GEOGRAPHIC DISTANCE AND R&D ACTIVITIES OF SUBSIDIARIES LOCATED IN SPAIN

Nadia AYARI[*]

Abstract *- This study investigates the impact of geographic distance between the home country of a Multinational Enterprise (MNE) and host countries where subsidiaries are located on the MNE's decision to carry out overseas research and development (R&D) activities in the host market. The analysis is based on a sample of 1,161 foreign affiliates taken from the PITEC database (Technological Innovation panel), based on the 2005 survey of firms' technological innovation activities compiled by the Spanish Statistical Institute (INE). Data allow to distinguish between internal and external R&D activities of firms. I find that, in the sample of Spanish subsidiaries of foreign MNEs, geographic distance negatively affects the likelihood of affiliates sourcing external R&D, but not that of carrying out internal R&D. Furthermore, the results also show that, conditional on doing external R&D, the greater the distance between the source and the host countries, the lower the probability of subsidiaries procuring R&D from local sources in the host country.*

Keywords **-** GEOGRAPHIC DISTANCE, EXTERNAL R&D, INTERNAL R&D, MULTINATIONAL ENTERPRISES

JEL Classification - O31, O33, R3

[*] *Departamento de Empresa, Facultad de Ciencias Económicas y Empresariales, Universidad de Navarra, Spain.* nayari@alumni.unav.es

1. INTRODUCTION

The last two decades have witnessed a substantial growth in the internationalization of R&D activities of multinational enterprises (MNEs). In fact, over 41% of European multinationals' R&D expenditures in 2003 occurred in their subsidiaries abroad, which represents a 60% increase relative to the previous decade (UNCTAD, 2005). Host countries' policy makers are likely to encourage incoming Foreign Direct Investment (FDI) since it is considered to play a crucial role in the diffusion of technology towards the host country. Indeed, a number of studies have tried to prove the existence of a relationship between multinational activities and host country productivity. Grounded on this relationship, many countries design specific policies aimed at attracting foreign R&D activity by MNEs and to benefit from international technology transfers that occur within MNEs.

Parent firms' propensity to transfer technology knowledge to their overseas subsidiaries is actually influenced by several factors. Some studies consider that, the choice of firms can be attributed to the need to adapt production to foreign markets, and to access technology in the host country. However, to a large extent, distance between the country where the MNE's headquarters are established and the country where it would locate its subsidiaries is one of the major concerns of firms that aim at carrying out overseas R&D activities. Indeed, although intangible goods are not affected by transportation costs in the same way as physical products, the level of communication infrastructure and the quality of information flows between the two countries account for essential effects of geographic distance in cross-borders knowledge transfer (Ghemawat, 2001). Moreover, I assume that distance exacerbates any information-asymmetry problems between units within the same MNE that are located in different countries. For instance, it makes the finding of local agents or the monitoring of the subsidiary's activities more difficult for the parent firm. It also makes it more difficult to assess the degree of technological development in the host country, the degree of complementarity of the technology locally procured by the subsidiary, or finding local partners for R&D collaborations. From a transaction cost perspective, distance increases the costs of carrying out all these types of transactions.

In this paper, I hypothesize that distance, by increasing communication and coordination problems, raises the costs of procuring R&D from sources external to the subsidiary, thus having a negative effect on the probability of doing external R&D. Regarding the effect on the performance of internal R&D, this is ex-ante ambiguous. On the one hand, it might reduce the likelihood of internal R&D, since distance makes the coordination and control of research in different locations more difficult. However, distance might also induce MNEs to substitute internal for external R&D in the operation of their foreign affiliates, due to the increasing complexity of finding local sources of external R&D.

I will search for empirical evidence using a sample of subsidiaries of foreign MNEs established in Spain in 2005. The dataset is especially valuable because it allows to observe the source country, and performance of internal and/or external R&D. I will analyze the effect of distance between the source and the host country on the likelihood of performing these two types of R&D. Additionally, I will analyze whether, conditional on procuring external R&D, subsidiaries of MNEs based in more distant countries are more or less likely to procure R&D from other Spanish firms. This analysis is possible because the dataset allows distinguishing between different types of sources of external R&D, specifically internal and external to the MNE, and in the host country or in some other country. In this paper, I analyze the effect of distance between affiliates located in Spain and their parent firms on the former R&D activities, distinguishing between internal and external R&D. Internal R&D is that performed by the firm, whereas external R&D is procurement of R&D, involving a third party actually carrying out these R&D activities.

When choosing their R&D strategy, MNEs may opt for different combinations of internal and external R&D for their foreign affiliates. One such strategy is to remove any R&D activities, whether internal or external, from foreign affiliates. In this case, if any technology is to be transferred to foreign affiliates, it is in a ready to be used form. This strategy has the advantage of minimizing information leakages, but it makes subsidiaries lack the ability of coming up with any technological improvements. A second type of strategy is subsidiaries engaging in external but not internal R&D. This way, the affiliate may enhance the MNE's technological basis, using external R&D services. However, this rarely leads to substantial improvement in the MNE's technology, since it is typically necessary for the affiliate to possess some internal R&D capabilities. Indeed, I very rarely observe this in my data. The subsidiary could also carry out internal R&D, but not external R&D. Internal R&D is required to make use of the technology provided by other units within the MNE, especially if this technology is somewhat sophisticated, or has some tacit component. Finally, when an affiliate carries out both internal and external R&D, it has the ability to generate new knowledge and coordinate complex R&D projects that require the collaboration of external sources. It is also in an optimal situation to absorb the technology that is available in the host country.

The paper is organized as follows: section 2 discusses the main contributions in the literature on determinants of subsidiaries' R&D strategies. Section 3 presents the data, which is analyzed in section 4. Section 5 presents some conclusions.

2. DETERMINANTS OF SUBSIDIARIES' R&D STRATEGIES

Despite its growing importance, corporate R&D remains among the least internationalized segments of the production process. In the existing literature several studies have attempted to investigate the determinants of R&D intensity of overseas affiliates. However, few recent contributions have analyzed the factors that determine MNEs decision to assign R&D activities to their foreign affiliates. The decision made by a multinational firm to undertake R&D abroad

depends on a combination of factors. In this section, I will review those that have been proposed in the literature, then focusing on the impact of geographical distance.

