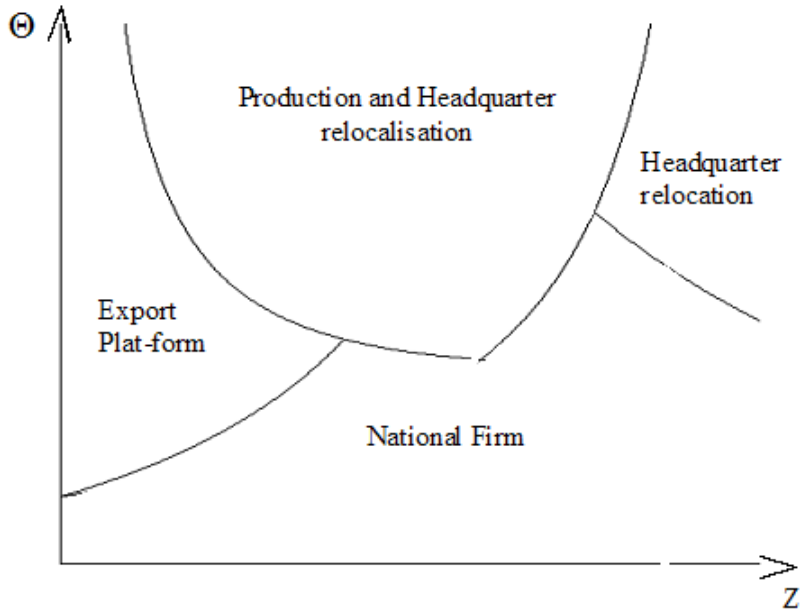

Figure 3: North to South reorganization of the value-chain

is possible to consider the fixed cost regarding to the variable cost as a human capital intensity. It is reflected by the parameter z, which represents the non qualified/qualified intensity of the headquarter.

Second, in the way to simplify as much as possible the model, we consider that the south market for differentiate products are equal to zero. So, all the strategies incorporating an distribution plant can be remote.

$$\pi_p = \frac{(1-\alpha)Y^W\Theta}{C_p} - F \tag{5}$$

$$\pi_h = \frac{(1-\alpha)Y^W\Theta}{C_h} - F \tag{6}$$

$$\pi_{ph} = \frac{(1-\alpha)Y^W\Theta}{C_{ph}} - 2F \tag{7}$$

The only optimal strategies (in addition to the national integration) are on the export-platform (see Ekholm *et al.* (2003)), when firms implant their manufacturing plant in the way to beneficiate of low cost. But this type of organization imply to pay two times the transport cost. An other strategies could be to implant both headquarters and production plant in the

south country, and to export the product to the north. Headquarters are usually considered as highly intensive in human capital. So, headquarter is the less incentive part of the value chain of factor price difference.

We can now consider the frontiers between the different integration strategies using the Θ which equalize profits between two type of organization[10]. The comparison of this different strategies is highly difficult and depend on the parameters of the model.

The comparison to our models with the case of the enlarged European Union case could conduce to consider a lot of type of organization strategies. Notably, it seems that multinational firm are highly attracted by both new emergent market and low cost. In the same time, their are not much difference in education and qualification between Eastern and Western country.

3 Econometric Model

3.1 Limits of the conditional logit test

We use individual firms location choices over a set of 23 European Union and eastern European Countries. The most used econometric modelling technique for this type of problem is the conditional logit model 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, we observe is the actual choice of each firm and the characteristics of the alternative locations. Suppose J=(1,...,J,...n), the set of possible location countries, location j is chosen by a firm if it allows this firm to obtain a higher profit than the ones obtained in the alternative location. The coefficients are estimated by the maximum likelihood procedures.

