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Investing in Localized Relationships with Universities: What are the Benefits for R&D Subsidiaries of Multinational Enterprises?

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ABSTRACT In spite of a long-standing interest in the distribution of knowledge spillovers from university research, there is only limited theoretical understanding of if and when opportunities to interact with a research university constitute a significant force of attraction for globally mobile investment in R&D. Based on an empirical investigation of the benefits of interaction with universities, this paper proposes an analytical framework and four ideal types of strategy for localised collaboration between R&D subsidiaries and universities. This taxonomy, which largely transcends industry sectors, and the illustrative cases presented in this paper provide insights into the potential scope for localised university-industry interaction from the perspective of multinational enterprises. By connecting the empirical results to the question whether these benefits are significant enough to enhance a region's attractiveness as a location for R&D, we are able to develop a better understanding of the alternative strategies for policymakers and university leaders interested in stimulating such linkages.

KEY WORDS: Knowledge spillovers, multinational enterprises, university-industry interaction, localisation of R&D

1. Introduction

Intra-organizational linkages in research and development (R&D) processes are recognized as an important aspect of many types of corporate innovation. In particular, following a series of results confirming the existence of localized knowledge spillover effects (Jaffe

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et al., 1993; Audretsch and Feldman, 1996), much attention has been given to functional regions as arenas for knowledge flows. The particular role of localized spillovers from universities received special attention from Jaffe (1989) and later from Anselin *et al*. (1997, 2000), Fischer and Varga (2003) and Furman *et al*. (2005). However, we do not know much about how the spillover effects captured by these studies can be adequately explained. In particular, it is not clear to what extent these studies of macro relationships between public and private R&D capture benefits that can be appropriated without cost by the average R&D performing firm (''pure spillover'') and marketed knowledge flows, respectively (Breschi and Lissoni, 2001). In order to disentangle these effects, more research is needed about the motives and abilities of specific firms as well as the mechanisms used by them to appropriate the returns from public sector R&D.

In the literature on localized knowledge spillovers from public research, there is a notable gap between the firm-level studies, which suggest that multinational firms actively seek to draw R&D-related benefits from locating R&D in regions well-endowed with public research resources (Cantwell and Piscitello, 2002, 2005; Davies and Meyer, 2004), and the rich literature that explores why such benefits may exist. In the latter type of studies, the dissemination of knowledge is typically tracked through labour mobility and social networks (e.g. Audretsch and Stephan, 1996; Giuri and Mariani, 2008). By exploring knowledge flows at the level of the individual, these studies have greatly advanced our understanding of the general transfer mechanisms of knowledge spillovers. However, the institutional dimension of linkage formation has been somewhat neglected in this focus on individuals. Again, the extent to which the observed linkages between universities and firms are the results of strategic activity by firms and formalized local interaction, as opposed to pure externalities, has not been clearly established. In addressing this gap in the evidence, this paper draws on case studies to explore how and why firms benefit from direct interaction with local universities.

The notion of universities as important institutions for regional development transformation is becoming a ''stylized fact'', and public policymakers have responded by trying to build on local academic capacities in their regionally oriented policies (Yusuf, 2007). In particular, regions with strong centres of academic research have sought to increase their attractiveness as a location for the R&D subsidiaries of multinational enterprises (MNEs), since these are seen as not only creating attractive jobs in a region, but also forming networks and acting as customers, which can improve the business climate of a region (Ylinenpää and Lundgren, 1998). However, the true scope for such policies remains open to debate (Andersson *et al*., 2004).

There is only limited theoretical understanding of if and when opportunities to interact with a research university constitute a significant force of attraction for globally mobile investment in R&D. By seeking to empirically identify spillover effects that are mediated by formal, localized interaction, we wish to theoretically address this question. We recognize that the factors determining the attractiveness of a region differ between the home base of an MNE and its ''foreign'' subsidiaries (Dunning, 2000). This study focuses on the special case of foreign-owned R&D subsidiaries. We draw on literature relevant for understanding: first, how firms externally access global knowledge for innovation; and, second, the role of certain universities and regions that are able to attract more foreign direct investment in R&D. This study therefore draws on the results from two relatively separate bodies of literature: international business and innovation studies.

Based on an empirical investigation of the benefits of local interaction with universities, this paper proposes an analytical framework and four ideal types of strategy for collaboration between firms and universities. The taxonomy, which largely transcends industry sectors, and the illustrative cases should provide insights into the potential scope for localized university–industry interaction from the perspective of MNEs. By connecting the empirical results of interaction benefits to the question of the extent to which these benefits are significant enough to enhance a region's attractiveness as a location for MNE R&D, we are able to develop a better understanding of the alternative strategies for policymakers and university leaders interested in stimulating such linkages.

The theoretical framework of this study is further discussed in Section 2. Section 3 addresses research design and methodology. Sections 4 and 5 present the empirical results and Section 6 discusses these in terms of the theoretical contribution they make.

2. R&D Localization and University–Industry Linkages

This section considers the relevant literature from international business and innovation studies, including the literature on the economics of innovation.

In the latter strand of literature, many studies provide insight into how university–industry relationships work and their effects on regional growth. Such studies, however, only occasionally provide insights into corporate strategy. University–industry relationships are the subject of a huge number of studies, which focus especially on the commercialization of patents and start-up companies as well as the effects of institutional changes on academic patenting (Shane, 2004; Mowery and Sampat, 2005). Other studies address the mechanisms and rationales for university–industry relationships in different countries and sectors, the differential importance of applied and fundamental research in different industries and the importance of universities to regional clusters (e.g. Mansfield, 1998; Salter and Martin, 2001).

Studies from the field of international business provide insights into how MNEs behave globally to access new knowledge and markets, and occasionally have a particular focus on universities *per se*. This literature has identified two trends in the reorganization of corporate R&D activities: (1) increasing globalization of R&D spending patterns; and (2) increasing reliance on external organizations such as networks and outsourcing.

The literature offers a number of motives for the first trend. According to Chiesa (1996), a more internationally dispersed corporate R&D structure is usually associated with a longer time horizon for the research activities. Gerybadze and Reger (1999) emphasize the market characteristics of the foreign location such as, for example, regulatory designs and sophisticated customer demands as driving forces that can provide impulses for ''global'' innovation. Dunning (2000) argues that the OLI-framework, which specifies that decisions about foreign direct investment are driven by factors of ownership, location and internalization, is also useful for R&D. In Dunning's framework, the ownership-specific advantages will allow the firm to exploit its R&D assets whereas location-specific advantages enable the firm to exploit local capabilities, and internalizing advantages are related to enhancing the knowledge base. Kuemmerle (1999) differentiates between home-base augmenting subsidiaries and home-base exploiting subsidiaries. Home-base augmenting subsidiaries will adapt existing assets to local prerequisites, and therefore

indicators of R&D and science determine the attractiveness of a location to the firm. LeBas and Sierra (2002) further develop this taxonomy by proposing four strategies to explain why an MNE locates R&D at a certain location: home-base augmenting, home-base exploiting, market-seeking and technology-seeking. The market-seeking strategy is primarily related to obtaining market access. The technology-seeking strategy is R&D that the firm is otherwise not able to perform, given the technological level of the firm and its home location. Their empirical results suggest that technology-seeking strategies are not common in Europe.

