COMPETENCE-CREATING vs. COMPETENCE-EXPLOITING ACTIVITIES OF FOREIGN-OWNED MNCs:
HOW INTERACTION WITH LOCAL NETWORKS AFFECTS THEIR LOCATION

John Cantwell
Rutgers Business School
111 Washington Street, Newark
New Jersey NJ 07102-3027, USA
tel: +1 973 353 5050
fax: +1 973 353 1664
Email: Cantwell@rbsmail.rutgers.edu

Lucia Piscitello
Politecnico di Milano
P.zza L. da Vinci 32 – Milano 20133
Tel. +39 02 2399 2740
Fax. +39 02 2399 2710
Email: lucia.piscitello@polimi.it

ABSTRACT
This paper examines how the characteristics of local inter-firm networks affect the location of subsidiary research and development (R&D) facilities. It distinguishes between subsidiary R&D that is competence-creating (creates new lines of technology for the multinational corporate group) and competence-exploiting (adapts established lines of technology). The key dimensions of local networks are the degree of cross-firm concentration or diversity in the relevant industry, and the relative presence of domestically-owned versus foreign-owned firms. The empirical investigation uses patents granted in the US to the world’s largest industrial firms for inventions achieved in their European-located operations, classified by the host European region in which the research facility responsible is locate, over the period 1987-1995. Intra-industry spillovers are positive from dominant insider firms that are well connected locally, but negative when these insiders are domestically-owned. Foreign-foreign spillovers from non-dominant firms are positive in the competence-creating case.

Key words: multinational corporations, R&D activities, spillovers, European regions.

Short running title: Competence-creating versus exploiting
1. Introduction

Beginning in the mid-1980s, changes in the structure of the global economy as well as an apparent trend toward internationalization of R&D activities within major multinational firms motivated researchers to treat seriously the possibility that foreign subsidiaries could play a crucial role as sources of new ideas and capabilities (Frost, 2001; Zanfei, 2000). Attention has been increasingly focused on the emergence of the trend for MNCs to establish internal and external networks for innovation (Cantwell, 1989; Kuemmerle, 1999; Zander, 1999). The new approach, drawing heavily on an evolutionary view of the firm and industry (Nelson and Winter, 1982) supposes that the multinational corporation (MNC) offers a superior way of organizing technological activities that cumulatively interact both with local networks in each vicinity in which they are sited, and with cross-border knowledge exchange over its dispersed but interconnected international network. Therefore, internationalization is increasingly motivated also by the desire to tap into the capabilities available in host countries so as to benefit from localized knowledge spillovers (Cantwell, 1995; Boschma and Lambooy, 1999; Martin, 1999; Frost, 2001; Le Bas and Sierra, 2002; Zedwitz and Gassmann, 2002).

In this context, the new relevance of a continuous interaction in knowledge creation between cross-border MNC networks on the one hand and intra-border local networks on the other, makes it increasingly important to examine how the drivers of that interaction affect the location of innovative activity of MNCs. Now it has been observed that the local technological efforts of foreign-owned MNCs tend to be strongly agglomerated at a sub-national and regional level (Braunerhjelm and Svensson, 1998; Barrel and Pain, 1999). However, the choice by MNCs of where to establish subsidiaries, and the location-specific determinants of subsidiary functions have so far been mainly analysed at the country level (Håkanson, 1992; Fors, 1996; Kumar, 1996; Odagiri and Yasuda, 1996), and only a minority of studies have recently started to investigate their regional or sub-national dimension (Almeida, 1996; Cantwell and Iammarino, 2001; Carrincazeaux et al. 2001; Frost, 2001;
Cantwell and Piscitello, 2005). Yet other authors have recently highlighted the importance of the sub-national level in delimiting the boundaries of technological capabilities and expertise (Krugman, 1990, 1991; Porter, 1990; Storper, 1992), and hence in establishing the local networks or innovation systems with which MNCs interact.

Accordingly, in this paper we examine the determinants of the location at a sub-national regional level (we refer to the European regions in the period 1987-1995) of foreign-owned MNC technological activities. We take care to distinguish between subsidiary research contributions of the newer competence-creating [CC] kind (that introduce lines of capabilities which are new to their respective corporate groups), and those of the more conventional competence-exploiting [CE] kind (that tend to adapt lines of capabilities which are already familiar to their parent companies). While we allow for inter-industry knowledge spillovers, and externalities stemming from the local scientific and educational base, we focus on the effects of characteristics of local inter-firm networks within the same industry as each MNC.

In particular, our principal concern is with how two characteristics of firms within such networks - the role of insiders as opposed to outsiders, and the importance of the liabilities of foreignness as opposed to the advantages of multinationality - impact upon the likelihood of beneficial knowledge spillovers to foreign-owned MNCs that are present locally.

Hence, our central research question is how variations in the characteristics of local networks (the degree of cross-firm concentration or diversity in the relevant industry, and the relative presence of domestically-owned versus foreign-owned firms) affect the location of subsidiary research and development (R&D) facilities in each of the competence-creating and competence-exploiting cases. The analytical setting within which we examine this question is given by the evolution of the relationship between a local network and the international technology networks of MNCs. By considering how this relationship tends to evolve, we suggest the characteristics of local networks that are likely to create a more (less) favorable relationship with international networks, and those that are likely to be supportive (disruptive)
of beneficial knowledge spillovers from local actors.

There are at least four strands of literature that are relevant to our study, and upon which we draw. First, as mentioned at the outset, there is a recent but now well established literature on the distinction between competence-creating and competence-exploiting types of subsidiary R&D activity. It has been suggested that there is a qualitative difference in the nature of these two types of subsidiary R&D, and that accordingly they require different locational characteristics of the place in which the subsidiary responsible is sited (Kuemmerle, 1999; Pearce, 1999). While the more common adaptive or competence-exploiting R&D is primarily demand-driven, and so depends upon the size and extent of differentiation in local markets, instead competence-creating R&D is essentially supply-driven, and so depends upon the quality of human and institutional knowledge-based resources in a location. It follows that knowledge spillovers from the local science base are more likely to influence the latter type of subsidiary R&D than the former.

