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Discussion Paper
Series 1: Economic Studies
No 09/2009

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Internet http://www.bundesbank.de

ISBN 978-3–86558–512–7 (Printversion)
ISBN 978-3–86558–513–4 (Internetversion)

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Abstract

Multinational corporations (MNC) search increasingly for lead market knowledge and technological expertise around the globe. We investigate whether their subsidiaries gain access to these valuable sources of host country knowledge to the same degree as domestic rivals. We develop a theoretical framework for "why" and "how" a lack of embeddedness and legitimacy (liability of foreignness) may translate into additional obstacles for foreign subsidiaries. We test these hypotheses empirically using a broad dataset of more than 1,000 innovative firms in Germany. We find that MNCs can compete on an equal footing with host country competitors when it comes to generating impulses for innovations from universities. They are significantly challenged by liabilities of foreignness, though, when host country customers are involved. The disadvantages are especially pronounced when the host country industry is at the technological forefront. We suggest that the disadvantages arising from liability of foreignness in the host country are particularly relevant when promising lead customers have to be identified and their tacit and often unarticulated impulses have to be transferred, understood and prioritized.

Keywords: Liability of foreignness, knowledge spillover, globalization

JEL-Classification: F23, O31, O32, D83

Non-technical summary

Multinational corporations (MNC) search increasingly for lead market knowledge and technological expertise around the globe. Global headquarters are no longer the sole origin of new technologies which are subsequently passed through and adapted by a network of subsidiaries. Instead, international MNC subsidiaries play a far more active role. Foreign subsidiaries with the ability to turn host country knowledge into successful innovation generate competitive potentials for the MNC as a whole. A crucial ingredient for these innovation activities are knowledge spillovers from the foreign host country. The primary focus of our analysis is therefore the access for foreign MNC subsidiaries to host country knowledge sources. To be more precise, we investigate whether their subsidiaries gain access to these valuable sources of host country knowledge to the same degree as domestic rivals.

We develop a theoretical framework for "why" and "how" a lack of embeddedness and legitimacy (liability of foreignness) may translate into additional obstacles for foreign subsidiaries. Our theoretical reasoning suggests that liability of foreignness prevents MNC subsidiaries in foreign countries from achieving seamless integration. Furthermore, we explore the origins of these disadvantages by distinguishing between different host country knowledge sources (customers and universities) as well as how technologically advanced host country competitors are. We reason that in technologically less advanced environments foreign MNC subsidiaries may find it easier to access host country knowledge.

We investigate these hypotheses empirically using a broad dataset of more than 1,000 innovative firms in Germany. We find that MNC subsidiaries can compete on an equal footing with host country competitors when it comes to generating impulses for innovations from universities. They are significantly challenged by liabilities of foreignness, though, when host country customers are involved. The disadvantages are especially pronounced when the host country industry is at the technological forefront. We suggest that the disadvantages arising from liability of foreignness in the host country are particularly relevant when promising lead customers have to be identified and their tacit and often unarticulated impulses have to be transferred, understood and prioritized.

Nicht-technische Zusammenfassung

Multinationale Unternehmen (MNU) intensivieren zusehends ihre weltweite Suche nach zukunftsträchtigen Markt- und Technologietrends. Im Zuge dessen hat sich auch die Rolle der ausländischen Niederlassungen von MNUs verändert. Es ist nicht mehr alleine die Konzernmutter, die neue Technologien und Innovationen entwickelt, sondern in zunehmenden Umfang auch deren ausländische Niederlassungen. Gelingt es den Niederlassungen, externe Impulse und Erfahrungen aus ihrem Gastland in innovative Produkte und Prozesse umzusetzen, kann dies zu einem Wettbewerbsvorteil für das gesamte multinationale Unternehmen werden. Das Augenmerk dieser Studie liegt daher auf der Untersuchung des Zugangs ausländischer Niederlassungen zu Wissensquellen in ihrem Gastland. Die zentrale Forschungsfrage ist dabei, ob es Niederlassungen ausländischer MNUs gelingt sich in ähnlichem Umfang Wissensquellen zu erschließen wie ihren inländischen Konkurrenten.

Die vorliegende Studie entwickelt konzeptionelle Argumentationslinien dafür, weshalb eine fehlende Einbindung von MNC Niederlassungen in bestimmte Netzwerke und Legitimierungsdefizite („liability of foreigness“) ein Hindernis für den Zugang zu Wissensquellen im Ausland sein könnten. Die Analyse unterscheidet dabei zwischen verschiedenen Wissensquellen und deren Eigenschaften und Motiven (Kunden versus wissenschaftliche Einrichtungen). Darüber hinaus wird die Hypothese entwickelt, dass diese Legitimierungsdefizite besonders in den Branchen ausgeprägt sind, in denen die heimischen Wettbewerber technologisch führend sind.

Um die Hypothesen empirisch zu testen werden Mikrodaten aus dem „Mannheimer Innovationspanel (MIP)“ benutzt. Es ist auf dieser Basis möglich ca. 1000 innovative Unternehmen in Deutschland zu analysieren. Es zeigt sich, dass die Niederlassungen ausländischer MNUs keine Nachteile gegenüber ihren deutschen Konkurrenten haben, wenn es um den Zugang zu Wissen aus Universitäten und anderen wissenschaftlichen Einrichtungen geht. Ganz anders sieht es dagegen beim Zugang zu Kundenwissen aus. Hier haben Niederlassungen ausländischer MNUs einen signifikanten Nachteil. In Branchen, in denen deutsche Unternehmen technologisch führend sind, ist der Nachteil sogar noch ausgeprägter.

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1 Introduction

The development of new technologies is concentrated in relatively few countries worldwide. The seven most industrialized countries accounted for 84% of global R&D expenditures in 1995 (Keller, 2004) and still 80% in 2005 (OECD, 2007), with some countries such as South Korea catching up in recent years (Furman and Hayes, 2004; Mahmood and Singh, 2003). Hence, the diffusion of knowledge across borders becomes a necessity for global growth (Romer, 1990). However, knowledge flows have been found to be geographically localized and largely an intra-national phenomenon (Branstetter, 2001). Geographical distance and language barriers (Keller, 2002) and not only national but also federal state borders restrict knowledge diffusion (Jaffe et al., 1993) even when controlling for regional clusters of production (Audretsch and Feldman, 1996). These border effects are typically explained by the tacit nature of important parts of the knowledge to be transferred, i.e. it cannot be articulated and is acquired through action (Polanyi, 1967) or understood through practical experience in changing contexts, similarly to the closely related concept of skills (Nelson and Winter, 1982). This makes tacit knowledge difficult to transfer. MNCs and their network of international subsidiaries have been seen as channels for facilitating knowledge flows though border-spanning intra-firm mechanisms based on interpersonal networks and social context (Kogut and Zander, 1993). This function of MNCs has been investigated with mixed results for knowledge flows into host countries (for a review, see Keller, 2004) and those out of host countries (see for example Almeida, 1996; Frost, 2001). We adopt the latter perspective.

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The authors thank Heinz Herrmann, Christian Rammer, Thorsten Teichert and Michel Clement for invaluable feedback and discussions.

