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The determinants of home-base-augmenting and home-base-exploiting Technological activities: some new results on multinationals' locational strategies[1]

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Abstract

The aim of this paper is to highlight the factors that explain the choice faced by MNCs between the two main location strategies identified in the literature on internationalization of R&D and related technological activities: *home-base-exploiting* strategy and *home-base-augmenting* strategy. We do this using a large database on the patenting activities of MNCs across a range of different countries. According to our findings, based on logit models, the factors increasing the probability of choosing the *home-base-augmenting* strategy are: the volume of technological activity (although this effect is very weak), the degree of technological specialization (the opposite of technological diversification) and the nationality of the firm. The estimates show that there is no significant effect of the current level of technological internationalization.

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1. Introduction: asset-augmenting versus asset-exploiting activities and internationalization of R&D and technology.

Dunning begins the introductory chapter of his book, "Regions, Globalization and the Knowledge-based Economy", by noting that internationalization of R&D is guided by two "apparently antithetical forces" which can be summarized as asset-augmenting and asset-exploiting activities. The former are aimed at increasing the existing stock of resources and capabilities within the firm while the latter signify the use of existing resources in order to increase value creation (Dunning, 2000: 30). This definition indicates that the firm often faces two basic options (or two basic strategies): either (1) to augment current stock of resources and capabilities in order to increase future profits, or (2) to produce more value added and more profits with the current stock of assets. Clearly, a large firm must necessarily employ both options simultaneously (Narula, 1995). In other words, it is important to analyze the asset-augmenting activities (AAA) and the asset-exploiting activities (AEA) as elements of a trade-off that the firm has to manage as effectively as possible in order to survive in its competitive environment. To some extent, this resembles the well-known trade-off popularized by March, namely, that between "exploration" and "exploitation" regarding the firm's knowledge activities. Despite the similarities the trade-off put forward by Dunning is more general in that it can be applied to a large spectrum of economic activities including, for instance, foreign direct investment. The two options, AAA and AEA, are complementary is the sense that the firm cannot augment its resources and capabilities indefinitely without seeking to make more value and more profit, that is to say, without exploiting them. By engaging in AEA, firms generate profits and survive, thereby creating the possibility for investment in AAA. These two concepts are important in helping us to understand the firm's behaviour and performance in the field of internationalization of technological activities.

Internationalization of R&D and technological activity is a recent phenomenon, with many MNCs rapidly increasing their foreign direct investment in R&D and related activities over the last decade. In general such activities tend to be concentrated in a few countries and regions rather than spread across the globe. At the same time, the literature on the *internationalization* of firm level R&D and technology activity (particularly for MNCs) has also grown.[2] This literature highlights the idea that *learning* is a key aspect of FDI in R&D, and MNCs build explicit locational strategies in order to identify, access, exploit, and expand knowledge resources throughout the world (Dunning, 2000). An increasing number of firms view internationalization of R&D "*as not only a vehicle for transferring a parent company's technology to the host country but, more important, as an opportunity to learn and develop externally-developed science and technology*" (Serapio et al., 2000). A very useful taxonomy regarding the *locational* strategies of MNCs stems from the seminal contributions of Dunning and Narula (1995) and Kuemmerle (1999b), that takes into account the trade-off between the transfer of knowledge potential created at home to a host country and exploitation of the knowledge capacity of the host country for augmenting the MNC's own knowledge capital. This issue has been systematically investigated by Patel and Vega (1999), who show that there are two dominant (among four) firm strategies related to the location of technological activity: home-base-exploiting (HBE for short) and home-base-augmenting (HBA for short). With the former, MNCs exploit abroad the technological advantages they have built at home, while with the latter, MNCs augment their initial knowledge capital advantages created at home. These ideas are of course very similar to those put forward by Dunning (2000) and discussed above.

There are a number of reasons for delving more deeply into the issue of why locational strategies are becoming important and why it is important to investigate the factors explaining such strategies. In the knowledge-based economy the unique competitive advantage of the MNC in a globalising economy is its "*ability to identify, access, harness and effectively coordinate and deploy resources and capabilities throughout the world*" (Dunning, 2000: 28). In many sectors, product and production strategies tend to converge, and thus the advantages that a firm possesses relative to its competitors (including foreign firms) are mainly (if not exclusively) based on the management of its dynamic capabilities or of its core competences that are non-transferable, non-exchangeable on markets and mainly tacit by nature (Teece, 2000). Accordingly, the gains obtained from knowledge activities (R&D and design) are

