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Multinational Firms' R&D Investment in Developing Countries: Determinants of Location Choices

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Abstract

Multinational companies increasingly internationalize what has been traditionally viewed as one of its most immobile functions: research and development. If this phenomenon is not exactly new, two recent trends have however stirred our interest. First, the core mission of R&D units is no longer limited to solving the problems of production and distribution but relates more and more to the creation of knowledge transferred between units of the MNF located worldwide. Secondly, the empirical evidence indicates a significant increase of FDI in R&D in a small group of emerging countries. In our paper, we propose to verify whether innovation and not only adaptation related factors are decisive in the location of MNFs' R&D units in developing countries. We believe that the results of the model we tested will serve to broaden the scope of analysis of the internationalization of R&D, taking into account the fact that the theoretical explanations for the deployment of R&D activities in this group of countries focuses on the hypothesis of adaptive R&D.

***Key words**: multinational firms, R&D internationalization, innovation, developing countries*

Introduction

In the context of increased global competitive pressures and multiplication of innovation centres around the world, the spatial dispersion of R&D units in different countries has gained unprecedented dimensions, the improved coordination of independent R&D laboratories thereby intensifying cross-border transfers of knowledge and technology within the multinational firm (MNF): from the parent company to the affiliates; from the affiliates to the parent company; and between the affiliates. Empirical evidence indicates the increase of FDI in R&D in both groups of countries: developed and developing countries. Although this particular type of investment is concentrated in developed countries, recent trends show a more accelerated growth in some developing countries. The major emerging destinations are China, India and Brazil. Malaysia, Thailand, the Visegrad countries and Mexico also stand out from the rest of the developing countries by the increased attractiveness for the location of multinational firms' R&D affiliates.

The establishment of R&D activities in developing countries is not a new phenomenon in the global economic landscape. However, the rapid growth of FDI in R&D in this group of countries and its geographical concentration in only a few emerging countries mark two relatively new trends. Essentially, these developments are fuelled by the new constraints and opportunities brought about by globalization. First, the intensification of global competition has triggered a technological race, which is largely responsible for the time reduction in product development and for the continuous decline in costs and prices. Under the impact of this double bind, international competitiveness depends more and more on the ability to accelerate innovation and lower the cost curve (UNCTAD, 2005). Secondly, the qualitative changes taking place in developing countries (political openness, liberalization of trade and capital flows, development of institutional, educational and R&D infrastructure), corroborated with the cost advantage, redefine and enhance the attractiveness of these economies.

In this dynamic context, a specific question is raised: What are the location-specific factors affecting the spatial distribution of MNFs' R&D in developing countries, and particularly in emerging countries? To answer this question, we propose and test a model that explains the overseas' location of R&D affiliates in a selected group of emerging economies.

The paper is structured into four sections. In the first part, we summarize the main trends of industry and geographical distribution of FDI in R&D in developing countries. In the second section, we systematize the theoretical approaches on the determinants of the internationalization of R&D and we are particularly interested in the R&D centralization and decentralization forces (Dunning, 1993, Madeuf et al, 1997, Carre et al, 2004, Granstrand et al , 1992) and in the determinants of different organizational forms of internationalized R&D (Le Bas and Sierra, 2002, Gerybadze and Reger, 1999, Gassmann and von Zedtwitz, 2002, Chiesa, 1996, Pearce, 1989, von Zedtwitz, 2006) . As it results from the literature review, the current theoretical and empirical studies generally assume the location of innovation activities in developed countries. Alternatively, we propose to test the relevance of innovation related factors in establishing MNFs' R&D activities in developing countries. In the fourth section, we present the results of the model test.