Provided that the MNE decides to perform R&D in their foreign affiliates, there are two basic strategies that may be adopted to develop R&D activity abroad: in-house or acquiring technology from external sources such as licensing, R&D contracts, outsourcing or strategic alliances. Foray and Mowery (1990) state that the use of both internal and external R&D strategies is efficient for the firm only if it focuses on technology creation strategy. Some firms prefer the internally developed technological strategy, mainly due to the confidential nature of innovation, to the lower availability of external information and to the risks associated with the possible loss of technological competitiveness, in spite of the considerable advantages that could be generated from an externally acquired technology. Nevertheless, theoretical evidence in favor of external R&D emphasizes that this strategy allows the affiliate to obtain new or complementary knowledge and to boost competitiveness (Helble and Chong, 2004). Jacquier-Roux and Le Bas (2008) argue that multinational firms using a knowledge-augmenting based strategy are more likely to need externally acquired knowledge through alliances and acquisitions in order to absorb foreign knowledge. Narula (2001) states that, by opting for external R&D strategies, firms can be motivated by the reduced risks, the smaller capital needed or the limited possible damage in case of failure, that characterize the externally acquired technology. However, Veugelers and Cassiman (1999) show that, in the case of collaboration with external entities, firms may be faced with higher costs related to negotiation with partners and monitoring of the external contracts. Besides, in technological outsourcing strategy, the weak control of firm on the technology outflow, can foster opportunistic behavior by collaborators and increase the previously mentioned costs.

It is also noteworthy that spillovers from external sources of knowledge have recently emerged as critical factor influencing MNEs' decision to assign R&D activities to their foreign subsidiaries. Since R&D activities are more knowledge-driven than manufacturing, I would expect R&D location decisions of firms to be more influenced by access to knowledge spillovers in a given place. Kumar (2001) and Fors and Zejan (1996) state that one of the major reasons behind the internationalization of R&D of MNEs is to benefit from localized knowledge spillovers and keep up with the innovative activities undertaken abroad. In their study of knowledge production function applied to European regions, Bottazzi and Peri (2003) used geographic distance as a measure of proximity to evaluate R&D external to a region. Their findings sustain that spillovers are localized and that they occur only within a distance of 300 km. In this context, geographic proximity would facilitate the effective transmission of knowledge from external sources to the home firm through its subsidiary. Guellec and van Pottelsberghe de la Potterie (2001), in their study of technology internationalization activity based on patent data indicators of multinational firms in the OECD countries, show that geographic proximity of countries is an important factor enhancing the bilateral collaboration in

technology. In their study, Jacquier-Roux and Le Bas (2008) sustain the evolutionary approach of the firm as a "bloc of knowledge". They consider that localization of Multinational Companies' R&D investments depends essentially on the red-based organizational approach of the firm. For instance, they argue that when MNCs' strategies consist in increasing their stock of knowledge capital through the knowledge acquired by their foreign laboratories, firms should take into account the importance of the distance effect when localizing their units.

Other factors related to firms size, cost of innovation, availability of skilled labor, host country characteristics or sector of activity have been studied in other parts of the literature. Zejan (1990), Odagiri and Yasuda (1996) and Graves and Langowitz (1993) find that large firms have a greater propensity to undertake innovative activity abroad, due to their lower risk, market power, or previous innovation experience, whereas Veugelers and Cassiman (1999) find that large firms have a higher capacity to combine both internally and externally acquired knowledge in their innovation strategies. Other factors related to costs of innovation and availability of skilled labor in the host country may affect affiliate's decision to perform R&D activity. Cuervo-Cazurra et al. (2007) argue that the lack of additional resources that the affiliate may need in the host country could negatively affect its operations and thus MNEs decision of internationalization. Moreover, theory predicts that differences in costs between source and host countries have greater importance in vertical FDI, which suggests that factor costs' impact on R&D decision would depend on MNEs incentives from conducting innovating activity abroad. Thus, lower costs may be an important motive to overseas R&D activity of vertically integrated multi-nationals. Other studies give support to the importance of industry in which firms are operating in the R&D activities of firms. Mansfield et al. (1979) confirm that American firms in drug industry have greater propensity to locate their affiliates abroad in order to avoid the high requirements of the Food and Drug Administration (FDA) in the United States. Also, Edler (2004) shows that German firms in knowledge-intensive fields are more likely to carry out their R&D activities abroad, especially in sectors like biotechnology or pharma-ceuticals. Indeed, the author highlights that the weight of these two sectors in total R&D activity of firms in Germany is considerably bigger abroad than at home.

An important question arises regarding whether the existence of external sources of knowledge that are distant from the home country can affect the likelihood of MNEs to locate their R&D activities and whether distance affects firms' propensities to carry out in-house or externally sourced knowledge. In fact, despite the importance of globalization in the economic activity, there is evidence that geographic "distance still matters". Ghemawat (2001) considers that firms must take into account the impact of distance before they go for global expansion activities. Some studies have established that it is still difficult to obtain knowledge from geographically distant sources (Jaffe et al., 1993; Thompson and Fox-Kean, 2005). Regarding the determinants of FDI location by MNEs, some studies find that distance between the source and host countries

has a significant and negative impact on investment in foreign markets. In particular, Bevan and Estrin (2004) consider that "the gains from overseas economies diminish with distance from the source economy". Rasciute and Pentecost (2007) find that distance between investing and receiving countries has a significant and negative impact on the decision to invest in Central and Eastern European Countries. The same results were reached by Bush et al. (2005), Becker et al. (2005) and Lefilleur (2008). They consider that geographical distance is positively correlated with costs associated with MNEs' decision to locate affiliates abroad and that it is a discouraging factor on location decision.

More recent studies have investigated the role played by geographic distance in international investment decisions through gravity equation models. Part of the literature shows that distance coefficients are stable across different time periods (Freund and Weinhold, 2000 and Egger, 2000). This finding is interpreted as supportive of the logic that the globalization process considerably contributes to the decrease of the importance of distance in the economy, which is particularly intensified by the expansion of modern communication techniques and the decline in transportation costs. However, according to Bush et al. (2004), this interpretation of distance coefficients is misleading, since they consider that the fall in distance costs still has an important impact in international economic activity. Besides, the authors believe that the right interpretation of the unchanged distance coefficients is that international activities between countries have expanded at the same proportion for countries located near each other as well as for countries located far away from each other.

Von Zedtwitz and Gassmann (2002) argue that distance impacts communication in terms of frequency and quality, raises transaction costs, and introduces principal-agent related difficulties. Despite modern communication technologies, the exchange of tacit knowledge, the creation of trust, and a common working culture require direct face-to-face communication. They find that most companies (42 out of 81) analyzed do domestic research and dispersed development, what they label as market-driven R&D.

