Historical changes in knowledge sourcing by MNCs:
The balance between localized vs. non localized knowledge

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 activity by tapping into host country capabilities (Cantwell, 1995; Cantwell and Mudambi, 2005).

Connections with external local business networks, and the relevant access to external localized knowledge, 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). The origins of this view of the firm and the MNC which we are here seeking to extend here rest partly on the premise that technological change has elements that are highly localized (Nelson and Winter, 1982), since it relies on tacit capabilities which are costly to develop and learn, and difficult or impossible to pass to others. Hence, the generation of new technological knowledge is characterized by both firm-specific and location-specific features, and technology transfer is a difficult process both between firms and between locations. As MNC sub-units come to access knowledge from networks grounded in the place in which they are sited, they may evolve towards locally competence creating (CC) activities through a development path that comes to rely relatively more on the location specificity of sources than it does on the firm (MNC group level) specificity of the sources required for new knowledge generation. We argue that location specificity does include not only the inherent context-specific characteristics but also the openness, i.e. the potential access to external non localized knowledge.

It is a quite natural step to suppose that the national innovation systems (Dosi, 1999; Freeman, 1995; Murmann, 2003; Nelson, 1993) and regional innovation systems (Cooke, 2001; Freeman, 2002) in which MNC sub-units are embedded are themselves strictly local in character, since they are marked out by the locally distinctive features of their institutions. However, the locational specificity of knowledge in our sense should be thought of as a mix of both localized and non localized knowledge. Namely, the notion of embeddedness in local business networks, and the relevant access to localized knowledge, has typically been seen to be inherently geographically confined. Instead, we claim that the more open is the local business network the more it allows the access to knowledge that is not merely confined to a locally bounded context.

This paper suggests that the knowledge needed to foster sub-units CC activities can be accessed through connections that are not purely local, and hence constitute a separate source of international relationships beyond those that come from within the existing MNC group. Thus, we focus on those aspects of the local system in which the MNC sub-unit is located that tend to facilitate access to non-localized knowledge. Namely, we examine the international openness of the local industrial system, as the business networks of local innovation systems involve a variety of actors, some of which are geographically dispersed. The more open industries and business networks in which MNCs' sub-units are located/embedded can themselves become part of their relational assets, and the capacity to build and sustain a variety of such networks of connected actors has itself become an important differentiating capability for firms.

We also argue that subunits' CC activities do not depend exclusively on the local embeddedness, i.e. the access to localized and/or non localized knowledge but also, and increasingly, on corporate integration. Our empirical analysis relies on data on the innovative activities by 244 among the world's largest industrial firms at the sub-unit level in each host country, over the period 1930-1995. Specifically, the sample considered is a large panel of sub-units' technological activity over time, proxied by their corporate patenting in the US.

Therefore, the paper provides two main contributions: (i) a conceptual one, related to the increasing role of non-localized knowledge in the MNC sub-units' CC activity; (ii) an empirical one, since the availability of a large data set covering several decades allows us to illustrate the increasing share of MNCs' CC activities conducted abroad, and to test the changing role and balance mix of the localized vs. non localized knowledge, and the MNC's corporate integration strategy.

The organization of the paper is as follows. The next section elaborates upon the interpretative framework for the study, and puts forward the hypotheses to be tested. In the third section, we illustrate the data employed as well as the econometric model, and the variables used. Section four reports results and some concluding comments.

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 (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 subunits' activities 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). Indeed, 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, and so forth. Therefore, MNC international networks have recently evolved from closed to open systems in order to facilitate the evolution of subunits from merely exploiting competences inherited from the parent company to greater locally explorative and creative activities.

In the literature on internationalization 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 characterized 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 MNC subunit's development process (from CE to CC) has been related mainly to the MNC locational choice and to the relevant location-based comparative advantages. The latter have been traditionally associated with factors influencing the competitiveness of locations, like local resources, education base, and institutions (Dunning and Lundan, 2008). However, the evolution of MNC sub-units (from CE to CC) cannot be simply considered as determined by inherent characteristics of locations. Indeed, the literature has already shown that their evolution 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). We add that one has to allow also for the openness of the local industrial systems in which sub-units are engaged, i.e the potential access to non localized external knowledge.