Malmberg and Maskell (2005) postulate that modern firms need “pipelines” to valuable technological expertise and market intelligence around the world. This implies a shift in the locus of knowledge production. Global headquarters are no longer the sole origin of new technologies which are subsequently passed through and adapted by a network of subsidiaries. Instead, host country subsidiaries play a far more active role. Intra-MNC knowledge transfers are still crucial but the central role of foreign subsidiaries stems from their ability to tap into localized pools of expertise in the host country and access technological and market-related information (Almeida and Phene, 2004). Foreign subsidiaries with the ability to turn these external impulses into successful innovation generate competitive potentials for the MNC as a whole (Birkinshaw and Hood, 1998). A crucial ingredient for these innovation activities are knowledge spillovers from the host country. The primary focus of our analysis is therefore the access for foreign MNC subsidiaries to host country knowledge sources. More precisely, we will focus on host country costumers and universities as major sources for market and technological knowledge (see, for example, Doz et al., 2001).

Managing these knowledge flows across cultural and social barriers can be challenging and has been found to be more frequently prone to errors and delays (Lord and Ranft, 2000). These frictional losses of multinational firms operating outside of their home market are typically summarized as liability of foreignness (Zaheer, 1995). We incorporate this stream of research into the more general concept of knowledge spillovers. Our theoretical reasoning suggests that liability of foreignness prevents foreign MNC subsidiaries from achieving seamless integration. Furthermore, we explore the origins of these disadvantages by distinguishing between different host country knowledge sources (customers and universities) as well as how technologically advanced host country competitors are. We reason that in technologically less advanced environments foreign MNC subsidiaries may find it easier to access host country knowledge. On the basis of these results, targeted countervailing strategies can be derived.

Additionally, we hope to contribute to the existing literature through the empirical testing of our hypotheses. Previous research has largely focused on high-tech industries (e.g. semiconductors) and traced only successful knowledge flows through patent citations (see, for example, Almeida and Kogut, 1999; Almeida and Phene, 2004). We are able to utilize survey

data from more than 1,100 companies in Germany from various industries and their innovation activities.

The paper is organized as follows. The next section presents our conceptual framework followed by the analytical part and hypothesis development. Section 3 outlines the empirical study. The results of these quantitative tests are interpreted in section 4. A discussion of these results and management recommendations are provided in section 5. The article finishes with concluding remarks and limitations of the research in section 6.

2 Theoretical framework

We choose the more general literature on knowledge flows in innovation activities as our starting point. We will highlight the role of the knowledge source and its willingness to share as an important element of the discussion. As a next step, we will invoke the literature on the "legitimacy" of organizations and the negative effects from a lack thereof as a primary reason for not receiving and sharing knowledge. In the international business literature this lack of legitimacy and the resulting disadvantages to foreign MNC subsidiaries have been defined as a "liability of foreignness" (Zaheer, 1995). We will relate this concept back to host country knowledge flows and derive hypotheses.

Knowledge flows and legitimacy deficits

Academic discussion on challenges and opportunities for managing knowledge flows with external partners has not been limited to MNCs. A broader stream of literature emphasizes the opportunities arising from interacting with external partners in innovation activities as well as the challenges of managing these interactions (see, for example, Chesbrough, 2003). In recent years industries and technologies have undergone major changes that have led to an increase in the uncertainty and complexity of innovation processes. The speed of technological changes requires firms to source knowledge externally because they cannot generate new ideas and inventions solely by using the knowledge they have in-house (Matusik and Heeley, 2005) or as Tsang (2000; p.225) put it, "tapping external sources of know-how becomes a must". Teece writes, "The modern corporation, as it accepts the challenges of the new knowledge economy, will need to evolve into a knowledge-generating, knowledge-integrating

and knowledge-protecting organisation." (Teece, 2000, 42). The increasing demand for (external) knowledge has been studied extensively (see, for example, Hagedoorn, 1993, 2002; Powell, 1987; Cassiman and Veugelers, 2002).

Many studies that investigate knowledge flows (in the innovation process) have built on the "absorptive capacity" concept introduced by Cohen and Levinthal (1989; 1990) [2]. They argue that in order to be able to source and use external knowledge in the innovation process, firms need to have absorptive capacities, i.e. the ability to "identify, assimilate and exploit knowledge from the environment" (Cohen and Levinthal, 1989; p.569). This literature focuses on how firms can build absorptive capacity (see overview by Daghfous; 2004) and has mainly been concerned with the characteristics and strategies of firms receiving knowledge spillovers.

More important for our study is the role of the knowledge source. Several authors conceptualize knowledge flows beyond the recipient firm and its absorptive capacity (Dyer and Singh, 1998; Lane and Lubatkin, 1998). From their perspective, no generally available pool of knowledge exists. Instead, knowledge flows are modelled as dyadic relationships. Their effectiveness and efficiency depend not just on the recipient but also on the context and the willingness and ability of the source to share (Szulanski, 1996; 2000; Dyer et al., 2001). Absorptive capacity can therefore be considered partner specific. Dyer and Singh (1998) call this the "relational view". The knowledge sender (i.e. its source) has to have an incentive to transfer the knowledge. Lane and Lubatkin (1998) find that learning is easier if the two partners involved in the process are similar. Additional costs incurred by the knowledge source for getting to know a potential knowledge recipient, developing relationships and sharing practices may therefore pose obstacles to successful knowledge sharing. We find this perspective especially relevant for our research question on how foreign MNC subsidiaries gain access to host country knowledge sources. We will extend this discussion to the general concept of legitimacy in knowledge exchanges and refine it towards the specific challenges for MNC subsidiaries.

Suchman (1995) defines legitimacy as "a generalized perception or assumption that the actions of an entity are desirable, proper, or desirable within some socially constructed systems of norms, values, beliefs, and definitions (p. 574)". Achieving legitimacy is desirable

[2] For overviews of studies using the concept see Zahra and George (2002), Lane et al. (2006) or Daghfous (2004).

for all firms as it provides them with access to valuable resources in their environment. Conversely, a lack of legitimacy can be perceived as a "liability". Often, these deficits stem from a lack of exposure (liability of newness), resources (size) or cultural roots (foreignness) (Zaheer and Mosakowski, 1997). Legitimacy perceptions are socially constructed and can originate from a variety of internal and external stakeholders of the firm (for a recent review see Rao Singh et al., 2008). Suchman (1995) compares two major dimensions of legitimacy: An institutional perspective emphasizing cultural pressures on all firms within a group or industry and a strategic perspective in which management can actively build and manipulate social support.

International business literature has investigated these challenges with a particular focus on MNC subsidiaries. Zaheer (1995) introduces the concept of "liability of foreignness" based on Hymer (1976): multinational companies face inevitable disadvantages abroad that companies operating in their home environment do not. These frictional losses from cultural and social barriers represent the roots of liability of foreignness (Zaheer, 1995). The forces behind liability of foreignness are sociological in nature and have structural, relational and legitimacy dimensions (Zaheer, 2002). Differences in language and hence communication and understanding are a major factor, yet not the only ones (West and Graham, 2004). The visible symptoms of these challenges are more frequent errors, unnecessary risks and delays (Lord and Ranft, 2000). These are as lasting as the liabilities of size and newness (Zaheer and Mosakowski, 1997). The literature on liability of foreignness has – like the more general legitimacy debate – derived institutional host country-specific factors and strategic MNC-specific factors behind these disadvantages. On the one hand, they are due to a lack of legitimacy in the firms' host country institutional environment. Host country stakeholders (customers, investors, politicians) have an increased level of uncertainty because of the missing knowledge about the foreign company and the quality of its products and services. On the other hand, foreign firms project their competitive practices and capabilities from their home countries onto the host market in ways that are not compatible with the local context (Hymer, 1976).

