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## **Stop the Knowledge Flow: Knowledge Protection Intensity of MNC**

### **Subsidiaries**

**Pedro de Faria**

University of Groningen  
Innovation Management and Strategy  
p.m.m.de.faria@rug.nl

**Wolfgang Sofka**

Copenhagen Business School  
Department of Strategic Management and Globalization  
ws.smg@cbs.dk

**Edlira Shehu**

University of Hamburg  
Institute of Marketing and Media  
edlira.shehu@uni-hamburg.de

### **Abstract**

Recent research has given special attention to international knowledge spillovers. Yet, multinational companies (MNCs) subsidiaries are generally treated as passive actors by most studies. We challenge this assumption by investigating the drivers of knowledge protection intensity of MNC subsidiaries. We argue that knowledge protection intensity is determined by MNC subsidiary mandates and by opportunities and risks originating from the host region. We hypothesize that not just competence-creating but also competence-exploiting mandates increase knowledge protection intensity. In addition, technological cluster regions in the host country can be expected to provide opportunities for knowledge sourcing and MNC subsidiaries may be willing to protect knowledge less intensively to participate in cluster networks. We test our hypotheses using a dataset of 694 observations of 631 MNC subsidiaries in Germany and develop recommendations for research, managers and policy makers.

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**Keywords:** Knowledge protection, Multinational Companies, Patenting

## **1 Introduction**

International economics (e.g., Haskel et al., 2007; Keller, 2002; Shaver and Flyer, 2000) and international business literature (Almeida, 1996; Frost, 2001) have given ample attention to multinational companies (MNCs) capabilities to transfer knowledge with host countries. Though, few studies try to understand how MNC subsidiaries protect their knowledge. This is particularly surprising since distinctive knowledge is a basis element of MNC success (Kogut and Zander, 1993). Our goal is to fill a gap in management theory with regard to the active role of MNC subsidiaries in protecting their knowledge. We develop theoretical arguments for explaining differences in the intensity of knowledge protection of MNC subsidiaries. We define the knowledge protection intensity of an MNC subsidiary as the degree to which an MNC subsidiary actively uses knowledge protection instruments in order to prevent that its knowledge becomes unintentionally available or useful to competitors. We exploit the opportunity to capture the intensity of an MNC subsidiary's knowledge protection for a comprehensive set of protection methods encompassing patents, copyrights, trademarks, industrial design, secrecy, lead time, and complex design. We argue that the knowledge protection intensity can be explained based on subsidiary mandates as well as opportunities and risks from the host country region.

Existing research has assumed that knowledge flows between MNC subsidiaries and host country firms are inevitable because of the nature of knowledge and its characteristics as a public good (Arrow, 1962). However, empirical studies provide inconsistent results. The absence of knowledge flows has been predominantly explained with a mismatch between MNC knowledge and host country capabilities for absorbing it (Keller, 2004; Meyer and Sinani, 2009). In addition, research has relied on patent statistics from MNCs as measures for knowledge production as opposed to their original role for preventing knowledge from being

imitated by competitors, i.e., knowledge protection (e.g., Almeida, 1996; Jaffe and Trajtenberg, 1999).

Empirical evidence on how MNCs actively protect their knowledge is limited and only focused on particular instruments an MNC can use to protect its knowledge. Alcacer and Chung (2007) and Shaver and Flyer (2000) give investigate how MNCs make their location choice when opening a subsidiary in a new host country. They find that MNCs look for industry clusters when they anticipate knowledge inflows and avoid them when they do not expect to benefit from the host country knowledge. Zhao (2006) claims that the R&D activities that a MNC decides to locate in China is dependent on the strenght of the intellectual property rights (IPR) of the country where the complementary knowledge was originally created. De Faria and Sofka (2010) find that the difference between the breadth of knowledge protection strategies of MNC subsidiaries and domestic firms is dependent on the firm level investment in innovation and on the characteristics of the host country.

A central advantage of MNCs lies in their ability to transfer knowledge across national borders (Kogut and Zander, 1993). Hence, MNC subsidiaries have especially strong incentives for protecting it and preventing its “misappropriation” by host country competitors (Katila et al., 2008). Our study applies appropriability theory and provides new insights by comparing MNC subsidiaries.

We develop two sets of hypotheses. First, we hypothesize that the knowledge protection intensity of an MNC subsidiary is determined by its mandates. Subsidiary mandates can be defined as the assignments of the subsidiary from its global headquarters. Mandates can range from simply applying and adapting MNC procedures or products (competence exploitation) to developing totally new capabilities, products, or markets for the MNC as a whole (competence creation; Cantwell and Mudambi, 2005). We argue that MNC

subsidiaries are different from strictly domestic firms in the sense that they have a need to protect knowledge that is produced and transferred from other parts of the MNC. Hence, it is not just competence-creation within the MNC subsidiary that requires intense knowledge protection but also competence-exploitation. Secondly, we suggest that knowledge protection intensity is influenced by the regional environment in which the MNC subsidiary is active. We argue that being located in a technological cluster entails both opportunities and risks for the MNC subsidiary. On the one hand, technological clusters have a high concentration of scientists and engineers working in the same industry that provide opportunities for knowledge sourcing. We claim that in these conditions an MNC subsidiary will lower its knowledge protection intensity in order to signal the willingness to participate in intra-cluster knowledge flows. On the other hand, clusters have a high level of personnel mobility and, therefore, key employees of MNC subsidiaries have multiple job opportunities. Hence, we expect that MNC subsidiaries located in regions with high levels of personnel mobility have higher knowledge protection intensity since labor flows entail higher risks of unintended knowledge spillovers.

The hypotheses are tested using a dataset of 694 observations of 631 MNC subsidiaries in Germany. Unique data allows us to distinguish between opportunities and risks originating at the regional level. We access comprehensive employment data for each subsidiary's agglomeration area in Germany. We can track opportunities from the technological development of these regions based on the number of scientists and engineers as well as the risks originating by the frequency of job switches in the region. Our data provides these regional variables at an industry level. This allows for much more precise testing of our hypotheses because opportunities and risks for MNC subsidiaries can be assumed to be much more pronounced within their own industry.

Our analysis adds to the emerging stream of research on knowledge protection by MNC subsidiaries by making two main contributions. First, we find that MNC subsidiaries not only actively protect the knowledge that results from their own R&D activities but also the knowledge that is created by the MNC headquarters and other subsidiaries and that they then exploit in their own local market. This result deepens our understanding of how MNCs transfer their competitive advantage from one country context to another by replicating and protecting knowledge and resources. Second, we separate the opportunities and risks associated with regional clusters. We find that MNC subsidiaries located in a region with a high concentration of scientists and engineers working in the focal subsidiary's industry have lower levels of knowledge protection intensity, but, contrary to our expectations, we do not find a significant relationship between regional personnel mobility and the MNC subsidiary's knowledge protection intensity. MNC subsidiaries' knowledge protection strategies are more sensitive to the opportunities than to the risks associated with their location.

Our findings also have major implications for both managers and policy-makers in host countries. The former must be aware of intense knowledge protection by MNC subsidiaries, especially outside of technological clusters of the host country. Hence, knowledge exchanges with MNC subsidiaries, e.g., through alliances, would require comparatively more effort. Host country policy-makers, with the intention of attracting MNC subsidiaries to generate knowledge flows to domestic firms, must be aware that they can expect intense protective behaviors from both competence-creating as well as competence-exploiting subsidiaries. The knowledge protection intensity is only lower if the MNC subsidiary locates in a technological cluster of the host country. Hence, subsidizing MNC subsidiary investments in peripheral regions for generating knowledge flows can be counterproductive.

