The influence of business network openness on MNC sub-units evolution

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ABSTRACT

Connections with external local business networks (BNs) in a host country have been recognized as a crucial factor in explaining the capacity of MNC subsidiaries for locally exploratory activity. Yet the notion of embeddedness in local BNs has typically been supposed to be inherently geographically confined. This paper relies instead on a concept of embeddedness in a wider perspective, in a network of actors that is not necessarily locally bounded. Relying on data on the innovative activities of the world's largest industrial firms over the period 1930-95, we find that a key element in the capacity of local BNs to generate an evolution towards competence creating (CC) activities in co-located subsidiaries is the international connectedness of those networks. The more open are the BNs in which MNC subsidiaries are embedded, the greater is the scale of local subsidiary technological efforts (for all industries at a national level), and the greater is the relative extent of subsidiary CC development (for industries whose BNs are more open compared to other industries in the same country).

1. INTRODUCTION

Since the mid-1980s, attention has increasingly focused on the emergence of internal and external networks for innovation in MNCs (multinational corporations). The new view has drawn heavily on an evolutionary view of the firm (Nelson and Winter, 1982), which may be extended to consider the co-evolution of the internal and external networks of firms (Volberda and Lewin, 2003). MNC technological activities cumulatively interact both with local networks in each vicinity in which they are sited, and cross-border knowledge exchange in international in-house networks (Nohria and Ghoshal, 1994). MNC internal networks may evolve towards increasingly exploratory kinds of learning as selected subsidiaries in an MNC group evolve towards more locally competence creating activities, partly by tapping into host country capabilities (Cantwell, 1995; Cantwell and Mudambi, 2005).

Connections with external local business networks in a host country have been a crucial factor in explaining the capacity of MNCs for locally exploratory activity (McEvily and Zaheer, 1999; Andersson and Forsgren, 2000; Andersson et al., 2002; Forsgren et al., 2005). Yet the notion of embeddedness in local business networks has typically been seen to be inherently geographically confined. However, the business networks of local innovation systems involve a variety of actors, some of which are geographically dispersed, and lie outside the host country. Therefore, the concept of embeddedness that we will adopt supposes a wider perspective, and is not merely confined to a locally bounded context. The more open business networks in which MNCs are becoming increasingly embedded can themselves become relational assets for the participant firms (or sub-units of firms), and the capacity to build and sustain a variety of such networks of connected actors has itself become an important differentiating capability for firms.

In particular, in this paper we suggest that a key element in the capacity of subsidiary embeddedness in local business networks to generate an evolution of subsidiaries towards competence creating (CC) activities is the international connectedness of those networks. This implies that local business networks provide subsidiaries with connections that are (i) not purely local, and hence (ii) a separate source of international relationships beyond those that come from their existing MNC group. Widening the diversity of a subsidiary's international contacts is likely to increase its access to new knowledge, new business ideas, and new market opportunities. In turn, this increases the likelihood of entrepreneurial initiatives by subsidiaries independently of their parent companies, but it also raises the chance of subsidiaries being granted greater autonomy by their MNC group in order to pursue some specialized or distinct area of new product development on behalf of the wider corporate group.

Our empirical analysis relies on data on the innovative activities of the world's largest industrial firms over the period 1930-1995. Specifically, the sample considered is a large cross-firm panel of technological activity over time, proxied by the corporate patenting in the US of the largest European and US industrial firms for inventions achieved in their foreign research facilities.

Therefore, the paper provides three main contributions: (i) a conceptual one, related to the impact of external business networks on the evolution of innovation across the geographically dispersed sub-units of MNCs; (ii) an empirical one, since the availability of a large, complex and consistent data set allows us to explore in a coherent way (that is for a consistent set of firms) the relationship between the degree of openness across locations and the pattern of competence accumulation in the world's largest firms; and (iii) a methodological one, since we provide an operationalisation of the distinction between local competence creating (CC) exploration and competence exploiting (CE) innovative efforts at a subsidiary level, by comparing patterns of technological specialization in each foreign sub-unit in with the equivalent technological profile of its parent company.

The organisation of the paper is as follows. The next section elaborates upon the interpretative framework for the study, and puts forward the propositions to be tested. In the third section, the data employed are described. In section four we specify the econometric models, and the variables used; while the results and some concluding comments are reported in section five.