However, 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, it has become desirable to find a means of empirically separating out within subsidiaries that part of R&D which is competence-creating, as opposed to that which is competence-exploiting. We propose such a measure below, using the structure of patents that are generated by subsidiary R&D. Also, at least in the earlier research on the divergence of drivers of subsidiary R&D, the location in which the subsidiary was sited - and hence the spillovers received from that locality - was treated as essentially exogenous. Thus, the issue of the interactive nature of the relationship between MNC international technology networks and local networks of firms in the same industry was not addressed. Yet this issue has been raised in the second and third strands of literature, to which we turn now.

The second is quite a long standing literature on the tensions within MNC organizational
structures between the desirability of global integration and the benefits of local responsiveness, sometimes referred to as the integration-responsiveness (I-R) framework of analysis of the MNC (see especially Doz, Bartlett and Prahalad, 1981; Prahalad and Doz, 1987; Bartlett and Ghoshal, 1989; and Ghoshal and Westney, 1993). Since integration concerns the coordination of activity across the international network of the MNC, while the capacity for local responsiveness depends critically upon associations with actors in local networks, the I-R framework is very much about how these networks interact. However, in most studies conducted within this framework the focus of attention has been on how the internal organizational arrangements of the MNC have affected this interaction, and little has been said from the other side about the influence of the characteristics of local networks. This framework has also been used to distinguish within individual subsidiaries between competence-creating R&D that creates local innovations or diffuses them to other parts of the MNC network, and competence-exploiting R&D that facilitates the local adoption of innovations obtained from other parts of the MNC (Ghoshal and Bartlett, 1988). Yet in doing so, the issue has generally been how features of the MNC, such as the extent of subsidiary autonomy or the quality of intra-firm communication, have differentially affected these distinct categories of subsidiary innovation.

A third strand of literature has more recently connected the first two, and has emphasized more explicitly how the competence-creating type of subsidiary R&D strategy depends upon the embeddedness of a subsidiary within its own local network (Birkinshaw, Hood and Jonsson, 1998; Nobel and Birkinshaw, 1998; Andersson and Forsgren, 2000). More especially, some recent studies in this vein have recognized the role of firm heterogeneity - in the sense that individual firms contribute to the properties of local networks, as well as each deriving spillovers from these networks - and they have stressed that competitive interaction may offset the attractions of knowledge spillovers (Shaver and Flyer, 2000; Alcacer and Chung, 2003; Aharonson, Baum and Feldman, 2004). It has been argued that the clustering of
firms in local networks may suffer from the problem of adverse selection, since laggards have more to gain from knowledge spillovers, but leaders have more to lose from knowledge leakages.

However, we maintain below that it may be instead that leaders derive their strength in part from their greater capacity to embed themselves in local networks (as opposed to building their knowledge in isolation from others), in which case it will tend to be leaders that crowd out laggards in effective local networks rather than the other way round. Thus, we direct more attention to firm heterogeneity in the sense of whether firms can be regarded as insiders or as outsiders within local networks. While the concerns over the appropriability of knowledge suggest that leading firms will be inclined to avoid any cluster of others, the differential ability to establish strong social connections is more likely to be locally specific. So which firms emerge as the leaders in this respect, or in other words as the key insiders in a region, is likely to vary from one local network to another.

The fourth strand of literature that is pertinent here has addressed a special case of becoming (or failing to become) an insider in local networks. Drawing upon Hymer's (1960) notion that when they entered new markets MNCs would be subject to costs associated with the liabilities of foreignness, the internationalization process model of Johanson and Vahlne (1977) supposed that foreign-owned MNCs gradually overcame these liabilities by acquiring knowledge and learning through their international operations as they evolved. In other words, subsidiaries can become more successfully embedded in their respective local networks over time, and thereby increase their receptiveness to knowledge spillovers and their capacity to learn from differentiated others in their local environment. So insider or outsider status in local networks can be related to the nationality of ownership, as well as to the experience and commitment of firms to the local market. A more recent liabilities of foreignness literature (Zaheer, 1995; Zaheer and Mosakowski, 1997) has extended this argument. However, in this perspective the focus has been on the negative connotations of
foreignness. Although the notion that there may be compensating advantages to multinationality has long been understood (this was a key element in Hymer's original discussion), here we pay attention to the particular possibility that subsidiaries may be closer to insiders rather than outsiders when we consider foreign-foreign spillovers (between different subsidiaries) in local networks. This type of advantage of multinationality represents a kind of inverse liabilities of foreignness effect.

The empirical investigation uses patents granted in the US to the world’s largest industrial firms for inventions achieved in their European-located operations, classified by the host European region in which the research facility responsible is located. Specifically, we concentrate on corporate research activity in Germany, the UK, France and Italy, as they host almost the 75% of the total innovative activities carried out in Europe by foreign-owned firms in the period considered. The model developed aims to explain spatial patterns of activity by foreign-owned firms through variables related to the potential for intra-industry spillovers from local networks, controlling for random and cumulative agglomeration effects. The model is estimated through count data techniques.

The paper is organized in the following way. Section 2 sets out the conceptual framework and develops the hypotheses about the role of spillovers and externalities on MNC locational choice. Section 3 illustrates the measures adopted in order to distinguish between CE and CC strategies of foreign-owned MNCs. Section 4 sets out the econometric model and the variables employed in order to econometrically test the hypotheses, while Section 5 reports and discusses the results. Finally, Section 6 presents some summarizing and concluding remarks, and indicates an agenda for future research.

2. Technological activities of foreign-owned MNCs, spillovers and externalities

If one accepts that technological development is a complex, cumulative, tacit, highly context-specific activity that requires socially organized learning processes, it is clear that geographic
proximity and face-to-face contacts become highly important considerations when developing new technologies. In this context, recent streams of literature have emphasized the need for subsidiaries to form favourable local network linkages with other companies and institutions in their own local environment (Birkinshaw, Hood and Jonsson 1998, Andersson and Forsgren 2000). To become embedded in local networks subsidiaries require a measure of strategic independence, but to retain their position in their MNC's international network they have to utilize that independence as a means of leveraging local assets and connectedness to enhance the competitive advantages of their MNC group as a whole (Andersson, Forsgren and Holm 2002). Although technological activities of MNCs may tend to agglomerate partly due to a random and cumulative process (Ellison and Glaeser, 1997) essentially related to certain natural advantages, so far as local technological spillovers and externalities are concerned, we distinguish among three kinds (of which in this paper we focus upon the first):

(a) **Intra-industry spillovers and specialization externalities**

Intra-industry spillovers are associated with the presence of a wide-ranging collection of technologically active firms within a given industry or sector, all concentrated in a common geographical area (Baptista and Swann, 1998, 1999; Braunerhjelm et al., 2000). The kinds of linkages that grow up between competitors, suppliers and customers in any regional district or area are to some extent peculiar to that location, and imbue the technology creation of its firms with distinctive features. For these reasons, other MNCs often need to be on-site with their own production and their innovatory capacity if they are to properly benefit from the latest advances in geographically localized technological development, to feed their innovation (Cantwell, 1989; Kogut and Chang, 1991). Moreover, due to the complexity of technological learning, and the significance of maintaining face-to-face contacts, the localization of technological contacts tends to occur at a regional level within host countries (Jaffe et al., 1993; Almeida, 1996; Verspagen and Schoenmakers, 2000).

