

STICKY PLACES IN SLIPPERY SPACE - THE LOCATION OF INNOVATION
BY MNCs IN THE EUROPEAN REGIONS

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Abstract

Evidence of tighter cross-border corporate integration of innovation coupled with heightened intra-border/inter-company exchange of knowledge renders it increasingly pertinent to investigate the precise nature and location of MNC technological activities. Whilst such new structures for innovation are a natural consequence of the globalisation process, certain shocks have served to accentuate this process. As a result of closer European integration, greater interdependency among MNC units in the EU provides us with a unique testing ground for analysing such phenomena. Drawing upon the results from three prior studies in the area, this paper presents a comparative analysis of the location patterns of multinational firms' innovative activities in the UK, Italy and Germany.

The basic premise of these studies is that there exists a hierarchy of research centres within and across EU economies. This is explored by examining the precise technological profile of foreign-owned firms located within regional centres of excellence. By investigating the degree to which these profiles complement the existing knowledge base within regions, we differentiate between higher and lower order research locations. This differentiation enables us to distinguish between the form of potential knowledge spillovers and technological networks in operation between foreign-owned firms and their indigenous counterparts in different regions in Europe. Our results support the thesis that the geographical distribution of technological innovation is highly concentrated within the three economies. There are however significant cross-regional variations in the sectoral distribution of technological activity which points to a very clear dichotomy between higher and lower research centres in the nature of interaction between local and international corporate knowledge exchanges.

Introduction

The changing nature of international production and business more generally, means that the competitive advantage of firms lies increasingly in their ability to create a coherent set of new capabilities and source technological knowledge internationally (Cantwell, 1989; Teece et al., 1994; Cantwell and Piscitello, 1999a). Although the majority of multinational corporations (MNCs) continue to locate a large proportion of their R&D in the home country, it is widely acknowledged that MNCs are making increasing use of international networks for technology development to augment that generated in their home base (Cantwell, 1995; Fors, 1997; Dunning and Lundan, 1998; Kuemmerle, 1999; Cantwell and Piscitello, 2000). Arising from such trends, the pertinent issue for the host economy in attempting to entice such high value-added activity, is to understand what renders a location attractive or 'sticky in such slippery space' (Markusen, 1996).

This paper represents a comparative study of such issues by drawing together the findings of three recent studies in this area (Cantwell and Iammarino, 1998, 2000, which focus upon regional innovation patterns in the UK and Italy, and Cantwell and Noonan, 1999, which examines innovation activity in Germany). The main premise of the three papers is that regional agglomerations of technological knowledge and capabilities in the EU attract FDI in R&D to a different extent and with a different sectoral spread, according to a geographical hierarchy of regional centres. The precise research location chosen by a MNC will therefore depend upon the number of regional centres available, their positioning in the geographical hierarchy and the degree to which the MNC has developed a strategy for new technological combinations and/or diversification through tapping into specific competencies across a range of centres. These three papers constitute a significant contribution to the analysis of sub-national innovative activity across the EU and represent a vital component in the formulation of a future EU wide technology policy that aims to foster regional systems through the promotion of inward FDI in technological innovation.

Drawing upon the results of these studies, this paper is divided into five parts. Part one reviews the recent literature on the globalisation of innovation, which highlights the importance of location in the globalisation process and therefore the supremacy of

a regional approach when analysing this phenomenon. After a short description of the data used for the empirical investigation, part three analyses the degree to which common patterns of innovative activity characterise the three economies under investigation. Firstly, we report upon the geographical distribution of innovative activities of large firms, both indigenous and foreign-owned, across the regions of these countries between 1969-95. We then focus upon the locational patterns observed for foreign-owned firms. In particular, by isolating the areas in which activity is most concentrated, we examine the importance of the existing knowledge base for foreign-owned firms when locating their R&D abroad. Section four documents the characteristics of the hierarchies of regional research centres, which exist across the EU. We suggest that the identification of such regions serves as a prerequisite to unveiling the potential technological communication (or technological spillovers) that may be in existence within and indeed across these regions. Finally, the paper focuses upon the differences recorded in the geography of MNC innovation across the three economies and the concluding section five highlights the future research agenda that arises from such observations.