The remainder of this article is structured as follows. Section 2 reviews the literature and derives the hypotheses. Section 3 presents the empirical study, and is followed by results presented and discussed in section 4. We draw conclusions and suggest pathways for future research in section 5.

## **2 Hypotheses development**

The goal of our theoretical discussion is to predict differences in the intensity of knowledge protection in MNC subsidiaries. Within our conceptualization, MNC subsidiaries (and all firms in general) have a set of knowledge protection instruments that they can use to prevent that their knowledge becomes unintentionally available or useful to competitors, e.g., patenting, secrecy, and copyright. Within this set of knowledge protection options, firms can choose how intensively they want to rely on each of these instruments: e.g., a pharmaceutical firm can opt for developing drugs in secret laboratory locations, patenting all of its discoveries, and applying for trademarks of drug names. We define the knowledge protection intensity of an MNC subsidiary as higher if it attributes higher importance to multiple knowledge protection instruments. Obviously, parts of the differences among firms in knowledge protection intensity can be explained at the industry level, based on technological opportunities and legal intellectual property rights regimes for using certain protection instruments (Arundel and Kabla, 1998). This conceptualization is different from other studies that explain, for example, differences in patenting activity among firms because the patenting activity may be driven by other motives than knowledge protection, such as signaling to potential partners and investors (Ndofor and Levitas, 2004).

Appropriability literature suggests that firms opt for value-capture strategies that combine several protection instruments (James et al., 2013). In contexts where patents and other formal instruments only give limited protection to knowledge, firms employ

organizational instruments such as lead time, secrecy, or complementary assets in order to achieve more complete knowledge protection. The simultaneous use of several protection instruments has been addressed empirically in several studies. Arora (1997) and Cohen and Klepper (1996) look at the simultaneous use of patents and secrecy, while Arora and Ceccagnoli (2006), Clarkson and Toh (2010), and Gans and Stern (2003) focus their attention on the simultaneous use of patents and complementary assets. De Faria and Sofka (2010) compare the breadth of knowledge protection strategies of MNC subsidiaries and domestic firms.

Academic research has given special attention to knowledge flows spillovers from host-country firms to MNC subsidiaries (see for example Almeida, 1996; Frost, 2001) and from MNC subsidiaries to host-country firms (Meyer and Sinani, 2009). Many important studies on MNCs and international knowledge flows have used patenting – the most prominent form of knowledge protection – as an indicator of knowledge production and related citations as observable knowledge flows (e.g., Almeida and Phene, 2004; Jaffe and Trajtenberg, 1999; Porter and Stern, 2000). However, the particular topic of knowledge protection strategies by MNC subsidiaries has largely been ignored in international business research so far (with the notable exceptions of Alcacer and Chung, 2007; de Faria and Sofka, 2010; Shaver and Flyer, 2000; Zhao, 2006).

Most research examining international knowledge flows from MNCs assumes that MNC subsidiaries have a considerable passive role when managing and avoiding knowledge spillovers (Keller, 2004). Alcacer and Chung (2007) and Shaver and Flyer (2000) show that MNC subsidiaries take in consideration the risk of outgoing knowledge flows when choosing their location in a specific country, but they do not study the management of knowledge spillovers by MNC subsidiaries after the location decision is made. We draw from the theory

on appropriability in innovation activities to departure from their work and other previous studies. We argue that, even after an MNC has chosen a certain host country location, the MNC subsidiary knowledge protection intensity is affected by the mandates assigned to it as well as by the amount of knowledge and the degree of personnel mobility in the region in which it is located.

## **2.1 MNC subsidiary mandates and knowledge protection intensity**

MNC management tends to concentrate R&D activities in subsidiaries with the environments that stimulate knowledge creation, leading to a greater variance in the levels and nature of R&D across subsidiaries (Frost, 2001). Many studies stress the role of subsidiary assignments from headquarters for explaining MNC subsidiaries behavior (e.g., Birkinshaw, 1996; Birkinshaw and Fry, 1998; Birkinshaw and Hood, 1998; Hakanson and Nobel, 2001). Subsidiaries can use and adapt knowledge created elsewhere, relying on the results of R&D undertaken in other subsidiaries, and/or take on a more technologically creative-function, contributing to a diversification into new scientific problems, issues, or areas (Frost et al., 2002). Kuemmerle (1999) identifies two motives behind the decision of MNCs to invest in R&D abroad: to increase the existing stock of knowledge, and to exploit this stock of knowledge within their boundaries. Pearce (1999) makes a similar distinction by differentiating MNC subsidiaries that are only responsible for adjusting products and processes developed elsewhere for a specific market, and thus have a technologically dependent and tactical role, from subsidiaries with a pro-active commitment to the creation of new knowledge. Following this evidence and the work of Kuemmerle (1999) and Pearce (1999), Cantwell and Mudambi (2005) distinguish between MNC subsidiaries' competence-exploiting and competence-creating mandates. Organizational learning theory provides the foundation for the distinction between explorative activities directed at generating new products, resources or capabilities, and exploitative activities which primarily adapt and use

them (March, 1991). We define MNC subsidiary mandates based on the framework of Cantwell and Mudambi (2005), who consider mandates to be assigned to an MNC subsidiary in the sense that an MNC subsidiary has a specific mandate or not. We extend this definition by taking into consideration that the competence-creating and the competence-exploiting natures of an MNC subsidiary mandate can have different intensity degrees across different MNC subsidiaries.

For the purpose of our study, it is also important to note that the knowledge residing in MNC subsidiaries can be produced there (competence-creation) or transferred from MNC headquarters as well as from other subsidiaries (competence-exploitation). It is not a necessary assumption that both mechanisms exist in isolation, i.e., an MNC subsidiary can benefit from intra-MNC knowledge transfers and its own knowledge production. Previous research on knowledge protection has built on this combination of subsidiary knowledge production and intra-MNC knowledge transfers. De Faria and Sofka (2010) show, based on this mechanism of knowledge transfer and production, that MNC subsidiaries use more knowledge protection methods than domestic firms with similar investments in knowledge production. We extend this argument to a comparison among MNC subsidiaries which can all be assumed to benefit from intra-MNC knowledge transfers, but differ in their mandates.

Competence-creating mandates imply that subsidiaries develop new resources and capabilities. They are associated with technologically creative activities aiming at generating new products targeting new markets for an MNC (Frost et al., 2002). Hence, by definition, the knowledge generated in competence-creating subsidiaries has a high degree of novelty (Cantwell and Mudambi, 2005; Pearce, 1999). In order to appropriate value from the new products and processes an MNC subsidiary needs to avoid or at least delay imitation by competitors by making use of knowledge protection instruments (Rivette and Kline, 2000).

Hence, similar to all other firms, we expect that MNC subsidiaries with a higher level of competence-creation in their mandate protect their knowledge with a higher intensity. We hypothesize:

Hypothesis 1: The higher the level of competence creation of an MNC subsidiary's mandate relative to the level of competence creation of the average MNC subsidiary's mandate, the higher the level of knowledge protection intensity of the focal MNC subsidiary.