Host country competitors can translate their "home field" advantage into superior effectiveness and efficiency (Mezias, 2002b). Even if MNCs rely heavily on host country management teams, they will always have to carry the extra burden of securing intra-firm consistency in communication and coordination across national and cultural borders (Mezias,

2002a; b). This generates frictional losses which firms do not face in their home markets. These relative disadvantages are hard to eliminate since they represent the sum of numerous small delays, bad decisions or unnecessary risks (Lord and Ranft, 2000). They include additional or disproportionately high costs for foreign firms, as well as foregone revenues and profits (Mezias, 2002a). Individual firms can overcome these liabilities of foreignness if they possess superior firm-specific competitive advantages (Caves, 1971).

The concept of liability of foreignness has been investigated and supported in numerous studies. They identify these disadvantages in various sectors (most prominently banking and currency trading) and at several performance levels, e.g., relative lack of efficiency or profitability, market exits, increased likelihood to be subject to labour lawsuits (DeYoung and Nolle, 1996; Hasan and Hunter, 1996; Hennart et al., 2002; Mezias, 2002b; Miller and Parkhe, 2002; Miller and Richards, 2002; Zaheer, 1995; Zaheer and Zaheer, 1997). We extend this line of research to potential disadvantages in the innovation activities of foreign MNC subsidiaries.

Liability of foreignness in knowledge access

Knowledge cannot be separated from the commitments and belief patterns of its holders (Nonaka, 1994). Long-lasting exposure, experience and interaction produce an entity that is tailor-made to function effectively and efficiently in the home market. This knowledge is largely acquired automatically at minimal extra costs. Substantial parts of these social and cultural laws are causally ambiguous and not codified (Jensen and Szulanski, 2004). Firms lose these home market certainties once they engage abroad. They encounter cognitive uncertainty, i.e. in predicting and explaining the behavior of others (Harvey and Novicevic, 2000). Foreign direct investments primarily reduce the spatial distance between a foreign firm and the host country knowledge pools. They do not automatically remove other important barriers to knowledge flows such as social, cultural, cognitive, administrative, institutional and organisational differences (Boschma, 2005; Ghemawat, 2001, 2003). These obstacles are particularly pronounced when foreign firms search for valuable sources of innovation abroad (Al-Laham and Amburgey, 2005).

Moreover, foreign subsidiaries operate in a dual context because they need to provide consistency with both the MNC and the host country (Almeida and Phene, 2004). They follow shared practices and procedures within the MNC that may not be compatible with the host

country environment. Harvey and Novicevic (2000) introduce the concept of global organizational ignorance to cross border interactions: an unawareness of relevant information and how to interpret it correctly. Managers rely on past experiences given the contextual ambiguity abroad (Dow, 2006). The underlying logic is derived from general decision-making theory. Deciders tend to rely on knowledge from their home market even when it is not suitable for the host country context. This is due to the fact that it is more readily available, can be related back to a class of previous experiences and provides consistency with previous convictions (Harvey and Novicevic, 2000). Hence we derive our first hypothesis:

> *Hypothesis 1: Foreign subsidiaries are less likely to benefit from host country knowledge spillovers in their innovation activities than domestic firms.*

Legitimacy is socially constructed by the relevant social group. Suchman (1995, p. 574) notes "it is possessed objectively, yet created subjectively". Hence, the disadvantages from a lack of legitimacy (i.e. liability of foreignness) may vary with regard to different groups of knowledge sources. External knowledge can be tacit or formal (e.g., Polanyi, 1967; Cowan et al., 2000; Bartholomaei, 2005; Dyer and Hatch, 2004), specific or generic (see e.g., Breschi et al., 2000), embodied or disembodied (Romer, 1990) or take the form of information and know-how (Kogut and Zander, 1992), to name a few widely-used distinctions of knowledge types. These attributes of knowledge are important for its degree of transferability. Unique experience and organizational learning are important. Therefore, only parts of knowledge can be codified. It is also the embedded routines, tasks, practices, norms and values of organizations (Bhagat et al., 2002) which hinder or support knowledge transfer. The complexity of knowledge makes its transfer less efficient as larger amounts of information have to be transferred for a complete and accurate transmission of its meaning (Bhagat et al., 2002). The transfer of tacit knowledge is less effective. It cannot be readily articulated or codified and is discovered only through action and experience (Polanyi, 1967). Absorbing this kind of knowledge entails causal ambiguities (Szulanski, 1996). Hence, access to host country knowledge sources and their willingness to engage in knowledge exchanges becomes crucial. We conclude that the effects of liability of foreignness differ with regard to different host country knowledge sources. Asmussen et al. (2009) discuss the multidimensionality of host country environments and subsidiary competences. They argue that host country market information would require skilled sales personnel with who can access and interact with demanding customers. Technological host country information, though, would mostly be

found in universities and requires skilled engineers to understand and extract the knowledge. A distinction between different knowledge sources appears therefore appropriate. We will further explore two particular host country knowledge sources: customers and universities.

Host country clients are promising knowledge sources for MNC subsidiaries as their input may immediately impact sales. However, identifying and exploiting promising customer knowledge for successful innovation has been found to be challenging. Customer needs are largely unarticulated (Von Zedtwitz and Gassmann, 2002) and their impulses have been found to be frequently wrong, myopic or narrow (Frosch, 1996). Therefore, identifying and activating reliable lead users (Von Hippel, 1988) requires extensive background knowledge and local experience, both of which are difficult for foreign firms to acquire. The lack of legitimacy and reputation in the host country is likely to amplify this effect further. The host country customer aspect of a "lack of legitimacy" in foreign markets has been a focal point of the marketing literature on country-of-origin effects. Put simply, it refers to buyer conceptions that treat the information of the country of origin as a clue as to product quality (Bilkey and Nes (1982) present an overview).

Foreign MNCs in search of technological and scientific knowledge are likely to try to gain access to knowledge held and produced by host country universities and public research centers. As Arundel and Genua (2004) have shown, the transfer of knowledge between firms and scientific institutions can be organized in various ways. They find that for Europe's largest firms the hiring of university graduates, informal contacts and contracted out research are the three most important channels of knowledge transfer. The importance of informal channels and personal contacts for the knowledge transfer from universities and public research institutions to industrial firms has also been confirmed by studies in the US (e.g. Cohen et al., 2002; Thursby and Thursby, 2001). In a similar vain, Laursen and Salter (2004) write that employees with a university background (science and engineering) are likely to use their relationship with universities to draw on the research results of universities.