There are four types of determinants of intra-industry spillover effects that we can identify
from the literature, although these four are not always clearly distinguished. First, there is an 'insider effect' that depends on the extent to which the local firms with which subsidiaries interact are themselves insiders successfully embedded into local networks. Second, there is a 'liability of foreignness effect' that supposes that foreign-owned firms are essentially outsiders to local networks and so will encounter spillovers of a negative kind. Third, there is a 'local variety effect' that depends on the extent to which there is a sufficient variety of local firms (or potential sources of spillovers) with which foreign-owned subsidiaries can interact. Fourth, there is an 'advantage of multinationality effect' that is the inverse of the liability of foreignness, and concerns the ease with which connectivity can be established between local and international networks, in the present context for the purposes of knowledge exchange and integration.

A summary of the typology of intra-industry spillovers that we are postulating is shown in Figure 1. Distinguishing between those subsidiary level technological development strategies that are competence-exploiting (CE) as opposed to those that are competence-creating (CC), the four lower rightmost columns of the figure correspond to the four spillover effects just indicated. Thus, it is reasonable to suppose that firms which dominate a local area, in the sense of being responsible for a high proportion of the technological efforts of large firms in that location, will themselves be very much well connected insiders (with other firms and other actors) in that region. So the third lower column of the figure (the fourth from the right) illustrates the insider effect, while the next column to the right shows the special case in which these insiders are also predominantly domestically-owned, which will bring into play the liability of foreignness effect. When instead the firms with which foreign-owned subsidiaries interact in a local area are non-dominant in the sense just described, then there is a greater variety of potential sources of spillovers, giving rise to the local variety effect in the penultimate column. If further many of these locally present firms with which subsidiaries interact are themselves other foreign-owned subsidiaries that also need to balance their
involvement in local networks with international connections of their own, then we have an advantage of multinationality effect shown in the final column to the right.

In what follows we develop five more specific hypotheses (H1-H5) from a discussion of the four spillover effects that we have described. In so doing, as should already be apparent, we attempt to distinguish between on the one hand insider-outsider and inter-firm variety effects that derive from the degree of concentration of technological activity in a host location, and on the other hand nationality of ownership effects. This is a key contribution of the paper, as this distinction has not been made before in the context of research on MNC innovation. A further key contribution is that in terms of the strategic distinction between CE and CC activities, 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 (eg. Pearce, 1999; Kuemmerle, 1999).

Considering first the insider effect, as argued earlier the recent subsidiary level literature has stressed that the ability of a foreign-owned subsidiary to tap into the knowledge sources of an area depends upon its becoming locally embedded in that region (Birkinshaw, Hood and Jonsson 1998, Andersson and Forsgren 2000). However, to achieve this aim it is critical that the other local firms with which the subsidiary can transact are themselves locally embedded with other actors and institutions in that vicinity. If these firms dominate corporate capability generation in an area then it is very likely that they have a high commitment to the area and that they are strongly embedded in the region, since the success of such local networks would have been a condition for them to develop a dominant position. Conversely, firms that are not so locally dominant are likely to be less committed or tied to the area, and to be less well embedded and more weakly integrated into local networks.

In this context the insider effect is associated with positive knowledge spillovers, since insiders are better connected with the sources of local expertise that foreign-owned
subsidiaries wish to access, and so they facilitate the transmission of local knowledge to foreign-owned companies. However, this argument applies far more to CE activities, in which the knowledge required has to do with the ease of adaptability of products and processes to local conditions, than it does to CC activities, in which what is sought is novel innovative ideas that are more difficult to communicate short of direct and intensive contacts with the relevant source. In the latter case the relative sparsity of alternative sources of locally-specific ideas (given that the firms in question are dominant) may further restrict the availability of such positive spillovers. Hence, we hypothesize that:

*H1: The presence in a region of a higher level of research activity by locally dominant firms in the same industry as foreign-owned firms will tend to increase the amount of CE technological development undertaken by foreign-owned companies in that region.*

Yet this effect leaves out of account a more widely discussed counter-effect when the locally dominant firms in question are domestically-owned. That is, if local networks consist essentially of domestically-owned and controlled insiders, then foreign-owned subsidiaries may find it difficult to connect to these networks and so may suffer a liability of foreignness (Zaheer, 1995; Zaheer and Mosakowski, 1997). It is important to understand that this effect is not the unavoidable consequence of simply being foreign as such - if foreign-owned subsidiaries have been in a location sufficiently long enough and have evolved to hold a substantive share of activity (so some may have themselves become locally dominant), then they can become insiders too (Eden and Molot, 2002). Yet acquiring the contacts and building up the degree of trust needed to effectively engage in local networks takes time, and is more difficult the greater is the institutional distance between the host region and the headquarters location of the firm.

However, there are two potential types of liability of foreignness effect, one that operates more on the demand side and the other on the supply side, that have not usually been distinguished. The main reason why these effects are not usually separated is that it is
empirically difficult to do so, but an advantage of our approach is that it allows us to make this distinction. That aspect which is typically recognized and operates on the demand side is the competition effect that is driven by the insider status of domestically-owned firms, whose local network linkages tend to operate at the expense of any new foreign-owned company with a different as yet unconnected set of cross-border networks (although the conventional spillover literature looks the other way at the impact of foreign-owned firms on indigenous companies, it acknowledges a competition effect from the output of subsidiaries that erodes the market shares of local firms - see eg. Aitken and Harrison, 1999; Driffield, 2001). Since the competition effect falls mainly on demand-oriented activity, it affects principally CE efforts. When instead the motive of subsidiary activity is more to access local streams of innovation and to globally integrate complementary knowledge, then the competition effect is less pronounced (given the international market orientation of CC activities), but there is still a gravitational pull effect on resources exercised by the dominant and better connected local companies that implies a lack of potential linkages for spillovers for newcomers. So we have:

**H2:** In regions that are more highly populated by domestically-owned firms, a higher level of research activity by locally dominant firms in the same industry as foreign-owned firms will tend to reduce the amount of CE technological development undertaken by foreign-owned companies in that region (owing to a local market competition effect).