However, not all valuable knowledge has to be produced in a specific MNC subsidiary. Kogut and Zander (1993) defines an MNC as a social community with a shared understanding on the production and transfer of knowledge through repeated interaction. This shared understanding enables MNCs to transfer even tacit knowledge between international subsidiaries. In this regard, MNC subsidiaries differ significantly from strictly domestic firms. For the latter, the need for knowledge protection can be derived from their own knowledge production. MNC subsidiaries, though, can be assumed to possess valuable knowledge even when it is not produced there. They can benefit from knowledge that is produced at global headquarters or other subsidiaries and transferred to the focal subsidiary.

Subsidiaries with competence-exploiting mandates rely on intra-MNC knowledge flows and adapt products and processes to meet local customer needs, local regulations, and local resource availabilities. We expect that the existence of a competence-exploiting mandate will also lead subsidiaries to actively protect their knowledge, as internal knowledge flows received from the MNC, and the adaptation to local markets, are also threatened by imitation. We predict that MNC subsidiaries with a higher level of competence-exploitation in their mandate will increase their knowledge protection intensity in order to avoid local competitors imitating the MNC knowledge that is adapted to the local market. We hypothesize:

Hypothesis 2: The higher the level of competence exploitation of an MNC subsidiary's mandate relative to the level of competence exploitation of the average MNC subsidiary's mandate, the higher the level of knowledge protection intensity of the focal MNC subsidiary.

## **2.2 Opportunities and risks from technological clusters in the host country**

The second set of theoretical predictions on the intensity of knowledge protection of MNC subsidiaries originates from the regional level. Existing research treats geographical distance as an important conduit for preventing outgoing knowledge flows or benefiting from knowledge inflows. MNCs locate their subsidiaries closer to industry activity in the host country if they expect to take advantage of incoming knowledge flows and farther away if they sense the risk of unintended spillovers (Alcacer and Chung, 2007; Shaver and Flyer, 2000). Within this conceptualization, geographical proximity with host country rivals is both an opportunity and a risk to MNC subsidiaries. They may gain from interacting with host country scientists who are concentrated in certain regions, but the risks also increase that the subsidiary's knowledge will unintentionally become available to host country rivals. We relax the assumption of existing theory that MNC subsidiaries face this trade-off exclusively when they enter a host country (Alcacer and Chung, 2007; Shaver and Flyer, 2000). Instead, we suggest that MNC subsidiaries will adjust the intensity of the knowledge protection even after they have made a location decision within the host country. What is more, we separate the opportunities of a host country region from its challenges. We capture the latter through personnel mobility in a region, arguably one of the most important channels of unintended knowledge outflows for firms (Arrow, 1962).

We start out by investigating the opportunities for MNC subsidiaries from being active in a technological cluster of a host country. Knowledge flows mainly occur between firms

that are located in the same region (Almeida and Kogut, 1999; Jaffe et al., 1993). This implies that knowledge available to a firm is location dependent and that the firm's knowledge development opportunities are reliant on the characteristics of the neighboring firms and institutions (Alcacer and Chung, 2007; Almeida and Kogut, 1999). Silicon Valley illustrates this mechanism. Firms located in the region benefit from a knowledge pool that is created by a dense network of firms and universities (Saxenian, 1996).

However, geographical proximity is typically only a proxy for underlying mechanisms of knowledge exchanges which are more likely to occur when firms and employees interact more frequently. Proximity increases the opportunities for informal exchanges of knowledge between firms and, consequently, facilitates knowledge flows (Alcacer and Chung, 2007; Harrison et al., 1996). Furthermore, the existence of common buyers and suppliers also creates flows of tacit and valuable knowledge (Alcacer and Chung, 2007). Therefore, firms located in a cluster with a high concentration of competitors and suppliers have access to a valuable pool of knowledge (Alcacer and Chung, 2013).

Nonetheless, the exchange of knowledge is not an automatic process. It requires the willingness of the knowledge source to share knowledge (Szulanski, 1996). Restrictive knowledge protection practices of MNC subsidiaries separate them from the network of host country knowledge flows because knowledge sources cannot expect to benefit from interaction in the future. Hence, we predict that MNC subsidiaries will have a lower knowledge protection intensity in technological clusters because of the potentials for benefiting from knowledge exchanges with local partners. Conversely, MNC subsidiaries outside of technological clusters have strong incentives to protect their knowledge intensely because there is nothing to gain from potential partners in technologically less-developed regions. We derive:

Hypothesis 3: MNC subsidiaries located in technological clusters have a lower intensity of knowledge protection than MNC subsidiaries located elsewhere.

An MNC subsidiary located in a cluster with intense knowledge flows has more opportunities to access valuable knowledge, but it will also face higher risks of unintended knowledge outflows (Alcacer and Chung, 2007; Shaver and Flyer, 2000). MNC subsidiaries are unique environments to develop valuable knowledge since MNC are especially efficient channels to overcome barriers in international knowledge flows (Kogut and Zander, 1993). While working for an MNC subsidiary, employees develop knowledge stocks that are valuable for domestic and other MNC firms since they have had access to a pool of valuable knowledge that is otherwise not readily available in the host country. Therefore, other firms located in a cluster consider MNC subsidiaries as potentially valuable knowledge sources (Alcacer and Chung, 2007).

Since personnel turnover is one of the primary channels for knowledge flows, key employees of an MNC subsidiary located in a cluster have multiple job opportunities. Employees not only apply skills that they have developed while working for an MNC subsidiary (Wang et al., 2009), but also transfer tacit knowledge (Almeida and Kogut, 1999; Song et al., 2003) and social capital (Corredoira and Rosenkopf, 2010; Dokko and Rosenkopf, 2010). The potential loss of employees to competitors constitutes a risk for an MNC subsidiary since strategic assets linked to competitive advantages can be exposed to competitors.

Hence, an MNC subsidiary has stronger incentives to guard itself against unintended knowledge outflows if personnel mobility in its host country region is high. As a consequence, we should see higher intensity levels of knowledge protection. We propose:

Hypothesis 4: MNC subsidiaries located in regions with high personnel mobility have a higher intensity of knowledge protection than MNC subsidiaries located elsewhere.

### **3 Data and Methods**

#### **3.1 Data and sample**

For testing our hypotheses, we use data from two waves of the European Community Innovation survey (2001 and 2005) comprising 694 observations of 631 MNC subsidiaries and their innovation behavior in Germany. Our data set consists of MNC subsidiaries participating in at least one of the surveys. 568 MNC subsidiaries are observed only once and panel estimation appears therefore not beneficial.

Germany is an especially fitting host country to test our hypotheses, as it has numerous domestic MNCs and is a major recipient of foreign direct investment (UNCTAD, 2005) with a long tradition of hosting foreign MNC subsidiaries. At the same time, Germany's setting as a host country offers interesting variance regarding the competitiveness of industries and regions. Many industries like automotive, machinery/equipment and chemicals are international technological leaders, while other sectors like manufacturing of consumer electronics are lagging behind OECD averages of R&D investment (OECD, 2009). Similarly, German regions are also heterogeneous regarding R&D expenditure since Germany has a strong federal tradition. Focusing on MNC subsidiaries in a single host country allows us to eliminate confounding effects which may originate from the country level, e.g., institutional or cultural differences.

The CIS survey is directed at decision makers on innovation activities within companies. Each survey wave covers the previous three years, e.g., the 2001 wave collects

information on the period between 1998 and 2000. The survey follows the OECD's Oslo Innovation Manual on measuring innovation inputs, outputs and processes (OECD, 2005) and provides data on the innovation activities of firms from manufacturing and service sectors. The survey sample is stratified by region, firm size as well as industry, and, consequently, is representative for Germany as a whole. This feature provides an opportunity for the investigation of our research question as regional and industry differences can be studied.

