

Formal and Strategic Knowledge Protection Strategies of Multinational Firms – A Cross Country Comparison

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Abstract

International knowledge spillovers, especially through multinational companies (MNCs), have recently been a major topic of discussion among academics and practitioners. Most research in this field focuses on knowledge sharing activities of MNC subsidiaries. Relatively little is known about their capabilities for protecting valuable knowledge from spilling over to host country competitors. We extend this stream of research by investigating MNC knowledge protection strategies that go beyond formal methods (patents, copyrights, trademarks) to include strategic ones (secrecy, lead time, complex design). We conceptualize the breadth and depth of a firm's knowledge protection strategies and relate them to the particular situation of MNC subsidiaries. Moreover, we argue that their approaches differ with regard to host country challenges and opportunities. We address these issues empirically, based on a harmonized survey of innovation activities of more than 1,800 firms located in Portugal and Germany. We find that MNCs prefer broader sets of knowledge protection strategies in host countries with fewer opportunities for knowledge sourcing. However, munificent host country environments require targeted sets of deep knowledge protection strategies instead. We deduce that these results are due to a need for reciprocity in knowledge exchanges to benefit fully from promising host country knowledge flows.

Keywords: Knowledge protection, Multinational Companies, Patenting, Appropriability

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1 Introduction

Global economic growth is spurred by international knowledge transfers (Romer, 1990). Multinational companies (MNCs) and their international subsidiaries have been identified as major channels for these knowledge flows (see for example Kogut and Zander, 1993). Against this background, innovation activities of MNCs abroad have been an important theme of discussion for both academics and practitioners. International business literature has primarily focused on MNCs knowledge acquisitions in host countries (e.g. Almeida and Phene, 2004) while international economics literature concentrates on spillovers from MNCs to host country firms (e.g. Keller, 2002). The topic has also caught the attention of policy-makers, prompting many governments to provide substantial financial support for MNC investment in their country or region (e.g. Daimler AG investing in Alabama or Motorola in Scotland, Haskel et al., 2007).

However, as Alcácer and Chung (2007) point out, and despite the increasing number of international patenting activities (Yang and Kuo, 2008), research has paid relatively little attention to MNCs strategies for preventing knowledge spillovers or has treated MNCs subsidiaries as rather passive actors in host country knowledge exchanges. One reason for this discrepancy may be that major studies in the field of international economics and business research use patenting, the most prominent form of knowledge protection, to trace knowledge spillovers, instead of inquiring about firms' strategies to protect knowledge (e.g. Audretsch and Feldman, 1996; Jaffe et al., 1993). Our goal is to contribute to addressing this lack of analysis of MNC knowledge management strategies by investigating the knowledge protection strategies of MNC subsidiary managers. More precisely, we focus on the protection methods that firms put in place to shield their knowledge from spilling over to competitors. If successful, these protection methods enable firms to appropriate the economic returns from their investments in knowledge production through R&D activities (Arrow, 1962). We go beyond formal forms of knowledge protection (patents, copyrights, trademarks), which rest upon legal protection, and include strategic ones (secrecy, lead time, complex design), which are built around organisational processes and procedures. These knowledge protection strategies vary widely with regard to how firms are able to apply them (e.g. firm size) and their effectiveness in protecting knowledge (e.g. Harabi, 1995). Hence, we consider the various forms of knowledge protection instruments an MNC subsidiary manager may use to generate breadth and depth in its knowledge protection strategy. We connect this discussion to the specific needs and opportunities of MNCs. In addition, we argue that these arrangements reflect different host country threats and opportunities in knowledge exchange. We address these issues empirically with data from the European Community Innovation Survey 2001 (CIS) for more than 1,800 firms from Portugal and Germany. The harmonized survey provides us with the unique opportunity to compare MNC knowledge protection strategies in host country environments that differ significantly.

This paper is structured as follows. Section 2 presents our conceptual framework of international knowledge flows and knowledge protection methods. We develop hypotheses based on this discussion in section 3. Section 4 presents the empirical study for testing these

hypotheses; the results follow in section 5. We discuss them in section 6, draw conclusions and suggest some pathways for future research in section 7.

2 Conceptual framework

Relatively few countries generate most of the world's new technologies. The seven most industrialized countries (G7) accounted for 84% of global R&D expenditure in 1995 (Keller, 2004) and still 80% in 2005 (OECD, 2007). Only a limited number of countries, such as South Korea, have been able to catch up in recent years (Furman and Hayes, 2004; Mahmood and Singh, 2003). A large number of the remaining countries depends therefore considerably on international knowledge spillovers as an important source of knowledge and growth (Romer, 1990). MNCs and their international subsidiaries have been recognized as important transmission channels for this knowledge transfer. The advantages of multinational firms for transferring knowledge across borders have been conceptualized in several ways, such as the internalization of transaction costs (e.g. Buckley and Casson, 1981), differentiated networks that provide a fit with varying environmental and resource contingencies (e.g. Ghoshal and Nohria, 1989) or social communities spanning borders (e.g. Kogut and Zander, 1993). Research in international economics has focused on their potential to transfer knowledge to the host country (see for example Aitken and Harrison, 1999; Keller, 2002; Haskel et al., 2007) while international business literature has chosen a different perspective by emphasizing the role of subsidiaries for accessing knowledge from host countries (see for example Almeida, 1996; Frost, 2001). However, relatively little is known about the active strategies MNCs pursue to prevent these spillovers and appropriate the returns of their R&D. We extend the work of Alcácer and Chung (2007) who focus on host country location strategies and Zhao (2006) who investigates the intra-MNC distribution of R&D activities. We consider a broad set of knowledge protection mechanisms ranging from patenting to secrecy and complex design. We start out by reviewing important contributions to the research on MNC knowledge spillovers and knowledge protection strategies.