2. CONCEPTUAL FRAMEWORK AND HYPOTHESES

The success of MNCs is, to an increasing extent, considered to be contingent upon the ease and speed by which knowledge is disseminated throughout the organization (Hedlund, 1986; Bartlett and Goshal, 1989; Gupta and Govindarajan, 1991; 2000). This business-related knowledge has been associated with technological competencies (Hakanson and Nobel, 2001; Iwasa and Odagiri, 2004), tacit know-how (Kogut and Zander, 1992), and managerial skills, marketing, production, and organization (Kostova, 1999; Bjorkman et al., 2004). Foreign direct investment (FDI) resulting in the formation of foreign subsidiaries has become an important means for the dynamic process of learning and competence creation within the MNC (Cantwell, 1995; Makino and Inkpen, 2003). This view is in contrast to the traditional view of the MNC, in which parent companies set up foreign subsidiaries to strengthen their market position and exploit their existing competencies to appropriate the maximum economic rent through greater market spread and market power (Hymer, 1960; Vernon, 1966).

Therefore, in the traditional view, MNCs located R&D in their subsidiaries abroad mainly for the purposes of the adaptation of products developed in their home countries to local tastes or customer needs, and the adaptation of processes to local resource availabilities and production conditions. Subsidiaries depended on the competence of their parent companies, and so their role was essentially just competence exploiting, or in the terminology of Kuemmerle (1999) their local R&D was “home-base exploiting”.

More recently, there has been a growing awareness among scholars that MNCs also use their multinational network to augment their competitive advantages and/or to create new advantages (Bartlett and Ghoshal, 1989; Cantwell, 1995; Kuemmerle, 1999; Pearce, 1999). Specifically, the increased role of geographically dispersed sourcing of technology through the international networks of globally integrated MNCs has led to a growing interest in the asset-acquiring motive for FDI (Cantwell, 1989; Kogut and Chang, 1991; Dunning and Narula, 1995; Cantwell and Piscitello, 2000). It is becoming recognized that the observed decentralization in the management of international R&D can be related to the capture of ‘home base augmenting’ benefits (Papanastassiou and Pearce, 1997; Kuemmerle, 1999). Researchers then started to treat seriously the possibility that foreign-owned subsidiaries could play a crucial role as sources of new ideas and capabilities (Frost, 2001; Zanfei, 2000). However, a recent but now well established literature distinguishes between competence-creating and competence-exploiting types of subsidiary R&D activity. Work in this field has typically related the typology of subsidiary R&D to the overall mandates of subsidiaries as a whole, whereas it seems reasonable to suppose that there may be elements of both types of R&D in many subsidiaries. Therefore, we argue that any given foreign-owned subsidiary, ceteris paribus, may evolve towards at least some CC activity, and so perform both CE and CC functions (Zander, 1999).

The evolution of the MNC group and their subsidiaries (or more accurately a sub-set of the activities undertaken by their subsidiaries) from the CE to CC kind could be framed within the new open innovations systems ideas (Chesbrough, 2003, 2006; Laursen and Salter, 2006) that emphasize the increasing interest of companies to tap into external sources of knowledge (Vanhaverbeke, Cloodt and Van de Vrande, 2007). Chesbrough et al. (2006, p.1) define open innovation as "... the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively.” External technology sourcing is becoming more important for a number of reasons: Shortening technology life cycles, emerging technologies with the potential to disrupt market leaders' positions, sharing costs and risks associated with science based technology such as nano-electronics, globalization of the R&D activities as a response of companies to the greater dissemination of knowledge throughout the world, increased rivalry between firms in their product markets, the growing importance of seed and venture capital to finance excellent business ideas, etc. Therefore, MNC international networks need to evolve from closed to open systems in order to enable the evolution to occur of a sub-set of subsidiaries from merely exploiting mandates to the more explorative and creative ones.

In the literature on internationalisation economics and international business, the competitive advantage of an MNC has been increasingly related to the ‘subsidiary-specific advantage’ that emanates from the location of units in multiple knowledge centers (Rugman and Verbeke, 2001). In fact, existing literature on subsidiary R&D typology (Feinberg and Gupta, 2004) has mainly focused on local resources and potential spillovers opportunities from the local context (Cantwell and Piscitello, 2005). Namely, better quality locations, i.e. those characterised by better local economic and non economic resource, as well as by higher knowledge spillovers stemming from public and private research, are more likely to attract MNC sub-units that undertake explorative activities. Conversely, lower quality locations are more likely to attract sub-units that undertake low level assembly, and activities purely exploiting the competencies of their parent MNCs (Kuemmerle, 1999; Pearce, 1999; Cantwell and Piscitello, 2007).

Consequently, the subsidiary development process (from CE to CC) has often been related mainly to the MNC locational choice and to the relevant location-based comparative advantages. The latter have been traditionally associated to factors influencing the competitiveness of locations, like local resources, education base, institutions[1] (Dunning and Zhang, 2007; Dunning and Lundan, 2008). However, the evolution of MNC sub-units (from CE to CC) cannot be held to be determined solely by inherent characteristics of locations. The evolution of sub-units depends also on their subsidiary-level organizational strategies as well as on the overall strategy of the MNC group (Birkinshaw and Hood, 1998; Birkinshaw et al., 1998). Therefore, one has to allow for the co-evolving trend towards openness by the local networks with which subsidiaries can become engaged (embeddeddness at the local level), as well as with the international connectedness of these networks (embeddedness at the global level).