CIS data have been the basis for several recent publications in highly-ranked management journals (e.g., Laursen and Salter, 2006; Leiponen and Helfat, 2010). Using CIS survey data has three primary advantages for our study. First, we can obtain information on knowledge protection for a variety of instruments which do otherwise not leave a paper trail but are highly important in certain firms and industries such as lead time (Arundel and Kabla, 1998; Leiponen and Byma, 2009). Second, we can obtain comparable information on the importance of these instruments for knowledge protection. This is an important feature because some instruments such as patenting have several other functions for firms in addition to knowledge protection (Ndofor and Levitas, 2004). Finally, we obtain information at the level of the MNC subsidiary which reflects opportunities and risks at the regional level much more closely than official policies set by global headquarters.

Additionally, we calculate the patent stock of each MNC subsidiary by adding patent statistics provided by the European Patent Office (EPO). This allows us to distinguish between the number of patents that an MNC subsidiary has applied for and the importance that it assigns to them for knowledge protection, i.e., the question in our CIS survey.

We further complement the dataset with additional official employment statistics collected by the Institute of Employment Research (IBA) of the Federal Employment Agency of Germany. The data are a 50 percent, stratified sample of all employees in Germany, and

therefore serve as an excellent predictor for the regional distribution of skilled labor and personnel mobility. More precisely, the data provide information on concentration of skilled employees (the share of engineers and scientists) as measures for technological clusters in a host country as well as on personnel mobility (number employees switching jobs) at a combined industry and regional level. The data has the advantage of allowing us to measure characteristics of host country regions of MNC subsidiaries specifically for the operating industry. All employment data is aggregated regionally at the level of agglomeration areas and two-digit NACE classification industry levels.

In addition, we add data from the ANBERD database of OECD which measures the industry specific R&D intensity for OECD countries. The data allows capturing the industry-specific strength of German R&D intensity compared to all OECD countries in order to control for related effects.

### **3.2 Dependent variables**

Our dependent variable is represented by the relative knowledge protection intensity of MNC subsidiaries compared to the industry average intensity of knowledge protection of all firms in the host country. The knowledge protection intensity is generated by adding up the importance ratings of all knowledge protection instruments used by MNC subsidiaries following Laursen and Salter (2005). These instruments include patents, copyrights, trademarks, industrial design, secrecy, lead time, and complex design. In the questionnaire firms are asked to assess the importance of each instrument with regard to the importance it has for protecting knowledge in their innovation activities on a four-point Likert-based scale with 3 meaning “instrument is very important” and 0 “instrument is not relevant at all.” By summing these ratings we build an index which displays the overall knowledge protection intensity of an MNC subsidiary. This measure provides a more comprehensive measurement

and more clarity in interpretation compared to simple counts of knowledge protection instruments in use (e.g., de Faria and Sofka, 2010) because it takes into account the importance of each instrument. Comparable, recent survey-based methods for tracing firms appropriability strategies in the US are discussed in Dechenaux et al. (2008) or McGahan and Silverman (2006).

Industries differ sharply in the technological and legal possibilities for applying certain knowledge protection instruments (Arundel and Kabla, 1998). In order to control for these industry specific effects, we build the relative knowledge protection intensity by an MNC subsidiary to the industry average knowledge protection intensity. This follows the basic rationale that the industry average reflects the technological and legal conditions of the industry, and that any deviation from this average can be interpreted as higher or lower knowledge protection intensity in the respective industry where this MNC is operating. Thus, our dependent variable is a quotient which compares the knowledge protection intensity of an MNC subsidiary to the average MNC subsidiary.

### **3.3 Independent variables**

For testing hypotheses 1 and 2 we construct two indices for competence-creating and competence-exploiting mandates based on questions on the effects of a firm's innovation activities. Again, firms rank several items on a four-point Likert scale ranging from "not relevant" to "highly important." We add up relevant items for each index and divide them by the maximum. An MNC subsidiary's mandate is considered to be competence-creating based on the importance of generating new products and serving new markets. An MNC subsidiary is considered to have a competence-exploiting mandate if quality improvements as well as resource and personnel cost reductions are considered to be important. Both indices are not

mutually exclusive. An MNC subsidiary can have competence-creating functions for certain products or markets and competence-exploiting ones for others.

For describing characteristics of the host country region of an MNC subsidiary, we define the regional and the industry context. A geographical region can be defined at different levels. Germany comprises 16 federal states which are subdivided into 439 districts (NUTS3). While the former classification may be too broadly defined, the latter one may be too narrow. Official German regional statistics also uses a functional classification of 97 agglomeration areas, so called “Raumordnungsregionen.” They typically consist of an urban center and the districts that surround it. These agglomeration areas are not strictly based on administrative borders but reflect functional linkages such as commuter streams. We consider this regional level of disaggregation as the most suitable for our analysis (henceforth regional level refers to measurements at the level of agglomeration areas outlined above). Industries are measured according to the statistical classification of economic activities in the European Community (NACE). Therefore, the data describing characteristics of the host country region for the operating industry of MNC subsidiaries are provided at a combined level of industry measured by the two-digit NACE and agglomeration area. This is a clear advantage over most other available data sources for knowledge production, like R&D expenditures or patent statistics, which typically capture only one dimension, i.e., region, industry, or technology. Our employment data have the advantage of simultaneously combining both dimensions of geographical region and operating industry of an MNC subsidiary. Hence, we are able to measure relative regional characteristics within operating industries for an MNC subsidiary allowing for more accurate measurements of the hypothesized effects.

For testing hypothesis 3 we are interested in the distribution (share) of highly skilled employees of the host country region for the operating industry of an MNC subsidiary which

serves as an indicator of the technological leadership of a region for the focal industry. We generate an index of the share of engineers and scientists working within an industry at a specific agglomeration area relative to the total number of engineers and scientists working within this industry in Germany. This approach does not require the ex-ante definition of technological clusters. If, for example, 15% of all scientists and engineers in automotive production work in a particular agglomeration area, this area is closer to being a technological cluster than a region with only 5% of all automotive engineers in Germany.

For hypothesis 4, we generate a second index representing the share of employees switching their jobs at a combined industry and regional level relative to the total number of employees in the respective industry in Germany. High values of this index represent a relative high density of labor flows at the combined industry and regional level.

### **3.4 Control variables**

Several other factors have to be controlled for as they influence the knowledge protection intensity of an MNC subsidiary. First, knowledge protection intensities may differ with regard to the MNC subsidiary's innovation and knowledge production engagements. We control for major innovation inputs by using R&D expenditures as a share of sales. In order to control for effects related to existing innovative knowledge within an MNC subsidiary, we add the MNC subsidiary's stock of EPO patents (in logs) to the model.<sup>1</sup>

MNC subsidiaries can also differ in the intensity in which they collaborate with other organizations for innovation activities. We capture this effect through an index on the breadth of a firm's innovation collaborations. Firms are asked whether they collaborate with suppliers,

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<sup>1</sup> The patent stock is the count of granted patents that depreciated with a yearly rate of 15 percent, which is widely applied in scientific publications (e.g., Aerts and Schmidt, 2008).

customers, competitors, consultancies, universities, or public research centers. We use the count of these partners for generating the collaboration index.