**H3:** In regions that are more highly populated by domestically-owned firms, a higher level of research activity by locally dominant firms in the same industry as foreign-owned firms will tend to reduce the amount of CC technological development undertaken by foreign-owned companies in that region (owing to a gravitational pull on local resources).

The third effect we are considering is a local variety effect. While locally dominant firms tend to be well connected insiders in a region their very dominance may also restrict the access to local knowledge of foreign-owned subsidiaries. Conversely, locally non-dominant firms tend to be less well embedded in a region, but they potentially provide foreign-owned subsidiaries...
with a greater variety of sources of local knowledge with which to interact, and so can create a greater diversity of opportunities for spillovers. This is consistent with the geographical cluster literature referred to above (e.g., Baptista and Swann, 1998), and also with the proposition in evolutionary economics that adequate variety is essential to learning and progress over time (Nelson and Winter, 1982; Saviotti and Mani, 1996; Metcalfe, 1998). However, this effect is more likely to be relevant in the case of CE activities, when what is at stake for foreign-owned subsidiaries is to search the environment for locally-specific knowledge that can be used to adapt products and processes to local conditions. This is consistent with the contention that there are benefits to co-locating with others that have already incurred investments in local product differentiation (Canina et al, 2005). For CC activities, the weaker connectivity of other large firms with key local actors may constrain the potential usefulness of local variety. Thus, we hypothesize:

**H4:** The presence in a region of a higher level of research activity by locally non-dominant firms in the same industry as foreign-owned firms will tend to increase the amount of CE technological development undertaken by foreign-owned companies in that region.

Lastly, the advantage of multinationality is an effect that is associated with the ability to better establish connectivity between local and international networks, the importance of which has been a focus of attention in the international business literature for the last 20 years (Hedlund, 1986; Bartlett and Ghoshal, 1989). The advantage of multinationality effect is a counterpoint to the liability of foreignness (Nachum, 2003). When foreign-foreign firm spillovers are the issue, the local actors are typically as well connected with international networks as they are with local networks, and so they have already established (or at least are in the process of trying to establish) the potential for learning what is available locally by outsiders. However, this argument only applies in the case of CC activities, in which the objective is to connect local with international sources of knowledge inputs into competence creation. In the case of CE activities, other foreign-owned subsidiaries may rely on adaptation
that derives in part from their corporate group elsewhere and so has less locally-specific content. So in the lower far right hand cell of Figure 1, the availability of innovative opportunities for learning in a local-global context generates strong knowledge spillovers, or in other words:

**H5:** In regions that are more highly populated by foreign-owned firms, a higher level of research activity by locally non-dominant firms in the same industry as foreign-owned firms will tend to increase the amount of CC technological development undertaken by foreign-owned companies in that region.

(b) **Inter-industry spillovers and diversity externalities**

Inter-industry spillovers are associated with the co-presence of firms from different industries, and active in different fields of research (with, of course, a few points of overlap, typically in fields of general purpose technologies that are common to multiple industries). Indeed, the more diverse the R&D conducted in the region is, the more the firm could potentially benefit. Such spillovers relate to diversity externalities, which favour the creation of new ideas across sectors, and go back to the concept of “urbanization economies” originally suggested by Jacobs (1969). They are more likely to occur in an all-round 'higher order' centre of excellence, which facilitates a more favourable interaction with indigenous firms, and greater opportunities for inter-company alliances for the purposes of technological collaboration and exchange (Cantwell and Lammarino, 2001, 2003). Moreover, there is some evidence relating to cities in the US that diversity across industries may better promote innovation and knowledge spillovers (Feldman and Audretsch, 1999).

**H6:** The greater is the cross-industry diversity of technological development in a region, the higher the attraction of both CE and CC technological development in foreign-owned firms.

(c) **External sources of knowledge, and science-technology spillovers**

The efforts of firms to advance technology do not generally proceed in isolation, but are strongly supported by various external sources of knowledge: public research centres,
universities, industry associations, an adequate education system and science base, as well as other firms (Kline and Rosenberg, 1986; Nelson, 1993; Rosenberg and Nelson, 1996; Nelson and Rosenberg, 1999; Breschi, 2000). There is growing evidence, so far mainly from the US, that the science-technology or university-industry linkages component of these influences from a firm's environment tend to be geographically localized (Jaffe et al, 1993; Audretsch and Feldman, 1996; Audretsch and Stephan, 1996; Acs et al., 2000; Adams, 2001). This is especially likely to be true of foreign-owned firms in an economy, which tend to have a greater degree of locational mobility when siting their corporate research, and so pay greater attention to being close to relevant public research facilities (see Görg and Strobl, 2001, on the greater international locational mobility of MNCs).

For our purposes, we are concerned to distinguish between the CC versus CE technological activities of MNCs, when examining the locational pull of a stronger local science base. We expect that CC activities are the ones that benefit from proximity to better local science and educational facilities (Kuemmerle, 1999). Indeed, developing new competencies requires CC facilities that are based in the most appropriate location for a given activity, selected from amongst centres in the growing number of locations that have become reputable players in the science and technological arena or which are technology leaders (Criscuolo et al., 2002). When the motivation for locating technological activity overseas is instead to facilitate the customization or adaptation of existing products and technologies to local market needs (CE activities), the process is stimulated mainly by host country demand and local market conditions.