For the home-base exploiting type of subsidiary, the attractiveness of a country's market determines its attractiveness as an R&D location. Narula and Zanfei (2005) draw on Dunning and Narula (1995) to develop their terminology of ''home-base augmenting'' or ''asset-seeking'' activities, on the one hand, and exploiting the activities of a subsidiary, on the other. Criscuolo *et al*. (2005) find that US MNEs in Europe do not have a tendency towards either, but instead strike a balance between exploration and exploitation types of activity. The exception is the pharmaceutical industry, which is dominated by exploitation activities. European MNE subsidiaries in the USA, however, were found to be dominated by exploitation types of activity in all of the five industries investigated. Simultaneous exploitation and augmentation in R&D subsidiaries is also reported by Kuemmerle (2002).

This first trend towards the internationalization of corporate R&D can be linked to the second trend, in that the degree of dispersion of (industry- and firm-specific) external sources of knowledge is related to the degree of dispersion of the key internal R&D resources. The globalization of MNE R&D is therefore accompanied by corresponding changes in corporate organization. In recent years, many large firms have either abandoned central R&D functions in favour of R&D tied to products or divisions, or imposed greater demands on these central R&D functions to coordinate the research agenda with division and product managers (Gerybadze and Reger, 1999). Consequently, the room for ''blue sky'' research paid for by corporate budgets has shrunk significantly, which would arguably help to explain why firms pursue research with universities.

The empirical literature also helps us to understand the relationship between region and university. Some results strongly suggest that a region's attractiveness for R&D investment by MNEs is affected by: (1) local market characteristics; (2) the presence of scientific and educational infrastructure; and (3) the presence of other firms that conduct R&D (Cantwell and Piscitello, 2002, 2005). A number of studies highlight the fact that the size of a market and the business opportunities offered there may not be the only determinants of its attractiveness. Gerybadze and Reger (1999) find that choice of location can be affected by a need to work in ''lead markets'' where impulses for innovation can be picked up and create advantages in the other markets of the MNE. While early studies emphasize market factors (Teece, 1976; Ronstadt, 1978), more recent studies stress factors related to knowledge and knowledge flows. Narula and Zanfei (2005) relate this development to two pressures: an increasing innovation pressure in the form of the increasing cost and complexity of technological development and shorter product cycles; and pressure from public customers to locate R&D in their region.

Hence, the question of collaborating with elite universities is linked to the advantages obtained by the MNE. One explanation for the decisions of MNEs to locate R&D activities in a region outside their country of origin is the opportunity to benefit from localized flows of knowledge, of which universities are a particularly important source (Dunning, 1994). While the role of proximity in innovation networks remains disputed, there is strong evidence that,

on average, a firm's ability to benefit from interaction with a university is facilitated by physical proximity (Mansfield, 1991, 1995; Arundel and Geuna, 2004). We conclude that the empirical evidence points to possible, albeit not automatic, benefits from proximity to academic R&D for the R&D activities of MNEs.

However, the discussion of spillovers and localized flows of knowledge needs to stand in relation to the characteristics of the universities. Meyer-Krahmer and Reger (1999) find only a few locations of ''worldwide centres of excellence'' of interest to firms which have knowledge-seeking/asset-augmenting motives. Such excellence can be measured in the form of input factors, such as skilled labour and spending on R&D, and output factors, such as patents, publications, innovation-related exports and so on. However, the literature provides different hypotheses about whether it is the science base *per se* or other factors that make a region attractive. Almeida and Phene (2004) in their analysis of subsidiaries of MNEs in the semiconductor industry do not find any proximity benefits to innovation from sheer strength in innovation but do find that the diversity of a country's science base significantly contributes to proximity effects on innovation.

Some literature therefore suggests that universities can help to attract R&D investment by MNEs, but often with a caveat. Feinberg and Gupta (2004) clearly associate locational choices with discrimination with regard to location by MNEs. Supporting evidence is provided by Davies and Meyer (2004) who conclude that only the presence of scientific institutions has a consistently positive effect on the incidence and level of subsidiary R&D. Some recent contributions question the importance of research linkages as media for proximity benefits. Andersson *et al.* (2004) and Faggian and McCann (2006), who have undertaken a similar analysis for the UK, find that R&D location is partly determined by a region's access to students in higher education, but that the region's level of academic R&D is an insignificant factor.

Both streams of literature—international business and innovation studies—have studied networks and collaborative relationships. This literature review suggests that theoretically and empirically, we can analyse how and why universities can sometimes help regions to attract R&D investment by MNEs by examining the nature of localized relationships. Our study relates the specific role of the university to the corporate strategy, that is, what the firm wishes to obtain from the collaboration, and to the characteristics of the research base. Moreover, although the studies described above provide convincing evidence that MNEs may gain advantages by locating corporate R&D close to leading universities, few studies have explicitly addressed the relationship between the R&D subsidiaries of MNEs and the geographically proximate university.

3. Research Design and Methodology

Based on the literature, we decided to address three issues concerning the relationship between the R&D subsidiaries of MNEs and the elite European research universities. These issues correspond to three variables, which were used to structure the interview guide and archival evidence: (1) the R&D activities of the subsidiary and the rationale for cooperation with the university; (2) the perceived effects of that cooperation; and (3) the organizational forms of collaboration with the university. We analysed each case in relation to the literature, before moving on to examine whether these variables varied systematically

across the cases. We used two levels in the cases: that of three regions and research universities; and that of 16 R&D subsidiaries of MNEs.

This study was designed to examine how and why firms benefit from localized interaction. Previous studies have not addressed the specific role of research universities when investigating the localization of MNEs' R&D. Furthermore, our research question diverges from the dominant stream of international business literature, in that we study the immediate locality (NUTS3-region) of three renowned European research universities, while other studies have often dealt with differences between locations at the country level, or in large regions in a specific country. Thus, the research design is similar to that found in economic geography and innovation studies.

We chose an exploratory case study design, with controlled similarities and differences across specific criteria, to address the four issues identified above. Sixteen R&D subsidiaries of MNEs with headquarters located in other countries were selected as case studies. The case study firms are all engaged in formal collaboration with one of the three elite research universities: the University of Cambridge (UK), ETH Zurich (Switzerland) and Karolinska Institutet (Sweden).