We control for an MNC subsidiary's degree of internationalization through the export share of sales. In addition, we control for potential biases due to industry-related effects by including two measures: First, we control for the competitive intensity within the focal MNC's industry by adding the Hirschman-Herfindahl concentration index.<sup>2</sup> Second, we add an index measuring the industry based strength of German R&D intensity reflecting whether a German industry is leading or lagging regarding R&D intensity compared to all other OECD countries (Salomon and Byungchae, 2008).

Moreover, we control for how long an MNC subsidiary has been operating in Germany (company age as years since founding) because potential "liability of newness" can affect firms' strategic decisions. Following previous studies, we also control for resource availability (firm size) and industry (e.g., Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Harabi, 1995; Leiponen and Byma, 2009): number of employees in logs and five industry dummies (medium high-tech manufacturing, high-tech manufacturing, distributive services, knowledge-intensive services and technological services). Low-tech manufacturing serves as the comparison group (see Appendix A for industry classification). Next, we control for whether the MNC subsidiary is headquartered in Germany or abroad, i.e., whether it is part of a domestic or foreign MNC. There is some evidence that MNCs are relatively homogeneous (Criscuolo and Martin, 2009), but other studies have highlighted

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<sup>2</sup> Calculating concentration indices for a representative country sample requires information on the population of firms. Germany did not have a federal firm register during our observation period. The credit rating agency Creditreform investigates all of the regional registers and compiles a dataset that is frequently used to determine the population of German firms (such the AMADEUS database of Bureau van Dijk). We use this dataset to calculate concentration ratios that were based on employment numbers because they are more reliably reported. An alternative index that is calculated based on the available sales information showed an almost perfect correlation with the index that is based on employment. The same is true for concentration ratios.

liabilities of foreignness for foreign MNCs in Germany (Schmidt and Sofka, 2009). Finally, we control for time effects by including a dummy variable for observations from year 2001.

### **3.5 Descriptive statistics and correlations**

Table 1 displays descriptive statistics of our dependent, independent, and control variables for the whole sample. Our sample comprises 303 observations for foreign MNC subsidiaries (44% of the sample) and 391 observations for domestic MNC subsidiaries. The average MNC subsidiary (foreign or domestic) is about 20 years old, has 577 employees, spends 3% of its sales on R&D and exports around 34% of the total sales.

- Insert Table 1 here -

We relate the knowledge protection intensity of MNC subsidiaries to the average of all firms in the host country industry. On average, MNC subsidiaries have a value of 1.93 (s.d.=1.83). This implies that MNC subsidiaries have on average almost twice the knowledge protection intensity of the average firm in the industry. The index cannot become negative but has no upper limit. The data show that competence-creating and competence-exploiting mandates have, on average, similar levels of importance for MNC subsidiaries ( $m=0.67$ ,  $s.d.=0.28$  for competence-creating and  $m=0.54$ ,  $s.d.=0.25$  for competence-exploiting mandates). A cross-tabulation of both indices based on median-splits of both indices reveals that 19% of the MNC subsidiaries in our sample have low levels for both mandates, 12% have high levels for the competence-exploiting and low levels for the competence-creating mandates, .25% of the MNC subsidiaries in the sample assign low importance to competence-exploiting and high importance to the competence-creating mandates and 43% attribute above sample median importance to both mandates (see Table 2). Only 6.05% of the MNC subsidiaries in the sample classified both competence-creating and competence-exploiting mandates as “non-relevant” and only 9 companies rated both mandates as “highly important”

(1.30%). The variables describing the characteristics of an MNC subsidiary's host country region display a high dispersion within our sample. The average share of scientists and engineers operating within the relevant industry in host country region is 4% while the average share of employee job-switching within an industry and region amounts to 12%.

- Insert Table 2 here -

Regarding the industry specific composition of our sample, the statistics reveal that the most represented industries are low-tech manufacturing (35% of the sample) followed by medium-tech manufacturing (28% of the sample). The lowest share is knowledge-intensive services (6%).

The correlation matrix does not reveal any multicollinearity problems: the mean variance inflation factor (VIF) is only 1.33 and the condition number is 22.56 (Appendix B; Chatterjee and Hadi, 2006).

### **3.6 Estimation model and method**

We conduct linear regression estimations with the knowledge protection intensity as dependent variable. We use robust standard errors to rule out potential heteroskedasticity issues. We believe that the possible leftover neglected heterogeneity only induces serial correlation in the composite error terms, not causing correlation between the composite errors and the explanatory variables.

We test the consistency and sensitivity of all results and specifications by estimating additional models. First, we control for effects related to country of origin of MNCs' headquarters and replace the indicator variable for foreign MNCs by four indicator variables for Europe, North America and Canada, Asia as well as a remaining variable comprising other countries of origin (Appendix C, model 1). Second, we control for the robustness of the

industry classification in our model and replace the industry group dummies (1) with the average industry R&D intensity that is provided by the ANBERD database of OECD (see Appendix C, model 2) as well as (2) with the relative share of scientists and engineers on all employees operating in the industry (see Appendix C, model 3). The latter measure is better suited for tracing industry-differences in the knowledge intensity of service sectors which may not require formal R&D investments. Fourth, we test whether the postulated effects differ for foreign MNC subsidiaries (see Appendix D). Next, we test the estimation accuracy of the linear regression and estimate a left-censored tobit model as well as a linear model where the knowledge protection intensity is operationalized as a difference between the MNC specific values and industry average. All consistency checks reveal consistent effects for testing our hypotheses in terms of sign and significance. Last, we control for simultaneity effects of both competence-creating mandates as well as the cluster variables. Both interaction terms are not significant.

## **4 Results and discussion**

### **4.1 Results**

Table 3 shows the results of the regression analyses. Our theoretical reasoning suggests that differences of knowledge protection for MNC subsidiaries are related to the mandates of an MNC subsidiary and to the opportunities and threats at the regional level. Indeed, our results show that there is a significant, positive relationship between both competence-creating and competence-exploiting mandates and the knowledge protection intensity, supporting our hypotheses 1 and 2. Both identified positive effects are also substantial with respect to the marginal changes. A standard deviation change of the competence-creating index from its mean value leads to a change of knowledge protection intensity of 16.2%, whereas a standard deviation change of the competence-exploiting index

corresponds to a change of 7.74% . The marginal effects show that the influence of mandates on knowledge protection intensity is substantial in terms of relative magnitude. We also compared by means of a Wald test whether both estimated coefficients differ significantly but did not find statistical support for this ( $F(1, 674)=1.48, p<.11$ ).

As predicted, MNC subsidiaries' intensity of knowledge protection is lower when they operate in a technological cluster region. The index expressing the concentration of scientists and engineers operating in the host country region of the MNC subsidiary influences the knowledge protection intensity negatively ( $p<.001$ ). We propose in the theoretical section that MNC subsidiaries have strong incentives to relax their knowledge protection if they can expect to become part of networks for knowledge exchange in technological cluster regions. These results support our predicted results in hypothesis 3.

Regarding the hypothesized effect related to the personnel mobility in the host country region, we find no significant effect. Thus, hypothesis 4 is not supported empirically.

It is important to stress that our results regarding the influence of location decisions within a host country are in line with previous research. Alcacer and Chung (2007) and Shaver and Flyer (2000) find that MNCs take in consideration the level and nature of regional knowledge flows when deciding the location of their subsidiaries. We extend this framework and explore how MNC subsidiaries adapt their knowledge protection when facing regional knowledge flows after the entry and location decision is made. In line with hypothesis 3, we find that MNC subsidiaries located in host country regions where their industry is technologically leading have lower levels of knowledge protection intensity. This supports our theoretical reasoning that MNC subsidiaries located in technologically leading environments can take advantage of ingoing knowledge flows if they lower the restrictiveness of their own knowledge protection. Conversely, in technologically lagging host country

industries, MNC subsidiaries increase the intensity of their knowledge protection to protect themselves because the counterbalancing incentive of getting valuable knowledge from the host country is absent.