The biggest assumption of this methodology is that errors terms are independently and identically distributed according to a type I extreme value distribution. The Independence of Irrelevant Alternative (IIA) assumption imply 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 on 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 that case, estimations

[10]plat form frontier is when $\pi_N = \pi_p$; headquarter relocation imply $\pi_N = \pi_h$; headquarter and production relocation area are obtained as the intersection of $\pi_p = \pi_{ph}$ and $\pi_h = \pi_{ph}$

of logit models are inconsistent. To test his assumption, we use a specification test proposed by Hausman and McFadden (1984). We estimate unrestricted and restricted models, omitting different choice one-by-one and we build a classical Haussman test (Hausman (1978)). The result of this test show that the IIA assumption is highly violated.

In fact, location choice decision of American or Japanese investor are more homogeneous than European investment. Two dimensions (home country and host country characteristics) interfere in location decisions of European firm (notably, due to the fact they can not invest internationally in their own country) while the second dimension seems to be the essential in explaining location decisions of non-European firms. This heterogeneity can lead to disturb the distribution of the errors and then to the inconsistency of the estimators.

3.2 Mixed logit

One of the way to relax the IIA assumption is to introduce individual random effect and to estimate a mixed logit model (Brownstone and Train (1999)). The utility function of a person i form alternative j is specified as: $\pi_{ij} = \beta_i' X_{ij} + \varepsilon_{ij}$ where X_{ij} are observed variables that, in our case, relate to decision-maker, β_i is a random vector of coefficients which vary over decision-makers in the population with density $f(\beta)$.ε_{ij} is a random term that is iid extreme value. So, we can write the utility function as:

$$\pi_{ij} = \beta_i^{'m} X_{ij} + \beta_i^{'s} X_{ij} + \varepsilon_{ij} \tag{8}$$

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

$$P_{ij} = \int \left(\frac{e^{\beta' X_{ij}}}{\Sigma k e^{\beta' X_{ik}}}\right) f(\beta) d\beta \tag{9}$$

We estimate β^m and β^s with simulation methods, assuming that $f(\beta)$ is normal.

This methodology also allow us to eliminate the perception difference on location choice of the multinational firms due to their heterogeneity. In fact, we do not want that this aspect affect variable coefficient directly linked to country characteristics. In other hand, variables directly linked to firms (i.e. number of affiliate plants and other derivate variables) would be consider as fixed coefficient. In fact, heterogeneity would be our principal concern on the study of this variables.

4 Data

4.1 The dependent variable : Location choice

The theory would be evaluated by econometric tests based on a database of multinational firms' new location in Europe: we consider 23 Countries including future EU members witch would enter on the union in 2004[11] covering the period 1997-2002 and computing more than 11000 projects.

The EIM database (European investment monitor) actually 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. It excludes acquisitions, licence agreements and joint ventures (unless they fall into the three aforementioned categories) retails, hotels and leisure facilities, fixed infrastructures, extraction facilities and portfolio investments.

The investment projects data are at an individual level and includes different functions (unit of production and different service activities functions). There are also the name of the firm, the name and the origin's county of the parent company and the city of the location.

Each project can be defined by sector or by function. there are 49 sectors classified as the nace classification, with sub-sector in the automotive, electric-electronic and the chemical sectors. We only consider industrial sector and exclude services sector. Indeed, it would have been difficult to know the domination between service functions and a service sectors[12]. We only consider five different functions : production plant, administration and regional headquarters, R&D centers, logistics, sale and marketing office.

The organization of the value chain can be decomposed in tree different sequences : support activities (headquarters , research & development...), which are upstream activities; we can also consider the principal activities including the production. Finally, we consider downstream function as marketing, sale and distribution services.

We realized different restriction on the sample : We only compute real creations (also known as greenfield), and do not take account brownfield for the construction of the dependent variable.

[11] we don't include Malt and Chypre. More generally we don't take into account particular geographical case, as island.

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

4.2 The independent variables

Wage (W): We calculate wage for each host country and for the five different functions. For that, we need to consider correspondence between function and the nace classification as follow. Because recent data for the year 2002 are not yet available, we only consider data for the year 2000. That is the case for the major part of our data. We expect a negative sign for all the function, but a higher coefficient for the production variable.