[2] See in particular Almeida,1996, Balcet and Evangelista 2004, Barré 1996, Blanc and Sierra,1999, Cantwell, 1989, Cantwell1995, Cantwell and Piscitello, 2000, Chiesa, 1996, DE Meyer,1993, Dunning and Narula, 1995, Dunning,1997, Florida, 1997, Granstrand, 1999, Håkanson1992, Jacquier-Roux 1994, Kuemmerle1999a, Kuemmerle 1999b, Odagiri and Yasuda, 1996, Patel, 1995, Patel and Pavitt, 1991, Patel and Vega 1999, Rainelli 1999, Shan and Song, 1997, Sierra, 1998 and 2003. Moreover basic books from Archibugi and Michie (1997), Cantwell and Molero (2003), Dunning (2000), Narula (2003) are dedicated to the technological activities of MNCs as well.

becoming increasingly important (Dunning, 2000). This implies that MNCs must crucially define an explicit and appropriate locational strategy and this is one of the key factors for understanding how they build, and persistently maintain, advantages in their knowledge activities. Building on these insights it is relevant to use (and not to abuse) the tools of strategic management for assessing the MNCs' locational choice, and consequently focus our attention on the factors explaining why a firm chooses a particular strategy and not the other. In our view, it is not the "old" notion of distance-related transaction costs that mainly governs the MNCs' locational choice of their knowledge activities. Rather, it is the "new" notion of "dynamic transaction costs" (Langlois and Roberston, 1995) that is more relevant for understanding how firms (and in particular large ones) organize, coordinate and manage their knowledge activities (see on this point Dunning, 2000; Sierra, 2003).[3]

The aim of the paper is to shed light on some firm characteristics that could explain the choice made in favour of one particular R&D locational strategy. We use a database on MNCs patenting. The paper is organised as follows. We re-examine the definition and the meaning of the different strategies regarding corporate technological internationalization currently found in the literature. We introduce our database before accurately defining the important variables and presenting the main empirical trends. The different models to be estimated and the findings of the estimates are presented in the last part. In conclusion, we emphasize the implications of the analysis.

2. Four types of corporate technological internationalization: a taxonomy

We build on Patel and Vega (1999) and Le Bas and Sierra (2002), where differing MNC strategies with respect to the *international location* of their knowledge-based activities are analysed by using a simple matrix of a firm's strengths and weaknesses regarding its FDI in R&D and related activities, constructed on the basis of its home country and host countries' technological profiles. From this point of view, there are four types of strategies.

Strategy 1: Technology-seeking FDI. The first type of strategy is directed towards offsetting home country weaknesses in a given technological field by selecting a host country with proven strength in the desired technology. This type of strategy has been labelled as 'technology-seeking FDI' in R&D (Shan and Song, 1997). Patel and Vega (1999) label this as

[3] Of course "transaction costs" are always implicated at the MNC level but are not, in our view, the main determinants of R&D foreign location. Dunning (2000) pointed out that contemporary trade and location theories are less useful in explaining the distribution of knowledge activities between and within countries.

‘host country-exploiting FDI’ in R&D as it refers to situations where a firm is simply exploiting host country technological advantages in areas of domestic *weaknesses*. In this respect the firm has two options. The first option consists of setting up local R&D units in a host country with proven technological superiority in order to upgrade a firm’s technological capabilities in fields in which it appears as relatively weak in its home country (Almeida, 1996; Chiesa, 1996). The second option is to undertake foreign technology acquisitions (Granstrand, 1999).

Strategy 2: Home-base-exploiting FDI in R&D and technology (see in particular Kuemmerle, 1999b), is the exact opposite of strategy 1. The rationale for the investment here is to exploit the existing corporate-specific capabilities in foreign environments. A firm possessing a competitive advantage in a technological field in its home market seeks to exploit it abroad, particularly in regions which are weak in the technological field considered.[4] Hewitt (1980) has labelled this strategy as ‘product adaptive R&D’, i.e., R&D related to adapting parent technology to the host country market. In a similar vein von Zedtwitz and Gassimann (2002) consider it to be predicated on market access considerations. Finally, this type of investment corresponds to what Patel and Pavitt (1990) refer to as ‘short-sighted learning’ (or myopic learning): firms exploit their knowledge base in order to make their technological capital profitable in the short-term, without trying to improve it through external investment.

Strategy 3: Home-base-augmenting FDI in R&D and technology (Kuemmerle, 1999b) or “strategic asset-seeking R&D” (Dunning and Narula, 1995). This third strategy consists of targeting technologies in which the firm has a relative advantage at home and the host country is also relatively strong. Such R&D activities are aimed at monitoring or acquiring competitive advantages that are complementary to those already possessed by the firm so as to augment a firm’s existing stock of knowledge. It matches the “access to Science” strategy as expressed by von Zedtwitz and Gassimann (2002) and is consistent with the view developed by many scholars (Cantwell, 1991; De Meyer, 1993; Dunning, 1997). This type of conduct corresponds to ‘dynamic learning’ (following the taxonomy of Patel and Pavitt,

[4] In some sense this strategy is very close to that described in the product cycle model initially proposed by Vernon (1966).