- Insert Table 3 here -

We develop no a priori hypotheses for the control variables. However, some results should be highlighted briefly.

We discover positive significant effects of an MNC subsidiary's patent stock and index of collaboration. Firms with a larger knowledge stock that are engaged in collaboration agreements face higher risks of unintended knowledge spillovers and therefore they have additional incentives to protect their knowledge with higher intensity. As other studies have found, the intensity of knowledge protection method depends on the availability of resources within a firm (Leiponen and Byma, 2009). We also find that the knowledge protection intensity increases with firm size measured as the number of employees. Younger firms protect their knowledge less intensively. This effect can be explained by the related costs for knowledge protection mechanisms, e.g., patents. We find some industry differences as suggested by a number of earlier studies (e.g., Arundel, 2001). MNC subsidiaries in medium and high-tech manufacturing (e.g., automotive production) and technological services (e.g., software) protect their knowledge less intensively. Most interestingly, we do not find a foreignness effect, i.e., knowledge protection intensity is not per se significantly different for foreign and domestic MNC subsidiaries.

#### **4.2 Consistency and sensitivity checks**

We compute consistency checks of our model to validate our empirical approach. First, we test for heterogeneity related to the country of origin of a MNCs' headquarters and

estimate a model where the indicator variable for foreign MNCs is replaced by four dummies for different headquarters locations (Europe, North America and Canada, Asia, and others). Domestic MNC subsidiaries, i.e., with headquarters in Germany, serve as control group. All hypothesized effects remain consistent; although we discover a significant negative effect of the indicator variable capturing “other” headquarters locations (Appendix C, model 1). A more detailed look shows that this group comprises MNCs with headquarters locations in Australia, Bermuda, Israel, South Africa, and South America. Thus, the lower knowledge protection intensity may be attributed to idiosyncratic country specific effects. In addition, we test the robustness of our results towards the industry classifications by dummies in our main model. For this, we estimate two models which replace the industry dummies by the average industry R&D intensity provided by the ANBERD database of OECD as well as by the industry share of scientists and engineers of all employees in the industry (Appendix C, models 2 and 3). All the postulated effects in hypotheses 1-4 remain consistent to the estimation in the main model, underlining their robustness.

Next, we replicate our estimation for the sample of foreign MNCs only. While we find consistent results regarding competence-creating mandates and host country region characteristics, the significant, positive effect of competence-exploiting mandates does not emerge, presumably due to the small sample size. We explore the latter effect further and add a multiplicative interaction effect between foreign MNC subsidiaries and competence-exploiting mandates to the original model. This provides us with the opportunity to benefit from the full sample size while still testing for particular effects for foreign MNC subsidiaries. The main effect of competence-exploiting mandates remains positive and significant in this specification, while the interaction effect is not significant. Hence, we conclude that there is no separate effect of competence-exploiting mandates for foreign MNC

subsidiaries and that the absence of significance in the sample split estimation is due to the small sub-sample size.

Next, we estimate two additional models in order to test the estimation accuracy of our linear regression. First, we estimate a left-censored tobit model to test whether accounting for the fact that our dependent variable cannot become negative affects the results. Second, we estimate a linear model where the knowledge protection intensity is operationalized as a difference between the MNC specific values and industry average. All postulated effects remain consistent.

Last, we test for simultaneity effect between the mandates as well as the cluster variables. We estimate two separate models with interaction terms between the mandates as well as between the share of engineers and scientists and the personnel mobility (share of employees switching jobs). Both interaction terms show no significant effects.

All results of the consistency check estimations that are not displayed in the Appendix can be provided by the authors upon request.

## **5 Conclusion**

The main objective of this article is to offer new insights into the active role MNC subsidiaries play in protecting knowledge. Building on the appropriability literature, we theoretically argue that knowledge protection intensity of MNC subsidiaries is affected by subsidiary mandates as well as by the opportunities and risks of the host country region in which the MNC subsidiary is located. We test our theoretical reasoning with a dataset of 694 observations of domestic and foreign MNC subsidiaries in Germany. We find that not just competence-creating but also competence-exploiting mandates positively influence the intensity of knowledge protection of MNC subsidiaries. Contrary to our expectations,

knowledge protection intensity of MNC subsidiaries does not significantly increase with the degree of personnel mobility in the host country region. However, MNC subsidiaries lower their knowledge protection intensity when they are located in technological cluster regions in which they can expect to benefit from participating in knowledge exchanges. relevant conclusions can be drawn for future academic research as well as for managers and policy decision makers.

## **5.1 Implications for research**

Despite the fact that knowledge flows involving MNCs have been studied in depth by international business and economics scholars, knowledge protection of MNC subsidiaries has deserved limited attention (Meyer and Sinani (2009) provide a recent meta-analysis). This is surprising since the evidence shows that MNCs play a very dynamic role in protecting their knowledge. However,

We address this gap in the literature by envisioning a comprehensive set of potential knowledge protection instruments an MNC subsidiary may rely on ranging from secrecy and patenting to lead time and copyrights. We are able to investigate the knowledge protection intensity of MNC subsidiaries beyond an MNC's decision where to locate its subsidiary. We show that knowledge protection intensity is not only higher for MNC subsidiaries with higher competence-creating mandates but also for MNC subsidiaries with higher competence-exploiting mandates. While the effect for competence-creating mandates is in line with existing research (de Faria and Sofka, 2010) and similar to all firms in general, the effect for competence-exploiting mandates is novel. We also find that the effect sizes of competence-creation and -exploitation do not differ significantly. This provides promising new routes for theorizing about the knowledge management of MNCs in the sense that they can spread knowledge creation and exploitation across subsidiaries, but there is still a large emphasis on

knowledge protection at the subsidiary level even when the knowledge was not produced in the particular subsidiary.

Concerning regional factors influencing MNC subsidiary knowledge protection, we are able to specifically measure host country influences at a combined regional and industry level. We benefit from a representative dataset for a large host country with significant variance across industries and regions. This lets us to test and identify mechanisms at the regional level between clusters and knowledge protection of MNC subsidiaries. We find that in technologically leading host country regions of a focal industry, MNC subsidiaries' knowledge protection intensity is lower. We treat this as a sign of a need for participation in knowledge exchanges within technological cluster regions. Weaknesses for knowledge outflows are to a certain degree tolerated if they firms expect to have access to valuable knowledge. Last, opposed to our prediction, we find no relation between knowledge protection intensity by MNC subsidiaries and personnel mobility in the subsidiary's host country region. Hence, the potential risks of unintended knowledge outflows through personnel mobility may be overestimated or firms may approach these risks in their human resource management practices, e.g., paying higher wages to key employees, instead of knowledge protection mechanisms.

In conclusion, we extend existing research by identifying knowledge protection as an important strategic asset for MNC knowledge management at the subsidiary level. By doing so, we add a nuanced perspective on the knowledge protection intensity by MNC subsidiaries, and on the influences of subsidiary mandate and regional host country factors shaping it.