In the recent literature it has been argued that subsidiaries, and especially competence-creating subsidiaries, are embedded in two kinds of business networks – internal networks with other parts of their MNC group, and external networks with a variety of other actors in their own environment, and they can be understood as co-evolving with each of these networks. Additionally, in a business theory context, it has been argued that the subsidiary’s external business network is a crucial factor in explaining its own competence (McEvily and Zaheer, 1999; Andersson et al., 2002; Zaheer and Bell, 2005; Forsgren et al., 2005). The underlying idea refers to the conceptualisation of a firm’s business network as a strategic resource (Gulati, 1998; Gulati et al., 2000). Namely, subsidiaries having strong ties to external business actors are in a better position to identify and absorb new technologies in their business environment. A high degree of external network embeddedness (that is a high degree of closeness in the relationship with customers, suppliers and the like) will be conducive to the subsidiary’s ability not only to assimilate new technology from the environment, but also to develop new technologies through close interaction with network partners. Therefore, the greater the local embeddedness of the subsidiary, the stronger the external network relationships that foster innovation, and the higher the likelihood that it will acquire a competence-creating mandate (Nobel and Birkinshaw, 1998).

This literature, also in relation with our previous point about the quality of location, has stressed the relevance of embeddedness in business networks that have been considered local and inherently geographically confined. However, these business networks involve increasingly a variety of actors that

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[1] Theoretical support for the economic impact of political institutions has expanded dramatically in the quarter century since North and Thomas (1973) first outlined a "transaction cost view of economic history". The crucial economic role played by socio-political factors which reduce the costs of bargaining, contracting, monitoring and enforcement has achieved the status of conventional wisdom not only in economic history (North, 1990) but also in economic development (Olson, 1996; The World Bank, 1997) and, more recently, in the context of internationalization. Indeed, as institutional development may directly reduce uncertainty over a future policy regime and provide investors with recourse in the event of arbitrary or capricious behavior, it thereby encourages investment. Researchers have recently illustrated that differences in local institutional contexts do matter for core questions of international business including the determinants of investment location, organization and performance (Barrell and Pain, 1999; Henisz, 2000, 2004; Henisz and Delios, 2002). However, they have not been considered in relation with the MNC subsidiaries evolution.

are geographically dispersed. Therefore, they are themselves decentralised and may creatively link selected subsidiaries to other actors that span across locations. The concept of embeddedness, here, assumes a wider perspective, that is not confined to a locally bounded context. The more open business networks in which MNCs are becoming increasingly embedded can themselves become loci for systems of international contacts for the participant firms (or sub-units of firms), and the capacity to contribute entrepeneurially to the formation of such networks at a sub-unit level may itself become a source of competitiveness for firms.

From the perspective of the host locations in which MNC sub-units are sited, we can think of the openness of local inter-organizational networks either in terms of the degree of overall national or country level openness, or in terms of the openness of sectorally disaggregated business networks at the level of the specific industry to which a given sub-unit belongs in the country in question. The concept of openness in the former sense of the aggregate national level has been the more widely explored, both through a longstanding literature on the economic openness especially through international trade but also FDI, and a more recent literature on the economic effects of the openness of political systems and a country's internal institutions.

A greater country level openness tends to increase both the potential size of the market that can be served from a given location (which positively affects the scale of local CE activities), and the potential access by firms that operate in the country to a wider diversity of resources and knowledge (which positively affects the scale of CC activities). This should apply to country level openness in the more purely economic sense, and in the sense of the openness of its political and related institutions. However, it may well be that the effectiveness of openness in this very broad country-wide sense only continues to increase the opportunities available to firms within the country up to some threshold level of openness. Beyond that threshold, once it has been attained, a further opening of a national system may have little additional effect, or even become counterproductive, given the trend towards greater openness across most locations (partly owing to a competitive game that obliges all countries to follow suit, but which thereby also limits the gains achievable through this route alone by any individual location). What is more, to benefit from the potential opportunities associated with greater openness requires that the local level of absorptive capacity also rises in line with the increased variety of opportunities, but the scope for doing so may be limited. Also, the offsetting effect of the greater ease with which external actors can serve the host country market or gain access to knowledge generated in the host country without being located there, may come to bite more at very high levels of openness.