1 (i) Internationalisation of R&D

The international business literature postulates a number of explanations as to why technological activities might be located outside of the home economy. In the early years of writing on the subject, much emphasis was placed upon the necessity of locating some lesser degree of R&D abroad to facilitate the localisation and adaptation of products to local tastes and requirements (Vernon, 1966). From the viewpoint of the firm, this was commensurate with the exploitation of existing technologies essentially developed at home. Empirical work that followed suggested instead that the internationalisation of R&D in large companies in the past was considerably greater than had at one time been supposed (on the basis of evidence of US MNCs in the early post-war period), but confirmed that such internationalisation was essentially motivated by dissimilarities in the implementation of technologies between home and foreign locations (see, *inter alia*, Cantwell, 1995). More recent contributions in this field reflect instead a shift in emphasis towards a new necessity for corporate strategy to focus on enhancing extant capabilities and creating new competencies within the firm (Cantwell and Piscitello, 2000).

Whilst there is evidence that much of the technology developed abroad by large firms lies in their core areas of strength¹, MNC research in foreign locations is also increasingly associated with a higher probability of entry into new and more distantly related fields of technology. Such knowledge-seeking activity is undertaken to help define the future directions in the evolution of the corporations' sources of competitiveness (Pearce, 1999). Whilst in the past the creation of new competencies was commensurate with increasing R&D allocations in the home economy, it is now increasingly associated with the commitment of research budgets to operations located abroad. Allied to this, the technical innovations of multinational companies occur increasingly as a result of internal and external networks².

Increased complexity and growing interrelatedness between technologies, coupled with increased costs of undertaking such R&D, render research interaction both within the corporation and with foreign-owned counterparts (often competitors) an increasingly crucial element of corporate survival (Cantwell, 1989; Kuemmerle, 1997; Cantwell and Barrera, 1998; Cantwell and Janne, 1999; Patel and Vega, 1999; Zander, 1999). Whilst establishment in a foreign jurisdiction facilitates the monitoring of developments in different technological fields, it also enables the extraction of local knowledge for MNC global networks (Cantwell, 1992, 1995; Chesnais, 1992; Granstrand and Sjolander, 1992; Dunning & Wymbs, 1997). In the case of the former, the firm is likely to be active abroad in technologies where complementarity between the strength of the host economy and its own strength exists. Regarding the latter, a firm locates its research facility abroad to exploit the technological advantage of the host region in order to alleviate technological weakness at home (Patel and Vega, 1999, p. 146). This differentiation in the type of R&D activity suggests that certain regions/locations will be favoured over others when R&D investment decisions are being undertaken. Following from this, it is therefore suggested that two types of agglomeration forces (or clustering) operate across regions. The first can be termed "localisation economies", which are sector-specific and tend to intensify intra-border sectoral integration through local external networks between foreign-owned affiliates, indigenous firms and local non-market institutions. The second are referred to as

¹ This suggests that adaptation and technical support to foreign manufacturing plants continues to be major explanatory factors.

² The globalisation of innovation refers, in fact, not only to the "use" of MNC technological competencies but, even more, to the way they are generated. As argued in our previous work (Cantwell

‘general external economies’, which attract all kinds of economic activities and tend to strengthen the inter-border intra-firm integration, allowing the feedback of knowledge, expertise and information within networks of affiliates.

Arising from this differentiation of agglomeration forces, it becomes possible to distinguish between higher and lower order sites or regional centres. Such centres arise ‘as a consequence of the interaction and the intensity of general external economies and localisation economies, which in turn depend upon the characteristics of the regional system considered’ (Cantwell and Iammarino, 1998, p. 387). Whilst in the case of a lower order research centre, knowledge in specific technological fields is accessed and injected into the multinational production network, affiliates located in higher order centres can enjoy a broader range of spillovers from the local environment. Differentiating between higher and lower order centres of innovation across space therefore highlights the attraction that various locations hold for MNCs or, in other words, the nature of the centripetal forces in play across regions.