It has been argued that the subunit'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 conceptualization 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 closeness in the relationship with the external localized network (customers, suppliers and the like) will be conducive to the subunit'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 stronger the sub-unit's 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 those features of business networks that are essentially purely local and inherently geographically confined. However, these business networks involve increasingly a variety of actors that are geographically dispersed. Therefore, they are themselves decentralized and may creatively link selected subsidiaries to other actors that span across locations. 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 entrepreneurially to the formation of such networks at a sub-unit level may itself become a source of competitiveness for firms.

The international connectedness of a local business system more widely (independently of the MNC group linkages of the sub-units operating there) typically operates primarily through international trade. For the purposes of new knowledge acquisition by local actors, exports are especially important, as they provide access to a variety of export network domestic partners, internationally located intermediaries, and in the major international markets served by a local system, to a differentiated set of needs and supporting expertise in customers and distributors. The international connectedness of a local business system varies significantly across industries in any given host country, since in some industries the actors involved have stronger export linkages than in others. The export networks of the relevant local business system provide a potentially rich source of knowledge internationally, which may be capable of being combined with the knowledge that a sub-unit may access through its parent company. Hence, we contend that as creativity within MNC groups has become more decentralized, so the extent of openness of industry-specific local business networks is likely to have become a crucial influence on 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 tends to be associated with an increased likelihood of a 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 fulfill 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.

Therefore, our first hypothesis is the following:

> *H1: MNC sub-unit CC activities increasingly (positively) depend on the potential access to non-localized external knowledge, i.e. on the international openness of the local industrial system.*

The traditional model of technology development and transfer in the MNC is widely believed to have prevailed in the historical past, in which technological knowledge in core fields of specialization was primarily created in the parent company, and then diffused as required to foreign sub-units of the same corporate group. In this model such CC activity as there was typically occurred in selected sub-units in local market contexts that required more demanding forms of product adaptation, which necessitated going beyond the competences inherited from the parent company. At that time, there were relatively few feedback effects from the sub-unit to the parent company, and hence the terminology of 'reverse technology transfer' came about, in contrast to the normal expectation of the direction of knowledge flows in an MNC, from parent to subsidiaries.

From this historical perspective on MNCs, global integration (relying on the central distribution of the knowledge of the parent company) and local responsiveness (granting a greater degree of local autonomy in selected sub-units to facilitate knowledge adaptation in line with local conditions) came to be treated as substitutes in the integration-responsiveness (IR) framework. Here instead, we contend that in more recent times there has been an increased interaction between local creativity and integration with the parent, such that they have become complementary. While it remains true that the appropriate balance between embeddedness in local networks and the corporate group network may be difficult to manage and sustain, as the IR literature has suggested, finding such a balance has become vital for the kinds of combinations of knowledge taken from internal and external sources that are the basis of CC activity. Firms need to relate local departures into new fields of specialization to their established competence base, both to enhance local CC development through relevant new parent company knowledge inputs as the sub-unit's agenda adapts, and to provide value to the MNC group by selectively feeding back at least some of the new knowledge combinations or novel applications that have the potential for further uses in other parts of the MNC. Somewhat paradoxically, if viewed through the conventional lens, MNC sub-unit CC activities have come to require a combination of adequate local autonomy for the exploration of new fields of knowledge, together with an increased corporate integration of knowledge between the parent company and key creative sub-units.

Thus, in the recent literature it has been argued that subsidiaries, and especially competence-creating subsidiaries, are engaged in two kinds of networks – internal networks with their parents and other parts of their MNC group, and external networks with a variety of other actors in or connected to their own environment, and they can be understood as co-evolving with each of these networks. The firm-specific dimension of access to non-localized knowledge refers to the availability of knowledge within the MNC group to which the sub-unit belongs. The capacity of MNC sub-units to evolve towards CC activities depends upon MNC group characteristics, as well as location-specific and subsidiary-specific elements (Birkinshaw and Hood, 1998, Cantwell and Mudambi, 2005). Of these MNC group factors, the most important is the extent to which the parent company comes to allow and perhaps to facilitate sub-unit autonomy of a kind that encourages local subsidiary entrepreneurship. From the perspective of any individual sub-unit, this is likely to have a direct positive effect in promoting local CC activities, but also an indirect positive effect by way of the greater background knowledge stock from which the sub-unit is likely to be able to draw, from the parent company but also from other sub-units of its corporate group.