1990), whereby corporations explicitly take into account the time and resources needed to build up their technological capital.

Strategy 4: Market-seeking FDI (Dunning, 1998). This corresponds to situations where a firm invests abroad in technological activities in which it is relatively weak in its home country and the host country is also relatively weak. In other words, there is neither a home technological advantage nor a host country technological advantage. The motivation for this fourth type of strategy is not technology-driven. Many authors have stressed that this case is probably the result of mergers and acquisition activities (Håkanson, 1992, Patel and Vega 1999), where the acquisition of technological assets are a by-product rather than the original motivation.

Clearly, strategy 1 and strategy 3 match Dunning's view of AAA, and strategy 2 is typical of AEA.

The quantitative studies seeking to assess the scale and scope of the locational strategies based on such a framework indicate that strategies 2 and 3 are dominant in the sense that they are numerically relatively more important than strategies 1 and 4. (Patel and Vega, 1999; Le Bas and Sierra, 2002). Such previous studies have mainly been based on data at the level of countries and product groups. An exception is Le Bas and Patel (2005) which provides an analysis of locational strategies at the firm (MNC) level.[5] Such firm level studies enable us to examine which types of strategies are implemented. Thus one can show that while an MNC can implement all the four strategies, the HBA strategy remains dominant (as demonstrated by Cantwell and Piscitello, 2004). Additionally such studies provide evidence that in a cross-section of firms adopting a home-base-augmenting strategy, the internationalization of technology may determine the level of technological diversification (Le Bas and Patel, 2005). On the other hand this effect is not present in the case of firms adopting a home-base-exploiting strategy, implying that the two types of strategies have different underlying mechanisms.

In order to empirically assess the factors underlying these four strategies, we follow the methodology previously implemented by Patel and Vega (1999) and Le Bas and Sierra (2002).[6] Accordingly, we use an index of revealed technological advantage (RTA) as a

[5] Henceforth, we simply use the term strategy. The reader must bear in mind we are dealing with *locational* strategies.

[6] Cantwell and Picitello (2004) use another approach for defining and measuring HBE and HBA activities in the European region.

measure of technological strengths and weaknesses calculated on the basis of European patents.[7] We explicitly distinguish between:

homeRTA, an indicator of a firm's relative strength or weakness in a particular technological field in its home country, i.e., in the country of the headquarters;

hostRTA, an indicator of the host country's relative strength or weakness in a particular technological field.

The RTA index varies around unity, such that values greater than one indicate that the firm, or the country, is relatively strong compared to other firms or countries in the same technological field, while values less than one indicate a relative weakness. The four strategies can be rigorously defined as indicated in the Table 1.

Table 1 . Four locational strategies for FDI in R&D

	Technological activities in the host country	
Corporate technological activities in the home country	**Strong**	**Weak**
Weak	Strategy 1 HomeRTA < 1 HostRTA > 1	Strategy 4 HomeRTA < 1 HostRTA < 1
Strong	Strategy 3 HomeRTA > 1 HostRTA > 1	Strategy 2 HomeRTA > 1 HostRTA < 1

Source: adapted from Patel and Vega (1999) and Le Bas and Sierra (2002)

[7] This indicator is now well known. For more details on its definition and calculation see, among others, Cantwell (1989), Cantwell and Janne (1999), Patel and Pavitt (1987) and Soete (1987). Another alternative for mapping the strategies is provided by patent citations analysis (see, in particular, Criscuolo et al. (2005) and Frost (2001)).

3. The data set and variable definitions

In line with many studies, we analyze the internationalization of technology using information contained in patent documents.[8] Our analysis is based on patent applications at the European Patent Office. It uses the so-called "EPAT+" database developed in France by the OST.[9] The main difficulty with patent data is that many patents are granted under the names of subsidiaries and divisions that are different from those of the parent companies, and are therefore listed separately. In addition, the names of companies are not unified, in the sense that the same company may appear several times in the data, with a slightly different name in each case. In this study, we use patent applications for two time periods: 1988-90 and 1994-96. For the present dataset, companies have been consolidated for the period 1994-96. This means that the structure of the firm over the two time periods of our analysis remains constant. We have selected 297 firms among a sample of 345 firms with the highest level of patenting over 1988-1990 that we used in previous studies (Le Bas and Sierra, 2002; and Le Bas and Patel, 2005). The 297 firms account for slightly over half of all EPO patents applied for by institutions. With respect to the original sample of 345 MNCs used in Le Bas and Sierra (2002) study, we have withdrawn:

1) The subsidiaries of universities or public research institutions that remained in the database;

2) The firms that implement dominant strategies other than HBE or HBA. These are too atypical for entering in a study devoted to the two main dominant strategies. There are 8 such firms;

3) The firms which are not headquartered in US, Japan or Europe. In the original dataset, there were 8 such firms (mainly Korean). The basic motivation is that the small number of such firms may introduce undue bias in our results.