(ii) Implications for the host economy

Arising from the internationalisation of MNC R&D activity, a plethora of issues has permeated the literature in recent years. These range from the short run implications for corporate performance to the long-run ramifications for the host economy’s economic growth. Focusing upon the latter, the array of positive externalities generated by a foreign-owned research unit means that a region’s long-term economic viability is strongly linked to its ability to entice R&D commitments from international sources. An important consideration for the host country is of course the precise nature and mix of the innovative activity located within its borders. Policies that aim to augment existing capabilities (that is, deepen the knowledge base) or, alternatively, diversify the extant aggregate technological profile (therefore widening the expertise that is potentially available to indigenous firms) help to firmly position the host economy in the international business arena. The region’s ability to attract such foreign-owned activity is first and foremost dependent upon the existing absorptive capacity of this location³. Whilst large differences in terms of absorptive

and Iammarino, 1998, 2000), by “globalisation” we refer to a high degree of interdependency among units, which constitute the MNC.

³ Highlighted as being a ‘necessary though not sufficient condition’ (Cantwell and Iammarino, 2000).

capacity may give rise to a considerable degree of clustering across the regions, knowledge will flow more easily and economic activity will be more evenly spread if high absorptive capability exists across space (Maurseth and Verspagen, 1998, p.4). If regions are therefore to entrench themselves in this globalisation process, it is paramount to foster local innovative specialisation in areas of traditional strength. Indeed, whilst evidence indicates an overall trend at country level toward increased technological specialisation over time (Pavitt, 1988; Cantwell, 1989; Archibugi and Pianta, 1992; Patel and Pavitt, 1994), at the sub-national level the broadening of specialisation is one of the possible forms of incremental change in the composition of regional innovation (Cantwell and Iammarino, 1999). In addition, policy should aim to promote research-conducive environments that facilitate interaction and knowledge exchange between the players⁴. Once such knowledge-seeking activity is located in the host economy “each region finds itself increasingly integrated into an international division of labour for the development of new technological systems” (Cantwell and Piscitello, 1999b, p. 19; see also Cantwell, 1991, 1994; Teece et al., 1994; Loasby, 1998; Chandler et al., 1998).

2. Data

Patent statistics are used to analyse the location of research activity across space. The data were obtained from the United States Patent and Trademark Office (USPTO) and cover all utility patents granted to large firms located in the UK, Italy and Germany over the 1969-95 period.

Each patent was classified into one of 56 technological sectors derived by mapping from the primary classification of the USPTO and organising patents into common groups (see Appendix for the resulting 56 sectors). To facilitate a sub-national analysis of location, the data were also regionalised according to the residence of the first-named inventor (research facility responsible). This was achieved by attributing the location of the principal facility responsible for the innovation to an area code obtained from Eurostat Nomenclature of Territorial Units for Statistics (NUTS). For further discussion of the data see Cantwell and Iammarino (1998, 1999, 2000) and Cantwell and Noonan (1999).

⁴ Which, as previously highlighted, is contrary to perceived wisdom vis à vis knowledge appropriation (Cantwell, 1999; Cantwell and Noonan, 1999; and Cantwell and Iammarino, 2000).

3. Location Dynamics of Technological Innovation

It is generally acknowledged that wide disparities in technological competencies exist across the economies and regions of Europe (Caniëls, 1996; Paci and Usai, 1997; Verspagen, 1997). Table 1 reports on the distribution and penetration of foreign-owned innovative activity across the three economies under study. Whilst the distribution figures (D) highlight the attractiveness of the various locations against one another, the penetration statistics (P) indicate the degree to which foreign-owned activity has infiltrated the aggregate local innovative activity within each of these economies.

[Table 1 here]

It is immediately clear that, whilst the UK hosted the largest proportion of foreign-owned activity in the early years, since 1973 Germany is the most attractive location (albeit declining since the mid-1980s) for foreign-owned patenting activity. It is also interesting to note the increase in the proportion of activity located in Italy since the mid-1980s. In terms of penetration, the overall proportion of foreign-owned research located in Europe has on average increased over this time period with a most noticeable rise in recent years. In marked contrast to patterns observed in the UK and Italy, where foreign-owned firms constitute a substantial and rising proportion of aggregate activity (with shares of 45.2% and 57.5% respectively in 1991-95), foreign-owned activity located in Germany constitutes an average of approximately 17 percent of the total at the end of the period considered. This highlights the historically strong indigenous technological base of the German economy.