*H7: The greater is the public sector science, R&D and education in a region, the higher the attraction of CC technological development in foreign-owned firms.*
3. CE and CC activities of foreign-owned MNCs’ in the European regions

In order to analyse the location of foreign-owned research activities at the regional level in Europe, we make use of the Eurostat scheme of classification - the Nomenclature of Territorial Units for Statistics (NUTS). The NUTS classification is based on the institutional divisions currently in force in member states, according to the tasks allocated to territorial communities, to the sizes of population necessary to carry out these tasks efficiently and economically, and to historical, cultural and other factors. Specifically, to provide a single uniform breakdown of territorial systems we used the NUTS 2 level for the four countries considered. The NUTS 2 level (206 Basic Regions) is generally used by the EU members for the application of their regional policies, and thus is the most appropriate level at which to analyse the regional distribution of technological activities (for a description of the pattern of R&D activities of foreign-owned MNCs in the European regions see Cantwell and Iammarino, 2003, and Cantwell and Piscitello, 2005).

Corporate research activity is measured by using patents granted in the US to the world’s largest industrial firms for inventions achieved in their European-located operations, classified by the host European region in which the research facility responsible is located (see Appendix 1 for a brief description of the database).

So far as the distinction between CE and CC activities is concerned, it is worth observing that any given facility, ceteris paribus, may perform both CE and CC functions (Zander, 1999). Indeed, any given subsidiary has a need for a variety of technologies, and any given host location (region) may possess a relative technological advantage in one area, but be relatively disadvantaged in another. Thus, an MNC in a given region 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 distribution across technological fields of each MNC’s technological activity carried out at
home with the distribution of its activity in each European region considered. Whenever the
firm's activity in field k in some region is responsible for a higher share of its patenting
emanating from that region than the share of the equivalent activity in the firm's patenting
from home research, we define it as a diversification; conversely, non-diversification occurs
when the technological activity of a foreign-owned firm in a region appears to be no more
than a supporting extension of what is already carried out by its parent company at home, in
that the share of locally originated patenting accounted for by a field at home is greater than
or equal to that in a given foreign location. Specifically, we proceeded as follows: let $P_{fh}$ be
the total number of home patents (h) for firm $f$, and $P_{fhk}$ the number of home patents in
 technological field k; likewise, $P_i$ is the total patents of firm $f$ in region i, and $P_{ik}$ the number
of patents in region i and field k. Then, if the share of home patents in field k (i.e. $P_{fhk}/P_{fh}$) is
greater than or equal to the equivalent share in region i (i.e. $P_{ik}/P_i$), we define firm $f$ as
carrying out CE activity in region i in field k; while if instead the reverse applies, then firm $f$
is treated as performing CC technological activity. Thus, by definition each firm has some
mix of CE and CC activities in each of the regions in which it is involved (unless the cross-
field distribution of activity happens to be identical to that in the home country).

4. The econometric model and specification of the variables used

As the phenomenon under study is the siting of foreign-owned research activities across
European regions by the category of activity, we considered the following two dependent
variables:

$\text{FORPAT}_{-\text{CEij}} = \text{number of patents granted to the foreign-owned MNCs of industry j for}
research activity carried out in region i over the period considered (1987-1995), and defined
as representing a more limited extension of the activities carried out by the parent company at
home.
FORPAT_CC\textsubscript{ij} = number of patents granted to the foreign-owned MNCs of industry \textit{j} for research activity carried out in region \textit{i} over the period considered (1987-1995), and defined as representing a diversification of the activities carried out by the parent company at home. \textit{i} = 1, \ldots, 116 regions (38 for Germany, 35 for the UK, 22 for France, and 21 for Italy); \textit{j} = 1, \ldots, 17 industries.

As the dependent variables are count variables, binomial regressions model were fitted to the data.\textsuperscript{7} Indeed, this kind of linear exponential model offers an improved methodology for count models in the case of patents and innovation counts (Cameron and Trivedi, 1998). The independent variables employed relate to the expectations drawn up in Section 2. It should be noted that, in order to rule out endogeneity problems, lagged independent variables have been used. These have been taken from the period 1969-1977, according to the following definitions:

(a) \textit{Intra-industry spillovers and specialization externalities}. The variable adopted as a proxy for intra-industry spillovers and specialization externalities is a measure of technological specialization of each region \textit{i} in each industry \textit{j}. The proxy is derived from the Revealed Technological Advantage (RTA\textsubscript{ij}) index of specialization, which allows us to control for inter-sectoral and inter-regional differences in the propensity to patent (Cantwell, 1995). In particular, as some differences in foreign-owned MNCs' location behaviour may arise when intra-industry spillovers originate from a long established presence of dominant firms, we distinguished technological specialization due to the activities of locally dominant companies (defined as companies having a share over 25\% of patenting in their industry that derives from development efforts in that region)\textsuperscript{1} from technological specialization due to the

\textsuperscript{1} It is worth noting that a sensitivity analysis was conducted, considering other threshold points. However, for the sake of simplicity, we report only that threshold leading to most significant estimation results, since alternative thresholds did not alter the basic structure of the findings.
activities of the other non-dominant firms (DOMIN_SPEC_{ij} vs. NONDOMIN_SPEC_{ij}). Specifically, RTA_{ij} is defined as follows:

$$RTA_{ij} = \frac{P_{ij} / \sum_j P_{ij}}{\sum_i P_{ij} / \sum_{ij} P_{ij}}$$

where P_{ij} is the number of patents by firms located in region i and belonging to industry j. The index varies around unity, such that values greater than one suggest that a region is comparatively advantaged in the sector of activity in question relative to other regions, while values less than one are indicative of a position of comparative disadvantage.

Moreover, dominant firms are more likely to be domestically-owned as dominance has to do with the length of involvement in, and the degree of commitment and maturity of the linkages with other actors in the area. Therefore, we introduced the share of domestically-owned (DOM_SH_{ij}) vs. foreign-owned activity (FOR_SH_{ij} = 1-DOM_SH_{ij}) in the region, and considered the interaction effect in the model.

(b) Inter-industry spillovers and diversity externalities. The variable adopted as a proxy for inter-industry spillovers and diversity externalities (DIVERSITY_{i}) relates to the breadth of technological development in a region creating the opportunity for inter-industry exchanges. Specifically, DIVERSITY_{i} has been measured by the inverse of the coefficient of variation over the profile of regional technological specialization across technological fields (DIVERSITY_{i} = \mu_{i}/\sigma_{i}). The profile of regional technological specialization is measured by the RTA index, RTA_{ik}, in region i and technological field k (where k = 1, ..., 56). Therefore, RTA_{ik} is a proxy for specialization of region i across technological fields k, and is calculated for this purpose in the following way:

$$RTA_{ik} = \frac{P_{ik} / \sum_k P_{ik}}{\sum_i P_{ik} / \sum_{ik} P_{ik}}$$

where: P_{ik} = number of patents granted in field k to firms for research in region i.