This emphasis on personal networks may put foreign MNCs at a disadvantage compared with domestic firms. Foreign MNC subsidiaries are more likely to lack the necessary embeddedness in the relevant social networks. Moreover, they face additional obstacles when trying to hire university graduates due to a lack of legitimacy or reputation as an attractive career opportunity (Newburry et al., 2006).

Then again, there are incentives for scientists to diffuse their knowledge and technologies widely. Large parts of their research are funded by the state. It is often times part of their mission to disseminate their findings and to commercialize research results (see e.g. OECD, 2000; OECD, 1998). Furthermore, output from scientists and institutions is evaluated according to the number and quality of their publications and sometimes the amount of money they generate through contract research. This provides incentives for knowledge sharing and collaboration with external partners at the individual researchers' level (Genua and Martin, 2003). These incentives may counterbalance the negative impact of liabilities of foreignness when dealing with foreign MNC subsidiaries. Furthermore, scientific knowledge is a public good once it is published (Arrow, 1962; Jaffe, 1986) and thus, in principal, available to all, including both domestic firms and foreign MNCs. This should allow subsidiaries of foreign MNCs to access knowledge from host country universities.

In conclusion, two potentially countervailing effects are at work for foreign MNC subsidiary access to host country university sources. Thus, the effects of liability of foreignness may be ambiguous. Our second hypothesis is therefore formulated in a way that compares access to customer knowledge – for which we did not identify an effect that counterbalances the negative liability of foreignness effect – and access to scientific knowledge. We expect host country universities' incentives for knowledge diffusion to render them more open than host country customers to sharing their knowledge with foreign MNC subsidiaries.

> *Hypothesis 2: Compared with domestic firms, foreign MNC subsidiaries are less likely to be able to access host country customer knowledge than scientific knowledge for their innovation activities.*

Finally, liability of foreignness is inherently a relative construct. Its degree can only be assessed relative to host country competitors (Mezias, 2002b). We expect heterogeneous disadvantages for foreign firms in host country industries. Salomon and Jin (2008) identify an effect of the technological leadership status of an industry on the propensity to benefit from international knowledge spillovers. Within our framework of MNC subsidiary knowledge sourcing we suspect that the negative effect of a lack of legitimacy induced by liability of foreignness will be especially pronounced if host country competitors in the same industry are at the technological forefront. This leadership status should give host country rivals higher levels of legitimacy within the host country. Foreign MNC subsidiaries may therefore be relatively more challenged from their lack of legitimacy. Put differently, we suggest that host country customers and university

knowledge sources may be more willing to engage in exchanges with foreign MNC subsidiaries if host country counterparts are comparatively less attractive partners and vice versa.

We hypothesize:

> *Hypothesis 3: In technologically advanced host country industries foreign subsidiaries are less likely to benefit from host country knowledge spillovers in their innovation activities than domestic firms, and vice versa.*

3 Empirical study

3.1 Data

For the empirical part of this analysis we use cross section data from the German innovation survey called the "Mannheim Innovation Panel" (MIP). The survey is conducted annually by the Centre for European Economic Research (ZEW) on behalf of the German Federal Ministry of Education and Research. It is the German contribution to the European Community Innovation Survey (CIS). The methodology and questionnaire used in the survey, which is targeted at enterprises with at least five employees, are the same as those in the Community Innovation Survey (CIS). For our analysis we use the 2003 survey, in which data was collected on the innovation activities of enterprises during the three-year period 2000-2002. About 4,500 firms in manufacturing and services responded to the survey and provided information on their innovation activities.[3] We use this data to operationalize the concepts presented above. Additionally, we complement this dataset with data on patents granted by the European Patent Office and data on business R&D expenditures provided by the OECD (ANBERD - R&D expenditure in Industry 2003). Non-innovating firms were excluded from our analysis, because several relevant variables are available for firms with innovation activities only.

Most of the literature presented above relies on patent statistics to analyse (international) knowledge flows. CIS surveys, by contrast, generate self-reported and largely qualitative data,

[3] The sample was drawn using the stratified random sample technique. For a more detailed description of the dataset and the survey see Rammer et al. (2005).

which raises quality issues with regards to administration, non-response and response accuracy (for a recent discussion see Criscuolo et al., 2005). To ensure high data quality the following measures are taken: First, our CIS survey was administered via mail which prevents certain shortcomings and biases of telephone interviews (for a discussion see Bertrand and Mullainathan, 2001). The multinational application of CIS surveys adds extra layers of quality management and assurance. CIS surveys are subject to extensive pre-testing and piloting in various countries, industries and firms with regards to interpretability, reliability and validity (Laursen and Salter, 2006). Second, a comprehensive non-response analysis in Germany of more than 4,000 firms uncovered no systematic distortions between responding and non-responding firms with respect to their innovation activities. Third, the questionnaire contains detailed definitions and examples in order to increase response accuracy. Longhand questions (e.g. "Please describe your most important product innovation briefly") allow consistency checks for multiple choice answers. Finally, heads of R&D departments or innovation management units are asked directly if and how they are able to generate innovations. This immediate information on the processes and outputs of innovation activities can complement traditional measures for innovation such as patents (Kaiser, 2002a; Laursen and Salter, 2006).

The major advantage of using CIS survey data for our study rather than patent data is that the surveys provide direct measures for a comprehensive set of knowledge sources (Criscuolo et al., 2005). On the downside, this survey information is self-reported.

Measuring knowledge spillovers (Dependent Variables)

The stock of knowledge generated and available in an industry is hard to measure (Jaffe, 1986) and so are knowledge spillovers. Knowledge flows leave hardly any paper trail. The exceptions are patent applications, which allow researchers to analyze the citing behavior of the applicant and trace some of the ideas in the application back to its origins (Jaffe and Trajtenberg, 1999). A fundamental issue with patent analysis is that "not all inventions are patentable, not all inventions are patented" (Griliches, 1990; p.1669). This fact limits the ability to trace knowledge spillovers through patents. Knowledge generated by customers is seldom reflected in patent citations and thus cannot be analyzed using patent data. With the advent of innovation surveys, some authors have started using questionnaires on the importance of external sources of information for the innovation activities of firms as a proxy for knowledge flows and spillovers (e.g., Cassiman and Veugelers, 2002; Belderbos et al., 2004; Bönte and Keilbach, 2005). The questions on external sources can be interpreted as a paper trail left by

spillovers. They are a more direct measure than patent data and cover a wider range of sources and types of knowledge than patent applications.

We use two survey questions to measure knowledge spillovers: one for knowledge from customers and one for knowledge from academic institutions. We use separate questions that ask firms whether their innovations during the three-year period 2000-2002 were essentially based on impulses from customers or academic institutions (universities and/or research institutes; for simplicity in presentation we will focus the discussion on universities) located in Germany.[4] Hence, our two dependent variables are binary and take the value one if the firm indicated that it received spillovers from German customers and/or German universities. These variables provide only a qualitative assessment of knowledge spillovers in the sense that we are not able to measure the level of spillovers or the number of impulses received. We know, however, that the spillovers we measure were important inputs for successful innovation projects. Note, with the data we have, we cannot identify the channels through which the knowledge from a given source reaches the firms (e.g. through joint R&D activities or publications).