Whilst the UK and Germany are similar in that they are amongst the leaders in terms of patenting activity in Europe, with Italy being further behind, considerable sub-national differences exist across these economies. Table 2 records the regional distribution of patenting activity by large firms located in the UK, Italy and Germany over the 1969-95 period⁵. The UK and Italian cases are particularly remarkable. In further support of the regional disparities and commensurate with the clustering activity thesis outlined above, very strong geographical agglomeration of patenting

⁵ Confirming the penetration figures reported through time in Table 1, Germany hosts the largest absolute number of patent grants but records a significant imbalance between those attributed to foreign-owned versus indigenous research. Whilst foreign-owned firms share of patents has been increasing over time in both the UK and Italy and averages approximately half in the 1991-95 period, this figure is substantially lower in Germany.

from innovative activity is found in these economies. Even allowing for potential population and economic size effects, a very high proportion of activity is concentrated in just one region in both economies - the South East in the UK (47%) and Lombardia in northern Italy (53 %).

[Table 2 here]

Whilst in Germany agglomeration of innovation is also recorded, it is spread across a greater number of regions. Concentration is relatively strong in the regions of Nordrhein Westfalen and Bayern, which together host 50 percent of total large firm patenting over this period. Coupled with these regions in Germany, substantial agglomeration of activity is also recorded in Baden Wuerttemberg and Hessen. Together, the four regions record over 80 percent of total MNC research in Germany⁶. Whilst not as broad as Germany, some degree of dispersion is also observed in the UK, where large firms located in the North West and West Midlands account for an additional 26 percent of total activity. In the Italian case, however, technological activity is concentrated in just one other region, Piemonte, which records approximately 25 percent of total patenting.

Hence, even taking a cursory look at the structure of R&D activity in these three economies suggests that they provide a unique comparative testing ground for analyzing the location choices of large innovating firms in the EU and ascertaining the factors that shape such decisions. The economies are similar in that all three record similarly high concentrations of innovative activity within their borders which allows for a generic classification of 'core' regions (that is, those which host the highest proportions of patenting activity over time). In the more detailed analysis that follows therefore, we restrict our study to these regional centres of excellence. Observable variations, such as a differing intensity of activity across these economies coupled with the differences in the geographical breadth of the pattern of locational concentration however renders them ideal cases for the purposes of intra-EU comparisons.

In Italy, just as for indigenous Italian firms, foreign-owned firms record the highest concentration of research (57 percent) in Lombardia. Outside of this very striking geographical agglomeration however, as highlighted by Cantwell and Iammarino (1998), foreign-owned research appears to be relatively more dispersed than that

⁶ The regions of Rheinland Pfalz and Niedersachsen are also included in the analysis because of the relatively high absolute number of patents granted to firms located there.

undertaken by their indigenous counterparts. Whilst foreign-owned firms locate approximately 68 percent of their R&D in the two core regions of Lombardia and Piemonte, 82 percent of patenting by indigenous firms is located there.

Substantial variations in foreign-owned by comparison with indigenous R&D location patterns are also recorded in the UK. Similarly to the case of Italy, foreign-owned firms are more highly concentrated in the core region (the SouthEast), than are their indigenous counterparts. However, in contrast to Italy, indigenous firms locate a substantial proportion of their innovative activity also outside of the core, in the West Midlands and the northwest - regions which, relative to their overall shares, have failed to attract much foreign-owned activity. Interesting also is the ability of regions such as East Anglia or Scotland to attract relatively high foreign-owned firm innovative activity despite their low overall share in the UK-owned figure. A similar and indeed stronger result is found in the German case. Despite the fact that Baden Wuerttemberg is only the third most popular location for German-owned research, hosting approximately 19 percent, this region represents the prime location for foreign-owned firms, which undertake 31 percent of their research there. The same pattern is recorded in the north west region of Niedersachsen - despite the fact that it hosts a low overall share of total activity (under 4 percent) - but where foreign-owned firms locate over 5 percent of their patenting activities.