Therefore, the first hypothesis we test is the following:

H1: Up to some threshold level, increased openness at a country level is likely to increase the scale of *local MNC sub-unit technological development.*

Turning now to openness instead the more specific business networks of a particular industry in a country, at a sectorally disaggregated level, local actors may be more or less internationally connected in the context of their own industry, above and beyond any country-wide traits. We contend that it is the extent of openness of these industry-specific business networks that is likely to be a more important influence (than is the openness of country-wide structures) to the evolution of subsidiary activity towards the CC type in a given industry in any location. The openness of local business networks to external connections at an industry level (or within some line of business) tends to raise the capacity of locally embedded firms to increase the extent or the variety of their own product development responsibilities for different markets or different categories of customers. This would be associated with some trend towards CC activities in an MNC sub-unit. In turn, the emergence and development of local product development (and not merely product adaptation) is likely to increase the scope of local sub-units to develop the independent capabilities needed within their industry to gain greater autonomy from their own parent company to fufill this role. Increased subsidiary capabilities are likely to run alongside, and to co-evolve with an acknowledgement of an expanded subsidiary role within the relevant MNC corporate group. However, the effect of the openness of local industry-based business networks on subsidiary CC activities is only likely to operate past some threshold extent of openness. The openness of local business networks needs to get to the point at which they become a significant separate source of international contacts and opportunities relative to those that can already been found through the MNC group's own international structure, and its own system of external relationships.

Therefore, this brings us to our second hypothesis, as follows:

H2: Beyond some threshold level, an industry that has more open business networks within a country is likely to increase local MNC sub-unit technological development of a CC kind, but not of a CE kind.

3. EMPIRICAL ANALYSIS

3.1. The Data

The study was based upon a database on the patenting activity in the US of the largest US and European companies over the period 1901-1995,[2] (see Cantwell 1995). The firms included in the database were identified in one of three ways. The first group consisted of those firms which have

[2]The advantages and disadvantages of using US patents as an indicator of technological activity are well known and quite widely discussed in the literature (e.g. Schmookler, 1950, 1966, Pavitt, 1985, 1988). Concerning our analysis, the major problems are controlled for by the methodology adopted - *e.g.* by the use of ratio measures such as RTA or INT (see below) which normalise for differences in the propensity to patent across sectors or firms, or the elimination of sectors with small numbers of patents in the calculation of DIV - and by the fact that we consider only the largest firms, which have a high propensity to patent their commercially useful inventions.

accounted for the highest level of US patenting after 1969; the second group comprised other US, German or British firms which were historically among the largest 200 industrial corporations in each of these countries (Chandler, 1990); and the third group was made up of other companies which featured prominently in the US patent records of earlier years. In each case, patents were counted as belonging to a common corporate group where they were assigned to affiliates of a parent company.[3] The location of the original research facility that gave rise to each patent (the country of residence of the original inventor) is recorded in the data. The location of the parent company is another important dimension of the analysis, as this is treated as the home country or the country of origin of the corporate group. By consolidating patents attributable to international corporate groups, it is then feasible to examine the geographical distribution of the technological activity of these firms (Cantwell, 1995). In addition, the primary field of technological activity of each patent can be derived from the US patent class system, which provides a measure of corporate technological diversification. We have grouped these fields into 56 technological sectors (see Cantwell and Andersen, 1996).

In all, the historical path was traced of the US patenting activity from the beginning of the century of 857 companies or affiliates that together comprise 283 corporate groups.[4] In particular, we considered data on cumulated stocks of patents for individual years spaced at five year intervals. Starting with the 1930 cumulated stock we have 14 observations (1930, 1935, .., 1995) for each firm. The stocks for each year were accumulated from patenting over the previous 30 years, incorporating a straight line depreciation function as in vintage capital models, based on the assumptions that new technological knowledge is partially embodied in new capital equipment which has an average life of 30 years, but that the value of this knowledge (like the devices in which it is partly embodied) depreciates over time (see Cantwell and Andersen, 1996). The justification for this procedure is that in our case patents are used as a proxy for advances in underlying technological knowledge, rather than as a direct measure of the legal instrument of the patent itself, the life time of which is shorter. So, for example, the stock in 1930 represents a weighted sum of patenting between 1901 and 1930.

The group of companies used in our empirical analysis consists of 244 firms, which are the ones for which complete time series relating to the period under examination were available, plus the most significant cases in which firms present throughout the period undergo a change in identity owing to mergers, acquisitions or break-ups (as in the case of IG Farben and its successors). The choice of this set of firms allows us to infer from our study evidence of the 'life cycle' or stage of development of

[3]Affiliate names were normally taken from individual company histories.

[4]Births, deaths, mergers and acquisitions as well as the occasional movement of firms between industries (sometimes associated with historical change in ownership) have been taken into account.

large companies (since they all came into existence at around the same time), as well as on the effect of changes in the international environment in which they operate.