Measuring liability of foreignness and additional independent variables

Firms' degrees of liability of foreignness cannot be readily observed and managers can hardly be expected to give reasonable estimates of it. We follow Mezias (2002a) who suggests an empirical approach to capture the effects of liability of foreignness. It is based on a broad definition of liabilities (costs that only foreign firms have to bear or bear disproportionately, including forfeiting benefits) and controls for other liabilities (e.g., age, newness, size) as well as contextual aberrations (e.g. regional differences), a comparison group of domestic firms (which can be multinational themselves) and an analysis at the firm level (preferably through a dummy variable).

The definition of foreignness is key to our analysis. Zaheer and Mosakowski (1997) discuss a number of concepts that indicate whether a company can be considered foreign: nationality

[4] The question is part of a section that initially defines external sources for innovation as impulses that were indispensable for the firm's new products, services or processes. The exact question is: "Have you introduced significantly improved products or processes between 2000 and 2002 because specific customers asked for them or demanded them directly? If yes, from which country did they come predominantly? … also from? …". The question on academic sources reads: "Have you introduced significantly improved products or processes between 2000 and 2002 that were only made possible through new research results by universities or public research institutions?" We consider an important German knowledge flow to be established when the respondent wrote "Germany" into the "predominantly" country field of the customer or academia question.

of the majority of workers (Reich, 1990), share of foreign shareholders, nationality of the largest single shareholder, perception of a company in a particular country or the location of international headquarters. We will use the latter. Hence, we treat a company located in Germany as foreign if it indicated that it is part of a multinational group with its headquarters abroad. The coefficient for this dummy variable should tell us whether we can identify liability of foreignness. Hypothesis 1 would be borne out if the coefficient is negative and significant. The effect for customers should be significantly larger than for academic institutions in order to support Hypothesis 2.

To achieve an unbiased estimate of the degree of liability of foreignness we have to check for other important influencing factors of knowledge spillovers (Mezias, 2002a). We suggest three components which need to be considered: different levels of absorptive capacity, varying needs and opportunities for knowledge sourcing and other liabilities (such as size). All three are described below.

Companies differ with respect to absorptive capacities, which are usually proxied by R&D related variables in empirical studies[5] (see Schmidt, 2005). In our model we use the R&D intensity, measured as the share of R&D expenditure over total sales, and a dummy variable for continuous R&D activities as proxies for absorptive capacity. Measuring absorptive capacity with the continuous R&D variable takes the path-dependent character of absorptive capacity into account (Cohen and Levinthal, 1990). Furthermore, this aspect will be captured by another variable that we include in our model: the patent stock per employee at the beginning of our observation period[6]. This variable also proxies the experience with and success of firms' R&D activities and can be seen as a measure of the accumulated stock of technological knowledge of a firm (see e.g. Kaiser, 2002b). R&D and patents are not the only building block of absorptive capacity. Additionally, it depends on the employees' skills (Cohen and Levinthal, 1990; Rothwell and Dodgson, 1991), which are represented by the share of employees with higher education in our empirical model. The management literature has stressed that the ability to access and exploit external knowledge is not a given, but has to

[5] Absorptive capacity is a multilevel concept which could also be measured by output indicators ("realized AC") see Zahra and George (2002). The data at hand does not contain these indicators. This is not a major drawback, however, since the link between the input measures we use and absorptive capacity is well established in the empirical literature.

[6] To construct the patent stock for each firm, we use information on all patents granted by the EPO to a given firm and employ a perpetual inventory method, with the standard depreciation rate of 15% (see e.g. Griliches and Mairesse , 1984).

be actively managed and stimulated (e.g., Lenox and King, 2004; Lord and Ranft, 2000; Mahnke et al., 2005). To capture this aspect of absorptive capacity, a scale for the stimulation of knowledge-sharing and innovation activities is calculated and included in the model.[7]

Furthermore, companies vary in their needs and opportunities for utilizing knowledge spillovers. Most importantly, they may have different mandates and goals for their German innovation activities. This has been found to be an important factor for the innovation activities of foreign subsidiaries (Birkinshaw and Hood, 1998; Nobel and Birkinshaw, 1998). Foreign subsidiaries may just adapt products to local tastes/regulations (Mansfield et al., 1980) or act as listening posts (Almeida, 1996). We control for these potential biases by introducing a scale variable indicating the breadth and depth of a firm's innovation strategy.[8]

We introduce additional industry-level measures: Most importantly, we introduce a measure on the technological leadership status of German industries (NACE 2) to test Hypothesis 3. We calculate the R&D index on the basis of the OECD ANBERD data[9] developed by Salomon and Jin (2008). The index is constructed by comparing the R&D expenditures of German industries with those of the other OECD countries. It allows the identification of industries in which Germany is a technological leader or laggard.

The following formula is applied:

$$RDI_j = \frac{R_j^{Germany}}{GDP^{Germany}} - \left[\sum_{k=1}^{n} \left(\frac{R_{kj}}{GDP_k} \right) \right] \bullet \frac{1}{n}$$

7 The scale was derived as follows: Companies indicated on a four-point Likert scale what importance their company assigned to nine different measures of stimulating innovation, ranging from targeted recruiting to non-material incentives and monetary bonuses. A principal component factor analysis was performed on these nine categories, yielding a single factor with an eigenvalue larger than one (5.94; Cronbach's alpha scale reliability coefficient 0.84; Kaiser-Meyer-Olkin measure of sampling adequacy 0.87). The scale represents these factor loadings after Varimax rotation rescaled between 0 and 1.

8 The scale was derived as follows: Companies indicated on a four-point Likert scale what importance their company assigned to five innovation strategies: technological leadership, cost leadership, first in industry with new products, first in industry with new processes, development of cutting edge technologies. A principal component factor analysis was performed on these five categories, yielding a single factor with an eigenvalue of more than one (1.88; Cronbach's alpha scale reliability coefficient 0.75; Kaiser-Meyer-Olkin measure of sampling adequacy 0.73). The scale represents these factor loadings after Varimax rotation rescaled between 0 and 1.

9 The OECD ANBERD database covers Australia, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom and the United States. Hence, it is considered a suitable proxy for global R&D business expenditures. We use data from 2001 (the beginning of our observation period). It can therefore be considered predetermined.

where R is R&D expenditure in industry j and country k or in Germany in 2001 and GDP is the gross domestic product of country k or Germany in 2001[10].

Our third hypothesis – that it is particularly difficult for foreign MNCs to gain access to German sources in industries in which Germany is a technology leader – would be confirmed if the interaction of this variable with our measure of foreignness turned out to be statistically significant.

To check for the other liabilities suggested by Mezias (2002a) we introduce company size (number of employees), age/newness (years since the founding of the company in Germany), regional deficiencies (East Germany) and internationalization experience (export share of sales, domestic MNC). Birkinshaw and Hood (1998) find that the mandates of foreign subsidiaries evolve over time. Therefore, the time from which the firm has been foreign controlled may be more important than its founding date in Germany (although the latter may be more important for reducing legitimacy effects). We have no information on the former.