To the best of my knowledge, the study of Athukorala and Kohpaiboon (2006) is the only work that considered the distance as a determinant of R&D intensity of MNEs' affiliates. These authors found that distance, as a proxy for the "search problem performed in identifying potential exchange pattern", has a positive sign on R&D intensity, which suggest, according to the authors, that geographic distance still affects MNEs choice for the location of their R&D activity abroad. However, the impact of distance on in-house and external R&D of subsidiaries has not been well explored in the literature. Un and Cuervo-Cazurra (2008), using a dataset of Spanish manufacturing firms, find that subsidiaries of foreign MNEs invest less on R&D. Distinguishing between internal and external R&D, they find that the effect is driven by the lower propensity of subsidiaries of foreign MNEs to invest in external R&D. The authors find no difference in investment in internal R&D between the two

groups of firms. They argue that the transfer of knowledge from other parts of the MNE substitutes for the acquisition of external R&D, and that internal R&D complements the technology transferred from elsewhere within the multinational. The problem is that external R&D may include acquisition of technology from other firms within the multinational. In this paper, I complement these findings by analyzing whether distance influences the likelihood of engaging in external R&D, focusing on subsidiaries of foreign firms. I will also distinguish between overall external R&D and external R&D procured from domestic sources outside of the multinational. I go one step forward relative to Un and Cuervo-Cazurra (2008) in the sense that their article belongs to the class of articles that analyze differences in R&D intensity between domestic firms and subsidiaries of foreign MNEs. I inquire into whether there are factors, specifically distance, that explain observed differrences within the group of subsidiaries.

3. DESCRIPTION OF THE DATA

Data used in the present study are collected from the PITEC database (Technological Innovation panel), based on surveys of firms' technological innovation compiled by the Spanish National Statistics Institute (INE) from 2005 to 2007. Questionnaires were sent to firms having at least 10 employees and that are located in Spain. The purpose of the survey is to collect detailed information on several research and innovation activity aspects of firms from all industries.

PITEC is designed as a panel survey, for which yearly data are available, starting from 2003. In the initial year, the sample did not include small firms with less than 200 employees that did not perform internal R&D activity. In the next years, the former type of firms was added to the sample, so that a comparison between firms that did and did not carry out internal R&D activities could be performed. For this reason, I conduct in the present paper a cross section analysis using 2005 data, since a panel estimation cannot allow for an estimation of time-invariant variables, specifically my interest variable geographic distance between home and host countries of foreign affiliates. Also, I choose the 2005 dataset since it represents the highest-quality data in the PITEC database. It actually includes complete information on foreign firms, which allows for the construction of the largest sample of foreign subsidiaries among the available cross-sections in the database. Firms in the database are classified according to their sector activity and grouped into 53 different 2-digit sectors following the Spanish classification, CNAE-93 Rev.1.

Data available in the sample provide information about the technological activity of firms. Particularly, it describes the nature of affiliates' R&D activity, distinguishing between internal and external R&D. PITEC also contains detailed information on the nature of firms' external R&D. On the one hand, it allows for a distinction between external R&D made by firms within the MNE, as well as by other firms or research institutions. It also allows for the distinction between external R&D carried out in Spain and that performed abroad. Finally, it allows the researcher to classify external R&D according to

the type of organization carrying it out (public administration, universities, research associations, private entities, international organizations, etc.).

The data also permits the construction of some useful variables that let the sample be restricted to innovative firms, since the inclusion of non-innovative firms could bias the estimation of the model. In fact, a firm is considered to be innovative if it either performed innovative product or process during the two-year period prior to the survey, or if it has in process or abandoned innovative activity. Other variables, such as HITECH[1] and MANUF, may be constructed in a similar way. The former is an indicator of the firm being in one of the following high or medium-tech industries: Pharmaceuticals, Office and computer machinery, Electronic components, Radio, TV and communication equipment, Medical precision and optical instruments, Aeronautic and spatial construction, Mail and postal activities, Research and Development activities, Chemical industry, Machinery and mechanical equipment, Car industry, Electrical machinery and materials, Aircraft and spacecraft and Other transport equipment. The later is an indicator variable of the firm being classified into a manufacturing industry.

The distance variable is geographic distance from Madrid to the capital of the country where the parent firm is located. This is taken from the Western Cotton Research laboratory database[2]. I then construct the observed distance to the maximum distance of the sample to construct my relative geographic distance variable (RevDist). As an alternative to the distance variable, I introduce a dummy variable for EU members to test the impact of sharing the same business and legal environment on R&D decisions by MNEs. This variable is negatively correlated with distance. I also introduce a variable that measures the technological resources in the source market (RDGDP). This variable evaluates the proportion of GDP devoted to R&D in the source country. It captures the level of technological development in the source country. I use this variable to test if the technological environment of parent firms affects the type of R&D of their Spanish subsidiaries. Data on the research and development expenditure to GDP ratio are collected from Eurostat web page[3].

Table 1 summarizes the variables. IDIN is an indicator of the firm deciding to undertake R&D activity, while IDEX indicates positive expenses in external R&D. I also construct a binary variable, IDEXDOM that equal one if external R&D activities are carried out by domestic firms external to the group, and zero otherwise.

Relative distance variable is measured by the ratio of distance between home and host countries of the affiliates to the maximum distance in the

[1] To construct this variable I followed the INE's classification of High and Medium-tech sectors.

[2] www.wcrl.ars.usda.gov/cec/java/lat-long.htm (The Western Cotton Research Laboratory database, US Department of Agriculture).

[3] www.epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database (Eurostat, 2005).

sample. Hence, I obtain values ranging between 0.047 and 1. The extreme values correspond to distances relative to MNEs from Lisboan (Portugal) and Tokyo (Japan), respectively. Other firm-specific variables, such as its size, industry, ability to export to international markets, evaluation of the source technological environment and target market characteristics are constructed. EMPL indicates whether the total number of firm employees is at least 200. It is measured as the number of employees in year t. This variable takes the value 1 if this number equals or exceeds 200 employees, and zero otherwise. EXPORT is a binary variable that indicates whether firms target the international market. It takes the value one when firms export to abroad markets and zero otherwise. A complete set of industry dummies has been constructed. These variables have been included because the literature finds important inter-industry differences in R&D internationalization. Among manufacturing industries, pharmaceutical and chemical, in particular, tend to be the most internationalized sectors by MNEs. Wortmann (1990) found that the pharmaceutical sector shows a high R&D intensity performed overseas. PITEC also provides information on whether innovation costs, lack of qualified personnel or lack of information about markets are factors hampering innovation. To evaluate the importance of these variables to the firm and their impact on R&D activity of the subsidiaries, I use the following qualitative variables CINNOV, LQPERS and LINFO. Actually, in the questionnaires, firms were asked to scale the importance of these factors on a four-point scale ranging from 1 (high) to 4 (not relevant at all), according to the corresponding importance of these variables to their R&D activity.