1. International location of multinational firms' R&D activities

a. Geographical distribution of overseas R&D

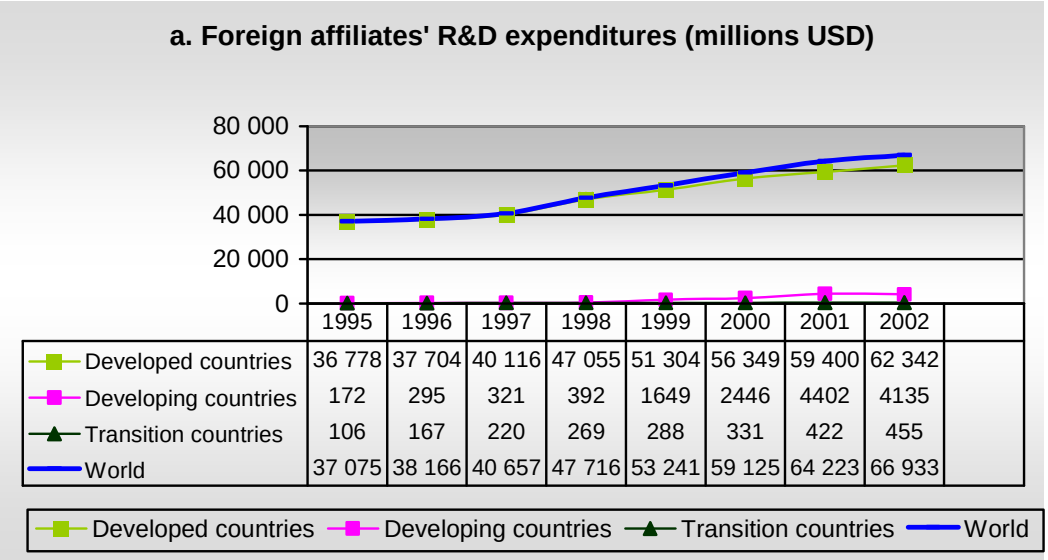
Multinational companies are the major global investors in research and development. In quantitative terms, their expenditure on R&D exceeds half of the world's total R&D expenditures and two thirds of business R&D. Beginning with the '80s, this particularly immobile function of the multinational firm is less and less centralized in the country of origin. Research and development is no longer the exclusive prerogative of laboratories located near the parent company. Even if the gap between the internationalization of R&D and that of production remains significant[1], MNFs show an increasingly marked propensity to locate research and development beyond national borders. The R&D performed by foreign affiliates increased from 37.07 billion USD in 1995 to 66.93 billion USD in 2002 (UNCTAD,

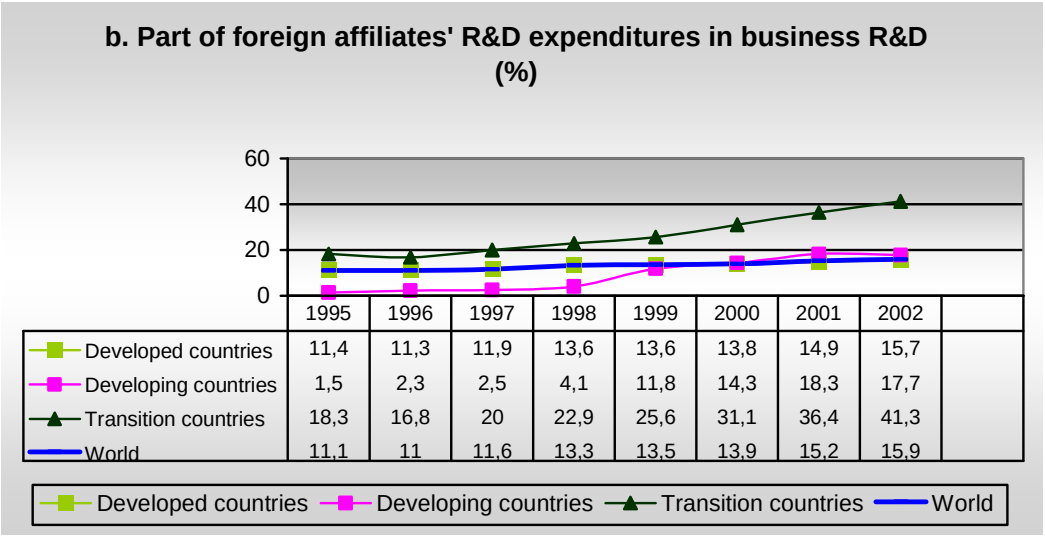
[1] In 2002, the degree of transnationalization of MNFs based in the United States (Transnationalization index), measured as the share of assets, sales and employment of affiliates located abroad in total assets, sales and employment of U.S. multinational firms, was estimated at 43.8% (UNCTAD, 2005, p. 16). In contrast, the proportion of R&D expenditures of U.S. foreign affiliates in total R&D expenditures of U.S. multinational firms was estimated at 13.3% (UNCTAD, 2005, p. 122).

2005, Appendix A.IV.1). During the same period, the share of foreign affiliates' expenditures in business R&D grew from 11.1% to 15.9%.

Developed countries are the main recipients of FDI in R&D, especially in high technology industries. On the other hand, developing economies play a peripheral role in the global innovation network of the MNFs. However, starting from the mid '90s, the increase of FDI in R&D in developing countries has been far more pronounced than the world average (Figure 1).

Figure 1. Foreign affiliates' expenditures in R&D, 1995-2002 (millions USD and % of business R&D)





Source: UNCTAD, 2005, Appendix A.IV.1

In the developing world, foreign direct investment in R&D has been largely concentrated in a small number of emerging countries, thus determining the creation of spatial agglomerations (clusters) of innovation centres integrating the foreign affiliates' R&D

activities. Besides the Asian NICs, the emerging major destinations for FDI in R&D are China, India, Brazil, Malaysia, Thailand, the Visegrad countries and Mexico.