In a sense, our new sample is more homogeneous in terms of activity (only industrial firms), in terms of nationality (only "triadic" firms) and in terms of international R&D location strategies (only firms which employ HBE or HBA strategies). The main variables used in our analysis are as follows:

[8] For the use of patent data in analyzing internationalization of technology, see Patel and Pavitt (1991).

[9] For more details on the process of data building see Le Bas and Sierra (2002).

- The main strategy followed by each firm. For each firm, we calculate the number of patents granted in one of the four cells of Table 1. An analysis of these data shows that majority of firms employ all four strategies at the same time and in the same regions (Cantwell and Piscitello 2004; Criscuolo et al., 2005). In other words firms employ both main options (HBA, HBE) simultaneously (Narula, 1995). However our data also reveal that there is a *dominant* strategy, that is to say, the *most important strategy in terms of the volume of patenting*.[10] This methodology was first used by Le Bas and Patel (2005) for a slightly different sample of firms. They showed that for 39% of their sample (or 134 firms) the predominant strategy is strategy 2, and that for a further 59% (203 firms) the predominant strategy is strategy 3 . Nevertheless, in many cases, the dominant strategy encompasses less than 50% of the overall amount of patents applied for by the firm.[11] Thus for each firm, we compute the proportions of patents that match the four strategies and use this information in our regression analysis. On average for the overall sample, we get the following distribution in terms of patenting: 7.8 % for strategy 1; 34.8 % for strategy 2; 52.4 % for strategy 3; and 4.9 % for strategy 4.

- The firms' nationality (US, Japanese or European).

- The size of the firms' technological activity: Tecsize (i,t). This is measured by the number of patents owned by firm i at time period t. The level of R&D expenditures would be a better measure, but this information is not available at a reasonable cost for many of the firms in our sample. Nearly 75 % of the firms have less than 200 patent applications in the period 1994-96, and one third have less than 100 patents. In other words, a large number of firms apply for a small number of patents, and a small number of firms have a large volume of patents.[12]

- The level of technological internationalization of the firm i at time period t: (INT(i,t). This is measured by the share of total patents applied for by the firm with an inventor address outside the home country. It is a proxy measure for technological activities

[10] To put it simply, the dominant strategy is the one that encompasses the greatest number of patents at the firm level.

[11] Sometimes the difference in terms of the number of patents between strategy 2 and strategy 3 is very small.

[12] An appendix displays descriptive statistics related to the main variables.

undertaken in foreign locations, and has been used in studies of internationalization of corporate technology (see, in particular, Patel and Vega, 1999). According to our data, 50 % of the firms are very weakly internationalized as far as technological activity is concerned with less than 5 % of their inventions coming from outside the home country. For this indicator, the average is around 15 % in 1994-1996.

- The firms' technological diversification. In this study, patenting has been broken down into 30 different technological fields (see Le Bas and Sierra, 2002). Consequently, we can calculate DIV (i,t) = 1 - Her (i,t), where DIV (i,t) is the level of the technological diversification the firm i at time period t, and Her (i,t) the Herfindahl index calculated for the firm i at time period t (the sum of the squares of the shares of the firm's patenting in 30 technological fields). This measures the concentration/dispersion of patents across technological fields for the time period t. The value of the index is between zero and one.[13] The lower the value of the Herfindahl index, the more technologically diversified the firm, i.e., the patents of the firm are dispersed among a large number of technological classes. We also experimented with the estimator of this index suggested by Hall, Jaffe and Tratjenberg (2002). However the analysis below is based on the Herfindahl as the results of the two estimations are almost identical.

- The firms' core technological competences. Here we aggregate all patents belonging to a firm into 6 technological fields (or macro-fields): electronics and electricity; instrumentation; chemicals and pharmaceuticals; industrial processes; machinery and engineering; consumer goods (including building and public works).[14] For each MNC, we define their main area of technological activity (their core competences or their dominant technological field) as the field in which it applies for the highest number of patents.

Table 2 shows the distribution of multinational firms of the sample according to their nationality and their dominant technological fields. The European MNCs are dominant in the

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[13] Cantwell and Piscitello (2000) use an alternative indicator for measuring technological diversification, namely the inverse of the coefficient of variation of the index of the revealed technological advantage of each firm (1/CVi). The two measures are highly correlated, with a coefficient of correlation (Pearson) of 0.9.

[14] In another study aimed at analysing the main factors explaining MNCs' foreign location strategies, Le Bas (2006) includes the capacity to exploit the new techno-economic paradigm based on ICT. Unfortunately, this variable (the proportion of patents the firm i applies in technological fields related to information technologies) is never significant, whether dummies for technological fields are included or not.

sample, but are behind the US firms. In terms of main dominant technological fields, the ranking is: chemicals and pharmaceuticals, machinery and engineering, electronics and electricity, industrial processes, Instrumentation, consumer goods, building and public works.