Table 1: Variables and Measures

Type of Variable	Variables	Measures
Dependent Variables	Internal R&D (IDIN)	The firm decides to undertake internal R&D (0-1)
	External R&D (IDEX)	The firm decides to perform external R&D (0-1)
	External R&D with Domestic firms (IDEXDOM)	The firm performs external R&D with firms from the local market (0-1)
Distance Variables	Relative Distance (RevDIST)	The distance in kilometers between firm's home and host countries divided by the maximum distance in the sample
	EU Membership (EU)	Firm is member of the EU (0-1)
Control Variables	Technological Resources in the Home country (RDGDP)	Share of home country GDP dedicated to R&D activities
	Exportation activity (EXPORT)	Firm exports its activities to international markets (0-1)
	Firm Size (EMPL)	Total number of firm employees is greater than 200 (0-1)
	Cost of Innovation in the Host Country (CINNOV)	Importance of the cost of innovation in the host country to the firm (1-4)
	Lack of Qualified Personnel in the Host Country (LQPERS)	Importance of lack of qualified personnel in the host country to the firm (1-4)
	Lack of Information about Markets (LINFO)	Importance of lack of information about markets to the firm (1-4)
	Industry	Sector of activity of the firm

Table 2 presents summary statistics of the variables used in the present paper. A total of 12803 firms were surveyed in 2005. Among them 2858 are subsidiaries of other firms, and 1176 are subsidiaries of foreign multinational companies. After removing countries with one-observation data from the sample, I am left with 1161 foreign affiliates, from 20 different countries.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
IDIN	1161	0.5116279	0.5000802	0	1
IDEX	1161	0.2825151	0.4504165	0	1
IDEXDOM	1161	0.2067183	0.4051262	0	1
RevDIST	1161	0.2358707	0.2098257	0.0467335	1
EU	1161	0.7390181	0.4393593	0	1
RDGDP	1161	2.2359260	0.6106294	0.51	5.44
EMPL	1161	0.6167097	0.4863976	0	1
EXPORT	1161	0.7941430	0.4045007	0	1
CINNOV	1161	2.7381570	1.1057840	1	4
LQPERS	1161	3.0895780	0.8918616	1	4
LINFO	1161	3.1817400	0.8255891	1	4

Table 3 displays subsidiaries' R&D strategies by country of location of the parent firm. It can be shown that almost 45% of the affiliates in my sample have performed neither internal, nor external R&D activities in 2005. Moreover, only a few firms decided to acquire technology from external sources without carrying out in-house R&D activity. Additionally, roughly the same proportions of firms that perform internal and external R&D activities simultaneously undertake only internal R&D, with a small preference for the later strategy in non-EU countries. However, in the group of EU members, 56% of Finnish affiliates in Spain are seen to carry out both internal and external R&D activities, whereas 11% decide to use only knowledge developed using the firm's internal resources.

Figure 1 displays the distribution of foreign affiliates in medium and high-tech industries. It may be observed that most foreign subsidiaries in my sample are from chemistry, transport equipment, machinery and mechanical equipment, software and other computer activities and pharmaceutical products industries.

Figure 2 presents the distribution of the different types of external R&D for medium and high-tech industries, on the one hand, and low-tech industries, on the other. As it may be seen, there is a high proportion of foreign affiliates that perform external R&D activity with domestic firms from outside the subsidiary group in medium and high-tech industries. The same pattern can be observed in external R&D performed abroad.

Table 3: Affiliates' R&D Activity
(Classified According to their Home Country Origin)

Countries	Number of Firms	% of Firms with IDIN=0 and IDEX = 0	% of Firms with IDIN=1 and IDEX = 0	% of Firms with IDIN=0 and IDEX = 1	% of Firms with IDIN=1 and IDEX = 1
EU Members					
FRANCE	237	0.49	0.23	0.06	0.22
GERMANY	202	0.40	0.25	0.05	0.30
U.K.	109	0.58	0.22	0.03	0.17
NETHERLANDS	105	0.45	0.25	0.05	0.26
ITALY	58	0.28	0.41	0.03	0.28
SWEDEN	36	0.36	0.36	0.08	0.19
LUXEMBOURG	28	0.32	0.36	0.04	0.29
BELGIUM	24	0.46	0.29	0.08	0.17
DENMARK	20	0.40	0.45	0.00	0.15
PORTUGAL	18	0.44	0.28	0.00	0.28
FINLAND	9	0.33	0.11	0.00	0.56
AUSTRIA	8	0.50	0.25	0.13	0.13
IRELAND	4	1.00	0.00	0.00	0.00
Total	858	0.45	0.26	0.05	0.24
Non-EU Members					
U.S.A.	197	0.47	0.26	0.04	0.23
SWITZERLAND	52	0.50	0.31	0.04	0.15
JAPAN	28	0.14	0.50	0.07	0.29
CANADA	11	0.18	0.55	0.00	0.27
NORWAY	8	0.38	0.38	0.13	0.13
MEXICO	4	0.50	0.50	0.00	0.00
ISRAEL	3	0.33	0.33	0.00	0.33
Total	303	0.43	0.31	0.04	0.22