One of the main processes associated with foreign direct investment is the generation of knowledge and productivity spillovers to and from host country firms. Frost (2001) identifies access to host country resources as one of the main determinants of a foreign subsidiary's capacity to generate innovations. Almeida (1996) analyzed citations of patents belonging to multinational subsidiaries in the USA, to identify learning and sharing aspects of multinational activities. Apart from employment opportunities and capital inflows, these spillovers happen when multinationals create productivity or efficiency benefits in the host country's local firms by increasing competition or introducing new production techniques, work processes, distribution technologies and management or marketing skills (Blomström and Sjöholm, 1999; Aitken and Harrison, 1999). The mechanism through which the spillovers occur differs from industry to industry. New products and processes are the main vehicle of knowledge transfer in industries with rapidly changing technologies and marketing strategies, while organizational skills are more associated with mature industries (Blomström and Kokko, 1998).

Even when multinationals are not interested in producing benefits for host countries, spillovers occur. Because technology and knowledge have many of the properties of public goods, local firms can capture productivity gains through forward or backward linkages with multinationals, imitation, or by hiring workers from multinationals. As stressed by Sanna-Randaccio and Veugelers (2007), these spillovers are larger when multinationals transfer R&D activities to foreign countries, since local firms are then closer to the knowledge source. In addition, the entry of a multinational (either through M&A or greenfield investments) can stimulate local markets. Faced with more intense competition, local firms are compelled to search for new technologies and increase productivity. Crespi et al (2007) analyze the effect of knowledge flows on the productivity of firms in the UK and they conclude that most relevant spillovers are associated with competitors and that multinational presence may be an important source of these spillovers. Finally, given that multinationals have more internationalization skills and are often part of international distribution networks, local firms can benefit from market access spillovers and thus improve their exports (Blomstrom and Kokko, 1998). Kokko (1992) stresses the impact of multinationals on the productivity of local firms by reviewing studies that demonstrated the positive effect of foreign subsidiaries of European firms in less developed countries.

Depending on the host country and industry characteristics, knowledge transfer can take place not only in the industry where the investment is made but also among suppliers and customers within other industries. The nature and intensity of such spillovers depend on country and firm level characteristics, such as the technology gap between the foreign investing firm and local firms and the ownership structure of foreign affiliates (Blomström and Kokko, 1998; Blomström and Sjöholm, 1999).

A growing stream of literature shows that MNCs respond positively to strong host country intellectual property rights regimes in their R&D investments. Branstetter et al. (2006) find this relationship for US affiliates with above average patent portfolios in 12 host countries and Belderbos et al. (2006) come to the same conclusion for Japanese MNCs. However, relatively little is known about how managers of MNC subsidiaries try to prevent these spillovers through active knowledge protection strategies. This may be due to the fact that important studies in the field rely on patent statistics, using patents not as an indicator of knowledge protection but to capture knowledge spillovers based on patent citations (for a review see Keller, 2004). In addition, the use of patents as a knowledge management indicator has several major shortcomings. First, not all patents are innovations and not all innovations are patented (Griliches, 1990). Furthermore, patent activity is rather concentrated. Bloom and Van Reenen (2002) report, for example, that among their sample of almost 60,000 patents by UK firms, 72% were filed by just 12 companies. More importantly, the patent system forces the disclosure and codification of knowledge in exchange for protection (Gallini, 2002). Cohen et al. (2000) found that in most industries firms do not consider patents as the most important way to protect their innovations. As a result, patent statistics reflect knowledge protection mechanisms and knowledge spillovers rather selectively.

Alcácer and Chung (2007) address MNCs' knowledge management and knowledge protection strategies by focussing on the location choices MNCs make in host countries. They find that MNCs consider not only the opportunities from incoming knowledge spillovers but

also the dangers from outward spillovers, i.e. they choose locations without related industry activity if they expect more outward than inward knowledge flows. Zhao (2006) finds that MNCs counter weak institutional protection in host countries by assigning interrelated R&D responsibilities that are only valuable in connection with other internal resources, a strategy that is more efficient in preventing valuable knowledge from spilling over. We extend this stream of research by focussing on a broader set of knowledge protection strategies by MNCs, ranging from formal methods like patents and trade marks to strategic ones like lead time and secrecy.

3 Hypotheses Development

Knowledge generated by R&D and innovation activities has characteristics of public goods (non-rivalry, non-excludability), since the investments undertaken and results achieved by one actor may become available to other agents (Arrow, 1962). As described by Adams and Jaffe (1996), knowledge production processes have two different types of effects: one direct, to the firm engaged in the knowledge production activity, and one indirect, to other firms that benefit from the public availability of some of the knowledge. These knowledge spillovers, which cannot be appropriated by the innovating firm, are substantial (varying considerably across industries) (Nadiri, 1993). They allow competitors to imitate a firm's innovative products, services or processes without investing into their development. Hence, managers have strong incentives to protect as much knowledge as possible (Mansfield et al., 1977).