The evolution of foreign affiliates' R&D in developing and transition economies during 1993-2002 confirms this trend. If in 1993, foreign firms' R&D expenditures accounted for 5.8% of total R&D in developing countries; by 2002 they soared to 59.5%. In developed countries, the percentage was 10.6% in 1993 and 15.7% in 2002. In addition, during the period 2002-2004, more than 50% of the total of 1,773 FDI projects in R&D, i.e. 1,095 projects, has targeted developing and transition countries.

In 1994, developed countries accounted for 92% of the U.S. MNFs' internationalized R&D. By 2002, their share had declined by 8 percentage points (UNCTAD, 2005, p. 129). Conversely, R&D expenditures of U.S. affiliates had increased by 6.1 percentage points in the Asia-Pacific region (excluding Japan) and by 3.4 percentage points in the Middle East. A downward trend is confirmed in Latin America and the Caribbean, while FDI in R&D in the African countries remains constant, but peripheral (Table 1). Globally, the share of the developing countries in the R&D expenditures of U.S. foreign affiliates increased from 7.6% in 1994 to 13.5% in 2002.

Table 1. Geographical distribution of R&D expenditures of U.S. foreign affiliates, 1994-2002 (%)

Year	*Europe*	*Canada*	*Japan*	*Asia-Pacific (excepting Japan)*	*Middle East*	*Latin America and Western Hemisphere*	*Africa*
1994	73.0	7.0	9.5	5.4	0.8	4.0	0.1
1995	72.7	8.5	10.2	4.6	0.8	3.1	0.2
1996	68.8	11.1	9.5	5.3	1.2	3.9	0.1
1997	68.5	12.5	7.5	5.3	1.4	4.5	0.2
1998	70.8	11.9	6.6	4.4	1.0	5.1	0.2
1999	67.3	9.3	8.4	9.4	2.1	3.4	0.1
2000	62.9	11.4	8.0	11.3	3.1	3.2	0.1
2001	61.2	10.8	7.6	13.6	3.7	2.9	0.1
2002	-	11.1	6.8	11.6	4.2	-	-

Source: NSF, 2006, Table 4-51

The geographical distribution of FDI in R&D of U.S. foreign affiliates indicates significant variations not only at an inter-regional, but also at an intra-regional level. In 2002, three emerging countries concentrated 43% of all FDI in R&D in developing countries: China (646 million USD), Brazil (306 million USD) and Mexico (284 million USD) (UNCTAD, 2005).

The employment increase in the U.S. R&D affiliates operating abroad also confirms the tendency of locating innovation activities in developing countries. According to UNCTAD, Asian countries' share in total U.S. foreign affiliates' employment has doubled during 1994-1999, from 4.1% to 8.1%. Compared to developed countries, the R&D intensity[2] of U.S. affiliates' in developing countries remains modest, only Singapore and the Republic of Korea registering values similar to the advanced economies, 2.3% and 2.2 % respectively (UNCTAD, 2005, p. 130).

[2] Share of R&D personnel in total employment.

The increased preference of multinational firms for developing countries as destinations for their R&D activities is also confirmed in a survey conducted in 2004 by UNCTAD. According to its results, the United States and the United Kingdom remain the main destinations of internationalized R&D; two developing countries - China and India - are ranked among the top 10 host countries mentioned by the 68 responders (UNCTAD, 2005, p. 133). A similar result is obtained by the Economist Intelligence Unit, following a survey investigating the R&D location choices of MNFs. The top 6 destinations for FDI in R&D are China, the United States, India, the United Kingdom, Germany and Brazil (EIU, 2004, pp. 19-25).

b. Industrial structure of overseas R&D

The analysis of the industrial structure of FDI in R&D points out the increasingly sophisticated forms of R&D carried out in developing countries, as revealed by the rise of R&D expenditures of foreign affiliates in high-technology industries, such as ICT, electronics, pharmaceuticals and biotechnology (UNCTAD, 2005). The increase of FDI in R&D in knowledge-intensive industries is concentrated in Asian emerging economies. In 2003, 43% of R&D expenditures of U.S. affiliates located in these countries concerned the computers and electronics sectors. In India, 57% of foreign affiliates' R&D (against only 20% in 1999) was undertaken in the service industries alone, thanks to growth opportunities for software developers. By comparison, the chemical and transport equipment concentrated more than 50% of R&D located in Brazil and Mexico (BEA, U.S. Direct Investment Abroad).

The most recent trends concerning the R&D activities of foreign affiliates in developing countries show a gradual shift towards services and particularly, the information technologies. During 2002-2004, 39% of the Greenfield projects in R&D in this group of countries were implemented in the IT sector. Moreover, the UNCTAD studies on the organization of R&D in developing countries indicate the expansion of more sophisticated forms of R&D, at the expense of the adaptive R&D activities (UNCTAD, 2005, p. 138).