Table 2. Distribution of the firms by nationality and main area of technological activity (for two time periods)

Country Main technological areas	USA	Japan	Europe	Total
Electronics	7.9	7.1	5.4	20.4
Instrumentations	5.4	2.4	2.4	10.1
Chemicals and pharmaceuticals	10.9	9.1	11.3	31.3
Industrial process	4.0	1.8	7.7	13.6
Machinery and engineering	5.2	4.2	11.4	20.9
Consumer goods, building and public works	1.2	0.6	1.8	3.7
Total	34.7	25.2	40.1	100.0

Table 3. Distribution of strategy choice according the firm nationality

Nationality	Strategy 2	Strategy 3	Total
1 USA	12.1	25.6	34.7
2 JAPAN	15.8	9.4	25.3
3 EUROPE	6.9	33.2	40.1
Total	34.9	65.1	100.0

The two following tables draw the distribution of HBE and HBA strategies according firm nationality (Table 3) and the main dominant technological field (Table 4). Recall that a firm can move from one strategy to the other (these cases are not unusual).

Table 4. Distribution of strategy choice in six technological fields

Main technological fields	Strategy 2	Strategy 3	Total
Electronics	8.2	12.1	20.4
Instrumentations	2.0	8.1	10.1
Chemicals and Pharmaceuticals	12.1	19.2	31.3
Industrial process	3.7	9.9	13.6
Machinery and engineering	7.9	13.0	20.9
Consumer goods, building and public works	0.8	2.9	3.7
Total	34.8	65.1	100.0

At this stage of the analysis, our first finding is the confirmation of the domination of strategy 3 that previous studies had highlighted for the overall sample of patenting (Patel and Vega, 1999; Le Bas and Sierra, 2002) or at the corporate level (Le Bas and Patel, 2005). However this trend is not general. In terms of nationality, the Japanese firms are much more strategy 2-oriented, while European firms score highest for strategy 3. As far as the main technological areas are concerned, strategy 3 is always dominant regardless of the technological field. The ranking of the technological fields according to this criterion is: Instrumentation, consumer goods, building and public works, industrial process, machinery and engineering, chemicals and pharmaceuticals, electronics.

The second result relates to the stability over time with respect to the technological internationalization strategy being pursued. Our analysis suggests that majority of the firms tend *to persist in their dominant strategy*. The total number of firms that pursue the same strategy over time is 151, that is, around 50 % of the overall sample (29 for strategy 2 and 122 for strategy 3). 87 firms move from strategy 2 to strategy 3, and 59 from strategy 3 to strategy 2. Strategy 3 can be considered to be persistent in two senses. First, because in each period the number of firms that employ it is larger than those that implement strategy 2, and second, because over the two time periods the number of firms pursuing strategy 3 is increasing.

Table 5. Move of (dominant) strategy: evolution though time

	Time period 2 Strategy 2	Time period 2 Strategy 3	Time period 2 Total
Time period 1 Firms performing Strategy 2 (117)	29	87	116
Time period 1 Firms performing Strategy 3 (180)	59	122	181
Total	88	209	297

The fact that the choice of a dominant strategy is persistent provides us with the motivation for investigating the main factors underlying its choice.

4. Models and estimates results

The main question addressed in our analysis is: *what are the main factors explaining the choice of strategy for internationalization of R&D and technology*? As both strategies 2 and 3 are important (as outlined above), this reduces to the factors governing the choice of one of these. We begin with the notion that a firm will choose a strategy that matches its own objectives. There are two main ways of modelling such a choice: the logistic regression (logit model) or the probit model. In general both produce similar results and this is the case in our analysis. Thus here we only report the findings of the logistic regressions.

The main determinants of the choice of strategy are related to the knowledge creation (including R&D) activities of the firm:

- The size of technological activities is an important factor (Tecsize (i,t)). This determines the economies of scale and thereby the efficiency of the process of knowledge production.
- Additionally the level of technological internationalization (INT(i,t)) is important.
- Technological diversification (DIV (i,t)) is also considered an important factor in the choice of strategy (see, among others, Cantwell and Piscitello, 2000; Cantwell et al. , 2005).