Of course, it is possible that greater local exploration, supported by an increase in MNC sub-unit autonomy from its parent, may lead to a sub-unit 'falling out of the loop' within its group, and becoming essentially a more separate entity in its own right. However, if this kind of parting of the ways were to occur and be sustained, it is likely that resources would be gradually withdrawn from the sub-unit by the parent company, or more simply that it would be spun off or acquired by another firm with a better fit to its new area of interest (Cantwell and Mudambi, 2005). Alternatively at the opposite extreme, international corporate integration within the MNC may be preserved so tightlythat it constrains the extent of local sub-unit autonomy, and hence reduces the ease of access to knowledge that might otherwise be available through local business networks. In this case, lacking the necessary external nourishment from its location, local CC activities are likely to decline in, or even to disappear from, the MNC sub-unit. This brings us back to the need to maintain a suitable balance between global integration and local responsiveness in the more combinatorial form of CC development that emerges once knowledge creation efforts become more decentralized in the MNC, since this shift in international organizational structure actually relies on a more (and not on a less) intensive access to parent company knowledge by sub-units engaged in CC activities.

Thus, our second hypothesis is the following:

> *H2: MNC sub-unit CC activities increasingly (positively) depend on the potential access to non-localized internal knowledge, i.e. on the magnitude of the knowledge stock of its*

parent company.

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[1] (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 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.[2] 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).

[1]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 normalize 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.
[2]Affiliate names were normally taken from individual company histories.

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.[3] 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[4].

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 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.

Specifically, in order to investigate the evolution of the MNC's activity at the subunit level, we considered the MNC's patenting activity in each host country throughout the period considered. Thus, we refer to a total number of subunits equal to 2,276 although the number of subunits observed each year is much lower. The number of available observations per year is shown in Figure 1.

3.2. The distinction between CC and CE activities

[3]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.

[4] 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.

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 subunit may have some element of each, whereas most previous studies have categorized the entirety of a subunit R&D facility, or the subunit 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 subunit 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 subunit's specialization in a certain technological field in some country is matched by an absence of specialization in the equivalent field at the parent company, in each case in comparison with other firms in the same industry (i.e. subunit RTA >= 1 but parent RTA < 1, see below), we define the relevant patents from the subunit 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 the parent company (RTA >= 1), then even if there is also a local specialization in the subunit 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 subunit i, located in host country h (h = 1, .., 60). The index varies around unity, such that values greater than one suggest that the subunit 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 subunit's parent company, and so refers to the pattern of inventions attributable to its research at home.

Thus, MNCs 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.

Table 1 reports the number of firms, subunits and host countries observed throughout the period considered as well as the total and the average amount of CC activities recorded over time. Likewise, Figure 2 illustrates the average number of CC patents per subunit and the average share of CC activity over time, thus confirming the mentioned increasing trend.

3.3. The models and the variables

The impact of localized and non-localized knowledge on MNC sub-units CC activities

As our main aim is to show that both localized and non-localized knowledge impact on the MNC sub-units competence creating innovative activities, our dependent variable concerns the MNC innovative activity conducted in each foreign country (i.e. in each subunit) with CC characteristics. Hence, the unit of observation is the subunit, and the dependent variable CC_{ijht} is the total number of patents corresponding to CC activities of the subunit i, operating in industry j, in the host country h, at time t. Therefore, we run the following model:

CC_{ijht} = f(localized_knowledge$_{ht-1}$; non_localized_knowledge$_{hjt-1}$; controls$_{it}$)

Where:

i = 1, .., 2276 sub-units

j = 1, .., 20 industries

h = 1,... 60 host countries

t = 1930, 1935, 1940, ..., 1995

Localized knowledge – As far as the localized (external) knowledge, we considered the following variables:

- The stock of knowledge available in the shot country: *Educ_pop*$_{ht}$ measures the share of students in universities on the total population in country h at time t. Both data on education and population come from Mitchell (2007a; b; c)
- The presence of other MNCs carrying out CC activities in the host country: *Other_MNCs*$_{ht}$ measures the total amount of CC patents developed by other foreign MNCs in the host country h at time t.