2. Determinants of the internationalization of R&D: the literature review

The propensity to deploy R&D abroad has fuelled a new economic literature, inspired by a new paradigm of R&D which diverges from the traditional view configured in the theories of the multinational firm (Gerybadze and Reger, 1999). This last approach suggests that innovative technologies, products and processes are developed in the country of origin, and only afterwards, used or adapted abroad, as part of the "home-base exploitation strategy" (Kuemmerle, 1999; Dunning and Narula, 1995). At the opposite pole, the paradigm of R&D internationalization puts forward the "home-base augmenting strategy", essentially defined by:

- the worldwide geographical dispersion of innovation activities;
- the cross-learning at different levels and functions of the value chain;
- the interactive and reversible technology transfer between organizational units and between the centres of excellence.

As the knowledge accumulation process via the establishment of overseas R&D laboratories shifts from peripheral to strategic in the organization of the MNF's value chain, a better understanding of this economic phenomenon becomes of special interest for the

theorists. The magnitude of the research effort is reflected in the multitude of works devoted to studying various dimensions of the internationalization of R&D. The aspects of most concern address: the location choices for the internationalization of R&D, the driving forces behind this process, the organizational structures of the global innovation networks, the types of overseas R&D laboratories, the coordination of internationalized R&D activities.

In this paper, we are interested in identifying the key factors driving the internationalization of R&D, as they are emphasized in the economic literature. We have distinguished between two main theoretic approaches. The first category bears links to the economic geography and focuses on the factors explaining the decentralization and centralization of the R&D function. The second category involves elements of the economics of industrial organization. It examines the main ways in which international R&D is organized and the determinants of the different forms of R&D deployed overseas.

The theoretical framework of "centripetal versus centrifugal forces" has been introduced by Krugman in an effort to explain the emergence of industrial clusters as resulting from the tension between the factors determining the concentration and dispersion of economic activities.

The main centripetal and centrifugal forces, such as systematized in the economic literature (Dunning, 1993, pp. 309-310, Madeuf et al, 1997, p. 65, Carre et al, 2004, p. 249, Granstrand et al, 1992 , p. 13) are presented in Table 2.

Table 2. Centripetal and centrifugal forces in the spatial organisation of R&D

Centripetal Forces	Centrifugal Forces
• economies of scale; • proximity to downstream operations; • proximity to clusters of related industries; • resource availability (R&D infrastructure, scientific skills, etc.) • experience in managing R&D; • international communication and coordination problems.	• adaptation to the local market conditions; • "on the spot" R&D (eg tropical diseases, pesticides etc.); • specificity of local materials; • need to test products locally; • proximity to centres of excellence; • accumulation of technology and exploitation of specialized expertise; • monitoring the R&D activities of foreign firms; • exploitation of immobile local resources; • government pressure / government incentives; • the regional or global strategy to improve the quality of affiliates' end products; • protecting the competitive position in sectors intensive in R&D.

Source: adapted from Dunning, 1993, pp. 309-310, Madeuf et al, 1997, p. 65, Carré et al, 2004, p. 249, Granstrand et al, 1992, p. 13

The main drawback of the "centralization versus decentralization forces" framework is that it can argue the spatial dispersion of R&D activities of the multinational firm, but not necessarily the location abroad.

The industrial organization-related approach overcomes this shortcoming by distinguishing between the determinants of the different forms of internationalized R&D. The works of Le Bas and Sierra (Le Bas and Sierra, 2002), Gerybadze and Reger (Gerybadze and Reger, 1999), von Zedtwitz and Gassmann (Gassmann and von Zedtwitz, 2002), Chiesa (Chiesa, 1996), Pearce (Pearce, 1989) and von Zedtwitz (von Zedtwitz, 2006) allow us to

identify the archetypes of internationalized R&D. A taxonomy that summarizes the current theoretical contributions systematizes the three generic forms of overseas R&D (UNCTAD, 2005, p. 157-177):

- *adaptive and technology support R&D*: is determined by the need to support local production, be near consumers, collaborate with local partners, gain market access, improve the local image of the MNF, avoid protectionist barriers to imports (von Zedtwitz and Gassmann, 2002, p. 584);
- *technology monitoring R&D*: is mainly determined by the spatial concentration of high technology and research activities leading to radical innovation;
- *innovative R&D*: depends on the quality of the national innovation system, and particularly the S&T skills, the presence of innovative firms, the network of research institutions, the protection of intellectual property; government policies in the areas of competition, education and promotion of FDI.