Furthermore, border effects have been found to be less pronounced in certain industries, such as semiconductors (Irwin and Klenow, 1994). Therefore, six additional industry group variables are introduced to capture industry-specific aspects that would distort the explanatory power of our other exogenous variables. These industry groups are more broadly defined as "medium high-tech", "high-tech" and "other" manufacturing, and "distributive", "knowledge-intensive" and "technological" services. Industry classification follows the product or service that generates the majority of turnover. Multiple industry assignments are not possible. The base group in all cases is "other" manufacturing. For details on the industry classification, see Table 7.1 in the appendix.

3.2 Descriptive statistics

Our final dataset consists of 1,129 companies located in Germany, after excluding observations with missing values. 109 of these indicated that they were part of a multinational

[10] According to this criterion, Germany's leading industries in 2001 are "Motor vehicles, trailers and semi-trailers" (NACE 34), "Machinery and equipment, n.e.c." (NACE 30), "Chemicals and chemical products" (NACE 24) and "Medical, precision and optical instruments" (NACE 33) and the most lagging industries are "Post and telecommunications" (NACE 64), "Real estate, renting and business activities" (NACE 70, 71) and "Radio, television and communication equipment" (NACE 32). Note that only industries listed in table 2 of the annex are considered.

group with headquarters abroad (foreign controlled firms). Table 2 of the annex provides an overview of the descriptive statistics. Major issues will be outlined briefly.

The prima facie comparison shows some differences in the sourcing behaviour of German and foreign controlled firms. Domestic customers are the most important source of knowledge for innovation. 52% of all firms in our sample use them. However, 54% of foreign MNC subsidiaries rely on domestic customers, compared with only 40% of German firms. Academic institutions in Germany are a knowledge source for just 14% of the companies in our sample (13% of foreign MNCs, 14% of German firms). Foreign and German controlled firms treat R&D activities largely as a permanent engagement. Likewise, the share of highly educated employees and the stock of patents per employee show no major difference between the two groups.

Interestingly enough, foreign controlled firms spent a smaller share of their turnover on R&D in 2001. However, they are more active in stimulating innovation and have, on average, more aggressive innovation strategies. They are also more prevalent in industries where Germany has a leading R&D position. These findings might, to some degree, be related to the fact that foreign controlled firms are larger and have a predominant tendency (39% of turnover through exports) to sell their products on markets outside of Germany. Given these facts, a multivariate analysis should provide additional valuable insights.

3.3 Model

The starting point for our empirical analysis is to investigate Hypothesis 1, i.e. the link between being a subsidiary of a foreign MNC and knowledge flows from German customers and/or universities. We estimate a probit model (model I) in which the dependent variable takes the value one if a firm indicates that knowledge from universities and/or customers from Germany provided an important knowledge impulse.

In a second step (model II), we analyze whether different effects can be identified for universities and customers (Hypothesis 2). The probabilities of knowledge flows from customers or academic institutions are not independent of one another. It is quite conceivable that firms receive knowledge flows from multiple sources over a given period. To model the link between the two sources adequately, we used a bivariate probit model instead of estimating the equations for each source separately.[11] Within our empirical framework, the

[11] On this topic, see Greene (1993).

bivariate probit is superior to multinomial logit models since it allows us to reflect simultaneous multiple-source usage. The bivariate probit model is directly derived from the standard probit model, but allows more than one equation with correlated disturbances. This technique is comparable to the seemingly unrelated regressions model. Estimating two equations simultaneously allows us to improve the estimated sampling precision and subsequently facilitates a more complete usage of the available information. In essence, each probit equation holds information on factors that influenced the decisions on both sources. Estimating these equations simultaneously utilizes this information for the complete system.

To explore whether foreign MNC subsidiaries are especially disadvantaged with respect to knowledge flows, if they operate in industries in which Germany is a technological leader (Hypothesis 3), we include the interaction term between the indicator variable for subsidiaries of foreign MNCs and the R&D index in model III. Our hypothesis would be confirmed if the interaction term between the two variables turned out to be negative and significant.

An analysis of the correlation matrix and variance inflation factors provides no evidence for any relevant degree of multicollinearity within the dataset. Full details are provided in Table 4 of the appendix.

4 Results

Table 1 summarizes the results of our estimation. The choice of a bivariate probit setup instead of two separate probit estimations is justified. The correlation between the error terms is both positive and highly significant. Additionally, we conduct a likelihood ratio test on a constrained model specification assuming equality of coefficients between the two source decisions. This test is rejected on a 99% significance level. In conclusion, the driving forces behind our two types of sources for innovation are related (significant, positive correlation of error terms) but not homogeneous (rejected likelihood ratio tests). When interpreting the results, one should bear in mind that we have restricted the sample to innovative firms (i.e. those with at least one new product or process). For all other firms, the response to the question on the sources of knowledge would automatically be zero.

Table 1 Marginal effects after probit/biprobit estimations (Robust standard errors in parentheses)

Variable	Model I	Model II		Model III	
	German source	German customer source	German university source	German customer source	German university source
Foreign MNC (d)	-0.10*	-0.12**	0.00	-0.08	0.00
	(0.06)	(0.05)	(0.03)	(0.06)	(0.04)
Interact.: Foreign MNC * R&D index				-0.13**	0.00
				(0.06)	(0.03)
Domestic MNC (d)	0.00	-0.02	0.00	-0.02	0.00
	(0.05)	(0.05)	(0.03)	(0.05)	(0.03)
Explorative innovation strategies (sca)	0.10***	0.08***	0.04***	0.08***	0.04***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Export share of sales (ratio)	-0.37***	-0.41***	-0.03	-0.41***	-0.03
	(0.07)	(0.07)	(0.04)	(0.07)	(0.04)
R&D exp. share of sales (ratio)	0.38**	0.32**	0.14*	0.33**	0.14*
	(0.18)	(0.16)	(0.08)	(0.16)	(0.08)
Continuous R&D (d)	0.12***	0.10***	0.07***	0.10***	0.07***
	(0.04)	(0.04)	(0.02)	(0.04)	(0.02)
EPO patent stock per empl. (ratio)	0.09	-0.01	-0.07	0.00	-0.07
	(0.12)	(0.13)	(0.11)	(0.13)	(0.12)
Share empl. w/ college educ. (ratio)	0.19**	0.14*	0.16***	0.14*	0.16***
	(0.08)	(0.08)	(0.04)	(0.08)	(0.04)
Importance of innovation stimulation (scale)	0.04**	0.06***	0.00	0.06***	0.00
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
No. of empl. (logs)	0.00	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Company age (years, logs)	-0.03	-0.02	-0.01	-0.02	-0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)
Location East Germany (d)	-0.02	0.00	-0.02	0.00	-0.02
	(0.04)	(0.04)	(0.02)	(0.04)	(0.02)
Industry R&D index 2001	0.00	-0.02	0.02	0.01	0.02
	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Medium high-tech manuf. (d)	0.00	0.04	-0.02	0.04	-0.02
	(0.05)	(0.05)	(0.03)	(0.05)	(0.03)
High-tech manuf. (d)	0.00	0.04	0.02	0.03	0.02
	(0.06)	(0.06)	(0.04)	(0.06)	(0.04)
Distributive services (d)	-0.06	-0.04	-0.04	-0.03	-0.04
	(0.06)	(0.06)	(0.04)	(0.06)	(0.04)
Knowledge-intens. services (d)	-0.03	-0.05	0.00	-0.04	0.00
	(0.07)	(0.06)	(0.04)	(0.06)	(0.04)
Technological services (d)	-0.13**	-0.13**	0.04	-0.12**	0.04
	(0.06)	(0.06)	(0.04)	(0.06)	(0.04)
Constant	0.33	0.22	-1.63***	0.21	-1.63***
	(0.20)	(0.20)	(0.28)	(0.20)	(0.28)
Rho		0.16 (0.07) **		0.16 (0.07)**	
Aldrich Nelson Pseudo R2	0.17	0.22		0.22	
N	1,129	1,129		1,129	
Wald chi2	112.80	198.71		200.54	
P-value	0.00	0.00		0.00	