Non-localized knowledge – As far as the non localized external knowledge we considered the following variables:

- The international openness of the local industrial system: in order to measure the extent to which local industries have developed outbound connections, we rely on the revealed comparative advantage of the host country in each industry (Balassa, 1965). Namely, the variable *Local_openness*$_{jht}$ has been built as follows:

  $Local\_openness_{jht} = (Exp_{jht}/\Sigma_j Exp_{jht})/(\Sigma_h Export_{jht}/\Sigma_j \Sigma_h Export_{jht})$

  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. Export data come from the UN Comtrade database.[5]

To proxy access to non-localized internal knowledge, we considered the following variable:

- Knowledge available at the parent company: we built the variable *Parent_knowledge* $_{it-1}$ that measures the total number of patents granted to the focal subunit's parent company (in the home country) at time t-1.

Control variables

- The MNC group strategy: in order to control for the fact that the increasing CC activity of the single subunit is part of the more general MNC group strategy towards increasing CC activities, we built the variable *Group_strategy* $_{it}$ that allows for the other CC activities within the focal subunit's group as in t. Namely, the variable has been measured as follows:

  $Group\_strategy_{it} = \sum_n CC_{nt}$

[5] The authors wish to thank Feng Zhang for her help with the collection of data.

where n indicate the sub-units belonging to the same MNC group of the focal sub-unit i.

- The geographical distance between the parent and the sub-unit: the literature suggests that geographical distance may still be a serious constraint (e.g. Manning et al., 2009), we inserted the variable $Parent\_distance_{hk}$, which measures the geographical distance between the home country k and the host country h.[6] Data come from the Centre d'Etudes Prospectives et d'Informations Internationales (http://www.cepii.fr/).

Summary statistics such as overall means, standard deviations, minimums and maximums of all the variables considered are reported in Table 2.

4. EMPIRICAL FINDINGS AND CONCLUSION

As the dependent variable CC is clearly a count variable, a negative binomial regression model was fitted to the data for each of the periods considered. Indeed, this kind of linear exponential model offers an improved methodology for count models for the cases of patents and innovation counts (Cameron and Trivedi, 1998). Additionally, it is worth observing that we adopted a robust specification (in order to control for heteroschedasticity in the data), and we did cluster the errors by firms (to allow for subunits belonging to the same MNC).

The empirical findings obtained from the estimations are reported in Table 3. The table shows the best specifications of the model (starting from 1940 instead of 1930 because of the low

[6] Specifically, we considered the geographical distance between the most important cities. However, 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.

number of observations in 1930 and 1935) for the dependent variable CC. Numbers in parentheses represent z-statistics.

Insert Table 3 about here

The results show that the MNC subunits' CC innovative process is highly cumulative (the lagged dependent variable CC_lag1 is indeed always positive and highly significant throughout the period considered) and coherent within the MNC group (the variable Group_Strategy does also come positive and significant throughout the whole period). Additionally, our results confirm that the subunit's CC activity has traditionally relied upon the availability and the access to localized external knowledge. Indeed, the variable Educ_pop_host is positive and significant almost throughout the whole period considered, often together with the presence of other foreign subunits carrying out CC activities in the same host country (the variable Other_MNCs is indeed positive and significant, especially in the last decades). However, as far as our Hypothesis 1 is concerned, i.e. the most recent role of the potential access to non-localized knowledge, results seem to confirm it. Namely, the proxy for 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 (*Local_openness*) does come out positive and significantly different from zero since 1975 onwards.

Concerning our second hypothesis, the econometric findings also confirm that the subunit evolution towards CC requires not only local embeddedness but also corporate integration, as shown by the significant role of the variable *Parent_knowledge* since the mid 1970s onwards. It is also worth observing that geographical distance seems to be still a barrier to integration.

Indeed, the variable *Parent_distance* does come out negative and significant in the recent decades (since 1980 onwards).

These results give a useful contribution to the literature on MNC sub-unit evolution, since the evidence on (i) long term period, and (2) the balance between localized and non localized knowledge in this context is still scanty.