Figure 1: Foreign Affiliates in High and Medium-Tech Sectors

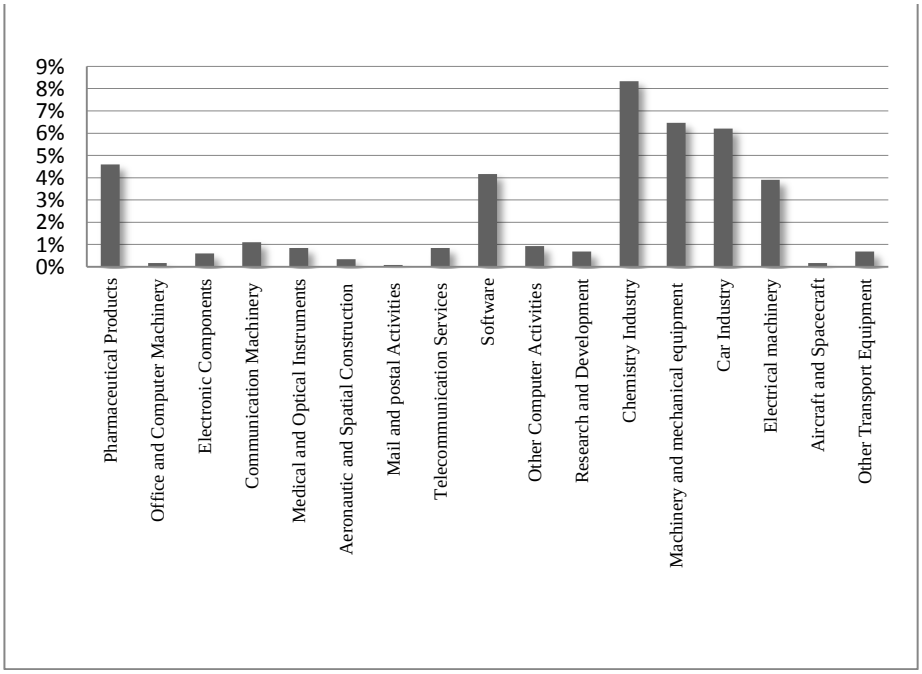
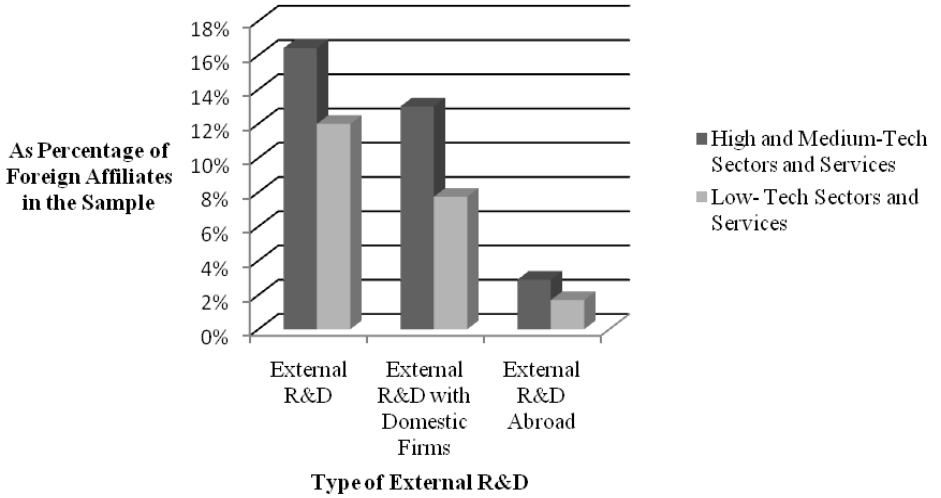


Figure 2: External R&D by Foreign Subsidiaries according to their Technological Class



4. EMPIRICAL ANALYSIS

As pointed out above, my focus is to analyze the effect of distance on firms' R&D decisions, distinguishing between internal and external R&D, and controlling for other influential factors. I initially consider two variables to be dependent in the analysis, namely IDIN and IDEX. The latter has received less attention in the literature, since the type of data employed in most studies does not allow for a distinction between the two types of R&D. An exception is Un and Cuervo-Cazurra (2008). In a second stage, I also make use of the IDEXDOM variable. I expect distance between home countries and their affiliates located in Spain, as described in the previous section of this paper, to have a negative impact on affiliates' R&D activities. The technological environment of the home countries RDGDP is expected to have a negative impact on R&D performed by affiliates located abroad. I also introduce a variable that indicates the size of the firm (EMPL), since this variable is commonly used in the literature and is related to firm's ability to undertake R&D activities (Zejan 1990; Odagiri and Yasuda, 1996). This dummy also allows me to control for differences between the two subsamples of firms. I expected a positive relationship between this variable and my dependent variables. To control for the degree of firm's internationalization, I use the variable Export. The expected sign of this variable is ambiguous. Other control variables used in the regression are the cost of innovation (CINNOV), the lack of qualified personnel (LQPERS) and the lack of information about markets (LINFO) in the host country. The domestic cost of innovation is a particularly important concern for the affiliates' R&D decision if technology seeking is a driving force behind overseas R&D activities. A positive relationship between

this variable and the dependent variables is expected, since I consider that the lower the relevance of innovation costs in the host country, the more likely it will decide to invest in R&D. Additionally, I control for the lack of qualified personnel by introducing the variable LQPERS. I expect this variable to have a positive coefficient, since the lower the relevance of lack of qualified personnel, the greater firms' incentives to invest in R&D in the host country. Then, I introduce the variable LINFO to control for lack of information about markets to innovation activities. This variable is expected to have a positive sign in the regression. Finally, industry-specific differences in the propensity to carry out internal and/or external R&D are controlled for with the inclusion of a complete set of industry dummies.

4.1. Econometric Method

I estimate R&D location decision by foreign MNEs in Spain with a bivariate probit model, using the variables that were presented in the previous section as explanatory variables. I carry out the investigation for a cross-section of foreign affiliates in 2005, using as dependent variable the decision of firms to perform R&D activity in Spain, which takes the value one if the affiliate's R&D expenses are different from zero, and zero otherwise. I set up a bivariate probit model provided that the random error terms of the two models are assumed to be correlated (Greene, 2000). Actually, since I include internal and external R&D decisions of firms as dependent variables, I consider that these two choices are simultaneous, and in part driven by the same unobserved factors,[4] which justify the use of the bivariate model. The model also estimates the degree of correlation between the two R&D strategy decisions. The statistical significance of the correlation between the two equations is measured by the statistical significance of the estimated coefficient of correlation between the equation errors. The estimated equations are specified as follows:

$$IDIN^{*}_{i} = \alpha + \beta_1 RevDIST_j + \beta_2 RDGDP_j + \beta_3 EXPORT_i + \beta_4 EMPL_i + \beta_5 CINNOV_i + \beta_6 LQPERS_i + \beta_7 LINFO_i + \beta_8 D_k + \mu_i \quad (1)$$

$$IDEX^{*}_{i} = \alpha + \beta_1 RevDIST_j + \beta_2 RDGDP_j + \beta_3 EXPORT_i + \beta_4 EMPL_i + \beta_5 CINNOV_i + \beta_6 LQPERS_i + \beta_7 LINFO_i + \beta_8 D_k + \varepsilon_i$$

where D is a dummy variable for each sector in the sample, and subscripts *i, j and k* denote firms, countries and industries, respectively.
i=1,…, nth firm;
j= 1,…,20th home country;
k = {1,…,53};
α: constant term, representing firm specific characteristics;
μ,ε: error terms, capturing other omitted influences, which are assumed to be distributed according to a bivariate normal with non-zero covariance.

[4] Cassiman and Veugerlers (2006) show the existence of a positive correlation between internal and acquired R&D activities.