Additionally we need to include some dummy variables for controlling the effects that cannot be taken into account directly such as the characteristics of the MNCs' home country (its geographical situation, its own industrial history) or the characteristics of the technologies that we assess through the firms' core competences.[15] Economic theory (including evolutionary economics) does not provide adequate guidance in relation to the size and direction of the expected effects of dependent variables on the choice of strategy. For example there is no particular a priori reason to assume that the volume of technological activities supports Strategy 3 versus Strategy 4. Nevertheless, useful insights on this issue might be provided from the life-cycle view of the firm. It could be noted that larger firms are likely to be at the more mature stage of their life cycle, and that the *home-base-augmenting strategy that is acknowledged as a more recent phenomenon might better match their situation.* From this point of view, a positive relationship might be inferred between the size of technological activity and the choice of strategy 3. We know from a previous work (Le Bas and Patel, 2005) that for the firms adopting a *home-base-augmenting strategy*, internationalization determines the level of diversification. Thus, among such firms, a higher level of internationalization of technology is associated with a greater level of diversification. These findings support the hypothesis that a *home-base-augmenting strategy* might be correlated with the level of technological internationalization and technological diversification.

We estimated four models (see table 6) in order to check for the robustness of the results.

Model 1 is a binomial logit model for identifying the main factors explaining the choice of strategy 3 versus strategy 2. The dependent variable takes on the value 1 when an MNC chooses the HBA as a dominant strategy, and 0 in the case of HBE. The three explanatory variables and dummies for nationality, core technological competences (macro-fields) and time period are included.

Model 2 is a panel binomial logit model with random effects and includes all the explanatory variables except the time dummy. Consequently, the effect of time is now included in the set of random perturbations.

[15] This is standard since the seminal work of Scherer (1965).

Model 3 has four equations (models 3a, 3b, 3c, 3d). Here the aim is to explain the proportion of patents related to each of the 4 strategies using the above explanatory variables. As a first approximation we use the standard OLS method for these estimations.

Model 4 is a binomial logit model where the dependent variable is the proportion of patents. In comparison with model 1, we now use all the available information. The underlying rational is that for two MNCs with a preference for HBA as a dominant strategy, the proportion of patents matching the HBA strategy may not the same, and we need to take this into account. We estimate two variants: model 4a based on proportion of patents related to strategy 3 versus the three other strategies; and model 4b where the reverse applies. The same set of explanatory and dummy variables are included in these estimations.

Regarding the results, the goodness of fit (the percentage of cases correctly predicted) is better for the two first models than for models 4a and 4b. The estimation of models 3a to 3d provides acceptable R-square once we take into account the fact we only have a limited number of explanatory variables. The analysis of the sign of the coefficients and their t-statistics tell a consistent story as follows:

- Increasing technological diversification tends to decrease the probability to choose the HBA strategy. To put it simply, strategy 3 is implemented by firms more specialized in terms of technological competences. This result shows the importance of the ongoing process of technological diversification for determining the type of strategy implemented[16]. However this result a little surprising as previous studies have postulated a positive relationship between diversification and the HBA strategy. For instance, Cantwell and Piscitello (2004) define the HBA strategy as a *diversification into new scientific problems*, issues or areas.[17] On the other hand the effect of technological diversification is positive in the case of the HBE strategy, i.e. firms that are more diversified are likely to employ this strategy.

- The effect of internationalization of technology is almost non-existent in the logit models (Models 1 and 2 and Models 4a and b). The only negative effect appears in

[16] Cantwell and Kosmopoulos (2003, p 52) point out that national technological leaders use their international networks for innovation in large part to promote their own comparative technological diversification.

[17] See also Zander (1999).

Model 4a, where it is only significant at the 10% level. This is confirmed by the result of Model 3c. This might be considered as evidence of a very weak negative impact of internationalization of technology on the choice of HBA strategy.

- The size of technological activity has a very weak (but significant) positive effect on the probability to choose the HBA strategy. The larger the firm, the greater the likelihood for choosing strategy 3. This effect of size is constant and remains significant when we control for firm nationality and technological fields. Moreover, the sign of the coefficient on size is negative when estimating the probability of choosing strategy 2 (model 4b), and this is confirmed with the OLS estimation (model 3b). These two results reinforce each other.[18]

- The results for the dummy variables for nationality show some contrasting patterns. When a firm is headquartered in the US or in a European country, the probability to choose strategy 3 will be stronger. The reverse is true for Japanese firms. The literature on internationalization of R&D and technology has highlighted the role of nationality. Thus a number of previous studies have confirmed that Japanese firms have the lowest share of R&D abroad and that the firms from Europe have a relatively high share.[19] These studies have considered Japanese firms as "latecomers" in the internationalization of R&D and have shown that Japanese firms have built up overseas R&D capabilities much more through acquisitions than internal growth (Belderos, 2001, 2003). Such studies have also discussed the implications of these trends for Japanese firms. For instance, Iwasa and Odagiri (2004) study the contribution of R&D investment in the US to Japanese firms own inventing activity, distinguishing between two types of firms: R firms and S firms. They suggest that for R firms, (which are R&D subsidiaries mainly aimed at conducting *research*), "knowledge sourcing is an important function of such subsidiaries and locational choice is important for this purpose". They are located in areas where universities and laboratories are clustered, that is, not where local technological strength is high (Iwasa

[18] We tested without success the relevance of a quadratic relationship between the size of technological activity and the probability of choosing strategy 3.