Teece (1986) defines appropriability regimes consisting of technological opportunities and legal mechanisms as the relevant conditions of environmental factors allowing a firm to capture the rents of innovation activities by creating barriers to imitation by competitors. Managers can choose active knowledge protection strategies within this framework to prevent their knowledge from spilling over to competitors. Encaoua et al. (2006) and Harabi (1995) provide excellent overviews on the topic. Most research on knowledge protection distinguishes broadly between two prototypes of knowledge protection strategies. One relies on legal forms of protection based on formal application processes (such as patents or copyrights). Accordingly, they are typically summarized as formal (Harabi, 1995) or legal protection methods (Encaoua et al. 2006; Laursen and Salter, 2005). The other form of knowledge protection rests on organizational processes within the firm to prevent knowledge spillovers in the first place or limit negative consequences (such as secrecy or lead time). These are typically referred to as strategic (Harabi, 1995), market-based (Encaoua et al., 2006) or first-mover methods of knowledge protection (Laursen and Salter, 2005). The items covered in each typology are largely identical. We opt for the labelling introduced by Harabi (1995) distinguishing between formal and strategic forms of knowledge protection. We will discuss both forms of knowledge protection and examine the major differences between them.

Formal knowledge protection strategies are built around knowledge protection based on legal intellectual property rights regimes which grant exclusivity rights to an invention for a certain period of time (Arrow, 1962). They provide temporary monopoly rights on the usage of an invention (e.g. patent) or its replication (e.g. copyright) (Porter Liebeskind, 1997).

Infringements can be punished in court. Patenting is the most prominent form of formal knowledge protection but protection may also be granted through trademarks, copyrights or design patterns. All of these include a formal process of applying for protection at a government agency (e.g. patent office) which sets standards for qualifying inventions such as novelty and inventive step in the case of patenting (Encaoua et al., 2006). This application implies the codification and disclosure of knowledge in exchange for protection once the patent is granted (Gallini, 2002). While legal protection is generally strong, its efficiency and effectiveness has been questioned (see for example Mansfield, 1986). The application process is typically lengthy and requires substantial resource commitments (e.g. consulting from specialized lawyers). It is therefore less attractive for smaller firms with limited resources (Byma and Leiponen, 2006). Brouwer and Kleinknecht (1999) show that the propensity to patent varies greatly: firms engaged in R&D activities or in knowledge intensive sectors are generally more likely to patent their knowledge. Based on evidence from surveys of firms from Europe and the US, Arundel and Kabla (1998) show that the percentage of patented innovations varies by sector since different sectors attribute different values to patents. Pharmaceutical, chemical, and machinery firms invest the most in patenting. What is more, patents provide firms with tangible representations of their R&D investments. This implies that firms may not only apply for patents because of knowledge protection concerns but because patents can signal the value of their otherwise intangible assets to external stakeholders (e.g. investors) (Harabi, 1995). Finally, patent protection appears to be most relevant for better-established knowledge, which can be more easily codified (as opposed to more tacit, early stage knowledge) and would otherwise be easily retrievable by many potential users (Saviotti, 1998).

In many sectors, legal protection mechanisms such as patents are not the most important form of knowledge protection but strategic ones (Encaoua et al., 2006). These strategies aim at preventing knowledge from spilling over in the first place or to mitigate the negative consequences of such spillovers through organizational processes (Harabi, 1995). Preventing spillovers is typically achieved through initial secrecy or complex design so that knowledge can only be fully exploited once it is combined with additional expertise. This adds extra barriers to knowledge transfers to competitors (see for example Szulanski, 1996). Besides, certain knowledge may only reach its full potential once it is used in a certain organizational context (Teece, 1998). Complementarities with other organizational functions such as unique production or marketing operations may therefore also provide efficient knowledge protection (Teece, 1986). This strategy is typically applied to process innovations, which are embedded in a production system and have been found to be less frequently patented than product innovations (Harabi, 1995; Byma and Leiponen, 2006). Secrecy requires the setting and monitoring of rules. They include restrictions on transfers of specified knowledge to specified recipients, on social interactions with them or on physical access to specified areas such as labs (Porter Liebeskind, 1997). Steps to mitigate the consequences of spillovers are usually associated with lead time or first mover advantages, which enable firms to establish competitive advantages before competitors can react (for a review see Lieberman and Montgomery, 1988). Strategic knowledge protection strategies do not involve a formal process. They therefore do not require dedicated investments, which makes them attractive to smaller or low-tech firms (Byma and Leiponen, 2006). However, they entail costs for

designing, monitoring and enforcing organization rules (Porter Liebeskind, 1997). In contrast to formal forms of knowledge protection, no knowledge codification or disclosure is required. This increases the effectiveness of strategic knowledge protection methods because they include the protection of tacit knowledge and thwarts opportunities for competitors to ‘invent around’ patented innovations (Harabi, 1995; Saviotti, 1998). However, the potential of strategic knowledge protection strategies is also limited as important parts of the valuable knowledge are simply visible in the final product (Ndofor and Levitas, 2004). Furthermore, personnel mobility negates the effectiveness of secrecy (Arrow, 1962). Table 1 summarizes the discussion based on the literature mentioned above.