3.2. The distinction between CC and CE

As far as the distinction between CC and CE activities, we rely on the methodology suggested in Cantwell and Piscitello (2007). Namely, we allow that any subsidiary may have some element of each, whereas most previous studies have categorized the entirety of a subsidiary R&D facility, or the subsidiary itself (in the form of its mandate) as being either of the CE or CC kind (e.g. Pearce, 1999; Kuemmerle, 1999).

Indeed, any given subsidiary has a need for a variety of technologies, and any given host location may possess a relative technological advantage in one area, but be relatively disadvantaged in another. Thus, an MNC in a given country may engage in both CE and CC activity simultaneously. Broadly speaking, CE activity represents an extension of R&D work undertaken at home, while CC represents a diversification into new scientific problems, issues or areas. In order to classify the activities of MNCs as CE or CC, we compared the specialization across technological fields of each MNC's technological activity carried out at home, with the local specialization of its activity in each host country considered. Whenever the firm's specialization in a certain technological field in some country is matched by an absence of specialization in the equivalent field at home, in each case in comparison with other firms in the same industry (i.e. host region RTA >= 1 but home RTA < 1, see below), we define the relevant patents from the host country as representing a diversification for the focal corporate group; conversely, we have non-diversification. If there is a positive specialization in a field of technological activity at home (RTA >= 1), then even if there is also a local specialization in the foreign-owned subsidiary in a given host country, this builds upon and enhances an existing domestic specialization, rather than representing a diversification away from these established fields.

The index of specialization employed is the Revealed Technological Advantage (RTA_{ihk}), which allows us to control for inter-field and inter-country differences in the propensity to patent (Cantwell, 1995). Specifically, RTA_{ihk} is defined as follows:

$$RTA_{ihk} = (P_{ihk}/\Sigma_k P_{ihk})/(\Sigma_h P_{hk}/\Sigma_{hk} P_{ihk})$$

where P_{ihk} is the number of patents in technological field k (k = 1, .., 56) by the single firm i, located in host country h (h = 1, .., 60). The index varies around unity, such that values greater than one suggest that the firm is comparatively advantaged in the technological field k relative to other firms in the country, while values less than one are indicative of a position of comparative disadvantage. An equivalent procedure is also used to calculate RTA_{ilk}, where l is the home country of the parent company i, and so refers to the pattern of inventions attributable to its research at home.

Thus, firms may sometimes have just CE or CC activities in a given country (where their local profiles of technological specialization are very highly focused on a few fields of activity), but quite commonly they have instead some mix of CE and CC activities in many of the countries in which they are involved. Interestingly, it emerges that the share of CC activities (calculated on the total number of firms) does increase over time (see Graph 1) thus confirming the rising trend of MNC innovation networks towards more exploratory types of activity.

4. THE MODELS AND THE VARIABLES

4.1. *The impact of openness on MNCs'subsidiaries*

As our main aim is to show that openness impacts on the scale and nature of MNC innovative activities. Namely, openness at the country level impacts on the scale of the innovative activity, while openness of the business networks influences the nature of the activity.

Our dependent variable concerns the scale of innovative activities carried out by each firm in each foreign location. Hence, we considered the MNC innovative activity conducted in each foreign country (Pathost). Namely: $Pathost_{ijht}$ is the total number of patents of the firm i, belonging to industry j, in the host country h, at time t;

$Pathost\_CC_{ijht}$ is the total number of patents corresponding to CC activities of firm i, belonging to industry j, in the host country h, at time t.

$Pathost\_CE_{ijht}$ is the total number of patents corresponding to CE activities of firm i, belonging to industry j, in the host country h, at time t.

Then, we run the following models:

$$Pathost_{ijht} = \alpha X_{it} + \beta H_{ht} + \delta D\_sector_j + \varepsilon_{ijht}$$

$$Pathost\_CE_{ijht} = \phi X_{it} + \gamma H_{ht} + \varphi D\_sector_j + \eta_{ijht}$$

$$Pathost\_CC_{ijht} = \nu X_{it} + \theta H_{ht} + \sigma D\_sector_j + \mu_{ijht}$$

Where:

X_{it} is a vector of firm i specific variables, at time t

H_{ht} is a vector of host country h specific variables, at time t

D_sector_j is a vector of dummies for sectors j

with:

i = 1, .., 244 firms

j = 1, .., 20 industries

t = 1, …, 14

Host country variables

Country-wide national openness

In order to measure country national openness, we consider both purely economic and institutional openness. Namely, as far as the former, we built the following variables:

- $Export\_gdp_{ht} = Export_{ht}/Gdp_{ht}$

  Data on exports come from the database UN Comtrade, while data on GDP come from the database built and maintained by Angus Maddison, University of Groningen (http://www.ggdc.net/maddison/) .