Our research methodology is thus based on a grounded theory approach (Glaser and Strauss, 1967), but has a more exploratory theoretical aim. More specifically, our cases are used to strengthen and explain the theoretically derived propositions, rather than derive and create new theory directly from empirical work. Section 2 defined how and why MNE subsidiaries can be expected to interact with research universities. We use these theories and the empirical case-based research as exploratory in the sense of being part of an iterative process to further strengthen and highlight important issues. These cases can be seen as the combination of our theoretically based propositions and initial exploratory findings. One aim is thus to develop and generate a more coherent and detailed taxonomy of how and why these types of firms choose to interact with leading research universities.

Two sets of criteria have been used to choose the cases. The first set is linked to European regions and elite research universities. All the seminal research on university–industry interaction has been on US universities (Mowery and Sampat, 2005; Thursby *et al.*, 2007). We therefore chose to focus on Europe. The decision to concentrate our studies on ''elite'' universities can be described as ''extreme case sampling'' (Patton, 1990).

The three European universities were selected from ranking lists produced by the British newspaper *The Times Higher Education Supplement* (*THES*), based on its 2005 rankings. The University of Cambridge repeatedly tops these lists, and thus is a natural choice. To avoid studying only British universities, which often top the European ranking lists, we left out Edinburgh; Imperial College; the London School of Economics; and the University of Oxford. Cambridge is not located in a major European city, so we therefore chose top-ranked universities in Switzerland and Sweden, since these two European economies also have smaller, more well-defined regions surrounding their universities than other major metropolitan areas such as Paris or Barcelona. ETH Zurich is consistently ranked among the top universities in Europe, and is ranked fourth European university in science in the *THES* 2005 list. In the same list, Karolinska Institutet was ranked fourth-best biomedical university in the world, surpassed only by Cambridge, Oxford and Harvard.

The three selected universities have clearly different research profiles. The University of Cambridge is active over almost the entire academic range, whereas the research efforts of ETHZ are heavily concentrated on science and engineering and Karolinska Institutet is

devoted to medical research in combination with life-sciences research in the biological and chemical sciences. The three universities can thus be described as representing leading research in the fields most strongly associated with direct industrial relevance, and therefore as suitable partners for firms seeking to interact with academics.

Our second set of case selection criteria is linked to the selection of firms. We started, with the assistance of university corporate liaison officers and regional enterprise officers, by compiling a list of all known formal collaborative relationships with R&D performing subsidiaries of MNEs. Extensive Internet searches and the university registers on collaboration of the University of Cambridge and Karolinska Institutet were also used in the research process. More specifically, we defined the population of firms that matched the following criteria:

- *C1*: The firm is an R&D subsidiary of an MNE located in either Stockholm County, the Canton of Zurich or the county of Cambridgeshire.
- *C2*: The firm belongs to an MNE group with more than 2,000 employees, distributed over at least six countries, with its headquarters located in a country other than that of the subsidiary.
- *C3*: The subsidiary has at least five employees assigned to R&D activities.
- *C4*: The subsidiary has been involved in a formal agreement on collaboration (e.g. contract research, facility sharing and/or personnel sharing) with the local university at some point in the period 2003–2006.

These four criteria were used in discussions with the universities and the regional officers to identify firms. All the firms interviewed match the four criteria.

As a result of applying these criteria, we identified 11 firms in Zurich, 12 firms in Stockholm and 10 firms in Cambridgeshire. Hence, the total identified population was 33 firms, and basic data were gathered on all of them. We contacted all the firms, but some declined to participate in the study. We were able to interview 16 firms for the case studies, about half of the population. Table 1 lists the firms interviewed.

Four main topics were addressed in the interviews with the representatives of the firms: (1) the R&D activities of the subsidiary; (2) the rationale for cooperation with the local university; (3) the effects of that cooperation; and (4) the effect on collaborative modes with the university organization and its researchers. Centrally placed R&D managers were targeted as those most likely to have an overview of the four topics. For the large subsidiaries, the views of the first respondent were compared to those of more operational R&D managers in complementary interviews. We thus interviewed between one and three

Table 1. Firms interviewed, sorted by university

University, region, country	Firms (R&D subsidiary at that location)
Cambridge University, Cambridgeshire, UK	Intel, Hitachi, Kodak, Microsoft, Unilever
ETH Zurich, Canton of Zurich, Switzerland	Alcan, IBM, Google, Elan Microelectronics
Karolinska Institutet, Stockholm County, Sweden	Arla Foods, AstraZeneca, Baxter, Linde Therapeutics, Merck, Pfizer, Wyeth

representatives of the 16 identified MNE subsidiaries. These interviews were performed in a semi-structured manner following an interview guide.[1]

Triangulation of data and complementary information has been ensured through the use of additional written material and interviews. We conducted interviews with representatives of regional economic agencies and also gathered material on the three universities from websites, as well as written and other published material from the firms and the regions.

4. Overview and Taxonomy

This section includes an overview of the three universities and of their collaboration at an aggregate level, including their most important features and the regional context in which they operate. We then propose a taxonomy of ideal types of firms' strategies for interacting with elite research universities.

Founded in 1810, Karolinska Institutet is today one of the largest medical universities in Europe. In 2005, the university had a turnover of approximately EUR 440 million and employed about 3,500 people. The university currently offers 4,500 square metres of office and lab space for private firms in three buildings on its two campuses. These are almost exclusively used by small firms, in particular, by firms with roots in university research. Further opportunities for co-location are planned in a new extension of the northern campus environment—the university hopes that this will attract resources also from major pharmaceutical companies.

Often described as Europe's leading research university, the University of Cambridge combines a commitment to fundamental research with a contemporary interest in the commercialization of research. The 800-year-old university is surrounded by one of the strongest science park clusters in the world. The university had a turnover of EUR 1.1 billion in 2004, and teaching and research activities make up about 80 per cent of its expenditure. It employs around 8,000 people. In some areas, the University of Cambridge has been cooperating with industry for a long time. In recent years the university has become more aware of the importance of these links, and has sought to build a support structure for this cooperation. About 17 per cent of the university's research income comes from companies, and most of these companies are multinational and have their headquarters outside the UK.

ETH Zurich was founded in 1855 and has been a leading research university for many years. In total about 8,200 people are employed by ETH Zurich and the university has a turnover of over EUR 800 million. ETH has sought to be close to the economy by cooperating with many corporations in the region. The best-known example is its relationship with IBM, which has one of its largest research facilities located close to the university.