Table 1 : relationship between function and NACE classification

function	nace classification	code
Regional headquarters	Financial activities	J
Research and development center	financial activities	J
manufacturing	manufacturing	D
logistics	transport services	I
sales & marketing center	sale sector	G

Productivity (Prod): We used a productivity variable for the year 2000 (Eurostat). This variable is calculated as the value added per head and is defined by function following the methodology used for the wage variable. We expect a positive sign for all the function, but it seems that the production variable would give an highest weight to this variable compare to other activities

Education (Educ): We consider the percentage of labor force with more than a secondary school level (ISCED 3 to 7) by function[13]. Moreover, some cultural aspect play a major role[14]. Service activities are usually more intensive in human capital, so we could expect an highest positif coefficient for the four service functions.

Distance (Dist): We also use the distance between home and host country as a variable. Distance is a proxy for transaction costs associated with every investment relocation. The variable consists of the distance between capital cities of countries, and it provided by the Cepii. We took into account this tendency of foreign firms to invest in locations near their country through a distance variable.

[13]We would have preferred to used a more precise variable of highly school level. Unfortunately, tertiary education (ISCED 5 to 7) is not a good variable due to the fact Eastern countries are possibly not comparable to other European Union member.

[14]for example, Austria have the lowest level of high tertiary education in all the 23 country of our sample, and Estonia the Highest

Demand (GDP): GDP of the host country for the year 2000 (Eurostat) is chosen as a measure of the potential demand. In fact, border still play an important role in the European Union. A firm will have a greater incentive to locate in a country where local demand to be served is high. This is only relevant if the firm actually sells locally. If FDI is totally outward oriented, local demand will have no impact. We could expect that the importance of this variable would be highest in the case of downstream activities.

Table 2 : Expected sign for each function

variables	regional head	R&D	production	Logistics	sale
Education	++	++	+	++	,++
Wages	-	-	- -	-	-
Productivity	+	+	++	+	+
Distance	?	?	?	?	?
GDP	0	0	+	++	+++

Agglomeration variables (Foreign Impl) : This variable is defined as the sum plus one of the cumulated number of multinational firms of the same function (or of the same sector in the case of production's function) located in the country the year before the location decision of a new firm, but not belonging to the same parent company (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/dispertion forces in the country. Because we need a time-lag of one year, we would have to exclude of the econometrics test the projects realized in the first year (1997).

We can also decomposed the agglomeration force variable depending of the nationality of the parent company, following Crozet et al (2003). There will therefore be two agglomeration variables: NH, and NO accounting respectively for the effect of the presence of same home country firms or other foreign firms. The sign and magnitude of each coefficient on those variables depends on the relative strengths of the competition effect and positive externalities exposed in the theory section. The comparison of coefficients on those variables will enable us to draw insights on the possibly different effects depending on different nationalities of the investors.

A precisions need to be made here in terms of interpretation : note that we follow Head *et al.* (1995) and assume a specification of those agglomeration effects that is linear in logs, of the form NH^e, NO^f , where e and f (very close to) respective elasticities of the probability of

choosing a country.

Implantation of affiliates (Implaffiliate) : number of plants plus one by country during the year N-1 by the firm and all affiliates of the parent company. We assume that the firm taking the decision takes its own investment into account in the anticipated level of agglomeration/dispertion forces in the country.

Linkages are likely to be strong between different company groups, which may motive them to locate to each other in order to access supplies and facilitate information exchange. We can also linked this variable to our theoretical model. In fact, the number of past investments could be a good proxy for the *time* that the firm have been implanted in a specific country. In fact, based on our theoretical model prediction, a high number of affiliate plants would have a positif effect on the probability implantation of upstream and a small (or negative) effect on downstream activities.