- In order to account for institutional openness, we relied instead on the political constraint index (Polcon) dataset built by Witold Henisz, Wharton School of the University of Pennsylvania (http://www-management.wharton.upenn.edu/henisz/POLCON/ContactInfo.html). Namely:

  $Polcon\_host_{ht}$ is the index for the "quality of political institutions" (see Henisz, 2000, p. 14) for the host country h in t.

International openness of local business networks

In order to measure the local industrial structure of openness in a more direct business sense, or in other words to measure the extent to which local business networks have developed outbound connections, across different industries, we rely on the revealed comparative advantage (Balassa, 1965). Namely, the variable RCA_host has been built as follows:

- $RCA\_host_{jht} = (Exp_{jht}/\Sigma_j Exp_{jht})/(\Sigma_h Export_{jht}/\Sigma_j \Sigma_h Export_{jht})$

  h is the host country. The index varies around unity, such that values greater than one suggest that the country h is comparatively advantaged in the sector j relative to other countries, while values less than one are indicative of a position of comparative disadvantage.

Other country-specific control variables

- Pop_{ht} is the population of country h in t. The source of data is again the database built and maintained by Angus Maddison, University of Groningen (http://www.ggdc.net/maddison/).
- $Educ\_pop_{ht}$ is a proxy for the amount of skilled labour available in country h at time t. Data on Education refer to the number of students in universities and come from Mitchell (2007a; b; c)

- Gdp_pc_{ht} is the country's h Gdp per capita at time t. Data come from the database built and maintained by Angus Maddison, University of Groningen (http://www.ggdc.net/maddison/).
- GDP_{ht} is the country's h GDP at time t. Data come from the database built and maintained by Angus Maddison, University of Groningen (http://www.ggdc.net/maddison/).
- Additionally, to control for the role of geographical distance between home and host countries (see Manning et al., 2009), we inserted geographical distance between the most important cities[5], $Dist_{lh}$. Data come from the Centre d'Etudes Prospectives et d'Informations Internationales (http://www.cepii.fr/).

Firm control variables

In order to control for the MNC characteristics, we considered:

- $Size_{it}$ is the total number of patents granted to firm i in time t;
- We also considered the share of GPT technologies developed by each firm i in t, relative to what other firms in the same industry are doing. Namely, our variable is the following:

  $GPT\_share_{it} = (Pat\_GPT_{it}/Pat\_tot_{it})/(\Sigma_i Pat\_GPT_{it}/\Sigma_i\ Pat\_tot_{it})$

  Where Pat_GPT is the number of patents in technological fields no. 5, 9, 11, 16, 29, 38, 39, 41, 53 (see Annex 1), as defined in Cantwell and Qui (2009).

5. EMPIRICAL FINDINGS AND CONCLUSIONS

Correlation matrix is reported in Table 1 while the empirical findings obtained from the econometric estimations are reported in Table 2. In particular, the table shows the best specifications of the model for Pathost as well as for Pathost_CC and Pathost_CE, respectively. Numbers in parentheses represent z-statistics.

Overall results confirm that the scale of MNC innovative activities is influenced by the host country's openness, once controlled for other country-speficic characteristics. Specifically, estimated coefficients reveal that country-wide national openness illustrates a threshold in the effects of openness on subsidiary innovativeness, whether in terms of the more purely economic (Export_gdp) or political

[5] However, it is worth observing that we tried all the alternative measures provided by CEPII for geographical distances, but results are all very similar. Specifically, CEPII provides two kinds of bilateral distance measures: simple distances, for which only one city is necessary to calculate international distances; and weighted distances, for which data on the principal cities in each country are needed (http://www.cepii.fr/). Specifically, the simple distances ($Dist_{lh}$ and $Distcap_{lh}$) are calculated following the great circle formula, which uses latitudes and longitudes of the most important city (in terms of population) or of its official capital. The weighted distance measures ($Distw_{lh}$ and $Distwe_{lh}$) use city-level data to assess the geographic distribution of population inside each nation. The idea is to calculate distance between two countries based on bilateral distances between the largest cities of those two countries, those inter-city distances being weighted by the share of the city in the overall country's population.

institutional (Polcon_host) aspects of openness. It exercises a positive effect in the earlier stages of openness (both Export_gdp and Polcon_host are positive and significant at $p<.01$ in Model 1 and Model 2), but it is less significant once openness has moved beyond some point (as indeed their quadratic terms, Export_gdp2 and Polcon_host2, comes out negative and significant at $p<.01$ in the two models). This result then confirms our first hypothesis. However, this is also consistent with previous findings that openness in this trading sense affects the increase in local innovative activity only in the relatively early stages of innovative development, but not once innovative development has become more advanced, and the kinds of international connectedness needed become more complex (Athreye and Cantwell, 2007).