Table 1: Comparison of formal and strategic knowledge protection strategies

Knowledge protection strategy	Formal	Strategic
Major forms	Patents, copyrights, trademarks, industrial design	Secrecy, lead time, complex design, complementarities with production or marketing
Basis of knowledge protection	Law	Prevention of spillovers
Process	Formal application to official agency	Organization
Costs of protection	Substantial time and resource commitments	Flexible element of organizational design
Embodiment of protection	Tangible	Intangible
Type of suitable knowledge	Easy to codify, large group of potential users, low costs/high risks of imitation, product innovations	All forms of knowledge
Limitations to effectiveness	Knowledge disclosure enables “inventing around”	Knowledge embodied in products on the markets, personnel turnover

We can infer from this discussion that the ability to achieve economic returns from knowledge related investments and, consequently, the knowledge protection strategy of firms and, in particular, of MNC subsidiaries may be less reflected in their number of patents than in the various knowledge protection methods they utilize. Managers may combine multiple forms of knowledge protection strategies reflecting the opportunities and needs of their knowledge production environment. They may for example decide to protect the tacit and not-codified knowledge of early stage research initiatives through secrecy but apply for patents or copyrights for knowledge embodied in new products. We introduce the construct of restrictiveness of a knowledge protection strategy to the discussion. We define a knowledge protection strategy encompassing multiple forms of protection as being more restrictive if the intention is to provide higher degrees of prevention of outgoing knowledge spillovers. Higher degrees of restrictiveness may be achieved along two dimensions. They may stem from combining a larger variety of protection methods to benefit from their unique characteristics (i.e. breadth of knowledge protection strategies) or from concentrating resources on few protection instruments with high intensity (i.e. depth of knowledge protection strategies). We will explore both types.

Kogut and Zander (1993) conceptualize an MNC as a social community with a shared understanding on the production and transfer of knowledge based on repeated interaction. This capability enables MNCs to transfer knowledge effectively and efficiently between international subsidiaries. It is especially relevant for types of knowledge which are not

codified or tacit in nature and may therefore be especially valuable for generating competitive advantage. They can hardly be protected through formal protection methods alone. Formal protection methods require codification (Saviotti, 1998). Using them exclusively would imply that MNC subsidiaries disclose some of the valuable knowledge by applying for formal protection, e.g. through patents (Gallini, 2002). Cassiman et al. (2002) provide empirical support for general complementarities between legal and strategic protection methods. We argue that the incentives for managers of MNC subsidiaries are especially strong for combining multiple instrument of knowledge protection into a broad strategy. We hypothesize:

Hypothesis 1: Multinational subsidiaries combine more different knowledge protection methods than local firms (Breadth).

However, MNCs have the opportunity to tailor innovation activities so that they fit into and exploit varying institutional environments across numerous host countries (Goshal and Bartlett, 1990). As stated above, they can manage the risks from outward knowledge spillovers in a particular country through internal, organizational arrangements that assign R&D responsibilities which are only valuable when connected with knowledge produced in a more protective institutional environment (Zhao, 2006). Domestic firms without foreign links do not have that choice. As a result, MNCs can optimize their knowledge protection strategies across several countries, while their local competitors cannot. All types of knowledge protection entail costs. Formal knowledge protection requires resources for the application process, strategic ones for the setting, monitoring and enforcement of rules. Therefore, the managers of MNC subsidiaries may be better off by focussing on a few, selected knowledge protection strategies but pursue them with high intensity. We propose:

Hypothesis 2: MNC subsidiaries concentrate their knowledge protection strategies on high intensity protection methods compared to local firms (Depth).

Finally, we suggest that the choice of combined knowledge protection strategies is not independent from the host country environment. For example, the legal settings for intellectual property rights differ significantly across countries due to diversity in economic development and trade policy (Yang and Kuo, 2008). We argue that the restrictiveness of a MNC subsidiary knowledge protection strategy will depend upon the challenges and opportunities of the host country. On the one hand, we argue that more technologically advanced host country environments favour more restrictive knowledge protection strategies. Host country competitors can be assumed to have better developed absorptive capacities for identifying, assimilating and exploiting knowledge from their environment (Cohen and Levinthal, 1989; 1990). MNC subsidiary managers may therefore have strong incentives to choose both broader and deeper knowledge protection strategies because of the risks of outgoing knowledge spillovers. We conclude:

Hypothesis 3a: MNC subsidiaries choose more restrictive knowledge protection strategies (both breadth and depth) in technologically advanced host countries.

On the other hand, host country factor endowments and opportunities for knowledge spillovers from local competitors have been identified as important determinants of MNCs' R&D engagements (Feinberg and Gupta, 2004). However, channels for acquiring local knowledge have to be developed over time through inter-firm and interpersonal engagements (Birkinshaw and Hood, 1998; Laursen and Salter, 2006), which generate a level of trust that facilitates knowledge flows. Rousseau et al. (1998, p. 395) define trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another". Hence, MNC subsidiary managers may accept certain vulnerabilities on disclosing valuable knowledge if they can expect to become better embedded in host country knowledge flows in the future. These positive expectations can be built through reciprocity mechanisms: "voluntarily repaying a trusting move at a later point in time, although defaulting on such repayment is in the short-term self interest of the reciprocator" (Gunnthorsdottir et al., 2002, p. 50). Based on the conceptual framework developed by Fehr and Gächter (2000) and Sobel (2005) where individual preferences depend on the acts of others, we apply the concept of reciprocity to the relationship between MNCs and host country firms. Reciprocity is an important driver for knowledge flows as firms are more willing to share their knowledge if they can expect to receive other knowledge in return (Hakanson and Nobel, 2001). MNCs will adapt their knowledge management strategies according to the level of promising knowledge potentially available from host country firms.

Cassiman and Veugelers (2002) provide some empirical evidence on the general relationship between knowledge acquisition and protection. They find that managers shape a firm's knowledge acquisition strategy in part through appropriation capabilities. We conclude that the availability of valuable inward knowledge spillovers will impact a MNC subsidiary's approach towards knowledge protection strategies. We derive:

Hypothesis 3b: In host country environments that offer more opportunities for knowledge sourcing, MNCs will deploy less restrictive knowledge protection strategies (in both breadth and depth).