[19] Cantwell and Kosmopoulos (2003, p77) provide the following explanation: when a national system of innovation is characterised by a tight coupling of industries (especially in the Japanese system), the degree of internationalization of corporate innovative effort is constrained.

and Odagiri, 2004: 819). By contrast, S firms aim mainly to support local manufacturing and sales activities. Their purpose is to adapt the superior technology at home to local conditions, and are thus employing HBE or Strategy 2. On the other hand R firms are expected to contribute to increasing the firm's "general technological capabilities", in line with the HBA strategy.[20] Using the taxonomy suggested by Zedtwitz and Gassiman (2002), for Japanese firms "access to markets" seems to be the dominant location rationale and "access to science" much less important.

Our results in relation to the European MNCs, show that the coefficient on the EU dummy is significantly greater than the constant which includes the dummy for US MNCs. Thus the asset-augmenting component of European R&D is stronger than its American counterpart. This generalizes the result found by Criscuolo et al. (2005) for chemicals and pharmaceuticals.

- There is a positive time effect in model 1 in relation to strategy 3 (once the other effects have been controlled), but this is not confirmed by model 4. This gives a weak indication about the existence of a time trend in favour of HBA strategy.

[20] Belderbos (2001), examining patents and overseas subsidiaries of 231 Japanese firms, found more mitigated results. These support the notions of a technology-exploitation motive for R&D as well as a substantial additional role for a technology-sourcing motive. However, Belderbos' sample included only electronics firms.

Table 6. Estimation results for the choice of HBA strategy models

	Model 1	Model 2	Model 3				Model 4	
	Binomial Logit Y=Strat.3	Panel Binomial Logit Y=Strat.3	OLS on patent proportions				Logit with proportions	
			a	b	c	d	a Y=Strat.3	b Y=Strat.2
Constant	1.5224**	1.1905**	-0.2482	0.0197***	0.8435***	-0.0103	1.5505**	-1.4103**
	2.32	2.16	1.59	2.87	12.93	1.18	2.70	2.35
DIV	-1.4553**	-1.0263***	0.1119***	0.2158***	-0.3991***	0.0714***	-1.8313***	1.0963**
	2.53	2.80	7.77	3.50	6.64	8.89	3.53	2.04
INT	0.1749	0.1462	0.1212***	0.0251	-0.1904***	0.0441***	-0.8433*	0.1612
	0.34	0.40	9.22	0.45	3.47	6.01	1.92	0.34
TECSIZE	0.0014***	0.0001***	0.0001	-0.0001***	0.0001***	0.0001**	0.0005*	-0.0007**
	3.33	4.32	1.34	4.28	3.72	2.53	1.90	2.72
JAP	0.4336	0.4299	0.0378***	0.1613***	-0.2119***	0.0129***	-0.9082***	0.6796***
	0.65	0.78	5.42	5.41	7.28	3.32	3.86	2.93
EUR	2.5813***	1.9307***	0.0157**	-0.1234***	0.1245***	-0.0168***	0.5384**	-0.6055**
	3.85	3.35	2.54	4.67	4.83	4.88	2.6	2.74
ELE	-0.6527	-0.4813	-0.0127	0.0444	-0.0358	0.0040	-0.2026	0.2623
	1.08	0.92	0.85	0.7	0.58	0.49	0.39	0.47
INS	0.3626	0.2437	0.014	-0.0372	0.0041	0.0191**	-0.0433	-0.1311
	0.55	0.42	0.88	0.55	0.06	2.16	0.08	0.22
CHIM	-0.4659	-0.3412	-0.0321**	0.0852	-0.0523	-0.0008	-0.2723	0.4201
	0.79	0.64	2.21	1.37	0.86	0.10	0.54	0.78
IND	-0.1621	-0.1223	-0.0095	0.0112	-0.0036	0.0019	-0.0612	0.0865
	0.26	0.22	0.61	0.17	0.06	0.22	0.11	0.15
MACH	-0.7548	-0.5314	0.0002	0.0605	-0.0625	0.0019	-0.3224	0.3269
	1.26	0.99	0.02	0.96	1.02	0.23	0.62	0.60
T	0.3634*		0.0475	-0.0248	0.0274	-0.0072**	0.1185	-0.1170
	1.87		0.92	1.12	1.26	2.51	0.68	0.64
Percent correctly predicted (%)	75	76					61	65
Log Likelihood	-323.65	-325.29					-380.79	-359.71
Pseudo R-sq.	0.16						0.08	0.28
R-sq. adjusted	-		0.26	0.19	0.25	0.25		
N	594	594	594	594	594	594	594	594

Absolute values of t-statistics under the parameters estimates:

*** - significant at the 1 percent level

** - significant at the 5 percent level

* - significant at the 10 percent level

The three quantitative variables (DIV, INT, TECSIZE) have been defined above. JAP and EUR are dummy variables for Japan and Europe. ELE, INS, CHIM, IND, MACH, are dummies respectively for the following technology groups: electronics and electricity; instrumentation; chemicals and pharmaceuticals; industrial processes; machinery and engineering. T is the variable taking account of the time period effect. Dummies for USA and for consumer goods, building and public works are omitted; default effects are included within the intercept.