The first form of R&D is decisively determined by demand factors (market factors), and the last two, by supply factors (technological factors). Although these studies are very useful in analyzing the types of R&D located in different groups of countries (developed and developing), the major limitation consists in the assumption that developing countries host adaptive R&D, while advanced countries, innovative and technology monitoring R&D. It is generally recognized that the need to adapt products, processes and technologies to local market conditions continues to dominate the spectrum of determinants of the location of R&D in developing countries. However, in the context of increasing pressure to tap into centres of excellence in order to increase the stock of technological assets, it is interesting to see if improvements in the national innovation systems of emerging countries had a positive impact on the strategic location choices of R&D activities by multinational firms. Thus, the establishment of an increasing number of R&D laboratories in knowledge-intensive industries in some developing countries, notably in China and India, requires a reconsideration of the factors that explain the setup of R&D affiliates in emerging countries.

The expansion of more sophisticated R&D activities of foreign affiliates in developing countries and their concentration in a small group of emerging economies encourages further study of the drivers of this phenomenon. To our knowledge, researches have generally concluded that innovative activities are deployed in developed countries. The immediate assumption is that R&D activities located in developing countries are confined to adaptation tasks and therefore the main determinants are the demand factors. In order to check this hypothesis, we test a model that includes a set of variables capturing the innovative and adaptive nature of R&D activities.

3. Determinants of the localization of R&D in developing countries

To explain the implementation of innovation activities in developing countries, we have constructed a theoretical model integrating the factors that we consider critical in this process. We are interested in the role of the following possible determinants of the location of innovative R&D in developing countries: the R&D personnel, the scientific research, the technological intensity; the R&D infrastructure.

a. Science and technology skills

The importance of scientific and technical expertise in the international location of R&D is particularly relevant in the case of innovation activities. Among the different forms of

R&D, the innovative R&D is particularly determined by the quality of national innovation systems.

The role of human resources in attracting foreign R&D affiliates occurs primarily in the context of the insufficient S&T skills in developed countries, both in quantitative (number of scientists and engineers) and qualitative terms (technical and scientific specialization). This pressure appears in the context of the increasing importance and complexity of innovation activities. Consequently, the expansion of R&D in developing countries, although limited compared to advanced economies, is significantly influenced by the availability of knowledge workers (UNCTAD, 2005, p. 203). The impact of this factor is decisive in the establishment of *innovative* R&D and concerns the skills in high technology and scientific areas. Given the human factor constraint in developed economies, the critical mass and the quality of R&D personnel are likely to play a crucial role in attracting FDI in R&D in developing countries.

Access to R&D employment pools is a determinant of FDI in innovative R&D provided that the quantitative dimension is corroborated with the qualitative one. Only in this case, the potential to tap into the developing countries' scientific and technological expertise exerts a gravitational pull on the multinational firm's R&D (Liu and Chen, 2003, p. 22). The critical mass of researchers and engineers stimulates inflows of FDI in R&D in developing countries, as long as both the quantitative and qualitative criteria are fulfilled. If the critical number of scientists and engineers is important, we believe that the quality and specialization of human skills to be exploited in the R&D activities carried out intra-muros is decisive and can determine the choice between several host developing countries. Accordingly, it is not enough for national policies to emphasize the quantitative dimension by increasing the tertiary enrolment rates. The quality of education largely depends on the capacity of the education system to supply the core competences in the technological and scientific fields of interest for the business sector (UNDP, 2001, p. 84). More precisely, the number of graduates, considered alone, does not positively impact on FDI in R&D, if the competences do not meet the specific R&D needs of the MNFs. Increasing the stock of FDI in innovative R&D is therefore conditioned by the development of technical and scientific skills relevant to the activity of the MNFs.

b. Scientific research

The construction of networks based on science-industry interactions, the ability to identify innovation opportunities and to exploit them through alliances with the scientific community, and the skills necessary to manage such collaborations play a role particularly important in the development of competitive advantages in industries based on new technologies (Walsh et al, 2004, p. 151). Therefore, the quality of the research conducted in specialized institutions positively impact on the national capacity for innovation, and subsequently, on the ability to attract FDI in R&D innovation.

According to Patel and Pavitt (Patel and Pavitt, 1994), the main functions of research within the national innovation system are:

- the generation of patentable or non patentable knowledge and products;
- the provision of technical services;
- the training of researchers.