Indeed the German case contrasts with patterns recorded for both the UK and Italy on a number of fronts. Whilst both foreign-owned and indigenous firms concentrate their research in the same region in the UK (the southeast) and Italy (Lombardia), the same does not hold for Germany. Nordrhein Westfalen (which borders Belgium and the Netherlands in the west of the country) hosts the highest concentration of indigenous activity (29 percent), but only represents the second most popular location for foreign-owned research. Foreign-owned firms, as noted above, record their highest concentration of innovative activity in the southwest region of Baden Wuerttemberg. This differing pattern for Germany, we believe, can be explained by considering the type of technological activity associated with Nordrhein Westfalen. This region is the traditional home of the German chemical/pharmaceutical industry and continues to record substantial technological advantage for indigenous firms that base their research there (see Table 7 below). This strength is further reflected in the research profiles of the universities and research institutes located in the region (Blind and Grupp, 1999, p. 461). We tentatively suggest therefore that because foreign-owned

chemical firms may experience difficulty in trying to access the deeply entrenched technology networks and communication channels that have evolved through time, they disperse their research more widely, and account for a relatively low share of total German research in chemicals. This contrasts quite significantly with the pharmaceutical industry in the UK, where despite historical strength in these technologies, high foreign penetration characterises this sector (Cantwell and Piscitello, 1999b).

Table 3 records the contribution of foreign-owned innovation to total regional activity by technological sector over the period 1969-95⁷. As expected, the highest contribution of foreign-owned activity to the regional totals occurs in the south-east region of the UK (43.3 percent), Lombardia in Italy (39.1 percent) and Baden Wuerttemberg in Germany (28.2 percent). In all cases these contributions are well above the national average (33.5 in the UK, 36.1 in Italy and 16.7 in Germany). With the exception of Hessen and Niedersachsen, all other regions in Germany report foreign-owned patenting activity that is considerably lower than the national figure. The relatively higher contribution of foreign-owned activity in Niedersachsen is rooted in chemical and pharmaceutical technologies (despite the fact that aggregate foreign-owned activity is low in this technology, as highlighted above). However, for the foreign-owned firms active in these technologies the pattern recorded in Niedersachsen suggests the importance of locating close to the bordering indigenous chemical/pharmaceutical cluster in Nordrhein Westfalen. While location within the cluster itself may be too costly (due to, inter alia, congestion effects, see Cantwell and Noonan, 1999), their ability to access indigenous expertise and know-how (however difficult) appears as a potentially important element in their decision to base their chemical/pharmaceutical research in Germany.

Whilst in the south-east, foreign-owned firms record a significant presence in electronics technologies (52% of the regional total research in the macro-sector), in Lombardia their contribution is even higher within this technological field (74.3%), and is also substantial in the mechanical sectors (58.5%). At a more detailed level of sectoral breakdown, a commanding foreign presence is particularly noticeable in

⁷ As explained in Cantwell and Iammarino (1998, 2000) and Cantwell and Noonan (1999), a number of technological sectors were dropped from the analyses. These correspond to technologies in which relatively low degrees of global patenting were recorded. Moreover, the three studies restrict their analysis to the most prominent technological sectors, which vary across the three economies, although the total 56 column refers to the total number of patents for all 56 technological sectors.

photographic processes (6) (in which they hold 88 percent of total regional patents in the southeast, and 67 percent in Lombardia). Foreign-owned research located in Baden Wuerttemberg is also quite pronounced in electronics technologies (46.1%), as well as in the mechanical sector (most noticeably in the textile and clothing machinery, and chemical, bleaching and dyeing technologies). Interestingly, the contribution of foreign-owned research to the regional total is also above the national average in the Niedersachsen (particularly in chemical technologies and transport) and Hessen (especially in transport, metal and mechanical technologies). Indeed, the concentration of foreign-owned patenting activity has been increasing over time in both of these regions (Cantwell and Noonan, 1999).