It should be noted that patents associated with some field k may be due to firms in any industry j, and so widespread regional technological development across a broad range of
fields k is usually indicative of the existence of areas of technological overlap between industries, and hence indicates the scope for technological spillovers between industries.

A remark on the interpretation of the proxy employed (i.e. the coefficient of variation) may not be out of place here. When $CV_i$ is low, the cross-sectoral distribution of RTA$_i$ is widely dispersed, that is the profile of the comparative technological advantage of region $i$ is highly diversified across fields, and not highly concentrated in some activities rather than others. On the other hand, when $CV_i$ is high, the RTA distribution is highly concentrated in certain fields and the degree of diversification of the region will be low. Thus, $CV_i$ constitutes an inverse measure of the extent of technological diversification of the region.

(c) External sources of knowledge and science-technology spillovers. In order to capture the complex character of local knowledge externalities, we considered several proxies for non-corporate R&D activities, and for the education level in each region. Specifically, the proxies used are the following:

R&D$_i$ measures the R&D employment in the public sector in each region $i$.

EDUCATION_HIGHI$_i$ measures the number of full-time and part-time pupils and students in higher education level in each region $i$, while EDUCATION_TOTAL$_i$ measures the total number of full-time and part-time pupils and students in each region $i$.

Control variables

The bulk of the analysis of overseas R&D argues that locational determinants related to the size and the characteristics of the local market have a positive and significant influence upon affiliate R&D location (Zejan, 1990; Kumar, 1996, 2001; Braunerhjelm et al., 2000). Therefore, we included GDPPC$_i$, measured by the GDP per capita in each region $i$ in 1992, as a control variable.

In order to control for any random cumulative mechanism and for the strong path-dependent character of technological agglomeration, we also included among the explanatory variables the relevant lagged dependent variables, calculated for the period 1969-1977.
Finally, since the use of absolute numbers of patents as a dependent variable poses difficulties associated with systematic differences in the propensity to patent across industries and countries, this has been circumvented by adding industry and country dummies to the specification of the model. Other conditions, like the availability of skilled labour in an area, the financial and fiscal context, the regulatory and legal environment, the intellectual property regime, might make a region an appealing location for foreign MNCs’ investment in research. Unfortunately, such data are not available at the European regional NUTS2 level.

5. Empirical findings

The empirical findings obtained from the estimations are reported in Table 1. The table shows both the most general and the best specifications of the model for FORPAT_CC and FORPAT_CE. Numbers in parentheses represent z-statistics. The interpretation of the negative binomial model follows the normal pattern: positive, significant values indicate that an increase in the variable in question increases the odds that foreign-owned research activity of the relevant kind is localized in the particular combination of region i and sector j, ceteris paribus. Negative values indicate the reverse.

Overall, the results confirm that the location of the innovative activities of MNCs is cumulative and path-dependent (the variable allowing for the pre-existing amount of foreign-owned patents, i.e. the temporally lagged variable FORPAT, is always positive and significant at p<.01 in both the CE and CC models), as well as strongly and positively influenced by both intra- and inter-industry spillovers, thus confirming that the two effects do actually work together (Paci and Usai, 2000; Cantwell and Piscitello, 2005).

Inter-industry spillovers (DIVERSITY) come out as positive and always highly significant (at p<.01), thus confirming (H6) that diversity externalities provide a region with a higher likelihood to attract the technological activities of foreign-owned MNCs, whether of the CE or CC variety. Intra-industry spillovers require instead a more intricate discussion. The
estimates obtained generally confirm our hypotheses (H1-H5) on the determinants of intra-industry spillovers, as developed in Section 2. In particular, when the technological strength of the region stems essentially from a long established presence of locally dominant firms, we find positive spillovers especially for CE activities (the variable DOMIN_SPEC is always positive in both the models, but highly significant, at p<.01 only in the CE models), thus confirming H1. However, if the region is more highly populated by domestically-owned firms, technological activities undertaken by foreign-owned MNCs (both CC and CE types) will be hampered by the “liability of foreignness effect” (the sign of the multiplicative variable DOMIN_SPEC*DOM_SH is always negative and significant at p<.01), thus providing support for both H2 and H3.

Conversely, when technological activities in the region do not pertain exclusively to locally dominant firms, they might provide foreign-owned subsidiaries with a greater variety of sources of local knowledge. As hypothesized in H4, this tends to increase the amount of CE technological development undertaken by foreign-owned MNCs (the variable NONDOMIN_SPEC comes out positive and significant at p<.10 only in the CE equations). However, consistently with H5, when the local scene is mainly populated by foreign-owned companies that are connected with international networks as well as they are with local ones, other foreign-owned MNCs might find some advantage in locating there their CC activities, but not their CE ones (the multiplicative variable NONDOMIN_SPEC*FOR_SH is positive and significantly different from zero only in the CC model, while it never comes out as significant in the CE one).

So far as spillovers related to local external sources of knowledge are concerned, the relevant variables are highly correlated and therefore they have to be considered with some care. However, all the estimates obtained show (in support of H7) that both the R&D employment in the government sector sustained locally, as well as the educational base constitute a significant pull factor only for foreign-owned MNCs when developing CC activities.
Concerning the impact of the GDP variable, it seems to be an important pull factor both in the CE and CC cases (it is always positive and significant at least at p<.10). This suggests that this variable acts as much as a proxy for the extent of local skills and productivity as it does for demand conditions, and therefore positively influences CC as well as CE activities.

6. Summary and conclusions
Since the late 1970s, large MNCs have increasingly extended or diversified their fields of technological competence through their use of internationally integrated networks for technological development. In each location in such a network MNCs tap into specialized sources of local expertise, and so differentiate their technological capability, by exploiting geographically separate and hence distinct streams of innovative potential. Our results support (in line with some other recent contributions, such as that of Frost 2001) a widely debated conjecture in the multinational literature, namely that foreign direct investment may be driven, at least in part, by the desire to gain knowledge from the diverse institutional contexts in which multinational firms operate. Thus, the first contribution of our paper is to distinguish effectively at an intra-subsidiary level that CC component of subsidiary technological efforts that builds upon sources of knowledge found in local competence-creating networks (as opposed to the CE element of subsidiary technological activities that simply adapts competences familiar to the MNC group and its parent company). Previous studies of this aspect of MNC technology strategies have reasoned instead at the level of subsidiary mandates, in which subsidiaries with significant CC activities are distinguished from subsidiaries that lack such activities.