The description below presents the results of our research into the 16 case study firms at an aggregate level (for more detailed empirical results see Broström *et al.*, 2009). Collaboration is analysed in terms of the three variables defined in Section 3 above: (1) the R&D activities of the subsidiary and the rationale for cooperation with the university; (2) the

[1] For details of the interview guide see Broström (2007).

perceived effects of that cooperation; and (3) the organizational forms of collaboration with the university.

In terms of R&D activities and the rationale for cooperation with the university, we first asked a control question about how intensively the R&D subsidiaries work with the universities, which we labelled either ''on-demand collaboration'' (5 firms) or ''continuous'' (11 firms). The five firms with ''on-demand collaboration'' interact only when they need a specific kind of research, and several stated that the university in closest geographical proximity is not a very relevant partner for R&D. Of the 11 firms with ''continuous'' collaboration, 10 of the firms expressed the need to obtain access to scientific networks, in particular, international contacts, and 7 of the 11 mentioned access to local networks. Other key rationales for collaboration were recruitment (8 of the 11) and opportunities to strengthen the brand of the firm and/or the product (7 of the 11). Three of the 11 firms referred to a continuous need for consultation and collaboration, coupled with a desire to affect the overall agenda of research at the university. These three stressed the unique nature of collaboration with the specific proximate local university and research team.

In terms of the perceived effects of the local cooperation, respondents at the subsidiaries were asked to evaluate and describe the effects of their collaborative relations, both from a list and in their own words. The analysis of the results was similar to that in existing literature, such as giving the firm orientation about technology, developing contacts (networks) and identifying opportunities for innovation. More interestingly, 13 firms stated that collaboration has important branding and/or marketing benefits for the firm. Hence, collaboration may be a way to access customers and markets, and improve branding rather than only a means to access science and technology.

Many different organizational forms of collaboration with the universities are visible. The existing literature suggests a number of organizational forms, and these were used in the interview guide in combination with open-ended questions. The most common forms for the R&D subsidiaries are joint venture research (12 of the 16), consulting (12 of the 16) and shared staff, for example, in the form of adjunct professors and PhD students with formal connections to the firm (11 of the 16). The least common organizational forms for collaborative R&D are also quite interesting, given the current emphasis in public policy and in the literature. Only 5 of the 16 emphasized patents and only 3 of the 16 mentioned jointly owned centres.[2] Our interpretation is that the most common organizational forms include types which involve direct and long-term collaboration (joint venture research and shared staff) as well as types which mainly involve arm's length relations in the market (consulting and commissioned R&D). Another way to analyse the results is that the most common organizational forms seem to involve primarily either people and networks (joint venture research and shared staff), or specific problem-solving on scientific and technical issues (consulting and commissioned R&D).

Our results suggest that two main dimensions can be identified to our proposed taxonomy. These dimensions capture some differences in the explanations for the behaviour of firms in collaborating with research universities between the interpretation of the case studies and the mechanisms found in existing literature, and when taking into

[2] We do not know the reason, but we could speculate that it may be related to the foreign ownership status of our firms, as funding agencies that set up such centres might possibly favour firms perceived as national or regional.

account the aggregate insights from the case study firms. The first dimension captures the heterogeneous strategic importance of collaboration with the university to the MNE. This highlights that for some firms, interaction with the local university is a primary strategic objective in reaching their goal, while for other firms, collaboration exists but is a secondary mechanism. The second dimension is linked to the type of knowledge involved. This highlights the finding that for some firms, collaboration helps them to develop scientific and engineering knowledge, whereas others more explicitly link such technical knowledge to specific improvements for customers and in branding.

These two dimensions generate a taxonomy with four ideal types of strategy for firms' collaboration with universities (see Table 2). Table 2 specifies four distinct classes of R&D subsidiaries, which are characterized by the distinctly separate sets of benefits they derive from localized collaboration with elite universities. They reflect systematic differences in the strategies and actions of firms over time.

This taxonomy should be understood as identifying broader patterns of behaviour, which are only industry-specific for those running clinical trials. Firms in the category *Running Clinical Trials* only benefit from the more indirect advantages of co-location with university research associated with clinical activities. Firms in the category *Solution Demanders* only use a few collaborative forms and benefits, in order to resolve specific technical issues. Firms in the *Competent Buddies* category are more likely to be engaged in sharing staff and facilities and to take part in more extensive knowledge exchanges than those in the former category. Subsidiaries in the *Seamless Network* category are able to draw on a wide range of potential benefits from collaboration.

By using this taxonomy to position each of the firms studied, we have also identified typical characteristics for each ideal type. These characteristics thus link the characteristics of the R&D activities of the subsidiary, the rationale for cooperation with the university, the perceived effects from that cooperation and the organizational forms of collaboration with the university. Table 3 summarizes these results.

Table 3 indicates that the four characteristics differ in systematic ways across the four ideal types, and that specific firms can be placed in one ideal type. If we return to the metrics on age, size and proximity, the total sample is relatively homogeneous across the ideal types. However, the most striking difference is in proximity to the local research university, where all firms are relatively close geographically except for the *Seamless Network* firms, which are often physically integrated into university departments. The *Seamless Network* firms identified here are also found to be relatively new establishments, suggesting that this

Table 2. Four ideal types of firm strategies to collaborate with universities

	Interested in science and technology	Interested in market, customers, branding
Collaboration a primary objective	Seamless Network	Running Clinical Trials
Collaboration a secondary objective	Competent Buddies	Solution Demanders

Table 3. Summary of variables and classification of the firms

	Typical forms of formal collaboration	Intensity of relation to local university	Main purpose of R&D activities*	Firms classified as such**
Running Clinical Trials	Clinical trials, research sponsoring	Continuous relations, albeit limited to clinical development	Asset-exploiting, market-seeking	Wyeth (*Sthlm*) Merck (*Sthlm*)
Solution Demanders	Joint-venture research Commissioned research	Less intensive collaboration	Applied research	Alcan (*ZH*) Arla Foods (*Sthlm*)
			Asset-augmenting, asset-exploiting	Elan Microelectronics (*ZH*) Google (*ZH*) Pfizer (*Sthlm*)
Competent Buddies	Joint-venture R&D, sponsor programmes, jointly owned centres	Semi-close intensiveness, differing between parts of subsidiary	Mainly asset-augmenting but also technology-seeking	AstraZeneca (*Sthlm*) IBM (*ZH*) Kodak (*Cam*) Linde Therapeutics (*Sthlm*)
Seamless Networks	Numerous forms	Close collaboration	Basic research	Baxter (*Sthlm*) Hitachi (*Cam*)
			Technology-seeking, asset-augmenting	Intel (*Cam*) Microsoft (*Cam*) Unilever (*Cam*)

* Adapted from the taxonomy of LeBas and Sierra (2002). As described in Section 2, this taxonomy identifies four distinct strategies behind MNE location of R&D: *home-base exploiting* (adaptation of existing assets to local markets), *market-seeking* (locating R&D to meet regulatory of key-customer demands on a significant market), *home-base augmenting* (complementary R&D to that done at home-base) and *technology-seeking* (R&D of a kind that draws heavily on local expertise and technological assets). We adapt this taxonomy slightly as we, in accordance with Dunning and Narula (1995) and Criscuolo *et al.* (2005), refer to asset-augmenting or asset-seeking activities rather than home-base augmenting or home-base exploiting. While useful for defining one dimension of our table, it should be noted that analysis of our cases show that it is not fully sufficient for discussing location rationales in correspondence to university–industry relations. The LeBas and Sierra taxonomy leaves no room for non-technological factors other than ''market-seeking'' motives.