[Table 3 here]

Analysing the degree to which the foreign share of innovative activity at regional level corresponds with the aggregate result, we find, as expected, that the southeast fits the bill in the UK, as does Lombardia in Italy. In both cases, innovative activity encompasses a relatively large number of technologies, which corresponds to the national pattern recorded in both economies. Interestingly in the German case, a great degree of correspondence to the national model is found in the Nordrhein Westfalen region - the favoured location for indigenous activity as highlighted above. Whilst Rheinland Pfalz and Hessen also correspond somewhat to the aggregate sectoral picture, the other regions of Germany (following a similar pattern to Piemonte [in Italy], or the West Midlands and North-West [in the UK]), seem to indicate more focused and locally-specific sectoral patterns in the distribution of foreign-owned participation in regional research.

4. Technological Profiles and the hierarchy of EU research centres

As highlighted elsewhere, one of the main drawbacks of using absolute numbers of patents is the difficulty associated with then making comparisons between the activity of heterogeneous areas of technological endeavour. Since the propensity to patent is higher in certain fields of activity (for example, pharmaceuticals), this poses potential problems when undertaking comparative analyses. This can be circumvented however, by employing the Revealed Technological Advantage (RTA) index, a technique first applied by Soete (1987) and subsequently developed by Cantwell

(1989, 1993). It is a proxy for technological specialisation and is calculated in the following way:

$$RTA_{ij} = \frac{(P_{ij} / P_{wi})}{(\sum_i P_{ij} / \sum_i P_{wi})}$$

where: P_{ij} = number of patents granted to technology i in region j

P_{wi} = number of world patents granted in technology i .

The RTA for a given region in a specified technology will vary around unity. An index greater than one indicates a relative advantage (or specialisation) in this technology whereas an index less than one points to a relative disadvantage⁸. What emerges from the analysis of the technological specialisation across the economies is a very clear dichotomy between higher and lower order research locations⁹. Firstly, looking at the dispersion of activity at a national level (as measured by the standard deviation of the RTA index across fields of activity, Table 4), it appears that the technological advantage of firms (both foreign-owned and indigenous) located in the UK are more widely dispersed at sectoral level than are their counterparts located in either Italy or Germany. While the cross-sectoral variance of the RTA index for Germany does not diverge much from that observed in the UK, the Italian figure, albeit somewhat lower for the activity of foreign-owned firms located there, is in aggregate, substantially higher relative to both the other two EU countries. This suggests that, while the overall Italian model displays the characteristics of a lower order research centre (since both foreign-owned and indigenous firms are highly concentrated in their technological activities), the aggregate UK and German models correspond to higher order research locations. The main explanation for this result is the smaller size of large firm technological activity in Italy, given that there tends to be a good inverse relationship between technological size and the degree of technological specialisation (Archibugi and Pianta, 1992; Cantwell and Santangelo, 2000).

⁸ Note that this is a proxy for *relative* (as opposed to *absolute*) advantage. A small region could demonstrate a high RTA in a particular sector but this could actually be associated with a relatively low patent count.

⁹ As highlighted in these studies, the fact that a number of regions were dropped from the analysis due to having inadequate numbers for statistical purposes in itself lends support, at least at first glance, to the hypothesis that internal geographical hierarchies exist in these economies.

[Table 4 here]

Focusing specifically upon the differences in the specialisation patterns of foreign-owned as opposed to indigenous firms at an aggregate level, it is interesting to note that, in contrast to the Italian case, foreign-owned firms in the UK and Germany have a similar degree of technological specialisation to their indigenous counterparts. More notably still, technological activity is significantly more sectorally concentrated in indigenous firms in Germany than it is in the UK, even though the level of indigenous company patenting from Germany is over three times as high (see Table 2). In light of the aforementioned expectation that there exists an inverse correlation between the standard deviation of the cross-sectoral RTA distribution and the overall size of innovative activity, (see also Cantwell and Bachmann, 1998; Cantwell and Fai, 1999), this result is especially interesting. Particularly so given that in Germany, unlike in the UK, the indigenous sector is considerably larger than the foreign sector - on average, approximately five times bigger. The finding that German-owned firms have a higher degree of technological specialisation in five of the six regions under study, is evidence of the very strong regional focus of these firms.