4 Empirical study

4.1 Data

To test our hypotheses, we need to compare at least two different host country environments with different characteristics. We test our hypotheses through a harmonized survey for Portugal and Germany. Both countries are part of the European Union and use the single European currency Euro. Hence, they are comparable countries with regard to basic economic infrastructure. However, important differences remain, making the comparison between both countries a good fit for our research framework. Table 2 summarizes main indicators of economic performance and science/technology in both countries. Germany's economy is large and technology-intensive, while Portugal's economy is smaller in size and less R&D intensive. Differences in subsidiary behavior may also arise from the effectiveness of legal mechanisms for knowledge protection at the national level. They are a major element of a

country's appropriability regime of "environmental factors [...] that govern an innovator's ability to capture the profits generated by an innovation" (Teece, 1986, p. 287). Several authors have suggested indices on the degree of patent protection across countries (e.g. Rapp and Rozek, 1990). Ginarte and Park (1997) construct an index for 110 countries based on a country's patent laws extent of coverage, membership in international patent agreements, provisions for loss of protection, enforcement mechanisms and duration of protection. In previous years Portugal has lagged behind Germany based on this patent rights index (Portugal reaches 1.98 out of a maximum of 5 in 1990 compared to Germany's 3.71). However, a more recent update of the index by Park (2008) shows that this gap has largely been closed (4.38 to 4.5 in 2005). Hence, differences in legal appropriability rights regimes are not expected to influence the results.

With respect to our research question, we would expect to find differences in the restrictiveness of MNC subsidiary knowledge protection strategies (Hypothesis 3a/b) between Germany than in Portugal based on the opportunities for spillovers from the host country.

Table 2: Selected economic and technology indicators for Portugal and Germany (2006)

	Portugal	Germany
GDP at current market prices (EUR 1 000 Mio.)	147	2 247
GDP per capita at current market prices (PPS) (EU-25 = 100)	71.4	109.8
Human resources in science and technology (employees with an S&T occupation, % of total employment)	18.6	36.9
Gross domestic expenditure on R&D (% of GDP)	0.8	2.5
Patent applications to the European Patent Office (number of applications per million inhabitants)	4.8	297.4
Index of patent rights (5 = highest patent right protection) (Park, 2008)	4.38	4.50

Source: Eurostat (2007): Europe in figures - Eurostat Yearbook 2006-07. Most recent year available reported.

We use data from the Community Innovation Survey III (CIS III), which was undertaken by the member states of the European Union in 2001. The survey collects data on the innovation activities of firms in each country from both the manufacturing and the service sector. The questionnaire and the methodology are based on the Oslo Manual (OECD, 1997) and harmonized across countries, allowing for comparisons between different countries. Some minor differences exist nonetheless, as countries are allowed to add questions to their questionnaire and to cover firms that are smaller than the threshold (ten employees) or belong

to industries outside the core sector coverage of the CIS. National data privacy protection laws restrict the access to the national CIS micro-datasets. It is not possible to merge both samples and we will analyze harmonized samples separately.

The Portuguese questionnaire is mainly a translation of the harmonized Eurostat questionnaire, but includes some additional questions. Nevertheless, and owing to the experience of CIS II, a more comprehensive design of the questionnaire was developed with several notes and examples to make it easier for the respondent to understand the questions. The German sample is stratified by region (East Germany and West Germany) in addition to size and industry to account for the effects of economic restructuring in East Germany.

To make the results of the surveys and our econometric analysis in the two countries comparable, all variables were constructed in the same way based on the harmonized survey questionnaire. Additionally, firms with fewer than ten employees were omitted from the German dataset and the NACE categories included in the German survey were brought into line with those covered in Portugal. Since most of the questions in the survey have to be answered only by innovative firms, i.e. firms that introduced at least one product or process innovation between 1998 and 2000 or had ongoing or abandoned innovation activities, we restricted our sample to this group of firms.

The CIS captures a larger variety of innovation activities rather than just R&D expenditures. These include the acquisition of patents and licenses, product design, personnel training, trial production and market analysis. Innovative output includes the introduction of innovative production processes and organizational changes. It contains also a wealth of information about the organization of innovation processes, including sources of knowledge, the reasons for innovating and the perceived strength of various knowledge protection mechanisms. For a detailed description of the survey see Peters (2008).

Heads of R&D departments or innovation management are asked directly if and how they are able to generate innovations. This leads to the production of direct measures for innovation processes and outputs which can complement traditional measures of innovation activity such as patents (Kaiser, 2002; Laursen and Salter, 2006). Moreover, CIS surveys are subject to extensive pre-testing and piloting in various countries, industries and firms with regard to interpretability, reliability and validity (Laursen and Salter, 2006). This multinational application of CIS surveys adds extra layers of quality management and assurance.

The industry coverage of both samples is representative for each country respectively. To ensure that results can be generalized we complement both datasets with official statistics for overall business R&D expenditures and foreign direct investment at the industry level. This additional information is intended to reflect that some industries may be more technologically advanced than others and/or may have received more attention from foreign investors. For Germany R&D data is derived from the OECD ANBERD database, for Portugal it is provided by the Portuguese statistical office and calculated in accordance with OECD procedures. Inflows of FDI data stem from the United Nations Conference on Trade and Development (UNCTAD).