Meanwhile, the estimated coefficients in Model 3 and Model 4 show that the openness of local industry-based business networks influences only CC activities but not CE activities (neither RCA_host nor RCA_host2 come out significant in any specification adopted). However, this is only likely to operate past some threshold extent of openness (RCA_host is negative and significant at $p<.10$, while RCA_host2 is positive and significant at $p<.05$, in Model 3). The openness of local business networks needs to get to the point at which they become a significant separate source of international contacts and opportunities relative to those that can already been found through the MNC group's own international structure, and its own system of external relationships. In other words, the results show that these local industry-based networks need to have built up some degree of maturity in the extent of their international connectedness before they impact positively on the scope of the local sub-unit innovativeness. Thus, as this effect applies for CC-based local innovation (which requires a more locally independent responsibility for developing some range of products for various international markets), but not CE-based innovation (which relies mainly on adaptation of existing products for the local market, and is therefore largely unaffected by any international connectedness of the actors in that local market), our second hypothesis seems to be confirmed.

Interestingly, control variables also come out significant. Namely, the estimated coefficient for GDP is positive and significant (at $p<.01$) while the estimated coefficient for Geo_dist comes out negative and significant (at $p<.01$) in all the models considered.

As far as control variables, GDP and geographical distance seem to influence both the scale and the scope of MNC innovative activities. Specifically, GDP comes out positive and significant at $p<.01$ in all the Models 1-4 considered; likewise, Geo_dist is always negative and significant at $p<.01$ in the Models.

These results give a useful contribution to the literature on MNC subsidiary evolution, since the evidence on (i) long term period, and (2) openness in this context is still scanty.

However, a remark must be taken into account. These results have been found by using data up to 1995 that certainly need updating in order to assess whether recent times show different patterns. It would be also interesting to understand whether and how some trends do also characterize new actors coming from emerging countries in recent years.

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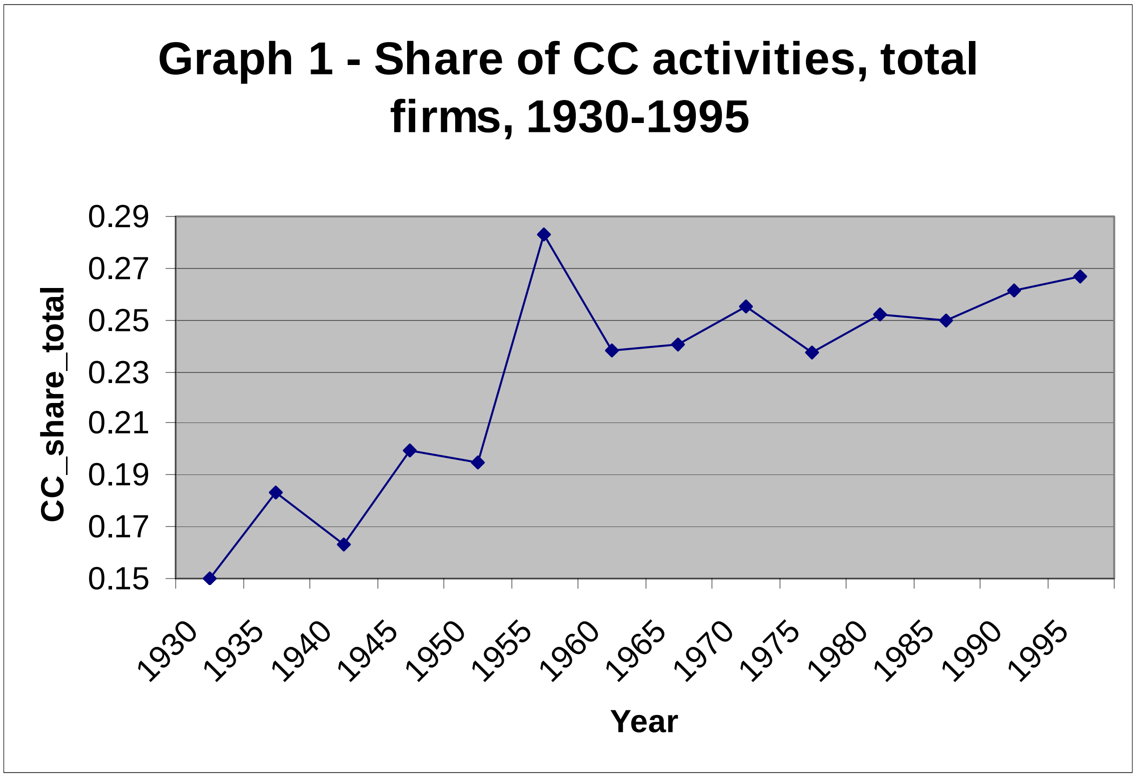
Graph 1 - Share of CC activities, total firms, 1930-1995
CC_share_total
0.29
0.27
0.25
0.23
0.21
0.19
0.17
0.15
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year