Comparing the technological activity of both groups of firms across the eleven European regions under study, it is apparent that technological activity is most broadly dispersed across sectors in the southeast region of the UK. The Bayern region in Germany also displays a rather wide cross-sectoral distribution of large firm innovation, particularly for indigenous firms, which is indicative that the general infrastructure and research environment fostered by these regions acts as a strong magnet to a wide range of corporate technological innovation. Contrasting somewhat with the aggregate picture across the three economies, foreign-owned firms are generally more diversified than indigenous firms at a regional level¹⁰. This sectorally-spread foreign-owned innovative activity at regional level is particularly strong in the German case as noted already, and it accords as well with a greater geographical dispersion of foreign-owned MNC innovation efforts in this country.

This might either reflect the fact that the German research infrastructure is developed to such a degree that proximity to any one cluster of activity (the indigenous hub for example) is not considered imperative in their location decision. Alternatively, it

¹⁰ There are however three exceptions - the NorthWest in the UK, Lombardia in Italy and Bayern in Germany in which indigenous innovation is characterised by activity across a broader range of technologies.

could be that activity is dispersed because firms cannot tap into all benefits from just one location. Additionally, whilst considerable regional differentiation of foreign-owned technological activity is observed in the UK and Italy, there is some similarity in the sectoral distribution of foreign-owned firm specialisation across the regions of Germany (Table 7). Therefore, not only are the foreign-owned firms of a given industry more likely to geographically disperse their innovative activity internally within Germany (than they are in the UK or Italy), they also tend to disperse themselves in a more similar cross-regional fashion than might have been expected.

The notion that all German regions conform to higher order locations is further supported by considering the degree to which the foreign-owned RTA distribution in each of the regions correlates with that in Germany as a whole (see Cantwell and Noonan, 1999). This is in marked contrast to results obtained for the two other economies, which, notwithstanding the regions of the southeast and Lombardia, otherwise demonstrate weak correlations with the aggregate foreign-owned specialisation patterns.

[Table 5, Table 6 and Table 7 here]

To test the hypothesis that lower order regions are characterised by very similar foreign/indigenous technological specialisation patterns, a simple regression analysis was carried out in each of the case studies (Table 8). First, we regress the sectoral specialisation profiles of foreign-owned firms by region and country between 1969-95 on that of indigenous firms at both regional and national level. In addition, by dividing our data into two separate time periods (1969-82 and 1983-95) we analyse the nature of this relationship over time. Specifically, we examine the degree to which our data lend further support to the thesis that the innovative activity of multinational corporations is path-dependent in nature i.e., that technological specialisation of foreign-owned firms in period t is highly correlated to that of locally-owned or indigenous firms in period $t-1$ (see Cantwell and Iammarino, 1998, 2000 and Cantwell and Noonan, 1999 for a more detailed discussion of the methodology employed).

[Table 8 here]

In the South East region of the UK, Lombardia in Italy and all six German regions, we fail to reject the null hypothesis, thus providing support for the thesis that these regions attract foreign-owned firms not because of the existing indigenous technological specialisation. Foreign firms are attracted to these regions because of the wider technological competencies and infrastructural supports available (for example,

the degree of openness to foreign-owned investors, business climate, corporate and enterprise culture, language, etc.). Technological activity of foreign-owned and indigenous firms in these regions is typically broad ranging in nature and extends across a spectrum of technologies. This is not to discard the possibility that intra technological communication (or technology spillovers) takes place between firms. Indeed, whilst our results suggest that limited intra-regional, inter-firm communication takes place in the same technological sector, knowledge spillovers in higher order regions seem to operate mainly through exchanges in and around core technological systems. Relationships then form between actors in otherwise quite separate alternative fields of specialisation. Such core systems appear to be rooted in the background engineering, mechanical methods and electronics technologies - sectors in which foreign-owned and indigenous firm's technological advantages appear to overlap in these higher order centres. It is suggested that foreign-owned firms' research in the biotechnology and pharmaceutical fields in the South East region of the UK for example, are attracted by this region's expertise in related disciplines (medical sciences for example),¹¹ rather than by the sectorally-specific indigenous capabilities. Similarly, the technological profile of foreign-owned firm activity in Baden Wuerttemberg in Germany seems to suggest that firms locate there not for any specialised expertise specific to this region but rather for the general capabilities of the region (particularly in mechanical engineering and information systems).