The second key contribution of the paper is the detailed sub-division that we have proposed of intra-industry spillover effects, which we believe is novel. Our typology of such spillovers...
combines effects that others have discussed but sometimes mixed up with one another, and allows us a means of separating out these different effects. We might have expected from earlier work the effect that we find on the technological efforts of foreign-owned MNCs that are engendered by the breadth of local technological activities in the region, that is the opportunity to enjoy diversity externalities and to capture inter-industry spillovers. Yet it is surely important to have an integrated framework for intra-industry spillovers of the kind that we have also set out which separates insider effects that have to do with the degree of cross-firm concentration of local development efforts from liability of foreignness effects; within the liability of foreignness to distinguish between the rather different market-based competition effect and the resource-based gravitational pull effect; and to establish the balance between liability of foreignness effects and the advantage of multinationality effect. In particular, we have shown how co-locating with dominant companies that are key insiders to local networks may confer positive benefits from knowledge spillovers for subsidiaries, and these partly offset the more frequently discussed costs from the liability of foreignness. Within the liability of foreignness effects, it is important to distinguish between the market-related constraints on CE activities imposed by the competition effect of dominant indigenous players, and the limitations on the accessibility of knowledge spillovers to CC activities that result from the gravitational pull effect of dominant domestic firms. However, with regard to CC activities, there is an advantage of multinationality effect enjoyed by foreign-owned subsidiaries that are mutually non-dominant in a local area. Co-located subsidiaries can more effectively transmit knowledge to one another from their CC efforts, owing to their common endeavor to connect what they learn locally to exchanges within their respective international networks. Indeed, if there are costs associated with codifying and translating knowledge for the purpose of sharing with their international networks, the knowledge that passes between subsidiaries in an area may be more mutually useful and less costly to convert.
A third contribution of the paper is to confirm the effect on CC activities of the presence of external sources of knowledge and science-technology spillovers. By differentiating between CC and CE activity at an intra-subsidiary level as we have done, we have provided evidence that local science-pull and skill-pull influences not merely subsidiary mandate decisions, but can affect the distribution of technological activity within most or all subsidiaries. The extent to which this does indeed apply across all subsidiaries (and not just as an average effect) would be interesting to explore further in future research.

It would also be interesting to examine further the findings on the competition or congestion effect due to local indigenous firms, which tend to be more consolidated and tightly linked with local players. In fact, in order to better capture this effect, it would be best to include a time dimension, i.e. the age, duration or length of local presence in the region, and the resultant degree of local interconnectedness. The lack of historical data at the firm level currently hinders this goal, but conducting a study at the firm level would allow us to get closer to achieving this objective. Such investigations may enable us to deepen our appreciation of the overall typology of intra-industry spillover effects that we have mapped out here.
References
Adams J.D. (2001) Comparative localisation of academic and industrial spillovers, WP 8292, NBER.