** A main classification of each firm has been made by the authors. Please note some degree of overlap between ideal types is possible. In particular, both Pfizer and AstraZeneca perform clinical trials in collaboration with the Karolinska Institutet, but the collaborative linkages in both cases span a wider set of objectives.

may be a relatively new phenomenon. The other three characteristics tend to vary in parallel, as is suggested in Table 3.

5. Ideal Types of Firm Strategies

The above taxonomy has been proposed to help us to understand and analyse how and why firms interact in specific ways with research universities. Thus, our contribution is to develop explanations for why firms act and think in specific ways when they collaborate. In doing this we go beyond current contributions in the literature, which analyse the relative occurrence of phenomena based on long lists of rationales and organizational forms for university–industry interaction. In other words, it is our position that university–industry interaction must be placed in relation to the expectations of the firm—rather than starting from the science and technology side. This section returns to the four ideal types, to discuss, using short illustrative cases, why the characteristics discussed above tend to vary in parallel.

5.1. Running Clinical Trials

The first ideal type is those firms Running Clinical Trials, which are R&D subsidiaries with an orientation towards clinical activities. The firms categorized as such are Wyeth (Stockholm) and Merck (Stockholm).

This ideal type is only relevant to the pharmaceutical industry, given the need for clinical trials to obtain approval for new medicines. Clinical trials constitute something of a special case in terms of university–industry relations. The clinical activities of pharmaceutical firms are almost totally dependent on access to the clinical expertise and patients of university hospitals, and such firms generally maintain continuous contacts with universities. However, firms running clinical trials are identified as a separate category because they are not necessarily drawing on university *research* capacity. Prompted by the specific institutional and regulatory context of this industry, these firms are looking for a type of long-term relationship with clinicians and doctors.

In this study, the firms running clinical trials are collaborating with Karolinska Institutet. Wyeth in Stockholm provides an illustrative example. The company is primarily in Stockholm in order to run clinical trials. According to Göran Skoglund, the Wyeth R&D manager in Stockholm, the subsidiary's collaboration with Karolinska Institutet beyond the concrete issue of clinical trials is limited to approaching a small number of professors when special consultation is needed.

5.2. Solution Demanders: R&D Subsidiaries with an Agenda Dominated by Development

The second ideal type is the Solution Demanders or R&D subsidiaries that have a research agenda dominated by development. The firms categorized as such are Arla Foods (Stockholm), Pfizer (Stockholm), Google (Zurich), Elan Microelectronics (Zurich) and Alcan (Zurich).

The firms in this ideal type have more loosely organized collaboration with the geographically closest university, with only limited numbers of organizational forms and a

lower intensity of contact. Moreover, the linkages to the university tend to be related to applied development rather than fundamental research. These linkages also often focus on existing R&D projects within the firm and on consultations rather than exploratory activities. Such firms are looking for a type of problem-solving activity related to the specific areas of expertise of the university. Some of these firms collaborate with universities in order to gain access to equipment and facilities that they do not have. If the competence profile of the geographically proximate university does not match that demand, they have no incentive to maintain an active relationship. Two complementary reasons given by firms for not interacting more often were limited funds and a limited need for external expertise.

In our empirical material, Solution Demander firms can be found collaborating with ETH Zurich and Karolinska Institutet. One illustrative case is Alcan, which is a global corporation with its headquarters in Canada. The corporation restructured its R&D following its acquisition of AluSuisse in 2000. Today, it has research laboratories and engineering centres in Canada, Switzerland, France and the USA. The research laboratory in Neuhausen, just north of Zurich, and the engineering centre in Zurich are among the largest R&D facilities of the group. The laboratory has two emphases: aluminium fabrication and packaging. The engineering centre is responsible within the group for development of its mass transportation industry-related projects.

From a central perspective, Alcan's Director of Innovation Management, Dr Ernst Lutz, states that the firm does not have much contact with ETH. The respondent argues that the gap between the needs of the incrementally oriented R&D at the firm and the research-oriented university is generally too great for regular collaboration to be set up. Dr Lutz plans to fund ''leading professors and places'' for regular consultancy and discussions to guide the firm's R&D without imposing demands on the specific research agendas that the academics pursue with the firm's funding. Further interviews confirmed the view of weak local linkages, but also identified an Alcan research manager who works in quite close contact with, and occasionally sponsors, an ETH research group.

5.3. Competent Buddies: R&D Subsidiaries with a Research-Intensive Agenda

The third ideal type is the Competent Buddies, which are R&D subsidiaries with a research-intensive agenda. The firms categorized as such are Kodak (Cambridge), Linde Therapeutics (Stockholm), AstraZeneca (Stockholm) and IBM (Zurich).

We call them competent buddies because they are looking for long-term, friendly relationships. These R&D subsidiaries differ in organizational characteristics from those found in the Seamless Network ideal type described below. These are significantly larger, more complex organizations that have a slightly weaker orientation towards research and a somewhat stronger orientation towards product development. At the same time, they tend to be major centres of R&D expertise within the MNE globally. Here, the interaction with the geographically proximate elite university is considered to be a more unique knowledge asset to the firm.

In the Competent Buddies category, both sides of the university–industry interaction are competent and likely have complementary knowledge. The regional research university is presented as a preferred partner in the subsidiary's often extensive academic network.

In our empirical material, Competent Buddy firms can be found collaborating with ETH Zurich, Cambridge University and Karolinska Institutet. One illustrative example of the

competent buddy strategy is IBM's research laboratory in Zurich, which is a classic example of a large, R&D-oriented MNE subsidiary that fosters strong linkages with the local university environment. Among the most notable forms of current collaboration are a commonly owned research centre (ZISC) and a programme for the utilization of IBM technological assets in academic research (CASE). The ZISC and CASE initiatives represent the two most structured forms of collaboration between ETH and IBM, an opinion supported by both R&D manager respondents and by IBM's local public relations manager. Both collaborative initiatives are described as ''interaction between peers''.