However, a qualifying remark may be in order here. 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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Fig. 1 - No. observations per year

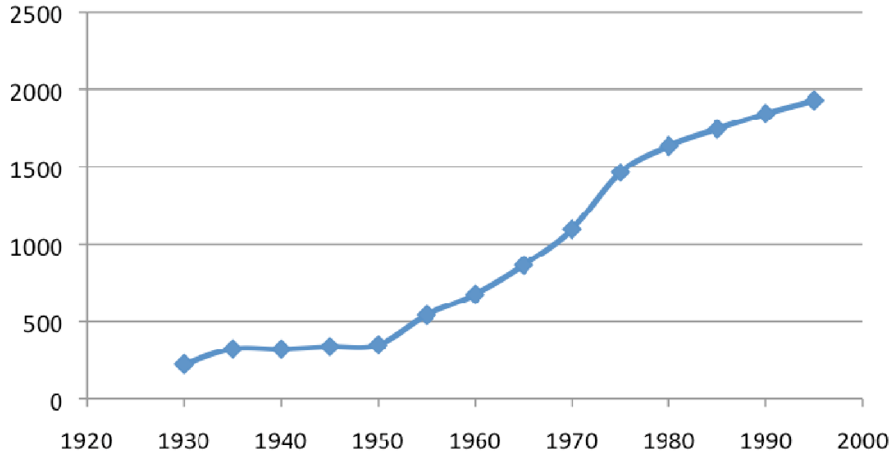

Figure 2 – Mean values of CC and cc_share (*100), by year

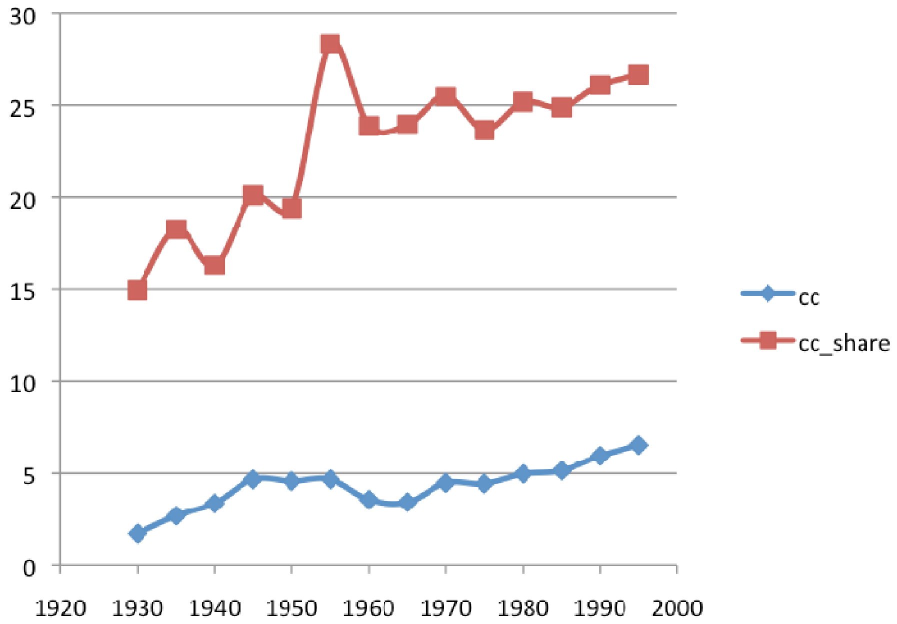

Table 1 – Descriptive statistics

Year	No. Subunits	No. Firms	Sub./Firms	No. host countries	No. CC patents (total)
1930	225	82	2.74	25	391
1935	323	108	2.99	30	874
1940	322	111	2.90	22	1087
1945	338	115	2.94	22	1581
1950	350	121	2.89	22	1604
1955	542	165	3.28	28	2537
1960	676	192	3.52	31	2416
1965	864	207	4.17	32	2970
1970	1096	191	5.74	40	4913
1975	1464	197	7.43	43	6509
1980	1635	200	8.18	43	8138
1985	1745	200	8.73	41	9001
1990	1844	201	9.17	44	10984
1995	1929	200	9.65	44	12621