Regression results for the other regions of the UK and Italy suggest the presence of lower order research locations. Technological specialisation profiles of foreign-owned firms were found to be closely correlated with those of indigenous technological expertise so that knowledge spillovers are likely to be intra-sectoral in nature. This is consistent with our hypothesis that lower order regions attract the innovative activities of foreign-owned MNCs because of a very particular set of sectorally-specific expertise on offer in that region. By basing research facilities in such locations, foreign-owned MNCs may be able to upgrade their own technological capabilities in particular technological fields which may be sub-sets of their own major areas of technological interest. For a similar analysis at a cross-country rather than an intra-country level of the locally-specific pattern of activity in lower order centres developed by MNCs of the leading European centres, see Cantwell and Janne (1999).

¹¹The regional scientific advantage is noticeably strong in this area (see Cantwell and Iammarino, 2000).

5. Summary and conclusions

The recent acceleration of the internationalisation (international spread) and globalisation (international integration) of large firm R&D has resulted in a revival of the importance of location in the international business literature. Whilst in the past, home-base exploiting activity by MNCs resulted in comparatively little feedback from the new knowledge being generated in foreign jurisdictions, more recently such firms are relying upon home-base augmenting activities to achieve their overall corporate growth strategy (Kummerle, 1999; Cantwell and Piscitello, 2000). Tapping into local knowledge sources through, *inter alia*, co-operative agreements and research alliances means that the ability of foreign locations to attract such high value activities constitutes a vital component of the host economy's industrial policy and overall growth strategy. This paper, in setting out to investigate the centripetal forces in operation, analyses the location of innovative activity across three selected countries of the EU. Whilst substantial agglomeration of activity is recorded across this space, differences in the geographical spread of such concentrations within national boundaries are highlighted, thus lending further support to the thesis that even within the higher income economies, significant regional disparities exist. Whilst research is highly concentrated in all three economies, it polarises in just two regions in Italy, three in the UK and across six regions in Germany. This variety in the geographical agglomeration of technological activity offers a unique testing ground for our analysis of foreign-owned firm location and indeed provides a number of interesting observations.

Firstly, this paper provides support to the hypothesis that hierarchies of research locations exist across economies. Whilst both in the UK and in Italy just one region attracts foreign-owned activity for its overall business climate, support infrastructure and wider range of skills and expertise rather than for any specific intra-sectoral knowledge base, most foreign-owned activity in Germany is concentrated in such centres. This is confirmed by the fact that foreign-owned technological activity in each of these regions is not correlated with that of the indigenous firms, as well as by the fact that foreign-owned technological specialisation for each of these regions correlates with aggregate foreign-owned specialisation in the relevant country. Indeed, Germany is unique on a number of fronts. Whilst both indigenous and

foreign-owned innovation favours mainly the same region in the UK and Italy, a divergence of preferences is observed for Germany. It is suggested that foreign-owned firms may be especially attracted to Baden Wuerttemberg because of the highly developed Mittelstand (i.e. innovative small and medium-sized industrial sector), although this finding requires further investigation.

In addition, whilst the regional differentiation of indigenous large firms in Germany is greater than that of their foreign-owned counterparts, foreign-owned firms are less locationally selective in accordance with this distinct pattern of domestic innovation. This might be explained by foreign-owned firms' preference to avoid direct competition with the local science-based strengths of German industry (most notably such as the chemical/pharmaceutical cluster highlighted above). The main motivation for foreign-owned firms to locate their research in this country, rather, is to access the more general core technological expertise available there. In contrast, outside the core regions of the South East in the UK and Lombardia in Italy, foreign-owned firms are highly focused on accessing local indigenous expertise, for example in chemicals in the northwest, or vehicles in Piemonte. Potential knowledge spillovers in these regions are likely to be highly intra-sectoral in nature.

Although still susceptible of further elaboration, our results, in highlighting the distinctive nature regional technological activity across Europe, may be helpful in devising policy tools, which seek to influence the impact of globalisation upon regional locational hierarchies. This in turn would signal the opening up a new phase of inter-regional development across Europe.

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[Appendix here]