The Zurich laboratory was established in 1955 as IBM's first R&D initiative outside the USA. It has a strong position within the IBM research organization and hosts the full range of R&D activities from research to product development. In recent years, its focus has shifted from internal R&D to collaboration in teams of researchers, developers and marketing managers on client-related projects. However, as opposed to the corporation's R&D laboratories in China, Japan and Israel, the Swiss laboratory is perceived to serve the needs of the IBM corporation in general more than serving a ''local'' market (Schär, 2006). According to the ZISC coordinator, Günter Karjoth, describing the rationale for establishing the centre, ''We realised that we had two world-class research teams sitting close to each other without talking very much to each other. In particular we wanted the PhD students at ETH to learn about our work.'' Besides these benefits from collaboration, Karjoth describes the need ''to look ahead, not to get insights in new technologies, but to prepare the avenue for new technologies''.

5.4. Seamless Networks: Integrated Research Units

The fourth ideal type is Seamless Networks, which are corporate R&D resources closely integrated—often even physically embedded—into university environments. In these interactions, the boundaries between industry and university can become quite blurred. These firms are looking for a type of continuous, multidimensional interaction with the university, from which they can access networks and people in relation to scientific and engineering knowledge. These R&D subsidiaries have a high intensity and a variety of organizational forms of collaboration with their specific elite university. They engage over a longer period of time in recruitment, access to university researchers and staff sharing as well as formal and informal collaborative arrangements.

Several firms of the seamless network type describe their collaboration as a way of connecting to ''blue sky'' research of a type that they are usually either unwilling or unable to perform themselves. In the interviews, and also theoretically, one of the main rationales for these R&D subsidiaries is linked to aspects of ''listening posts''. The R&D managers stressed the need to engage in the latest fundamental research, and to gain access to the results, equipment and networks that result from such research.

Another rationale appears to be an attempt to achieve a critical mass of research staff and equipment, where partial payment from each actor helps to create an organizational form where both parties benefit. The MNE can leverage its internal research investment with public resources and the university can augment and develop specific lines of research. By co-locating and maintaining a close collaboration, knowledge flows directly from the university to the MNE, and vice versa. This finding suggests that localized knowledge

spillovers may be an important reason for firms to collaborate with universities, but that these differ from previous descriptions in the sense that the spillovers occur through daily interactions in an embedded laboratory, rather than at the regional level.

The firms categorized as seamless networks are Intel (Cambridge), Unilever (Cambridge), Hitachi (Cambridge), Baxter Healthcare (Stockholm) and Microsoft (Cambridge). Interestingly, four of these establishments are fairly young, having existed for only 5–10 years. Hitachi's Cambridge laboratory is an illustrative example.

Hitachi has had an embedded laboratory in Cambridge since 1989. This unit is oriented towards fundamental research, which it performs in collaboration with the Microelectronics Research Centre in Cambridge. The laboratory specializes in advanced measurement and characterization techniques, and the university department specializes in nanofabrication techniques. At the intersection of these fields, Hitachi seeks to increase its knowledge of semiconductor physics for use in future electronic and optical devices.

The director of the laboratory, Dr David Williams, states that this form of close collaboration makes it possible for Hitachi to gain access to the university's researchers on a daily basis. By co-locating to such an extent, a firm like Hitachi can gain access to more researchers than they are paying for themselves. Conversely, the university gains access to around 25 researchers in Hitachi's Cambridge laboratory.

6. Summary and Conclusions

Many studies have focused on university–industry relationships and on the benefits of regional spillovers from universities, providing insight into the potential benefits of co-locating corporate R&D with academic centres of excellence and into the effects on regional growth. This paper addresses something that few studies have done. It provides insight into the workings and benefits of localized university–industry interactions between global firms and elite European universities.

To do so, we developed explorative case studies with a close relationship to theory. Based on existing literature we proposed an initial set of variables that were used to structure the interviews and gather material: (1) the R&D activities of the subsidiary; (2) the rationale for interaction with the local university; (3) the effects of that interaction; and (4) the modes of interaction with the university organization and its researchers. Interviews were performed at 16 R&D subsidiaries of MNEs that have formal collaborations with either ETH Zurich, Karolinska Institutet or Cambridge University. We discussed the results in terms of these variables and then proposed a framework, which consists of two main dimensions.

The taxonomy is one of our contributions, because future work can verify empirically whether the four ideal types put forward hold for other firms and regions, as well as go further in explaining the results theoretically. The first dimension captures the heterogeneous and strategic importance of collaboration with a university to the MNE, highlighting the finding that collaboration with the local university is a primary strategic objective for some subsidiaries, while for others collaboration is a secondary objective. The second dimension is linked to the type of knowledge involved; that is, whether the firms are primarily looking for scientific and engineering knowledge or more explicitly linking such technical knowledge to specific improvements and branding. The resulting matrix enabled us to identify four ideal types of strategy for firms for university–industry interaction: Running

Clinical Trials, Solution Demanders, Competent Buddies and Seamless Networks. We then classified the 16 firms studied and illustrated each of the four ideal types.

The results provide insights that are directly relevant to many of the academic and policy discussions on university–industry relationships, as well as those on regional spillovers and the role of the university in promoting economic growth. One issue is the extent to which we can see integration of global companies into regional systems of innovation, an issue which may be over-generalized in the literature (Breschi and Lissoni, 2001). Clearly, the companies analysed here are not ''automatically'' integrated into their respective regions. Nor do they obtain knowledge spillovers. Several firms explicitly state that the research conducted by their local university is not relevant to their current activities. Those firms that are interested in the research of their co-located universities either wish to have a ''listening post'' for potentially disruptive technologies or to use the university to address specific bottlenecks arising in internal firm R&D. Many are interested in accessing networks and facilitating recruitment through active interaction. This suggests that the benefits of localized interaction with the research university depend primarily on the strategic function of that R&D subsidiary within the overall R&D strategy of the corporation. Thus, the firm is the active partner in the collaboration and these types of firms are highly strategic and proactive in accessing certain networks and problem-solving capabilities.

A related issue is the extent to which firms are looking for research as opposed to development activities—and a recognition that the same firm may look for different benefits in their multiple relationships with universities around the world. Von Zedtwitz and Gassman (2002) address the different locational drivers for both research and development. However, our results place the issue of R&D in relation to the firm's goals. Our ideal types categorize the organizational forms, intensity and rationale for interaction, and the illustrative cases suggest that these aspects are aligned either to the firm's desire for more access to people or to specific problem-solving. The Seamless Network firms, which were mainly located in Cambridge, clearly stated that their collaboration was unique. They were the only firms to articulate the importance of being close to cutting-edge science per se. By co-locating with the university, these firms often seem to benefit from the direct knowledge flows that occur from the daily interaction with researchers. The Running Clinical Trials firms, which were collaborating with Karolinska Institutet and active in pharmaceuticals, found access to clinicians and doctor and patient groups vital, but were mostly not interested in fundamental research at that university.