We can also decompose this variable by function, in five different variables : IMP affiliate *f*, for the function f (see table 3). we do consider the number of plants of the function i in the country j by affiliates. We are also hoping to find linkages between functions. Unfortunately, due to the limited number of plants by affiliates, we are unable to consider only the year N-1 and use the period 1997-2002 for build the variable and 2000-2002 as the dependant variable. So, we do use the same sample and methodology than for the "Implantation" variable. Except the fact, We consider for building this variable all the project of the sample (Greenfield and Brownfield). But it could be possible that we take into account few times the same project (for example, a creation and different extensions of the plant operated during the next years). So, we count just one all the project in a particular function realized by an affiliate in a particular city.

Table 3 : Functions location definition

affiliate head	Number of regional headquarter by affiliates.
affiliate RD	Number of R&D center by affiliates.
affiliate prod	Number of production plant by affiliates.
affiliate logi	Number of logistic center by affiliates.
affiliate sale	Number of sale and marketing office by affiliates.

Table 4 : Independent variables description

Variable	Definition	Source	year
countries variables			
GDP	Gross Domestic Product	CHELEM	2000
DIST	Distance between home and host country	CEPII	
Wage	Labor cost differing by function	Eurostat	2000
Educ	% of labor force with more than a secondary school level (ISCED 3 to 7)	Eurostat	2000
prod	Productivity : value added per head	Eurostat	2000
agglomeration variables			
foreign impl	NB impl plus one of the same function	EIM	N-1
NH	NB impl plus one of the same function by firm with the same nationality	EIM	N-1
NO	NB impl plus one of the same function with an other home country nationality	EIM	N-1
networks variables			
Implaffilialte	NB of impl of affiliate plus one by country	EIM	N-1
Impl *f*	NB of impl in the fonction *f* plus one by affiliates (see table 3)	EIM	1997-1999

all variables are in log.

5 Econometric test

5.1 Functions and countries characteristics interaction

Table 5 summarizes the results concerning the determinants of location choice during the period 1998-2002 for the five different functions in the 23 countries of the enlarged European Union using Mixed logit. All variables are taken in log, which enables to consider the coefficients to be quite precise approximation of the elasticity of the probability of choosing a particular country with respect to the considered variable for the average investor.

The comparison of coefficients on those variables in the different sequences of the value chain will enable us to draw insights on the possibility different effects depending on function. The coefficient structure shows that function characteristics and countries endowment interact. Unfortunately, coefficient are not always significant for service functions, and rarely in the R&D specific case, which steel stay a mystery.

Countries and functions characteristics interaction: We had considered a possible interaction between functions and country characteristics. The lecture of econometrics tests seems to demonstrate this aspect :

The education variable (Educ) is always positive and significative for all the function expect R&D, which one has a low and non-significant coefficient[15]. The coefficient structure show

[15]In some other regression not reported here, the exclusion of the productivity variable or the use of a sample with only European firms location show a negative coefficient for this function

that services activities give a biggest importance to the education level of the labor force than Production plant.

It is the opposite for *labor cost* (W) coefficient, which are negative and significant in the case of production function and positif in the case of regional headquarters and R&D centers. The used of a *productivity variable* (Prod) is usually not often used in the location literature. It is always positive and significative for central function.

The distance variable (dist) is always negative and as expected is more significant and higher for the production and logistic function. Two different explanations can be provided : We can consider than distance play a major role for activities linked to goods, as production or logistics due to transport cost. It is also possible to consider that the setting-up of a R&D center or a regional headquarter is used for local transfer, in the very faraway location.

Demand variable : We had consider on the theoretical framework section a possible value chain organization from upstream to downstream as Follow : regional headquarters, R&D center, manufacturing, logistics and sale office. We was expected that demand variable would play a more important role in the case of downstream function, as sale office. Regressions seem to demonstrate this organization : the sale function has the highest coefficient and the R&D and headquarters centers the lowest. But, it is also surprising to see how important this variable is for all the functions. As mentioned by Head and Mayer (2004), company want to build there plants *where the markets are.* If it is clear that sale function have an interest have an interest to be located in an important market due to the importance of border effect, this reason can not be used for regional headquarters or R&D center, for which coefficients are highly significant. It could also due to omitted variable as financial sector or technological externality generally correlate with the size of the country.