* Significant at 10%; ** significant at 5%; *** significant at 1%; (d) Dummy variable

We start by focusing on the core of our study: whether foreign MNC subsidiaries face liabilities of foreignness in their host country knowledge access in Germany. We find support for Hypothesis 1. Foreign MNC subsidiaries are significantly less likely to receive valuable knowledge from German customers and/or scientific sources (model I). However, model II puts this finding into context. The negative effect stems from domestic customers only. Hypothesis 2 can therefore be accepted. Hypothesis 3 (interaction effect in model III) is confirmed for customer knowledge and rejected for university knowledge. We find a significant negative influence of the interaction term between foreign MNC subsidiaries and the R&D index variables for the former. Apparently, the negative effect for foreign MNC subsidiaries is confined to German customers in industries at the technological forefront. We will return to these findings in the subsequent discussion section.

We add a number of control variables without developing explicit a-priori hypotheses. Hence, the discussion of their estimation results is explorative in nature. We find the most consistent positive effect from the boldness of a firms' innovation strategy (or mandate). In addition, the mechanisms regarding absorptive capacities do not vary according to the source they try to access. German customer and university sources both benefit from continuous R&D engagements, which is in line with the central finding by Cohen and Levinthal (1989, 1990) that absorptive capacities are a by-product of performing R&D. In that sense R&D expenditures in a particular year are as important as accumulating knowledge consistently over time. The EPO patent stock per employee, however, has no significant effect. The share of employees with a university education, by contrast, shows a positive and significant effect. Employing more university graduates increases the likelihood of accessing knowledge from both sources. The effect is stronger for domestic universities than for customers as knowledge sources. This fits nicely into the concept of social capital, with education and career as a channel and facilitator for knowledge flows (Adler and Kwon, 2002). Moreover, it supports the findings of Lane and Lubatkin (1998) that congruence between "teacher" and "student" institutions facilitates learning engagements. Furthermore, we find that more ambitious motivational schemes for stimulating innovation resonate in an increased likelihood for listening to domestic customers for innovative ideas. In summary, our estimation results support the literature on the importance of various innovation inputs constituting absorptive capacities which lead to increased knowledge sourcing from customers and/or universities.

Interestingly, firms that sell more on foreign markets are significantly less likely to rely on domestic customer impulses. This seems plausible, given that higher export intensities should increase the importance of foreign customer knowledge. We find no liabilities of size (number of employees), newness (firm age) or regional deficiencies (East Germany). The industry group variables are not significant, with the exception of technological services. Technological service firms seem to have difficulties in benefiting from customer knowledge spillover. The inclusion of the R&D index (at a more disaggregated industry level) may have contributed to this finding, even though this variable is also insignificant.

5 Discussion and recommendations

We designed this study to combine the existing literature on sources for innovation and accessing external knowledge with the research stream on liability of foreignness and develop it further, and to test the relationship empirically. The topic is especially relevant as more and more firms rely on the knowledge production of their foreign subsidiaries for generating a competitive advantage. Hence, access to localized expertise for these foreign MNC subsidiaries becomes crucial. We derive theoretical arguments for why foreign MNC subsidiaries should face additional hurdles in host country knowledge sourcing compared with domestic competitors. We suspect that this is due to a lack of host country legitimacy, which translates into a measurable liability of foreignness.

Our empirical study of more than 1,100 firms in Germany supports this hypothesis. What is more, we are able to pinpoint the roots of these disadvantages more precisely. The negative effects of liability of foreignness become visible when foreign MNC subsidiaries source knowledge from host country customers. An additional step of the analysis reveals that the disadvantages of dealing with host country customers occur in industries in which host country competitors are at the technological forefront. We conclude that the effects of liability of foreignness emerge in particular when host country customers can turn to leading host country competitors. At the same time, these leading competitors can also be expected to be very adept in identifying and activating leading host country users. Therefore, the lack of roots and legitimacy limits the opportunities for foreign MNC subsidiaries. An additional element of this legitimacy deficit may stem from a tendency of host country customers to protect their technological knowledge from reaching subsidiaries of foreign firms or foreign

firms in general. This may be in the interest of the German economy as a whole, since it helps to protect the technological and comparative advantage of its leading industries.

Managerial recommendations can be drawn from these results. First, MNCs concerned about the integration of their subsidiaries in host country knowledge flows are, at least on average, fine when it comes to sourcing knowledge from host country universities. We suspect that this is due to the incentives for academic institutions for disseminating the results of their research, which may counterbalance potential lack of legitimacy effects. Second, and more importantly, the link to host country customers is crucial. This is especially important for firms operating in host country environments that are at the technological forefront. We suggest two countervailing strategies. If foreign subsidiaries face markets with large numbers of dispersed, heterogeneous customers a defensive strategy may be appropriate. That would entail outsourcing early stage market research and innovation marketing to local firms with established networks and procedures. If it is easier to identify, observe and evaluate local customers, foreign MNC subsidiaries should move towards active strategies. This could imply recruiting key personnel from customers (following the personal network rational), collaborations or joint development with key customers. The latter should be focused on establishing broad interfaces and personal networks between subsidiary employees and local customers to generate extensive channels for future knowledge transfer. Third, our research shows that domestic firms cannot count on preferential access to local academic knowledge. Their home field advantage in innovation activities depends largely on their embeddedness with local customers. Deepening and cultivating this link may be an important source for gaining a future competitive advantage.

6 Concluding remarks and limitations

In conclusion, we face certain limitations in our analysis that should be acknowledged; however, this may stimulate research in the future. We did benefit from a large, high quality dataset that enables insights that could not have been drawn from traditional patent analyses. However, it was not specifically designed for this analysis and limits our empirical study. Most importantly, we can observe knowledge flows but have relatively little information (apart from the source) on how they were achieved. This limits our potential for recommendations. Moreover, more detailed information, especially on the history of the

foreign controlled firms, might be helpful. Finally, our study is not confined to a particular industry but to a particular country. While the German perspective may contribute to other studies that have mostly dealt with the US, its economic, historical and cultural environment cannot be readily generalized. Comparative studies would certainly provide further interesting insights.