Table 2 – Variable definitions and summary statistics

Variable	Unit	Source	Mean	Std. Dev.	Min.	Max	No. obs. (subunits*year)
Dependent variable							
CC	No. patents		4.9147	33.299	0	1393.6	13353
Localized knowledge							
Educ_pop_lag1	No. students	Mitchell database	1.552	1.301	0	6.078	12758
Other_MNCs	No. patents		56.746	151.533	0	1678.433	13353
Non-localized knowledge							
Local_openness		UN Comtrade	1.574	3.647	.0000108	184.242	13267
Parent_knowledge	No. patents		2014.001	2525.883	.6333333	14078.23	13353
Control variables							
Group_strategy	No. patents		69.85684	202.292	0	2137.233	13353
Parent_distance	Kilometers	CEPII	4939.62	4085.105	173.03	19147.14	12805

Table 3- Econometric results (negative binomial estimation), Dependent variable = CC

	1940	1945	1950	1955	1960	1965
Localized external knowledge						
Educ_pop_lag1	-.0295761	.1733141	.0576414	.1369854	.1452838	.2318193
	-0.28	2.15**	0.65	1.95*	1.82*	3.44***
Other_MNCs_lag1	.0022835	.0011863	.0015476	9.53e-06	.0002	.0002275
	3.76***	1.32	1.49	0. 01	0.31	0.56
Non-localized external knowledge						
Local_openness_lag1	-.0318479	.0464611	.0134622	-.0213375	.0095815	.0049637
	-0.84	1.28	0.48	-1.20	0.13	0.24
Non-localized internal knowledge						
Parent_knowledge_lag1	-.0000676	.0000166	1.26e-06	.0001011	.0000182	-.000033
	-1.48	0.59	-0.04	2.58**	0.34	-1.02
Control variables						
CC_lag1	.0839151	.129088	.0583089	.0558047	.0455127	.0840714
	2.99**	4.73***	2.91***	2.75**	2.58**	4.73***
Group_strategy	.0152996	.0055714	.009359	.0046887	.0017797	.0043791
	2.08**	2.05**	4.87***	3.68***	0.52	1.96*
Parent_distance	.000083	.0000224	-.0000265	.0000113	-6.36e-06	.0000177
	1.57	0.68	-0.50	0.30	-0.17	0.62
Constant	-.521292	-.9515691	-.3940201	-.6922761	-.0599111	-.4590007
	-1.47	-3.72***	-1.46	-3.39	-0.20	-2.34**
Wald chi2(7)	58.37***	45.56***	36.46***	77.95***	21.03***	59.32***
No. obs.	179	233	238	295	397	521
Clusters (firms)	78	97	99	108	147	172

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

Table 3- Econometric results (negative binomial estimation), Dependent variable = CC

	1970	1975	1980	1985	1990	1995
Localized external knowledge						
Educ_pop_lag1	-.0023226	.0926549	.1132568	.1009647	.1699594	.1425336
	-0.04	2.19**	3.54***	3.12***	3.03***	3.12***
Other_MNCs_lag1	.0013314	.0015907	.0006679	.001417	.0015932	.000554
	4.18***	3.42***	2.02**	3.50***	2.41**	1.40
Non-localized external knowledge						
Local_openness_lag1	.004261	.0276068	.0520044	.1036177	.0477407	.0254799
	0.21	1.74*	2.60***	4.06***	2.45**	0.46
Non-localized internal knowledge						
Parent_knowledge_lag1	-.0000267	.0000532	.000029	.0000569	.0000754	.0000834
	-0.73	1.97**	1.85*	2.33**	3.48**	3.80***
Control variables						
CC_lag1	.0723024	.0639861	.0718459	.0588456	.0540682	.0701692
	3.33***	3.18**	4.64***	4.07***	3.48***	4.07***
Group_strategy	.0044651	.0013933	.0006032	.0005847	.0006755	.0006954
	1.79*	4.91***	2.70***	3.09***	3.42***	3.36***
Parent_distance	.0000231	-8.82e-06	-.000047	-.0000257	-.0000292	-.0000201
	0.86	-0.64	-4.79***	-2.03**	-2.11**	-1.66*
Constant	.2038181	-.045868	-.1722097	-.2135078	-.1402564	-.162284
	0.84*	-0.32	-1.07	-1.80*	-0.94	-0.89
Wald chi2(7)	44.47***	99.67***	36.46***	123.60***	68.43***	69.00***
No. obs.	636	952	1216	1308	1402	1393
Clusters (firms)	168	187	195	195	198	197

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