Table 5 : Location choice by function of multinational firms in the enlarged European Union during the period 1998-2002

variables	Headquarter		R&D		Production		Logistics		Sale	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Education	$1,02^{c}$	$0,97^{c}$	0,32	0,34	$0,28^{b}$	$0,30^{b}$	$1,50^{a}$	$1,49^{a}$	$1,20^{a}$	$1,15^{a}$
	(0,54)	(0,54)	(0,37)	(0,33)	(0,12)	(0,12)	(0,46)	(0,47)	(0,28)	(0,30)
Wages	$2,07^{c}$	$1,81^{c}$	-0,18	-0,23	$-1,38^{a}$	$-1,53^{a}$	-0,34	-0,35	0,41	0,33
	(1,10)	(1,07)	(0,46)	(0,27)	(0,16)	(0,16)	(0,52)	(0,53)	(0,28)	(0,28)
Productivity	-0,13	-0,13	$0,90^{c}$	$0,98^{b}$	$1,06^{a}$	$1,23^{a}$	$3,37^{a}$	$3,45^{a}$	$-1,58^{b}$	$-1,40^{b}$
	(0,90)	(0,85)	(0,47)	(0,47)	(0,21)	(0,21)	(1,10)	(1,13)	(0,65)	(0,62)
Distance	-0,34	-0,42	-0,26	-0,27	$-0,50^{a}$	$-0,50^{a}$	$-0,61^{b}$	$-0,61^{b}$	-0,18	-0,11
	(0,43)	(0,46)	(0,28)	(0,27)	(0,09)	(0,08)	(0,30)	(0,30)	(0,20)	(0,19)
GDP	$0,29^{b}$	$0,32^{b}$	$0,25^{a}$	$0,28^{a}$	$0,40^{a}$	$0,45^{a}$	$0,33^{c}$	$0,35^{b}$	$0,54^{a}$	$0,55^{a}$
	(0,15)	(0,14)	(0,08)	(0,09)	(0,05)	(0,05)	(0,17)	(0,18)	(0,10)	(0,10)
Foreign Impl	$0,63^{a}$		$0,80^{a}$		$0,77^{a}$		$0,59^{a}$		$0,48^{a}$	
	(0,13)		(0,10)		(0,04)		(0,16)		(0,07)	
(NH)		$0,25^{c}$		$0,31^{b}$		$0,57^{a}$		$0,42^{a}$		$0,65^{a}$
		(0,14)		(0,12)		(0,07)		(0,17)		(0,09)
(NO)		$0,50^{a}$		$0,58^{a}$		$0,51^{a}$		$0,38^{b}$		-0,01
		(0,39)		(0,11)		(0,04)		(0,18)		(0,09)
Observations	173	173	253	253	1330	1330	198	198	525	525
Pseudo R2	0,36	0,37	0,22	0,22	0,17	0,17	0,16	0,17	0,21	0,23
log likelihood	-352	-350	-614	-616	-3408	-3408	-508	-507	-1292	-1265

Notes: Standard errors in parentheses with a, b, c respectively denoting significant at the 1%, 5% and 10% level.
All variables are in log.

Agglomeration effects. The number of establishment realized by other multinational firms in a particular function (Foreign Impl) has a consistently positive and very significant positive impact on the potential attractiveness of host countries (see regression (1)). Our agglomeration are build on the same way than Head *et al.* (1995). Unfortunately, we face the same problem than them : the coefficient of this variable would absorb all the variance due to omitted variables or unobservable endowment factors. It could be possible to consider this variable as completely endogenous.

The decomposition of the foreign plant into two different variables (NH) and (NO) in the regression (2), respectively defined as the number of establishment in N-1 by foreign firm with the same nationality than the investor firm or with a different nationality.

The agglomeration effect due to foreign investment with the same nationality is significant for all the sequence of the value chain but the coefficients are higher for downstream activities as sale office. This is maybe due to the importance of the exchange knowledge of the market between company, facilitated by the same culture.