4.2 Variables

Dependent variables

Patent applications have been considered the primary indicator for knowledge protection in large parts of the literature. However, firms patent for a variety of reasons, e.g. to deter competitors or to signal the value of their knowledge to investors (Harabi, 1995). The goal of this study is to present a more comprehensive picture of knowledge protection strategies. We follow Laursen and Salter (2005, 2006) and construct indices for the breadth and depth of the methods firms use to protect their knowledge. More precisely, breadth is defined as the number of different knowledge protection methods applied by a firm (testing hypothesis 1). These include patents, copyrights, trademarks, industrial design, secrecy, lead time and complex design and follow directly Laursen and Salter (2005). Hence the count variable ranges from 0 to 7. Respondents also rate the importance of each knowledge protection strategy on a four point Likert scale ranging from not relevant to highly important. Again, we construct the depth count variable following Laursen and Salter (2006) by counting all knowledge protection strategies that were considered highly important (testing hypothesis 2). Like the breadth variable, the depth variable can also range from 0 to 7. The ranking in terms of importance is not included in the Portuguese survey, which limits cross country comparability to the breadth count variable alone.

Independent variables

The focal point of our analysis is the identification of differences in the breadth and depth of knowledge protection strategies that are specific to MNC subsidiaries. Consequently, we add a dummy variable indicating whether the survey firm is part of a multinational group with headquarters abroad. The coefficient of this variable (“foreign group”) should be positive and significant in all estimations to support hypotheses 1 and 2. It should differ between Portugal and Germany to support hypothesis 3a or b.

We add an additional variable indicating whether a firm is part of a group with domestic headquarters (“domestic group”) to define the reference group of purely domestic firms more precisely. In addition, we control for a firm’s degree of internationalization through the share of their turnover that comes from exports. Most importantly, knowledge protection strategies may differ with regard to firms’ innovation and knowledge production engagements. We control for major innovation inputs. The indicators we use are innovation expenditures as a share of sales, the share of employees with college education and whether the firm performs R&D activities (innovation activities/expenditures also include engagements that are directed at promoting and marketing innovations, like costs for organizing market introductions). Several studies highlight the importance of subsidiary assignments (mandates or charters) from headquarters for explaining their behavior (e.g. Birkinshaw and Fry, 1998; Birkinshaw and Hood, 1998; Hakanson and Nobel, 2001). Cantwell and Mudambi (2005) provide an in-depth discussion of subsidiary mandates, relating them back to March (1991) and the distinction between explorative (directed at new products, capabilities and markets) and exploitative innovation activities (built around and for existing capabilities and customers). We construct two indices for explorative and exploitative innovation strategies based on a question 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 and divide them by the maximum. Firms' innovation strategies are considered explorative based on the importance of generating new products and serving new markets. Innovation strategies are considered exploitative if quality improvements, resources and personnel cost reductions were dominant. Finally, we control for basic firm features like size (number of employees) and regional differences (location in economically challenged East Germany). We also add four industry dummies (medium high-tech manufacturing, high-tech manufacturing, distributive services and knowledge-intensive services). Low-tech manufacturing will serve as the comparison group. Appendix A shows the detailed industry classification.

Besides, we add two control variables at the industry level accounting for differences in industry composition between Portugal and Germany. They should reflect differences in technological leadership and previous inward FDI investments. We will also use these variables for additional consistency checks (industry coverage of comparable FDI data is limited, so we restrict their usage to consistency check estimations). Salomon and Byungchae (2008) construct an index (RDI) for industry technological leadership based on OECD ANBERD data. The index is calculated through the subtraction of the R&D intensity of an industry in the country under consideration (Portugal or Germany) from the average industry R&D intensity of all other OECD countries. Positive values can be interpreted as relative technological leadership in an industry and negative values indicate a lagging status. We calculate the RDI index separately for Portugal and Germany using values from 1998 (the beginning of our observation period). The formula for the RDI index is:

$$RDI_{jt}^h = \frac{R_{jt}^h}{GDP_t^h} - \left[\sum_{k=1}^n \left(\frac{R_{kjt}}{GDP_{kt}} \right) \right] \times \frac{1}{n}$$

RDI_{jt}^h : R&D index of country h for the jth industry in year t

R_{jt}^h : R&D expenditure of country h in the jth industry in year t

GDP_t^h : GDP of country h in year t

GDP_{kt} : GDP of country k in year t

n: number of OECD countries (excluding country h)

With regards to inflows of FDI at an industry level, we calculate an industry's average share of total FDI in the five years preceding our observation period (1994-1998) for Portugal and Germany.

4.3 Model and method

Since the dependent variable is count data in nature, the ordinary least squares regression does not deliver robust results because it does not consider that the variable only can have nonnegative integer values. Put simply, the variation in the data is not correctly reflected in the estimation. In our case, there is more variation in the data than predicted. OLS estimations would produce inefficient, inconsistent and biased results. It is therefore preferable to use models purposely designed for count data, like Poisson regressions. However, our dependent

variables are non-negative count variables and reveal over-dispersion (variance > mean) violating one of the basic assumptions of the Poisson model. In addition, likelihood ratio tests reveal that Poisson models would underestimate the degree of dispersion in our sample. Over or under-dispersion can lead to biased standard errors and to erroneous p-values (Cameron and Trivedi, 1998). In this context, we apply a negative binomial regression model, which deals with over-dispersion and is frequently applied in innovation studies, in particular in studies using patent data (Hausman et al., 1984).