Figure 1: The Typology of Intra-Industry Spillovers

<table>
<thead>
<tr>
<th>Orientation of local technological effort</th>
<th>Intra-industry interaction with</th>
<th>Locally dominant firms</th>
<th>Locally non-dominant firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>In regions relatively more populated by domestically-owned firms</td>
<td>Overall</td>
<td>In regions relatively more populated by foreign-owned firms</td>
</tr>
<tr>
<td>CE</td>
<td>Actors strongly locally embedded (H1: +)</td>
<td>Competition effect (H2: -)</td>
<td>Actors weakly embedded, but variety of local adaptation (H4: +)</td>
</tr>
<tr>
<td>CC</td>
<td>Few sources of competence-creating spillovers</td>
<td>Gravitational pull effect (H3: -)</td>
<td>Weaker local networks for competence creation</td>
</tr>
<tr>
<td></td>
<td>Competence creating (Dependent variable: FORPAT_CC)</td>
<td>Competence exploiting (Dependent variable: FORPAT_CE)</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>-1.26 (-3.52) ***</td>
<td>-1.41 (-3.92) ***</td>
<td>-1.23 (-3.42) ***</td>
</tr>
<tr>
<td>FORPAT1_CC, FORPAT1_CE</td>
<td>0.03 (8.56) ***</td>
<td>0.03 (8.82) ***</td>
<td>0.03 (8.69) ***</td>
</tr>
<tr>
<td>DOMIN_SPEC</td>
<td>0.08 (1.68) *</td>
<td>0.07 (1.48)</td>
<td>0.06 (1.41)</td>
</tr>
<tr>
<td>NONDomin_SPEC</td>
<td>-0.02 (-0.47)</td>
<td>-0.02 (-0.50)</td>
<td>-0.02 (-0.44)</td>
</tr>
<tr>
<td>DOMIN_SPEC*DOR_SH</td>
<td>-0.19 (-3.14) ***</td>
<td>-0.18 (-2.95) ***</td>
<td>-0.18 (-2.97) ***</td>
</tr>
<tr>
<td>NONDomin_SPEC*FOR_SH</td>
<td>0.21 (2.22) **</td>
<td>0.22 (2.32) ***</td>
<td>0.22 (2.30) **</td>
</tr>
<tr>
<td>DIVERSITY</td>
<td>187.69 (7.74) ***</td>
<td>164.25 (6.31) ***</td>
<td>166.64 (6.30) ***</td>
</tr>
<tr>
<td>EDUCATION_TOT</td>
<td>0.00 (3.70) ***</td>
<td>0.00 (3.93) ***</td>
<td>0.00 (1.72) *</td>
</tr>
<tr>
<td>EDUCATION_HIGH</td>
<td>0.00 (3.93) ***</td>
<td>0.00 (3.57) ***</td>
<td>0.01 (1.78) *</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>0.01 (4.17) ***</td>
<td>0.01 (3.42) ***</td>
<td>0.01 (3.70) ***</td>
</tr>
<tr>
<td>GDPPC</td>
<td>-0.77 (-4.64) ***</td>
<td>-0.18 (-1.12)</td>
<td>-0.36 (-2.34) **</td>
</tr>
<tr>
<td>UK</td>
<td>-0.80 (-3.37) ***</td>
<td>-0.30 (-1.52)</td>
<td>-0.34 (-1.74) *</td>
</tr>
<tr>
<td>ITALY</td>
<td>-0.76 (-4.85) ***</td>
<td>-0.22 (-1.41)</td>
<td>-0.43 (-2.95) ***</td>
</tr>
<tr>
<td>GERMANY</td>
<td>0.05 (0.15)</td>
<td>0.17 (0.56)</td>
<td>0.14 (0.45)</td>
</tr>
<tr>
<td>D1</td>
<td>1.79 (6.52) ***</td>
<td>1.88 (6.79) ***</td>
<td>1.86 (6.70) ***</td>
</tr>
<tr>
<td>D2</td>
<td>1.18 (4.05) ***</td>
<td>1.26 (4.27) ***</td>
<td>1.25 (4.26) ***</td>
</tr>
<tr>
<td>D3</td>
<td>0.65 (2.27) **</td>
<td>0.75 (2.61) **</td>
<td>0.74 (2.57) **</td>
</tr>
<tr>
<td>D4</td>
<td>1.22 (4.33) ***</td>
<td>1.29 (4.55) ***</td>
<td>1.28 (4.51) ***</td>
</tr>
<tr>
<td>D5</td>
<td>1.80 (6.42) ***</td>
<td>1.87 (6.64) ***</td>
<td>1.86 (6.62) ***</td>
</tr>
<tr>
<td>D6</td>
<td>1.27 (4.26) ***</td>
<td>1.36 (4.54) ***</td>
<td>1.32 (4.43) ***</td>
</tr>
<tr>
<td>D7</td>
<td>1.16 (4.09) ***</td>
<td>1.23 (4.30) ***</td>
<td>1.25 (4.37) ***</td>
</tr>
<tr>
<td>D8</td>
<td>-0.04 (-0.13)</td>
<td>0.05 (0.16)</td>
<td>0.00 (0.01)</td>
</tr>
<tr>
<td>D9</td>
<td>-42.79 (-0.00)</td>
<td>-43.40 (-0.00)</td>
<td>-42.69 (-0.00)</td>
</tr>
<tr>
<td>D10</td>
<td>-2.07 (-4.46) ***</td>
<td>-2.46 (-4.55) ***</td>
<td>-2.28 (-4.49) ***</td>
</tr>
<tr>
<td>D11</td>
<td>0.18 (0.47)</td>
<td>0.37 (0.98)</td>
<td>0.33 (0.86)</td>
</tr>
<tr>
<td>D12</td>
<td>-1.89 (-5.02) ***</td>
<td>-1.76 (-4.66) ***</td>
<td>-1.73 (-4.57) ***</td>
</tr>
<tr>
<td>D13</td>
<td>0.84 (2.83) ***</td>
<td>0.91 (3.07) ***</td>
<td>0.93 (3.12) ***</td>
</tr>
<tr>
<td>D14</td>
<td>0.57 (1.99) **</td>
<td>0.65 (2.24) **</td>
<td>0.65 (2.23) **</td>
</tr>
<tr>
<td>D15</td>
<td>0.39 (1.16)</td>
<td>0.52 (1.55)</td>
<td>0.48 (1.45)</td>
</tr>
</tbody>
</table>

Log likelihood   -2721.55   -2719.77   -2721.55   -914.74   -915.80   -915.29
Restr. log likelihood  -18795.38 -18795.38 -18795.38 -5261.23 -5261.23 -5261.23
LR statistic (29 df) 32147.67 32151.22 32147.67 8692.99 8690.86 8691.88
LR index (Pseudo-R2) 0.86 0.86 0.86 0.83 0.83 0.83
Notes: Numbers in brackets are z–statistics. *** significant at p<.01; ** significant at p<.05; * significant at p<.10
APPENDIX 1- The database

The database used for the study consists of patents granted in the US to the world’s 792 largest industrial firms as of 1982, derived from both the Fortune 500 US and the Fortune 500 non-US firms listings (Dunning and Pearce, 1985). Of these 792 companies 730 had an active patenting presence during the period 1969-1995. Another 54 historically significant firms were added to these, making 784 corporate groups in all. The additions include (mainly for recent years, but occasionally historically) enterprises that occupied a prominent position in the US patent records, some of which are firms that were omitted from Fortune’s listing for classification reasons (e.g. RCA and AT&T were classified as service companies), and others that reflect recent mergers and acquisitions or new entrants to the population of large firms. Patents have been consolidated at the level of the international group of ultimate ownership, allowing for changes due to mergers and acquisitions since 1982. For patents that are attributable to research facilities located in selected European countries we have identified the precise (sub-national) regional location of research.

The use of corporate patents as an indicator of advanced technological capacity and the ability to develop innovation is one of the most established and reliable methods of estimating the cross-sectional patterns of innovative activities. The advantages and disadvantages of using patent statistics are well known in the literature (Pavitt, 1985, 1988; Griliches, 1990). Some of the best known problems are that not all innovations are patented, not all patents are commercialised, and that the so-called propensity to patent varies by industry. Nevertheless, most surveys of these issues tend to conclude that patent statistics can be useful indicators (Verspagen and Schoenmakers, 2002). For example, as a conclusion of an analysis comparing innovation count data and patent data as indicators of innovation at the regional level for the USA, Acs et al. (2000, p. 1080) conclude that their “empirical evidence suggests that patents provide a fairly reliable measure of innovative activity”.

The use of patent records provides information on both the owner of the invention (from which the country of location of the ultimate parent firm has been derived through a consolidation of patents at the level of international corporate group) and, separately, the address of the inventor, thus allowing the identification of where the R&D underlying the invention was carried out in geographical terms. Therefore, each patent has been associated with a NUTS code, according to the location of the first-named inventor of each patent attributable to research in the EU countries. Moreover, patents can be classified by detailed technological fields, which would not otherwise be possible by using other common indicators (such, for example R&D expenditures). Finally, it is worth observing that the choice of US patenting is convenient, since large firms are especially prone to patent their best quality inventions in the US market, the largest and the most technologically advanced, following more extensive testing in their respective home markets. It is therefore more likely that our data reflect the patenting of inventions that have a significant commercial importance.