In the case of the foreign establishment with an different nationality during the year N-1, it seems to be an important and significant aspect for upstream variable, as headquarters and R&D center, which are the most sensitive to externalities provided by an international environment, but don't have any effect on business operation. Of course, this function his the most subject to the competition to other firms.

Affiliate Establishment : The particular contribution on the next regressions is on the used of the establishment of affiliates variable (Implaffiliate), witch correspond of the number of establishment realized by the firm and by all the affiliates of the parent company by country during the year N-1. As mention in the economic model, we estimates regression by using a mixed logit. So, we estimate β^m and β^s with simulation methods, assuming that $f(\beta)$ is normal for all the variables which are not directly linked to the firm. The "affiliates establishment" variable is consider as fixed coefficient, as in the logit model.

By incorporated this variable in the regression (3) of the table 6, coefficients seems to be always positif but only significant for the central functions (R&D, production and logistics). We can fallow Head *et al.* (1995), who consider the case of Japanese *Keiretsu* that co-agglomeration of affiliates establishment corroborates with the hypothesis that supply relationships and technological spillovers are stronger between members of the same industrial group.

Table 6 : Intra-group agglomeration by function in the enlarged European Union during the period 1998-2002.

variables	Headquarter	R & D	Production	Logistics	Sale
	(3)	(3)	(3)	(3)	(3)
ln Education	$0,99^{c}$	0,29	$0,27^{b}$	$1,46^{a}$	$1,20^{a}$
	(0,54)	(0,38)	(0,12)	(0,46)	(0,28)
ln Wages	$1,88^{c}$	-0,16	$-1,38^{a}$	-0,28	0,41
	(1,07)	(0,47)	(0,16)	(0,52)	(0,28)
ln Productivity	0,02	$0,90^{b}$	$1,07^{a}$	$3,26^{a}$	$1,58^{b}$
	(0,92)	(0,46)	(0,21)	(1,10)	(0,65)
ln Distance	-0,35	-0,26	$-0,48^{a}$	$-0,64^{b}$	-0,18
	(0,44)	(0,28)	(0,09)	(0,30)	(0,20)
ln GDP	$0,29^{c}$	$0,24^{a}$	$0,40^{a}$	$0,32^{c}$	$0,54^{a}$
	(0,15)	(0,09)	(0,05)	(0,17)	(0,10)
ln +1 Foreign Impl	$0,63^{a}$	$0,77^{a}$	$0,74^{a}$	$0,55^{a}$	$0,48^{a}$
	(0,13)	(0,10)	(0,04)	(0,16)	(0,08)
ln +1 ImplAffiliate	0,60	$0,54^{b}$	$1,18^{a}$	$0,98^{a}$	-0,01
	(0,54)	(0,25)	(0,13)	(0,38)	(0,31)
Observations	173	253	1330	198	525
Pseudo R^2	0,37	0,22	0,18	0,17	0,23
log likelihood	-352	-612	-3376	-504	-1292

Notes: Standard errors in parentheses with a, b, c respectively denoting significant at the 1%, 5% and 10% level. All variables are in log.

5.2 The importance of the firm network

We now propose to decompose the number of affiliate establishment by country, as in the regression (3) but also by function. In fact, if a company starts by a business operation, we could expect that such a presence in a country could increase the probability of establishment of a logistics or a production plant, which one would have in the future the effect to increase the probability of establishment of a regional headquarters or R&D center. Due to the small number of affiliates establishment by parent company, we can not used the year N-1 and consider all the project of the whole period 1997-1999. We use the project realized in 2000 and 2001 as the dependant variable. We do not only consider new creation but also enpension (which have not already been accounting as a creation) for the dependance variable construction.

we do not include diagonal of the decomposed network variables (For which setting-up a function i would be explain by the same function already implanted by affiliate). In fact, this variables would incorporated agglomeration effect more than the network linkages that we proposed to study. We can remark that *the probability to implant a function i in a particular*

country, decrease if other affiliates had already implanted a function j, if j is just before or just after i in the value chain organization. This result is maybe due to vertical linkages.