Then, in the second part of my analysis, conditional on the firm performing external R&D, I estimate a probit model where I study the following equation:

$$IDEXDOM^{*}_{i} = \lambda + \gamma_1 RevDIST_j + \gamma_2 RDGDP_j + \gamma_3 EXPORT_i + \gamma_4 EMPL_i + \gamma_5 CINNOV_i + \gamma_6 LQPERS_i + \gamma_7 LINFO_i + \gamma_8 D_k + \delta_i \quad (2)$$

where δ represents the error terms.

4.2. Empirical Results

Tables 4 and 5 present the econometric results of the estimation of regression (1) applied to innovative firms. In table 4, I observe that from the initial 1161 firms in my sample, only 865 are shown to be innovative affiliates[5]; while in table 5 the number of innovative firms that operate in high and medium-tech manufacturer industries is equal to 267. In the first table, I report two alternative analyses to check for robustness of the results. I present results of regression (1) using, in columns (I), relative distance and, in column (II), EU membership dummy variable.

In table 4, the results from the two analyses are almost similar when the dependent variable is internal R&D as well as when I estimate external R&D. The only difference that could be noticed concerns the signs of the variables distance and EU membership.

Distance is shown to have a negative impact on the decision to undertake internal and external R&D activity by foreign affiliates. However, the effect is statistically significant only when R&D is procured from outside the firm. In fact, the increase of distance between affiliates' home countries and Spain tends to decrease their purchases of external R&D.

I also observe that EU membership has a positive and significant impact on external R&D, showing that when the home country belongs to EU, affiliates appear to have more propensities to carry out innovation activity in Spain, especially external R&D. This result is consistent with the estimated coefficients on distance.

The level of technological resources in the source country and the ability of the affiliate to export its activities are found to have no significant effect on the decision to carry out R&D. Additionally, the results show that firm size only matters when affiliates decide to carry out internal R&D. Actually, when firm size increases, the probability that firms undertake in-house R&D tends to decrease both in models (I) and (II). The importance of the cost of innovation seems to significantly affect affiliates' R&D decisions only when they carry out internal R&D. In that case, a decrease in the probability of performing internal

[5] I refer to innovative firms as firms that introduced new products or processes during the period of 2003-2005 or that have in progress or abandoned innovative activity during the same time period.

R&D is observable when the cost of innovation is less important to affiliates. Lack of qualified personnel has no statistically significant effect on internal R&D, whereas it negatively affects the probability of performing external R&D. The importance of lack of information available on markets has shown no significant effect on R&D decision. However it seems to negatively affect internal R&D and positively affect external R&D.

Table 4: Estimation Results of Regression (1)

	Dependent Variable: Internal R&D (IDIN)		Dependent Variable: External R&D (IDEX)	
	(I)	(II)	(I)	(II)
RevDIST	-0.125 (0.2259)	-	-0.574** (0.245)	-
EU	-	0.147 (0.126)	-	0.365*** (0.119)
RDGDP	-0.026 (0.093)	-0.002 (0.092)	0.089 (0.085)	0.106 (0.083)
EXPORT	0.194 (0.163)	0.192 (0.164)	-0.122 (0.169)	-0.129 (0.169)
EMPL	-0.361*** (0.109)	-0.357*** (0.109)	0.101 (0.100)	0.107 (0.100)
CINNOV	-0.213*** (0.056)	-0.211*** (0.056)	-0.067 (0.050)	-0.062 (0.050)
LQPERS	-0.095 (0.079)	-0.095 (0.079)	-0.133* (0.070)	-0.136* (0.070)
LINFO	-0.128 (0.086)	-0.130 (0.086)	0.015 (0.075)	0.018 (0.075)
Industry dummies	Included	Included	Included	Included
Intercept	7.512 (30739.16)	7.194 (25637.19)	6.786 (24614.81)	6.230 (26176.68)
N	865	865	865	865
/athrho	0.353*** (0.069)	0.350*** (0.069)	0.353*** (0.069)	0.350*** (0.069)
Rho	0.339 (0.061)	0.336 (0.061)	0.339 (0.061)	0.336 (0.061)
Log likelihood	-921,631	-919,476	-921,631	-919,476

*Standard errors appear in parenthesis. Industry dummies are included in the analysis. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.*
Rho and Arthrho measure the statistical correlation between the two firms R&D strategies. The later being a statistical transformation of rho and used in the estimation of bivariate probit model.
Column (I) provides results for regression (1).
Column (II) provides results for regression (1) when I replace relative distance by the EU dummy variable.

In table 5, I report results of regression (1) applied to innovative manufacturing firms in medium and high-tech industries, not including industry dummies in the specification. In column (III) I estimate the effect of distance, whereas in column (IV), I report results of regression (1) replacing distance by EU membership variable.

Results show that Distance still affects negatively external and internal R&D, but its effect is stronger in this sub-sample of R&D-intensive subsidiaries. I also observe that distance is only significant in explaining external R&D decision. The estimated coefficient on the EU membership is similar to that reported in Table 4. Actually, affiliates with an EU member parent firm have more probability of investing in external R&D in Spain.

Firms from High and Medium-Tech sectors that export to international markets are shown to have less probability to carry out external R&D in Spain. In this sub-sample I also notice that firm size has a significant and positive effect on the decision to acquire knowledge from external sources. In fact, bigger firms show a greater propensity to use externally developed R&D

activities. The effect of the importance of cost of innovation on internal R&D decision has almost not changed when I consider sample of high-technology firms in manufacturing industries. I also observe that now the importance of lack of qualified personnel is no longer significant in explaining either external R&D activities of subsidiaries, or their internal R&D decisions.