A final issue is the overall importance of interacting with the elite university. The results raise questions about our current understanding of the value of ''knowledge flows'' as a driver for co-location, which is emphasized in the literature about localized knowledge spillovers. Direct and strong flows of knowledge between university research and corporate R&D activities are only found to be relevant for the understanding of one ideal type—the Seamless Networks. In fact, our tentative conclusion that Seamless Network subsidiaries are mainly found in the vicinity of only one of our three elite universities, Cambridge, suggests that even the academic excellence of a university in itself does not guarantee R&D investment from foreign MNEs. With the exception of Baxter Healthcare, which is located on the south campus of Karolinska Institutet, Seamless Network firms are all found either on the campus or in the immediate vicinity of Cambridge University. ETH Zurich primarily attracts Solution Demanders. Karolinska Institutet has formal collaborations with R&D

subsidiaries categorized in all four of the ideal types, and is also the only university to attract firms that are Running Clinical Trials.[3]

Our interviews indicate that the R&D subsidiaries have located close to these elite European research universities for very different reasons. In one ideal type, that of Seamless Networks, the interview results suggest that these elite research universities can exert a clear force of attraction on R&D investment that is embodied as R&D subsidiaries. Similarly, firms acting as Competent Buddies also find a lower level but still multifaceted rationale for being geographically proximate to their university. However, Solution Demanders identified only minor direct benefits from interaction with the local research university. For firms Running Clinical Trials, localized interaction is crucial, but their local linkages are limited to contacts with doctors and clinical researchers. Thus, they benefit from co-location with excellent university hospitals rather than with excellent universities per se.

These empirical results also have implications for public policy and for university leaders. Our results indicate that the opportunity to interact directly with a local research university does not seem important enough to act as a ''magnet'' for all decisions about R&D-related foreign direct investment. Moreover, if not even the top-ranked and most renowned universities can attract subsidiary R&D by the direct power of their research excellence, the situation for other universities seems bleak. It is also interesting that global firms will go to a leading university such as Karolinska in order to run clinical trials even though they have other types of formal collaboration in place.

Therefore, policymakers and university leaders must develop a more nuanced understanding of firms' differing rationales for collaboration. One aspect is the technology and industrial sector. Public policymakers and university leaders cannot assume that firms within specific industries are necessarily looking for fundamental research or applied development, respectively. Our illustrations clearly show that this is not always the case. With the exception of the category of clinical trials for pharmaceuticals, this classification extends beyond commonly used sectoral divisions. This may be surprising, as the heterogeneity of needs for collaboration between industries is a stylized fact in much of the existing literature on university–industry relations (Nelson, 1986; Meyer-Krahmer and Schmoch, 1998) and the differences between sectors is documented in the literature on R&D localization by MNEs (Hegde and Hicks, 2008).

Another implication involves the ways in which public policy and university strategies work with these firms. Special arrangements in terms of facilities and legal contracts may need to be arranged for Seamless Network firms, whereas Solution Demanders may be dealt with using the technology transfer instruments which have been developed in the past 10 years or so. These results call for a better understanding of how the ''branding'' of universities affects corporate decision-making concerning university interaction. Public

[3] In order to check this result for bias we looked more closely at the other firms in the total population of 35 firms that fit our four criteria (see Section 3). We examined archival evidence and documents, and conducted interviews with representatives of regional agencies. From this we have been able to make preliminary classifications of the remaining R&D subsidiaries. These results are tentative but they are in line with the above paragraph. For Cambridgeshire, the other firms collaborating with the University of Cambridge are primarily in the Seamless Network category. Furthermore, we found no other firms in either Stockholm or Zurich that could obviously be placed in this ideal type. All the seven R&D subsidiaries in Stockholm were identified but we did not study the Running Clinical Trials firms.

policy and university strategies may also affect later developments. It seems plausible that a successful Seamless Network subsidiary may be "upgraded" to a Competent Buddy, or that a subsidiary of the latter type may be "downgraded" to a Solution Demander as a consequence of, for example, an inadequate supply of R&D labour.

Our results thus suggest that certain firms go to elite research universities to access particular types of international scientific knowledge which have a high value to the firm. Even among the elite universities, only a few can offer this. Firms access these universities because they find it more beneficial than to develop all these competencies in-house. Even though specific relationships may have developed over long periods of time, in each case the R&D managers were clearly reflecting on what they gained from any specific collaboration with a particular university. Depending on the answer to that question, the managers developed different strategies, goals and outcomes for the university–industry interaction. From the perspective of the firm, they are clearly placing their R&D investment in a specific region as a part of the strategy of a global company.

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References

Almeida, P. and Phene, A. (2004) Subsidiaries and knowledge creation: the influence of the MNC and host country on innovation, *Strategic Management Journal*, 25, pp. 847–864.

Andersson, M., Gråsjö, U. and Karlsson, C. (2004) Industry R&D location: the role of accessibility to university R&D and institutions of higher education, CESIS Working Paper Series, No. 68.

Anselin, L., Acs, Z. and Varga, A. (2000) Geographic spillovers and university research: a spatial econometric approach, *Growth and Change*, 31(4), pp. 501–515.

Anselin, L., Varga, A. and Acs, Z. (1997) Local geographic spillovers between university research and high technology innovations, *Journal of Urban Economics*, 42(3), pp. 422–448.

Arundel, A. and Geuna, A. (2004) Proximity and the use of public science by innovative European firms, *Economics of Innovation and New Technology*, 13(6), pp. 559–580.

Audretsch, D. B. and Feldman, M. P. (1996) R&D spillovers and the geography of innovation and production, *American Economic Review*, 86(3), pp. 630–640.

Audretsch, D. B. and Stephan, P. E. (1996) Company–scientist locational links: the case of biotechnology, *American Economic Review*, 86(3), pp. 641–652.

Breschi, S. and Lissoni, F. (2001) Knowledge spillovers and local innovation systems: a critical survey, *Industrial and Corporate Change*, 10(4), pp. 975–1005.

Broström, A. (2007) Guide for interviews with firms, *Collaboration for Competitiveness*, Appendix II. Available at http://www.ab.lst.se/upload/Projektwebbar/Innovation%20Society%202006/Dokumentation/Collaboration_for_competitiveness_Appendices.pdf (accessed 20 December 2008).

Broström, A., McKelvey, M. and Sandström, C. (2009) Elite universities and the R&D subsidiaries of multinational enterprises, in: M. McKelvey & M. Holmén (Eds), *European Universities Learning to Compete: From Social Institutions to Knowledge Businesses* (Cheltenham: Edward Elgar).