The contribution of universities and research institutions to the construction of a functional national innovation system depends on the intensity of interactions with the business sector, aspect particularly important in developing countries for two main reasons. Firstly, the bulk of R&D is conducted by the public sector. Secondly, in most developing countries, public research is carried out independently of the specific needs of enterprises (Lall and Pietrobelli, 2002), which produces a break between public and business R&D. This

separation explains the low commercial applicability of the public R&D output. The "vacuum" between the two sectors is largely explainable by the lack of expertise and infrastructure to support research in the specialized institutions, and to the insufficient institutional framework able to encourage the science-enterprise interactions. As the interdependence science-technology increases and the time required for the commercialization of scientific discoveries contracts, multinational firms establish more close relations with public research institutions, and particularly with universities. Moreover, they tend to internationalize this type of collaboration, which implies the establishment of centres of R&D in the proximity of overseas campus universities. The interaction between basic research institutions and firms is possible provided that universities adapt research efforts to the specific industrial needs. By providing the knowledge and/or developing the technologies that play a critical role in the international competitiveness of enterprises, the scientific research generates the stimuli for the establishment of foreign R&D affiliates.

c. Technological intensity

Besides being a relevant indicator of the compatibility between a country's revealed technological advantages and the type of technology sought by the MNF, technological specialization implicitly reveals the capacity of innovation of a specific country. The technological intensity directly relates to the output of R&D and to a country's capacity to compete in the world technology market. If the R&D personnel, scientific research and R&D infrastructure are key inputs for industrial innovation, technological intensity, measured by the number of patents, reflects the country's performances in the production of marketable innovations and is implicitly illustrative for the quality of the environment for innovation. Technological specialization is not only a guarantee of the quality of inputs for innovation, but also of the ability of the national innovation system of the host country to anticipate and adequately respond to market needs.

The contribution of developing countries to the development of advanced technology is marginal, as developed countries claim the central part in this process. This comparative disadvantage can be partially offset via the development of industrial clusters. In order to stimulate the spatial agglomeration of firms and thus spur innovation, the public authorities often resort to the establishment of technology parks. So, in developing countries, the traditional logic of comparative advantage of countries tends to be dominated by the logic of the absolute advantage of companies and sites (Lallement et al, 2007, p. 40). However, one must also take into account that the increased risk of knowledge leakage and reproduction of the same patterns, industrial espionage and economic intelligence impact negatively on the attractiveness of technology parks, especially when conducting innovative R&D. The public good nature of knowledge and the problems associated to its appropriability give inventions and more generally, innovations a certain danger in terms of ownership, danger that is actually reinforced by spatial proximity (Rallet and Torre, 2007, p. 12). However, this assertion is questionable, and it must be related to the different stages of R&D. In the phases of information gathering on partners, product testing or solving technical problems, the spatial distance is commendable. On the other hand, in the stage of collaboration between partners, geographical proximity becomes necessary. During this phase, knowledge dissemination is critical for R&D and it is realized through cooperation between companies, industries and research institutions, through the mobility of R&D personnel and even the purchase of patents.

d. R&D Infrastructure

Universities and research institutions are key components of the R&D infrastructure. In developing countries, national policies play a crucial role in the development of the R&D infrastructure, mainly because of the insufficient private initiative. Public intervention is needed to finance activities that create specialized factors via the mechanisms that facilitate the appropriation of returns on investments in R&D, the implementation of procedures for science-industry collaboration and the creation of financial institutions that ensure the execution of projects likely to generate significant externalities.

According to UNCTAD (UNCTAD, 2005, p. 219), the commercialization of university research output is facilitated within S&T parks, so these structures are frequently viewed as nodes of NIS. The proximity to universities and specialized providers of research and development services, as well as the presence of a significant number of firms are generally expected to enhance the attractiveness of these structures vis-à-vis investors in innovative R&D. In the special case of science and technology parks, regardless of the specific objectives and nature of the R&D activities carried out within, the major challenge when organizing such structures concerns the establishment of support and network relations that stimulate entrepreneurial initiatives and facilitate knowledge exchange.

However, in order for the interactions to produce innovations, spatial proximity must add up to another form of proximity: the organizational proximity. The last one depends upon (Torre, 2006, pp. 26-27): (1) membership in an organization, which shapes the interactions between members according to a set of common rules and routines and / or (2) the similarity logic, based on sharing a common set of representations, beliefs and knowledge. Sharing the same set of implicit or explicit rules, representations and / or values by members of common social or organizational networks is the basis for interaction within the national innovation system. Otherwise, the location near the different actors of innovation is doomed to failure and it only leads to the emergence of spatial agglomerations of isolated organizations that do not produce synergistic effects. The importance of organizational proximity for the development of the R&D infrastructure is all the more important in the context of the proliferation of S&T parks, often built ex nihilo by government initiative based on the assumption that they are infallible sources of marketable innovations. This is not always the case.

4. Data and econometric specification

We hypothesize that the location of MNFs' R&D activities in developing countries is decisively determined by a set of factors related to the quality of the national innovation system: the availability of R&D personnel, the technological intensity of the host country, the quality of scientific research, the R&D infrastructure. The significance levels of the innovation related variables should illustrate the innovative nature of the multinationals' R&D activities in this group of countries.