## **5.2 Implications for managers and policy makers**

Governments at the national and regional level compete for foreign MNCs investments by providing subsidies and other kinds of attractive conditions (Haskel et al.,

2007). The major motivation behind these policies is to attract international MNC subsidiaries that creates and transfers valuable knowledge to a region which potentially will “spill over” to host country firms. However, previous studies have shown mixed results regarding the actual occurrence of these spillovers (e.g., Keller, 2004). We find that managers of domestic firms who want to take advantage from international knowledge flows through MNC subsidiaries will find more open partners in technologically leading host country clusters. In these environments, MNC subsidiaries appear to be more open to engage in knowledge exchanges even when this implies accepting certain vulnerabilities of outgoing knowledge flows.

Implications for policy makers can also be derived. We find that even subsidiaries with a competence-exploiting mandate are highly involved in preventing knowledge outflows. Interestingly, our results suggest that MNC subsidiaries are willing to reduce knowledge protection if they can benefit from knowledge inflows in technologically-leading host country industries and regions. This implies that policies directed at maximizing access to international knowledge through FDI should target regions in which the host country is technologically-leading regarding a specific industry instead of regions in which the host country would like to catch up. Targeting the latter could be counterproductive as MNC subsidiaries increase the intensity of their knowledge protection strategies in such environments. Moreover, we find no indication that MNC subsidiaries with competence-exploiting mandates are more likely to allow knowledge outflows.

### **5.3 Limitations and further research**

In conclusion, our study provides new perceptions into the determinants of knowledge protection intensity of MNC subsidiaries. However, our research allowed us to identify aspects which are currently underexplored and deserve further attention. First, we believe internationally-comparative studies may provide additional insights. It would be particularly

interesting to conduct a similar study in countries with weak IPR regimes. Second, due to the structure of our data, we cannot conduct a panel estimation and account explicitly for remaining heterogeneity between MNC subsidiaries. While our robustness checks underline the validity of our empirical results, it could be promising to use longer-term panels and investigate long-term effects for MNCs' knowledge protection mechanisms. Further avenues for future research are possible changes or discontinuities in the host country environment. Such discontinuities, e.g., changes in technology or in the competitive landscape, may influence the intensity of knowledge protection by MNC subsidiaries. In addition, panel datasets or exogenous shocks could allow testing causal relationships which go beyond what we are theoretically predicting and are able to empirically test in this article. We are focusing explicitly on the knowledge protection aspect. Future studies could expand our findings by investigating determinants of voluntary or mandated knowledge disclosure by MNC subsidiaries. Last, we believe that a study that expands our approach to non-MNC firms would be a very interesting extension of our work and that could be a relevant contribution to the open innovation literature.

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#### **Appendix A: Industry breakdown**

<b>Industry</b>	<b>NACE Code</b>	<b>Industry Group</b>
Mining and quarrying	10 – 14	Low-tech manufacturing
Food and tobacco	15 – 16	Low-tech manufacturing
Textiles and leather	17 – 19	Low-tech manufacturing
Wood / paper / publishing	20 – 22	Low-tech manufacturing
Chemicals / petroleum	23 – 24	Medium high-tech manufacturing
Plastic / rubber	25	Low-tech manufacturing
Glass / ceramics	26	Low-tech manufacturing
Metal	27 – 28	Low-tech 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	Low-tech manufacturing
Electricity, gas and water supply	40 – 41	Low-tech manufacturing
Construction	45	Low-tech 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, 64.2	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

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## Appendix B: Correlations and collinearity statistics

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1 Competence-creating mandate (index)	1																			
2 Competence-exploiting mandate (index)	0.34	1																		
3 Share of indu. scientists/engineers in region (total)	-0.06	-0.09	1																	
4 Share of empl. switching jobs in indu. and region	-0.08	-0.12	0.05	1																
5 Share of R&D exp. of sales (ratio)	0.1	-0.02	-0.09	-0.06	1															
6 Patent stock (log)	0.12	0.18	-0.04	-0.12	0.11	1														
7 Index of collaboration (ratio)	0.13	0.14	-0.11	-0.09	0.22	0.22	1													
8 Share of exports on sales (ratio)	0.13	0.21	-0.16	-0.32	0.1	0.27	0.18	1												
9 Company age (years, logs)	0.04	0.06	0.04	0.01	-0.09	0.13	-0.02	-0.01	1											
10 No of employees (log)	0.01	0.19	-0.05	-0.02	-0.12	0.32	0.24	0.17	0.1	1										
11 Herfindahl competition index (NACE 2)	-0.13	0.02	0.12	-0.01	-0.01	-0.01	0.01	-0.06	0.01	0.08	1									
12 RDI industry (index)	-0.03	0.11	-0.09	-0.27	0.01	0.2	0.13	0.15	-0.02	0.15	0	1								
13 Medium high-tech manufacturing	0.01	0.16	-0.13	-0.3	-0.02	0.22	0.16	0.31	0.02	0.1	0.09	0.55	1							
14 High-tech manufacturing (d)	0.08	0.02	-0.11	-0.12	0.18	0.07	0.05	0.1	0.05	-0.01	0.06	-0.04	-0.25	1						
15 Distributive services (d)	-0.09	-0.08	0.07	0.2	-0.11	-0.13	-0.11	-0.23	0.04	-0.06	-0.09	-0.16	-0.19	-0.12	1					
16 Knowledge-intensive services (d)	-0.02	-0.11	0.26	0.38	-0.08	-0.12	-0.07	-0.28	0.04	-0.02	0.07	-0.14	-0.16	-0.1	-0.59	1				
17 Technological services (d)	-0.01	-0.15	0	0.3	0.24	-0.11	-0.04	-0.18	-0.12	-0.21	-0.06	-0.2	-0.19	-0.12	-0.09	-0.08	1			
18 Foreign MNC(d)	-0.07	0.02	0.01	-0.02	0	-0.01	-0.09	0.05	-0.01	-0.06	0.05	0.03	0.02	0.04	0.02	0	-0.03	1		
19 Year 2001 (d)	-0.04	-0.03	0.01	0.26	-0.02	-0.06	-0.02	-0.1	-0.01	-0.02	-0.05	-0.07	-0.05	-0.1	0.07	0.08	0.08	-0.05	1	
VIF	1.21	1.25	1.16	1.66	1.25	1.29	1.2	1.43	1.06	1.3	1.11	1.57	1.92	1.32	1.31	1.52	1.53	1.03	1.09	
Mean VIF	1.33																			