Table 1- Correlation matrix

		1	2	3	4	5	6	7	8	
Forpat	1									
Forpat_CC	2	0.85								
Forpat_CE	3	0.95	0.70							
Size	4	0.12	0.09	0.12						
GPT_share	5	0.00	-0.00	0.00	-0.01					
Export_GDP	6	-0.02	-0.02	-0.02	0.03	-0.00				
Polcon_host	7	-0.01	-0.01	-0.02	-0.02	0.00	0.08			
RCA_host	8	-0.00	-0.01	0.01	-0.05	0.02	-0.05	0.03		
GDP	9	0.26	0.20	0.26	-0.13	0.01	-0.15	-0.04	-0.02	
Geo_dist	10	-0.01	-0.02	-0.00	0.20	-0.03	-0.10	-0.07	-0.06	0.

Table 2- Econometric results (Robust GLS estimation)

	Model 1			Model 2			Model 3			
Dependent variables	Pathost			Pathost			Pathost_CC			Pathost_(
Std Explanatory variables										
Size	15.452	(11.10)	***	15.455	(11.09)	***	3.960	(8.83)	***	11.4
GPT_share	0.043	(0.08)		0.042	(0.07)		-0.065	(-0.43)		0.1
Export_gdp	2.180	(3.53)	***	2.188	(3.54)	***	0.359	(1.90)	*	1.8
Export_gdp2	-1.601	(-3.88)	***	-1.606	(-3.90)	***	-0.274	(-2.23)	**	-1.3
Polcon_host	4.534	(2.46)	**	4.528	(2.46)	**	1.439	(2.90)	***	3.0
Polcon_host2	-5.562	(-3.04)	***	-5.555	(-3.04)	***	-1.515	(-2.79)	***	-4.0
RCA_host	0.044	(0.06)		0.126	(0.34)		-0.369	(-1.70)	*	0.4
RCA_host2	0.107	(0.20)					0.313	(2.03)	**	-0.2
GDP	30.665	(10.86)	***	30.666	(10.85)	***	8.204	(7.39)	***	22.4
Geo_distance	-9.981	(-11.72)	***	-9.977	(-11.80)	***	-3.136	(-9.11)	***	-6.8
Industry dummies	Yes			Yes			Yes			Y
No. obs.	12,713			12,713			12,713			12,7
No. groups	244			244			244			2
Obs per group										
Min	1			1			1			
Avg	52.1			52.1			52.1			5
Max	198			198			198			1
R-sq within	0.106			0.106			0.067			0.1
R-sq between	0.057			0.057			0.078			0.0
R-sq overall	0.107			0.107			0.074			0.1
Wald chi2	364.64 ***			353.90 ***			272.07 ***			376.

Legenda: Z values in brackets. Significance levels: ***<.01; **<.05; *<.10.

Annex 1 - The description of 56 technological fields

Tech	Technological Fields	Tech	Technological Fields
1	food and tobacco product	**29**	other general industrial equipment
2	distillation processes	**30**	mechanical calculators and typewriters
3	inorganic chemicals	**31**	power plants
4	agricultural chemicals	**32**	nuclear reactors
5	chemical processes	**33**	telecommunications
6	photographic chemistry	**34**	other electrical communication systems
7	cleaning agents & other compositions	**35**	special radio systems
8	disinfectants & preservatives	**36**	image and sound equipment
9	synthetic resins and fibers	**37**	illumination devices
10	bleaching and dyeing	**38**	electrical devices and systems
11	other organic compounds	**39**	other general electrical equipment
12	pharmaceuticals and biotechnology	**40**	semiconductors
13	metallurgical processes	**41**	office equipment
14	miscellaneous metal products	**42**	internal combustion engines
15	food drink and tobacco equipment	**43**	motor vehicles
16	chemical and allied equipment	**44**	aircraft
17	metal working equipment	**45**	ships and marine propulsion
18	paper making apparatus	**46**	railways and railway equipment
19	building material handling equipment	**47**	other transport equipment
20	assembly and material handling equipment	**48**	textile, clothing and leather
21	agricultural equipment	**49**	rubber and plastic products
22	other construction and excavating equipment	**50**	non-metallic mineral products
23	mining equipment	**51**	coal and petroleum products
24	electrical lamp manufacturing	**52**	photographic equipment
25	textile and clothing machinery	**53**	other instruments and controls
26	printing and publishing machinery	**54**	wood products
27	woodworking tools and machinery	**55**	explosives, compositions and charges
28	other specialized machinery	**56**	other manufacturing and non-industrial