7 Annex

7.1 Industry breakdown

Table 2 Construction of industry variables

Industry	NACE Code	Industry Group
Mining and quarrying	10 – 14	Other manufacturing
Food and tobacco	15 – 16	Other manufacturing
Textiles and leather	17 – 19	Other manufacturing
Wood / paper / publishing	20 – 22	Other manufacturing
Chemicals / petroleum	23 – 24	Medium high-tech manufacturing
Plastic / rubber	25	Other manufacturing
Glass / ceramics	26	Other manufacturing
Metal	27 – 28	Other manufacturing
Manufacture of machinery and equipment	29	Medium high-tech manufacturing
Manufacture of electrical machinery	30 – 32	High-tech manufacturing
Medical, precision and optical instruments	33	High-tech manufacturing
Manufacture of motor vehicles	34 – 35	Medium high-tech manufacturing
Manufacture of furniture, jewellery, sports equipment and toys	36 – 37	Other manufacturing
Electricity, gas and water supply	40 – 41	Other manufacturing
Construction	45	Other manufacturing
Retail and motor trade	50, 52	Distributive services
Wholesale trade	51	Distributive services
Transportation and communication	60 – 63, 64.1	Distributive services
Financial intermediation	65 – 67	Knowledge-intensive services
Real estate activities and renting	70 – 71	Distributive services
ICT services	72, 64.3	Technological services
Technical services	73, 74.2, 74.3	Technological services
Consulting	74.1, 74.4	Knowledge-intensive services
Other business-oriented services	74.5 – 74.8, 90	Distributive services

7.2 Descriptive statistics and correlation statistics

Table 3 Descriptive statistics: means, standard deviations in parentheses

Variables	*Total*	*Domestic firms*	*Foreign MNC subs.*
Observations	1,129	1,020	109
% of total	-	90%	10%
Foreign MNC (d)	0.10	-	-
	(0.30)	-	-
Domestic MNC (d)	0.13	0.14	-
	(0.33)	(0.35)	-
Export share of sales (ratio)	0.21	0.19	0.39 ***
	(0.26)	(0.24)	(0.32)
R&D exp. share of sales (ratio)	0.06	0.06	0.04 ***
	(0.11)	(0.12)	(0.06)
Continuous R&D (d)	0.57	0.57	0.61
	(0.50)	(0.50)	(0.49)
EPO patent stock per empl. (ratio)	0.01	0.01	0.01
	(0.29)	(0.10)	(0.03)
Share empl. w/ college educ. (ratio)	0.29	0.29	0.26
	(0.28)	(0.28)	(0.23)
Importance of innovation stimulation (scale)	0.00	-0.03	0.29 ***
	(0.92)	(0.92)	(0.86)
Explorative innovation strategies (scale)	- 0.00	-0.03	0.30 ***
	(0.87)	(0.87)	(0.77)
No. of empl.	208	191	366 ***
	(343)	(331)	(417)
Company age (years)	17.24	17.01	19.42
	(17.96)	(18.00)	(17.60)
Location East Germany (d)	0.33	0.35	0.21 ***
	(0.47)	(0.48)	(0.41)
Industry R&D index 2001	0.15	0.13	0.37 ***
	(0.66)	(0.62)	(0.91)
Other manufacturing (d – reference)	0.30	0.30	0.26
	(0.46)	(0.46)	(0.44)
Medium high-tech manuf. (d)	0.22	0.20	0.39 ***
	(0.41)	(0.40)	(0.49)
High-tech manuf. (d)	0.12	0.12	0.16
	(0.32)	(0.33)	(0.36)
Distributive services (d)	0.09	0.09	0.07
	(0.28)	(0.28)	(0.26)
Knowledge-intens. services (d)	0.09	0.09	0.06
	(0.28)	(0.29)	(0.23)
Technological services (d)	0.19	0.20	0.06 ***
	(0.39)	(0.40)	(0.24)

Note: *** mean significantly different at 1%; (d) dummy variable.

Table 4 Correlation matrix and variance inflation factors

	Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
(1)	Foreign MNC (d)	1.00								
(2)	Domestic MNC (d)	-0.13	1.00							
(3)	Export share of sales (ratio)	0.24	0.18	1.00						
(4)	R&D exp. share of sales (ratio)	-0.05	-0.07	0.04	1.00					
(5)	Continuous R&D (d)	0.02	0.15	0.25	0.30	1.00				
(6)	EPO patent stock per empl. (ratio)	0.00	0.09	0.04	0.04	0.08	1.00			
(7)	Share empl. w/ college educ. (ratio)	-0.04	-0.05	-0.09	0.38	0.18	0.03	1.00		
(8)	No. of empl. (logs)	0.23	0.35	0.26	-0.25	0.12	0.07	-0.39	1.00	
(9)	Company age (years, logs)	0.06	0.04	0.07	-0.13	-0.05	0.01	-0.25	0.30	1.00
(11)	Location East Germany (d)	-0.09	-0.11	-0.16	0.16	0.03	-0.05	0.18	-0.22	-0.22
(12)	Industry R&D index 2001	0.11	0.11	0.25	-0.03	0.12	0.04	-0.18	0.19	0.11
(13)	Medium high-tech manuf. (d)	0.14	0.12	0.31	-0.01	0.20	0.07	-0.11	0.16	0.04
(14)	High-tech manuf. (d)	0.03	0.00	0.13	0.14	0.17	0.03	0.09	-0.02	-0.01
(15)	Distributive services (d)	-0.01	0.00	-0.15	-0.12	-0.19	-0.03	-0.12	-0.02	0.02
(16)	Knowledge-intens. services (d)	-0.04	-0.05	-0.22	-0.10	-0.12	0.00	0.13	-0.05	0.04
(17)	Technological services (d)	-0.10	-0.06	-0.18	0.30	0.08	-0.01	0.53	-0.31	-0.22
(18)	Importance of innovation stimulation (scale)	0.10	0.16	0.19	0.00	0.21	0.05	-0.04	0.32	0.09
(19)	Explorative innovation strategies (scale)	0.11	0.14	0.25	0.13	0.28	0.08	-0.01	0.25	0.04
	Variance Inflaction Factors (VIF)	1.19	1.28	1.4	1.38	1.37	1.02	1.97	1.8	1.18
	Variable	***(11)***	***(12)***	***(13)***	***(14)***	***(15)***	***(16)***	***(17)***	***(18)***	***(19)***
(11)	Location East Germany (d)	1.00								
(12)	Industry R&D index 2001	-0.05	1.00							
(13)	Medium high-tech manuf. (d)	-0.03	0.59	1.00						
(14)	High-tech manuf. (d)	0.01	0.03	-0.20	1.00					
(15)	Distributive services (d)	0.00	-0.13	-0.16	-0.11	1.00				
(16)	Knowledge-intens. services (d)	-0.03	-0.17	-0.16	-0.12	-0.10	1.00			
(17)	Technological services (d)	0.05	-0.33	-0.25	-0.18	-0.15	-0.15	1.00		
(18)	Importance of innovation stimulation (scale)	-0.13	0.08	0.07	0.06	-0.06	-0.03	-0.05	1.00	
(19)	Explorative innovation strategies (scale)	-0.16	0.11	0.13	0.06	-0.14	-0.12	0.00	0.43	1.00
	VIF	1.18	1.69	2	1.46	1.24	1.45	2.34	1.33	1.39
	Mean VIF	1.48								
	Condition Number	15.58								

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