Negative binomial regression models account for an omitted variable bias, while simultaneously estimating heterogeneity (Cameron and Trivedi, 1998; Hausman et al, 1984). These models have Poisson-like structures but correct the over-dispersion problem by adding more variance (unobserved heterogeneity) through an additional parameter α . In other words, this parameter reflects the unobserved heterogeneity among observations avoiding the problem of the Poisson regression model that under-fits the amount of dispersion in the outcome (Long and Freese, 2006).

More formally, the model has the following final structure:

$$\Pr(y | x) = \frac{\Gamma(y + \alpha^{-1})}{y! \Gamma(\alpha^{-1})} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu} \right)^{\alpha^{-1}} \left(\frac{\mu}{\alpha^{-1} + \mu} \right)^{\alpha^{-1}}$$

Where $\Gamma()$ is the gamma function (the error is assumed to follow this distribution), x is the observed variable, y is a random variable indicating the probability of observing any count of the variable, and μ is the expected count of the variable in a given period (for details of the Poisson and negative binomial regression models see Long and Freese, 2006).

We estimate three different models: breadth and depth of knowledge protection strategies for Germany and breadth only for Portugal because of data availability.

4.4 Descriptive statistics

Appendix B presents descriptive statistics for the Portuguese and German sample. Major features are outlined briefly in this section. There are some interesting similarities but also differences between the two samples. The average German firm is larger (300 employees) than the average Portuguese one (252 employees). 13% of firms in the Portuguese sample are subsidiaries of foreign firms, compared to 10% in Germany. The share of firms that are part of a group with domestic headquarters is higher in Germany (32%) than in Portugal (26%). However, firms in both countries generate on average the same share of sales from exports (21-22%) and invest 7% of their sales in innovation activities.

However, there are major differences in innovation activities. The share of employees with higher education is almost twice as high in Germany (23%) as in Portugal (12%) and firms perform more innovation activities directed at new products and new markets (i.e. explorative innovation) in Germany. Some of these differences can be explained by country specific industry compositions. The majority of Portuguese firms operate in low (32%) or medium tech manufacturing sectors (31%). In comparison, low tech manufacturing in Germany

accounts for only 13% of the sample and the largest shares stem from medium tech manufacturing (47%) and knowledge intensive service sectors (22%).

These structural features are also apparent in firms' knowledge protection activities. Portuguese firms use typically narrower sets of knowledge protection strategies compared to their German counterparts. Interestingly, German firms report that on average only one knowledge protection strategy is highly important for protecting their knowledge (this number is not available for Portugal). We break these knowledge protection numbers down further and report details in Appendix C. There are stark differences in knowledge protection behavior. Only 9% of Portuguese firms patent actively while 36% of German firms do. Patents are the most widespread form of formal protection in Germany while trademarks dominate in Portugal. Lead time is the most frequent non-formal form of knowledge protection in both countries followed by secrecy. Then again, total numbers show strong differences. 55% of German firms use lead time compared to just 28% in Portugal. When we compare knowledge protection strategies between foreign MNCs and domestic companies in both countries we find similar patterns. Foreign MNCs are more likely to engage in knowledge protection across all forms of knowledge protection. However, these gaps are more pronounced in Portugal than in Germany.

In conclusion, the descriptive part of our analysis highlights major differences between Portugal and Germany in innovation activities and knowledge protection strategies. However, these could be due to other factors like firm size or industry composition. As a result, a multivariate analysis is warranted. We find that correlations between independent variables and subsequent levels of multicollinearity are no limiting factors for our analysis. Variance inflation factors are reported in Appendix D.

5 Results

Table 3 presents the results of our multivariate estimations. As mentioned above, the Portuguese database does not include information on the importance attributed by firms to the different knowledge protection strategies, so this model is only estimated for Germany. Following this analysis, we will compare results for the determinants of knowledge protection breadth in Portugal and Germany.

Table 3: Estimation results of negative binomial models for Portugal and Germany

	Germany		Portugal
	Depth of knowl. prot. strategy	Breadth of knowl. prot. strategy	Breadth of knowl. prot. strategy
MNC with HQ abroad (d)	0.25** (0.11)	0.06 (0.08)	0.26** (0.15)
Domestic group (d)	0.15** (0.08)	0.10* (0.05)	-0.07 (0.12)
RDI of technological leadership at industry level (index)	0.02 (0.07)	-0.04 (0.05)	0.04 (0.11)

	Germany		Portugal
	Depth of knowl.	Breadth of knowl.	Breadth of knowl.
	prot. strategy	prot. strategy	prot. strategy
Exports as a share of sales (ratio)	0.33** (0.14)	0.43*** (0.10)	-0.01 (0.16)
Share of empl. with college educ. (ratio)	0.58*** (0.18)	0.55*** (0.12)	0.78** (0.39)
R&D activities (d)	0.91*** (0.12)	0.82*** (0.08)	0.38*** (0.11)
Innovation exp. as a share of sales (ratio)	1.15*** (0.26)	0.89*** (0.18)	-0.22 (0.30)
Explorative innovation strategy (index)	0.96*** (0.14)	0.43*** (0.09)	0.88*** (0.17)
Exploitative innovation strategy (index)	0.22 (0.14)	0.18* (0.10)	0.25 (0.19)
No of employees (log)	0.11*** (0.03)	0.11*** (0.02)	0.17*** (0.04)
Location in East Germany (d)	-0.14* (0.08)	-0.24*** (0.05)	
Medium tech manufacturing (d)	0.20 (0.12)	0.24*** (0.08)	-0.10 (0.13)
High tech manufacturing (d)	0.28* (0.15)	0.27** (0.11)	0.03 (0.25)
Distributive services (d)	0.28* (0.16)	0.19* (0.11)	-0.52*** (0.18)
Knowledge intensive services (d)	0.01 (0.15)	0.08 (0.10)	-0.10 (0.18)
Constant	-2.46*** (0.22)	-1.28*** (0.14)	-1.53*** (0.23)
Ln alpha	-1.43*** (0.23)	-2.60*** (0.34)	-0.42*** (0.16)
Pseudo R2	0.09	0.10	0.06
N	1095	1095	744
LR/Wald chi2	301.57	437.03	129.94
P-value	0.00	0.00	0.00