Table 5: Estimation Results of Regression (1) for manufacturer firms in High and Medium-Tech sectors

	Dependent Variable: Internal R&D (IDIN)		Dependent Variable: External R&D (IDEX)	
	(III)	(IV)	(III)	(IV)
RevDIST	-0.391 (0.376)	-	-0.752** (0.370)	-
EU	-	0.087 (0.204)	-	0.375** (0.190)
RDGDP	-0.008 (0.159)	-0.050 (0.155)	-0.041 (0.146)	-0.060 (0.143)
EXPORT	0.211 (0.418)	0.214 (0.420)	-1.123** (0.437)	-1.126 (0.436)
EMPL	-0.158 (0.193)	-0.160 (0.192)	0.442*** (0.168)	0.439*** (0.168)
CINNOV	-0.261*** (0.097)	-0.262*** (0.097)	-0.022 (0.083)	-0.029 (0.083)
LQPERS	0.050 (0.144)	0.041 (0.143)	-0.072 (0.126)	-0.085 (0.126)
LINFO	-0.068 (0.157)	-0.055 (0.156)	-0.138 (0.134)	-0.123 (0.134)
Industry dummies	Not included	Not included	Not included	Not included
Intercept	1.559** (0.663)	1.475** (0.707)	1.861*** (0.645)	1.448** (0.689)
N	267	267	267	267
/athrho	0.326*** (0.113)	0.337*** (0.113)	0.326*** (0.113)	0.337*** (0.113)
Rho	0.315 (0.102)	0.325 (0.101)	0.315 (0.102)	0.325 (0.101)
Log Likelihood	-304,2574	-304,6251	-304,2574	-304,6251

*Standard errors appear in parenthesis. Industry dummies are not included in the analysis. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.*
Rho and Arthrho measure the statistical correlation between the two firms R&D strategies. The later being a statistical transformation of rho and used in the estimation of bivariate probit model.
Column (III) provides results for regression (1) when sample is restricted to manufacturer firms in High and Medium-Tech sectors.
Column (IV) provides results for regression (1) when I rather consider the EU dummy variable and sample is restricted to manufacturer firms in High and Medium-Tech sectors.

Results displayed on Table 6 show that distance has also a negative and significant impact on affiliates' decision to source external R&D activities with domestic firms in Spain, especially for firms in Low-Tech manufacturer sectors. In fact this could be explained by the lack of information available on the local market that increases with distance and generates a reduction in the probability of carrying out R&D activities by other domestic firms, particularly if affiliates operate in non R&D-intensive sectors.

Results also show that when technological resources of subsidiaries' parent firms increase, the probability that affiliates acquire external R&D activities by domestic firms decreases for R&D-intensive companies. The importance of the cost of innovation still has a negative but smaller impact on external R&D decision carried out by domestic firms.

Table 6: Estimation Results of Regression (2)

	Dependent Variable: External R&D with Domestic Firms (IDEXDOM)		
	(V)	(VI)	(VII)
RevDIST	-0.296* (0.153)	0.302 (0.251)	-0.574** (0.253)
RDGDP	-0.082 (0.058)	-0.287** (0.120)	0.012 (0.083)
EXPORT	-0.049 (0.099)	0.417 (0.278)	0.162 (0.273)
EMPL	0.013 (0.060)	0.046 (0.098)	-0.095 (0.094)
CINNOV	-0.065** (0.030)	-0.062 (0.043)	-0.097* (0.053)
LQPERS	-0.076* (0.039)	-0.099 (0.065)	-0.021 (0.059)
LINFO	-0.012 (0.044)	0.047 (0.068)	-0.040 (0.069)
Industry dummies	Included	Included	Included
N	295	130	114
Log Likelihood	-137,548	-55,245	-56,830
Pseudo R^2	0,2195	0,3182	0,1715

*Standard errors appear in parenthesis. Industry dummies are included in the analysis. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.*
Column (V) provides results for regression (2); Column (VI) provides results for regression (2) when sample is restricted to manufacturer firms in High and Medium-Tech sectors; Column (VII) provides results for regression (2) when sample is restricted to manufacturer firms in Low-Tech sectors.

Summarizing, these results suggest that geographic distance between a MNE and its overseas affiliates is a discouraging factor for the implementation of R&D strategy by the foreign subsidiaries when they aim to acquire knowledge from external sources, especially domestic ones. This result can be in part explained by the *Transaction Cost Economics*. For instance, although researches on internationalization of R&D activities supported the motivation of MNEs to accede to foreign markets in order to beneficiate from the localized knowledge spillovers, the results in this study show that acquiring knowledge from external sources that are distant from the home firm of the foreign affiliate increases the uncertainty and the high risk associated to these kinds of technology transactions and, hence, increases the transaction costs linked to the external knowledge acquisition. Therefore, it is likely that the concept of transaction costs associated to distance is still affecting MNEs' choice of localization of their overseas subsidiaries. However, distance does not appear to exert a significant influence on intramural R&D activity of foreign subsidiaries located in Spain. Indeed, with the absence of asymmetry problems characterizing internal R&D activity of foreign affiliates and the technology activity they transfer from their parent firm, distance is likely to not matter for this kind of R&D activity.

These findings call for an integration of spatial dimension into the choice of the country where MNEs would locate their affiliates. Actually, as mentioned by Guellec and van Pottelsberghe de la Potterie (2001), managers are expected to benefit more from less distant sources to acquire knew knowledge available in the foreign market. Also, from a macroeconomic view, since less distant firms have higher propensities to invest in R&D activities in the local market, higher incentives should be implemented to facilitate the flow of incoming FDI.

5. CONCLUSION

This paper has analyzed whether geographic distance has an effect on the choice of R&D strategies by affiliates of MNEs. Using a sample of Spanish subsidiaries of foreign MNEs in 2005, I found that geographic distance does not have a statistically significant effect on the likelihood of affiliates conducting internal R&D. In contrast, distance seems to negatively affect the likelihood of firms sourcing external R&D. This effect is obtained both using the relative distance variable and the European Union dummy variable. Furthermore, conditional on doing external R&D, distance is negatively associated with the probability of procuring external R&D from domestic sources. I interpret these findings as evidence that distance exacerbates asymmetric information problems between the parent firm and the subsidiary, inducing the MNE to opt for a R&D strategy where affiliates play a less active role like adaptive R&D rather than innovative R&D strategy. In particular, affiliates are endowed with internal R&D capabilities, which allow them to implement technology transferred from other units in the MNE, but are less likely to conduct and coordinate their own research projects, and thus less likely to do external R&D.

These findings may be of use for managers and policymakers when designing their strategies and policies. On the one hand, provided that affiliates from less distant countries seem to be more active in the generation of new knowledge, it is more likely that domestic firms benefit from this type of knowledge, by means of interaction with these affiliates. This calls for the implementation of policies that provide stronger incentives to inward FDI coming from more proximate countries. From a managerial perspective, if distance indeed affects communication and coordination costs, managers should choose more proximate sources of new knowledge if the purpose of FDI is to source new knowledge developed in some foreign country. If the purpose of FDI is to exploit the MNE's knowledge in some foreign market, managers should be aware of the existence of these costs, and should therefore invest in improving communication and monitoring channels in order to minimize them.

REFERENCES

Athukorala P.C. and Kohpaiboon A. (2006). "Multinational enterprises and Globalization of R&D: A Study of U.S-based Firms", Australian National University, Economics RSPAS Departmental working Papers 2006-06.