Source: own calculations (LIMDEP v.3.08).

5. Conclusions

The aim of the paper is to identify the determinants explaining the choice of a particular strategy in terms of MNCs' foreign location of R&D and related technological activity. The analysis of the choice can be considered to be a "game" between a home-base-exploiting strategy (strategy 2) and a home-base-augmenting strategy (strategy 3), the two dominant strategies discussed in the more recent literature on this subject.[21] Each strategy is linked to one type of economic activity put forward by Dunning (2002): asset-exploiting and asset-augmenting activities.

On the basis of logit models (complemented by some OLS regressions) we show that the level of technological internationalization has very little effect on the choice of strategy once we control for other factors. The factors that increase the probability of choosing home-base augmenting strategy are: increasing technological diversification, the size of technological activity (but the effect is very weak), the firm's nationality (US, Europe).

There are three possible extensions to this analysis[22]. The first concerns the use of more up-to-date data. This would enable us to assess whether the new context marked by the emergence of low-wage countries in R&D activities (China and India in particular) changes the motives for investing in foreign R&D and technological activities. Our current knowledge points to the fact that the HBE strategy continues to play a role even in the case of "low cost" locations. Among others, Balasubramanyan and Balasubramanyan (2000) point out that it is the talents and skills possessed by India's engineers which are the target of the asset-augmenting variety of FDI in the Indian software sector. Another motive for updating the data is that it would enable us to analyse the impact of the recently observed strong trend in the de-location of plants[23] on the strategy of foreign R&D location. At the same time more up-to-date information would also enable us to see whether the new strategy linked to the Open innovation model (Chesbrough, 2003) modifies the long term the locational strategy of MNCs.

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[21] Our dataset on the patenting activity of the largest MNCs shows that these two behaviours are largely predominant.

[22] Some authors have pointed out the importance of the internal management of the MNC (see, for instance, von Tunzelman, 1995: 311). At this stage of our knowledge, it is still difficult to consider variables that we could take into account for testing its linkage with the choice of strategy.

[23] For a discussion of this trend see Berger (2005).

The second extension concerns the characteristics of the location. Recent research has shown that when MNCs decide to assign R&D responsibilities to an existing subsidiary, *host-country characteristics* (Feinberg and Gupta, 2004) or *regional knowledge profiles* (Cantwell and Piscitello 2004) are important.[24] Within our framework, host country characteristics are expressed only through their RTA index. Thus we do not take into account the main characteristics of host countries in terms of the level of technological knowledge or of technological opportunities and spillovers. Feinberg and Gupta (2004) show that potential knowledge spillover opportunities are also very important.[25] Thus in future research it would be important to include a number of location specific variables.

Thirdly in our model, the *level* of technological diversification has an impact on the choice of strategies. It would be interesting to examine if the *type* (model) of technological diversification also has an impact. For instance, Suzuki and Kodama (2004) have shown through a study of two large Japanese companies that there are two types of technological diversification: exploring around the core technology relating to the product (see our own concept of technological diversification into the macro-field) and "exotic" technological diversification, that is, exploring far from the core and importing the new knowledge into the existing technologies. In both cases, the firms have produced world class competitive performance. The problem is that the two models of technological diversification can have the same level of the Herfindahl index through which we measure diversification. We can hypothesize that the two models should be related to the implementation of different strategies in particular for the foreign R&D location. Future empirical work should assess if the type of technological diversification has an impact on the choice between HBE and HBA.

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[24] For Criscuolo et al. (2005), note in particular: any given R&D facility's capacity to exploit and/or augment technological competences is a function not just of its own resources, but also of the efficiency with which it can use complementary resources associated with the relevant local innovation system. Just as asset-augmenting activities require proximity to the economic units (and thus the innovation system) from which they seek to learn, asset-exploiting activities draw from the parent's technological resources as well as from the other assets of the home location's innovation system.

[25] Cantwell and Piscitello (2004) note that science-technology spillovers affect only the HBE strategy.

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Appendix: Descriptive statistics (N=594)

Variable	Mean	Std.Dev.	Skewness	Kurtosis	Minimum	Maximum
INT	0.1489	0.2115	2.0351	6.8411	0.0000	1.0000
TECSIZE	253.2947	341.9677	3.2914	15.6687	0.3330	2279.7660
DIV	0.7079	0.1984	-1.8802	6.4685	0.0000	0.9229