Cantwell, J. and Piscitello, L. (2002) The location of technological activities of MNCs in European regions: the role of spillovers and local competencies, *Journal of International Management*, 8(1), pp. 69–96.

Cantwell, J. and Piscitello, L. (2005) Recent location of foreign-owned research and development activities by large multinational corporations in the European regions: the role of spillovers and externalities, *Regional Studies*, 39(1), pp. 1–16.

Chiesa, V. (1996) Managing the internationalization of R&D activities, *Engineering Management*, 43(1), pp. 7–23.

Criscuolo, P., Narula, R. and Verspagen, B. (2005) Role of home and host country innovation systems in R&D internationalisation: a patent citation analysis, *Economics of Innovation and New Technology*, 14(5), pp. 417–433.

Davies, L. N. and Meyer, K. E. (2004) Subsidiary research and development, and the local environment, *International Business Review*, 13(2), pp. 359–382.

Dunning, J. (1994) Re-evaluating the benefits of foreign direct investment, *Transnational Corporations*, 3(1), pp. 23–52.

Dunning, J. (2000) The eclectic paradigm as an envelope for economic and business theories of MNE activity, *International Business Review*, 9(1), pp. 163–190.

Dunning, J. H. and Narula, R. (1995) The R&D activities of foreign firms in the United States, *International Studies of Management & Organization*, 25(1/2), pp. 39–73.

Faggian, A. and McCann, P. (2006) Human capital flows and regional knowledge assets: a simultaneous equation approach, *Oxford Economic Papers*, 58(3), pp. 475–500.

Feinberg, S. E. and Gupta, A. K. (2004) Knowledge spillovers and the assignment of R&D responsibilities to foreign subsidiaries, *Strategic Management Journal*, 25(8/9), pp. 823–845.

Fischer, M. and Varga, A. (2003) Spatial knowledge spillovers and research: evidence from Austria, *Annals of Regional Science*, 37(2), pp. 303–322.

Furman, J. L., Kyle, M. K., Cockburn, I. and Henderson, R. M. (2005) Public and private spillovers, location and the productivity of pharmaceutical research, NBER Working Paper Series, No. 12509.

Gerybadze, A. and Reger, G. (1999) Globalization of R&D: recent changes in the management of innovation in transnational corporations, *Research Policy*, 28(2/3), pp. 251–274.

Giuri, P. and Mariani, M. (2008) Inventors and the geographical breadth of knowledge spillovers, DRUID Working Paper, No. 08-01.

Glaser, B. G. and Strauss, A. L. (1967) *The Discovery of Grounded Theory: Strategies for Qualitative Research* (Chicago: Aldine Transaction).

Hegde, D. and Hicks, D. (2008) The maturation of global corporate R&D: evidence from the activity of US foreign subsidiaries, *Research Policy*, 37(3), pp. 390–406.

Jaffe, A. (1989) Real effects of academic research, *American Economic Review*, 79(5), pp. 957–970.

Jaffe, A., Trajtenberg, M. and Henderson, R. (1993) Geographic localization of knowledge spillovers as evidenced by patent citations, *Quarterly Journal of Economics*, 108(3), pp. 577–598.

Kuemmerle, W. (1999) Foreign direct investment in industrial research in the pharmaceutical and electronics industries: results from a survey of multinational firms, *Research Policy*, 28(2), pp. 179–193.

Kuemmerle, W. (2002) Home base and knowledge management in international ventures, *Journal of Business Venturing*, 17(2), pp. 99–122.

LeBas, C. and Sierra, C. (2002) Location versus home country advantages in R&D activities: some further results on multinationals' locational strategies, *Research Policy*, 31, pp. 589–609.

Mansfield, E. (1991) Academic research and industrial innovation, *Research Policy*, 20, pp. 1–12.

Mansfield, E. (1995) Academic research underlying industrial innovations: sources, characteristics and financing, *Review of Economics and Statistics*, 77(1), pp. 55–65.

Mansfield, E. (1998) Academic research and industrial innovation: an update of empirical findings, *Research Policy*, 26(7/8), pp. 773–776.

Meyer-Krahmer, F. and Schmoch, U. (1998) Science-based technologies: university–industry interactions in four fields, *Research Policy*, 27, pp. 835–851.

Meyer-Krahmer, F. and Reger, G. (1999) New perspectives on the innovation strategies of multinational enterprises: lessons for technology policy in Europe, *Research Policy*, 28(7), pp. 751–776.

Mowery, D. and Sampat, B. N. (2005) Universities in national innovation systems, in: J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds), *Handbook of Innovation*, pp. 209–239 (Oxford: Oxford University Press).

Narula, R. and Zanfei, A. (2005) Globalisation of innovation: the role of multinational enterprises, in: J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds), *Handbook of Innovation*, pp. 318–346 (Oxford: Oxford University Press).

Nelson, R. (1986) Institutions supporting technical advance in industry, *The American Economic Review*, 76(2), pp. 186–189.

Patton, M. Q. (1990) *Qualitative Evaluation and Research Methods* (Newbury Park, CA: Sage).

Ronstadt, R. C. (1978) International R&D: the establishment and evolution of research and development abroad by seven US multinationals, *Journal of International Business Studies*, 9(1), pp. 7–24.

Salter, A. J. and Martin, B. R. (2001) The economic benefits of publicly funded basic research: a critical review, *Research Policy*, 30(3), pp. 509–532.

Schär, P. (2006) Die internationalisierung von F&E am beispiel des IBM forschungslaboraorium rüschlikon, Masters Thesis, University of Zurich, Institut für Empirische Wirtschaftsforschung.

Shane, S. (2004) *Academic Entrepreneurship: University Spinoffs and Wealth Creation* (Cheltenham: Edward Elgar).

Teece, D. J. (1976) *The Multinational Corporation and the Resource Cost of International Technology Transfer* (Cambridge, MA: Ballinger Pub. Co.).

Thursby, M., Thursby, J. and Gupta-Mukherjee, S. (2007) Are there real effects of licensing on academic research? A lifecycle view, *Journal of Economic Behavior and Organization*, 63(4), pp. 577–598.

Von Zedtwitz, M. and Gassman, O. (2002) Market versus technology drive in R&D internationalization: four different patterns of managing research and development, *Research Policy*, 31(4), pp. 569–588.

Ylinenpää, H. and Lundgren, N.-G. (1998) Regional dynamics: a comparison of two Nordic regions, paper presented at the conference *SMEs and Districts*, LIUC, Castellanza, Italy, November.

Yusuf, S. (2007) University–industry links: policy dimensions, in: S. Yusuf & K. Nabeshima (Eds), *How Universities Promote Economic Growth*, pp. 1–25 (Washington, DC: World Bank).