Becker S.A., Ekholm K., Jäckle R. and Mündler M.A. (2005). "Location Choice and Employment Decisions: A Comparison of German and Swedish Multinationals", *Review of World Economics*, 141 (4), 693-731.

Bevan A.A. and Estrin S. (2004). "The Determinants of Foreign Direct Investment into European Transition Economies", *Journal of Comparative Economics*, 32, 775-787.

Bottazzi L. and Peri G. (2003). "Innovation and Spillovers in Regions: Evidence from European Patent Data", *European Economic Review*, 47 (4), 687-710.

Bush C.M, Kleinert J, Lipponer A. and Toubal F., 2005, "Determinants and Effects of Foreign Direct Investment: Evidence from German Firm-level Data", *Economic Policy*, 20 (41), 51-110.

Cassiman B. and Veugelers R., 2006, "In Search of Complementarity in Innovation Strategy: Internal R&D and External Knowledge Acquisition", *Management Science*, 52 (1), 68-82.

Cuervo-Cazurra A., Maloney M.M., and Manrakhan S., 2007, "Causes of the Difficulties in Internationalization", *Journal of International Business Studies*, 38 (5), 709-725.

Edler J., 2004, "International research strategies of multinational corporations: A German perspective", *Technological Forecasting and Social Change*, 71, 599-621.

Foray D., Mowery D., 1990, "L'intégration de la R&D industrielle : nouvelles perspectives d'analyse", *Revue Économique*, 41(3), 501-530.

Fors G. and Zejan M., 1996, "Overseas R&D by Multinationals in foreign Centers of Excellence", Stockholm School of Economics, Working Paper 111.

Ghemawat P., 2001, "Distance Still Matters: The Hard Reality of Global Expansion", *Harvard Business Review*, 79 (8), 137-147.

Graves S.B. and Langowitz N.S., 1993, "Innovative Productivity and Returns to Scale in the Pharmaceutical Industry", *Strategic Management Journal*, 14 (8), 593-605.

Greene W., 2000, *Econometric Analysis*, fourth ed. Prentice-Hall, Upper Saddle River, NJ.

Guellec D., van Pottelsberghe de la Potterie B., 2001, "The internationalisation of technology analysed with patent data", *Research Policy*, 30 (8).

Helble Y. and Chong L.C., 2004, "The Importance of Internal and External R&D Network Linkages for R&D Organisations: Evidence from Singapore", *R&D Management*, 34 (5), 605-612.

Jacquier-Roux V., Le Bas C., 2008, "Localisation des activités de R-D des firmes multinationales, modes d'organisation en réseaux et transfert trans-national des connaissances: un cadre d'analyse", *Région et Développement*, 28, 11-38.

Jaffe A.B., Trajtenberg M. and Henderson R., 1993, "Geographic Knowledge Spillovers as Evidenced by Patent Citations", *Quarterly Journal of Economics*, 108 (3), 577-598.

Kumar N., 1996, "Intellectual Property Protection, Market Orientation and Location of Overseas R&D Activities by Multinational Enterprises", *World Development*, 29 (4), 673-688.

Kumar N., 2001, "Determinants of Location of Overseas R&D Activity of Multinational Enterprises: the Case of US and Japanese Corporations", *Research Policy*, 30, 159-174.

Lefilleur J., 2008, "Déterminants des Investissements Directs Étrangers en Europe Centrale et Orientale : Un bilan de la Transition", *Revue d'Études Comparatives Est-Ouest*, 39 (2), 201-238.

Mansfield E., Teece D. and Romeo A., 1979, "Overseas Research and Development by US-Based Firms", *Economica*, 46, 187-196.

Narula R., 2001, "Choosing Between Internal and Non-Internal R&D Activities: Some Technological and Economic Factors", *Technology Analysis and Strategic Management*, 13 (3), 365-387.

Odagiri H. and Yasuda H., 1996, "The Determinants of Overseas R&D by Japanese firms: an Empirical Study at the Industry and the Company levels", *Research Policy*, 25, 1059-1079.

Rasciute S. and Pentecost E.J., 2010, "A Nested logit approach to modelling the location of foreign direct investment in the Central and Eastern European Countries, *Economic Modelling*, 27 (1), 32-39.

Thompson P. and Fox-Kean M., 2005, "Patent Citation and the Geography of Knowledge Spillovers: A Reassessment", *American Economic Review*, 95 (1), 450-460.

Un C.A. and Cuervo-Cazurra A., 2008, "Do Subsidiaries of Foreign MNEs Invest More in R&D than domestic Firms?", *Research Policy*, 37, 1812-1828.

UNCTAD, 2005, *World Investment Report 2005*, Geneva: United Nations Commission for Trade and Development.

Veugelers R. and Cassiman B., 1999, "Make and Buy in Innovation Strategies: Evidence from Belgian Manufacturing Firm", *Research Policy*, 28, 63-80.

Von Zedtwitz M. and Gassmann O., 2002, "Market versus Technology Drive in R&D Internationalization: Four Different Patterns of Managing Research and Development", *Research Policy*, 31, 569-588.

Wortmann M., 1990, "Multinationals and the Internationalization of R&D: New Developments in German Companies", *Research Policy*, 19, 175-183.

Zejan M.C., 1990, "R&D Activities in Affiliates of Swedish Multinational Enterprises", *Scandinavian Journal of Economics*, 92 (3), 487-500.

DISTANCE AU PAYS D'ORIGINE ET ACTIVITÉS DE R&D DES FILIALES DES ENTREPRISES ÉTRANGÈRES EN ESPAGNE

Résumé *- Cette étude examine l'impact de la distance géographique entre le pays d'origine des firmes multinationales et le pays où sont situées leurs filiales sur leur décision d'entreprendre des activités de Recherche et Développement (R&D). L'analyse utilise un échantillon de 1161 filiales étrangères installées en Espagne collectées à partir de la base de données PITEC (Panel d'Innovation Technologique), fondée sur le questionnaire de l'année 2005 sur l'activité d'innovation technologique des firmes de l'Institut Espagnol de Statistiques (INE). Les données permettent de distinguer entre les activités de R&D internes et externes des filiales. Les résultats d'un modèle biprobit montrent que pour les filiales étrangères en Espagne, la distance a un impact négatif sur la probabilité de recourir à la R&D externe. Toutefois, la distance n'a pas d'effet statistiquement significatif sur la probabilité de faire de la R&D pour les filiales des firmes étrangères. Par ailleurs, les résultats montrent que plus la distance entre les entreprises-mères et les filiales situées en Espagne est grande, moins celles-ci sont susceptibles d'acquérir la technologie de source locale.*