To test the predictions outlined in the previous section, we propose the following econometric model:

$$RD_{it} = C_i + C(2)_i*ART_{it} + C(3)_i*RD\_INFR_{it} + C(4)_i*PAT_{it} + C(5)_i*RD\_PERS_{it} + C(6)_i*COL_{it} + C(7)_i*TS_{it} + \varepsilon_{it}$$

where,

RD= foreign affiliates' R&D expenditures in developing country *i* in the year *t*

ART= scientific articles produced by the developing country *i* in the year *t*

RD_INFR= R&D infrastructure in the developing country *i* in the year *t*
PAT= USPTO patents granted to developing country *i* in the year *t*
RD_PERS= total number of researchers and engineers in the developing country *i* in the year *t*
COL= university-industry collaboration in the developing country *i* in the year *t*
TS= foreign affiliates' total sales in the developing country *i* in the year *t*

The variables ART, RD_INFR, PAT, RD_PERS and COL reflect the quality of the national innovation system and capture the impact of the innovation related factors on the R&D expenditures of foreign affiliates. We also want to test the impact of foreign affiliates' total sales on their R&D expenditures in order to verify if there is a close link between the foreign affiliates' R&D activities and the production activities. If such a link is confirmed, we can conclude that the R&D activities of affiliates located in developing countries are predominantly adaptive. Our choice of variables allows us to distinguish between the two main R&D forms – innovative and adaptive - and to establish the role they play in the location of MNFs' R&D activities in emerging countries, as in our case.

We used data collected from different international organizations' databases, which in our view offer the advantage of being internationally comparable and more reliable. . In order to construct the RD_INFR and COL indicators, we used the scores for the following variables: the local availability of specialized research and training services and the university-industry research collaboration, respectively, as estimated by the World Economic Forum in the annually published *Global Competitiveness Reports*. The *Reports* provide the most comprehensive image of the productive potential of nations worldwide, thus enhancing the understanding of the key factors determining economic growth and explaining why some countries are more successful than others in insuring high income levels and opportunities for their populations. The *Reports*' assessments are based on the scores and rankings covering more than 100 indicators grouped in several pillars: institutional quality, infrastructure, macroeconomic stability, health and primary education, higher education and training, goods markets efficiency, labour market efficiency, financial market sophistication, technological readiness, market size, business sophistication and innovation The RD_INFR index is computed by also taking into account the number of universities included in the Top 500 *Academic Ranking of World Universities* annually published by the Shanghai Jiao Tong University. The patent data have been retrieved from the USPTO database and the R&D personnel data from the UNESCO Institute for Statistics' online report on Science and Technology. The article counts are taken from the *Science and Engineering Indicators* 2008[3] and are based on articles published in a set of journals covered by the Science Citation Index (SCI) and the Social Sciences Citation Index (SSCI). Since the data cover the period 2000-2005, we have computed the data for 2006 and 2007 based on the annual average growth rate over the period 2000-2005.

The test was conducted on a sample of 10 emerging countries and covers the period 2000-2007. Because of insufficient data on foreign affiliates' R&D expenditures by country of origin or by host country, we considered R&D expenditures of United States affiliates located in the following emerging countries[4]: Argentina, Brazil, China, Czech Republic, Hungary, India, Mexico, Malaysia, Poland and Thailand. We used data relative to the R&D expenditures of majority-owned foreign affiliates of U.S. multinationals, as published by the U.S. Bureau of Economic Analysis. Given the peripheral position of developing countries in

[3] Published by the National Science Board, this report provides a broad base of quantitative information on the U.S. and international science and engineering enterprise.
[4] We used the IMF classification of the developed and developing countries (IMF, 2008).

world innovation, statistics on R&D in this group, especially in non-OECD countries, are incomplete or entirely missing.

Using the software Eviews 6, we find that the variables COL, PAT and TS exert a positive impact on the foreign affiliates' R&D expenditures. The other three variables appear as insignificant.

The test's results show that:

- The quality of the scientific research environment, measured by the intensity of collaboration between enterprises and universities determines the location of MNFs' R&D facilities in emerging countries. Foreign affiliates are probably interested in locating in proximity to universities in order to exploit the results of applied research.
- The technological intensity of host countries is decisive when locating R&D activities in emerging countries. Although developing countries do not possess an international specialization in high-tech industries, the production of marketable innovations, measured by the number of patents granted, has been growing fast in a small number of countries from the developing world during the recent years. In this group of countries, the rate of patenting has been higher in those economies that concentrate the most FDI in R&D.
- The large number of R&D personnel does not have a significant impact on the MNFs' R&D activities. This is probably explainable by the key importance of the quality of researchers and engineers in the host country, as the quantitative dimension alone does not guarantee good performances in innovation.
- The quality of scientific research measured by the article counts does not appear as a determinant of the establishment of foreign R&D affiliates in emerging countries. This result should not be interpreted in the way that scientific research is not relevant for the international location of the MNFs' R&D activities (UNCTAD, 2005). On the contrary, it is one of the main reasons the bulk of FDI in R&D is directed towards developed countries. The test's result rather points out that unlike applied research, the quality of basic research carried out in emerging countries does not match the MNFs' specific needs.
- R&D infrastructure also emerges as an insignificant location factor for MNFs in the process of selection of host countries for their R&D activities. It is highly probable that the qualitative and quantitative precariousness of universities and research institutes in developing countries make this factor irrelevant in the selection of overseas locations for R&D activities, when the choice is made among countries belonging to this group. In qualitative terms, the lack of organisational proximity is likely to play a dissuasive role on the need for spatial proximity. For instance, the organisation of S&T parks is often perceived as an artificial measure promoted by governments to spur local innovation (Torre, 2006).
- Foreign affiliates' total sales exert a strong and positive influence on foreign affiliates' R&D activities. This shows that demand factors and more precisely, adaptation to local markets is an important component of the MNFs' R&D activities in emerging countries.

In sum, supply and demand factors play a significant role in the location of MNFs' R&D in emerging countries, thus pointing out that innovative and adaptive R&D are both part of the multinationals' R&D organization strategy in this group of countries. The non-significance of variables related to the quality of basic research and R&D infrastructure

indirectly suggests that the innovative R&D relocation risk in favour of developing countries is very weak in the context of the existing and widening scientific gap between the developing and the developed economies (OCDE, 2006, p. 158).

Conclusions

The specific issue of our theoretical and empirical research concerns the determinants of R&D located in developing countries. Our interest in extending the study of this matter to the developing countries case was stimulated by the rapid expansion of the R&D expenditures by MNFs' foreign affiliates in this country group. This recent trend has been highlighted in the brief analysis of the geographic and spatial distribution of FDI in R&D.

The analytical approach has been articulated around two parts: the literature review and the empirical work, which synthesizes our contribution. The first part allowed us to identify the limits of the current theoretical framework of the internationalization of R&D. In order to contribute to a better understanding of the reasons why some developing countries are more attractive than others for the establishment of foreign R&D affiliates, we constructed and tested a model which integrates both innovation and adaptation related variables.

The test's results pinpoint the relevance of a set of innovation related factors in R&D location choices in developing countries: the intensity of collaboration between enterprises and universities and the technological intensity, measured by the number of patents granted by the USPTO. The fact that these two determinants are strongly embedded in the national innovation system of the host economy shows the growing role of emerging countries in the multinationals' global innovation networks. However, the number of researchers and engineers, the scientific articles' output and the R&D infrastructure do not seem to be relevant factors when locating R&D activities in the developing world. One possible explanation is the poor interest of the MNFs towards the basic research carried out in this group of countries. Furthermore, we have noticed that foreign affiliates' total sales significantly influence the affiliates' R&D expenditures, which confirms the strong links between production and sales units and R&D laboratories located in developing countries. This result reinforces the view that foreign direct investment in R&D in developing countries continues to be predominantly adaptive in nature.

Appendix I. Results of pooled estimations with no effects

Dependent Variable: RD?
Method: Pooled Least Squares
Date: 10/15/09 Time: 10:11
Sample: 2000 2007
Included observations: 8
Cross-sections included: 10
Total pool (balanced) observations: 80
Cross-section SUR (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-299.1898	117.0700	-2.555649	0.0127
COL?	70.94594	18.26874	3.883460	0.0002
RD_INFR?	0.001436	0.007429	0.193358	0.8472
PAT?	0.386483	0.121844	3.171961	0.0022
RD_PERS?	0.000209	0.000173	1.205920	0.2317
ART?	0.712168	4.018317	0.177231	0.8598
TS?	0.002785	0.000163	17.07604	0.0000

R-squared	0.877178	Mean dependent var	193.3875
Adjusted R-squared	0.867083	S.D. dependent var	221.9083
S.E. of regression	80.90290	Akaike info criterion	11.70781
Sum squared resid	477805.3	Schwarz criterion	11.91624
Log likelihood	-461.3124	Hannan-Quinn criter.	11.79137
F-statistic	86.89250	Durbin-Watson stat	0.620296
Prob(F-statistic)	0.000000		

Appendix II. Results of the Wald test

Wald Test:
Pool: EC

Test Statistic	Value	df	Probability
F-statistic	65.11265	(6, 73)	0.0000
Chi-square	390.6759	6	0.0000

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-299.1898	117.0700
C(2)	70.94594	18.26874
C(3)	0.001436	0.007429
C(4)	0.386483	0.121844
C(5)	0.000209	0.000173
C(6)	0.712168	4.018317

Restrictions are linear in coefficients.

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