d: indicator variable

## Appendix C: Consistency checks for variable operationalization

	[1] Headquarters location	[2] Industry R&D intensity ANBERD	[3] Industry share of scientists/engineers
Competence creating mandate (index)	1.13 *** (0.25)	1.12 *** (0.25)	1.07 *** (0.25)
Competence exploiting mandate (index)	0.59 ** (0.28)	0.51 * (0.29)	0.58 * (0.30)
Share of ind. scientists/engineers in region of country total	-3.62 *** (1.18)	-2.53 ** (1)	-2.89 *** (1.06)
Share of employees switching jobs in industry and region	-0.22 (0.83)	0.82 (0.89)	0.97 (0.89)
Share R&D exp. of sales (ratio)	0.51 (0.66)	0.82 (0.68)	0.90 (0.70)
Patent stock (logs)	0.12 *** (0.04)	0.09 * (0.05)	0.08 * (0.05)
Index of collaboration (ratio)	1.29 *** (0.28)	1.23 *** (0.31)	1.20 *** (0.30)
Share exports of sales (ratio)	0.60 ** (0.23)	0.25 (0.24)	0.26 (0.24)
Company age (years, logs)	-0.03 (0.07)	-0.04 (0.07)	-0.05 (0.07)
No of employees (log)	0.12 ** (0.06)	0.15 *** (0.06)	0.13 ** (0.06)
Herfindahl competition index (NACE2)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
RDI industry (index)	-0.05 (0.06)	-0.17 *** (0.06)	-0.31 *** (0.06)
Medium high-tech manufacturing (d)	-1.24 *** (0.15)		
High-tech manufacturing (d)	-1.42 *** (0.15)		
Distributive services (d)	1.09 *** (0.42)		
Knowledge-intensive services (d)	0.51 (0.41)		
Technological services (d)	-0.59 *** (0.21)		
Foreign MNC (d)		-0.07 (0.13)	-0.09 (0.13)
Year 2001	0.09 (0.13)	0.05 (0.13)	0.11 (0.14)
MNC HQ in Europe	-0.18 (0.15)		
MNC HQ in USA/Can	-0.03 (0.2)		
MNC HQ in Asia	0.12 (0.42)		
MNC HQ in other country	-0.89 (0.47)		
Indu. R&D int. OECD within Germany		-99.27 *** (12.11)	
Share of scientists/engineers on empl. in industry			-12.74 *** (2.28)
Constant	0.46 -0.40	0.36 (0.4)	0.59 (0.41)
R <sup>2</sup>	0.26	0.19	0.18
N	694.00	694	694

\* p<0.10, \*\* p<0.05, \*\*\* p<0.01; d: indicator variable

## Appendix D: Consistency check for effects related to foreign MNC subsidiaries

	[1] Sample of foreign MNCs	[2] Total sample with interaction between foreign MNCs and exploiting mandates.
Competence creating mandate (index)	1.33 *** (0.38)	1.14 *** (0.25)
Competence exploiting mandate (index)	0.27 (0.46)	0.75 ** (0.34)
Interaction Foreign MNC*Competence exploiting mandate		-0.32 (0.51)
Share of industry scientists/engineers in region of country total	-3.74 *** (1.43)	-3.56 *** (1.17)
Share of employees switching jobs in industry and region	2.87 (1.77)	-0.14 (0.85)
Share R&D exp. of sales (ratio)	-0.38 (0.73)	0.53 (0.65)
Patent stock (logs)	0.25 *** (0.08)	0.12 *** (0.04)
Index of collaboration (ratio)	1.06 *** (0.41)	1.3 *** (0.28)
Share exports of sales (ratio)	0.07 (0.34)	0.61 *** (0.23)
Company age (years, logs)	-0.01 (0.12)	-0.03 (0.07)
No of employees (log)	0.22 ** (0.1)	0.11 ** (0.06)
Herfindahl competition index (NACE2)	0 (0)	0 (0)
RDI industry (index)	-0.03 (0.08)	-0.04 (0.05)
Medium high-tech manufacturing (d)	-0.98 *** (0.24)	-1.23 *** (0.15)
High-tech manufacturing (d)	-1.47 *** (0.23)	-1.38 *** (0.15)
Distributive services (d)	0.53 (0.6)	1.08 ** (0.42)
Knowledge-intensive services (d)	0.47 (0.74)	0.51 (0.41)
Technological services (d)	-0.58 (0.37)	-0.58 *** (0.21)
Foreign MNC (d)		0.02 (0.32)
Year 2001	0.1 (0.22)	0.09 (0.13)
Constant	-0.44 (0.67)	0.38 (0.42)
R <sup>2</sup>	0.25	0.26
N	303	694

\* p<0.10, \*\* p<0.05, \*\*\* p<0.01; d: indicator variable

## Tables

**Table 1: Descriptive statistics**

Variable	N	m	s.d.	min	max
Knowledge protection relative to industry average	694	1.97	1.83	0.00	11.84
Patent	682	1.40	1.39	0.00	3.00
Design pattern	682	0.80	1.19	0.00	3.00
Trademark	682	0.85	1.22	0.00	3.00
Copyright	682	0.28	0.8	0.00	3.00
Secrecy	682	1.55	1.34	0.00	3.00
Complex design	682	0.62	1.11	0.00	3.00
Lead time	682	1.66	1.41	0.00	3.00
Competence-creating mandate (index)	694	0.67	0.28	0.00	1.00
Competence -exploiting mandate (index)	694	0.54	0.25	0.00	1.00
Share of industry scientists/engineers in region of country total	694	0.04	0.06	0.00	0.71
Share of employees switching jobs in industry and region	694	0.12	0.09	0.02	0.99
Share of R&D exp. of sales (ratio)	694	0.03	0.07	0.00	0.75
Patent stock (log)	694	0.54	1.11	0.00	8.65
Index of collaboration (ratio)	694	0.18	0.26	0.00	1.00
Share of exports on sales (ratio)	694	0.34	0.28	0.00	1.00
Herfindahl competition index (NACE 2)	694	7.81	22	0.10	213.78
RDI industry (index)	694	0.28	0.8	-0.92	4.12
Company age (years, logs)	694	2.63	0.89	0.00	4.54
No of employees (log)	694	5.52	1.36	1.61	8.95
Low-tech. Manufacturing	694	0.35	0.48	0.00	1.00
Medium high-tech manufacturing	694	0.28	0.45	0.00	1.00
High-tech manufacturing (d)	694	0.14	0.34	0.00	1.00
Distributive services (d)	694	0.08	0.27	0.00	1.00
Knowledge-intensive services (d)	694	0.06	0.24	0.00	1.00
Technological services (d)	694	0.09	0.28	0.00	1.00
Foreign MNC(d)	694	0.44	0.5	0.00	1.00
Year 2001 (d)	694	0.43	0.49	0.00	1.00

**Table 2: Cross-tabulation of mandate indices\***

		Competence-exploiting mandate (index)			
		low	high	Total	
Competence-creating mandate(index)	low	N	131	86	217
		%	19%	12%	31%
	high	N	173	304	477
		%	25%	44%	69%
	Total	N	304	390	
		%	44%	66%	

\*: classes are built based on median splits of both indices: low=values smaller than median value; high: values equal to median or higher

**Table 3: Regression results of relative knowledge protection intensity to industry**

	b	s.e.
Competence-creating mandate (index)	1.14 ***	(0.25)
Competence-exploiting mandate (index)	0.61 **	(0.28)
Share of industry scientists/engineers in industry and region of country total	-3.59 ***	(1.17)
Share of employees switching jobs in industry and region	-0.18	(0.84)
Share R&D exp. of sales (ratio)	0.54	(0.65)
Patent stock (logs)	0.12 ***	(0.04)
Index of collaboration (ratio)	1.3 ***	(0.28)
Share exports of sales (ratio)	0.61	(0.23)
Herfindahl competition index (NACE2)	0.00	(0.00)
RDI industry (index)	-0.04	(0.05)
Company age (years, logs)	-0.03	(0.07)
No of employees (log)	0.11 **	(0.06)
Medium high-tech manufacturing (d)	-1.24 ***	(0.15)
High-tech manufacturing (d)	-1.4 ***	(0.15)
Distributive services (d)	1.08 **	(0.42)
Knowledge-intensive services (d)	0.51	(0.41)
Technological services (d)	-0.57 ***	(0.21)
Year 2001	0.09	(0.13)
Foreign MNC (d)	-0.15	(0.13)
Constant	0.46	(0.39)
R <sup>2</sup>	0.25	
N	694	

\* p<0.10, \*\* p<0.05, \*\*\* p<0.01; d: indicator variable