Table 7 : Location choice by function of multinational firms in the enlarged European Union during the period 2000-2002

variables	Headquarter	R & D	Production	Logistics	Sale
	(4)	(4)	(4)	(4)	(4)
ln Education	0,31	0,04	0,14	0,02	0,25
	(0,45)	(0,24)	(0,10)	(0,28)	(0,24)
ln Wages	0,48	-0,03	$-1,66^{a}$	-0,67	$0,77^{a}$
	(0,57)	(0,31)	(0,19)	(0,43)	(0,24)
ln Productivity	-0,39	0,70	$1,28^{a}$	1,35	$-1,16^{c}$
	(0,74)	(0,48)	(0,28)	(0,98)	(0,61)
ln Distance	-0,16	0,04	$-0,30^{a}$	$-0,62^{a}$	0,08
	(0,31)	(0,26)	(0,08)	(0,19)	(0,22)
ln GDP	$0,43^{b}$	$0,22^{b}$	$0,45^{a}$	$0,23^{b}$	0,13
	(0,17)	(0,10)	(0,06)	(0,12)	(0,13)
ln +1 ForeignImpl	$0,54^{a}$	$0,66^{a}$	$0,74^{a}$	$0,66^{a}$	$0,60^{a}$
	(0,14)	(0,12)	(0,06)	(0,14)	(0,14)
ln +1 affiliate Head		0,82	-1,22	-0,23	-1,24
		(1,01)	(0,95)	(1,24)	(1,38)
ln+1 affiliate RD	$1,64^{c}$		$0,70^{b}$	-0,70	0,66
	(0,94)		(0,35)	(1,44)	(0,63)
ln +1 affiliate Manu	-0,38	0,46		0,71	0,29
	(0,71)	(0,36)		(0,41)	(0,47)
ln +1 affiliate Logi	0,36	0,56	$1,38^{a}$		$2,26^{a}$
	(1,72)	(0,95)	(0,45)		(0,87)
ln +1 affiliate Sales	1,32	-0,97	-0,63	$0,42^{c}$	
	(1,42)	(1,33)	(0,77)	(1,06)	
Observations	74	155	719	84	221
Pseudo R2	0,33	0,19	0,18	0,18	0,21
log likelihood	-157	-388	-1851	-225	-553

Notes: Standard errors in parentheses with a, b, c respectively denoting significant at 1%, 5% and 10% level. all variables are in log.

In the affiliate function establishment variables matrix, coefficients touching the diagonal are always positif and significant in 5 to 8. Other coefficient are never significant and negative in 7 to 12. It is especially the case for production plant location, which are strongly attract by logistics and R&D affiliates location at an 1 percent significant level. More generally, we can conclude than a group in a specific country is at a specific stage on the value chain added and implant nearly functions on the value chain.

6 Conclusions

We focus in this paper on location choices of multinational firms in the enlarged European Union during the period 1997-2001. Results of econometric estimations suggest that location choice differ with the nature of the functions, and that there are an interaction between functions and countries characteristics.

Agglomeration variables seem to be key variables for all the sequence of the value chain, but the reenforcement effect is different depending of nationality of past investment. We found an agglomeration effect on downstream investment by location of company with the same nationality than the investor but an centrifuge effect of other nationality. It is the opposite for upstream investment which prefer a large diversity of nationality of the past investment.

We also demonstrate the presence of vertical linkages between nearly functions on the value chain, but also of a coordination between affiliate own by the same parent company to implant functions of a specific part of the value chain.

The relationship between the multinational theory and fragmentation, is an interesting way of research by putting on light some strategic aspect of the location for policy makers. In fact, some function as headquarters or R&D center have a strategic aspect for both multinational firms and host countries. The ongoing process of European Union integration and its likely impacts have made understanding the evolution of EU location patterns as an important policy issue. The new political activism seems to be on the rise at the local level. So an possible extension of this work would be on the consideration of the regional level.

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