Significance levels: * p<0.10, ** p<0.05, *** p<0.01.
d: Dummy variable. Standard errors in parentheses.

The primary results of our empirical analyses are the coefficients for the variable on whether a firm is part of an MNC with headquarters abroad. We find interesting distinctions between the results for Portugal and Germany. MNCs in Germany do not choose broader knowledge protection strategies compared to local firms but deeper ones. It is important to highlight the advantages of the cross-country comparison. An investigation focussing solely on the German context would have concluded that depth is important for MNCs, while broad knowledge protection approaches are not. Contrasting these findings with the Portuguese context (based on a harmonized dataset) reveals that this is not generally the case. The foreign group dummy variable is significant for breadth in Portugal but not in Germany. Hence, hypothesis 1 is supported for Portugal while hypothesis 2 is supported for Germany. We conclude that the distinction stems from the differences in host country opportunities for knowledge sourcing suggested in hypotheses 3a and b. We cannot simply reject one or the other because depth is not observable for Portugal. However, we can conclude from the

breadth-estimation models that managers of MNC subsidiaries choose more restrictive strategies in host countries with fewer opportunities for knowledge sourcing such as Portugal but not in Germany. This lends support to hypothesis 3b suggesting a need for reciprocity in host country knowledge exchanges. Then again, MNC subsidiary managers also devise deeper knowledge protection strategies for Germany indicating that their approach to knowledge protection in technologically advanced host countries requires more targeted or selected choices of protection strategies.

We will briefly discuss significant effects of control variables although we did not develop a-priori hypotheses for their predicted outcomes. Focussing on the first column of Table 3 and the results on depth of knowledge protection strategies for Germany we find that being part of a group leads to deeper knowledge protection strategies. The export share also has a positive influence on the knowledge protection depth of German firms. All variables that measure innovation and knowledge production engagements (share of employees with college education, engagement in R&D activities and innovation intensity), are positively related to the dependent variable, indicating that investments into knowledge production trigger deeper knowledge protection strategies. When it comes to firms' innovation strategies, the explorative innovation variable has a positive and significant impact on knowledge protection depth while the exploitative innovation variable is not significant. Firms with innovation strategies directed at new products and markets have both broader and deeper knowledge protection strategies. Exploitative innovation activities built around existing capabilities and customers have no significant effect on depth. Firm size (number of employees) has a positive effect, while location in East Germany shows a negative one. Finally, the technological leadership status of an industry has no significant impact. There are some remaining industry effects from firms in high-tech manufacturing (such as medical devices) and distributive services (such as logistics) which tend to favor deep knowledge protection strategies.

Columns 2 and 3 of Table 3 present the results obtained when estimating the empirical models on the breadth of knowledge protection strategies as the dependent variable using the German and the Portuguese data, respectively. Some differences exist between the two countries with respect to control variables. The results for Germany on breadth are similar to the ones obtained for knowledge protection depth, only differing with regard to the significance of the exploitative innovation strategy variable and industry dummies (distributive services). All other determinants that explain the importance attributed to the breadth of knowledge protection strategies are similar to the ones that explain knowledge protection depth. The Portuguese results are different to Germany with regard to insignificant results for the variables on national group, share of exports and innovation intensity. The breadth of knowledge protection strategies of Portuguese firms seems to be much more determined by performing R&D and having skilled employees than the amount of money spent on innovation activities or international markets served.

In that sense we identify a noteworthy trend in the results of the control variables. Higher degrees of internationalization (being part of a multinational group with domestic headquarters as well as higher export shares) are associated with more breadth and depth of knowledge protection strategies in Germany but not in Portugal. We cannot draw any conclusions on the direction of causality based on our estimations. However, the inclusion of

knowledge protection strategies in the discussion on whether firms “learn from exports” or “learn for exports,” i.e. are more productive in the first place (for a review see Keller, 2004), appears to be a fruitful path for further research.

Consistency checks

We conduct additional consistency check estimations to test the stability of the estimation results. First, we add the average inward FDI (as a share of total) in the five years preceding our observation period to the model. The rationale for this addition lies in the fact that some MNC subsidiaries may be more active in some host country industries but not in others. We did not add this variable to estimation model represented in Table 3 because UNCTAD data coverage is limited and we would lose roughly 300 observations due to missing values. Secondly, we add two interaction terms to the consistency check model. They interact our focus variable (being part of an MNC with headquarters abroad) with the industry R&D index on technological leadership and the share of FDI separately. Significant findings would indicate a multiplicative industry effect not covered by the additive model formulation. The results can be found in Appendix E. All main effects including the effect of foreign MNC manager choices of knowledge protection strategies remain significant and stable. The FDI variable provides no additional explanatory power. The interaction with the R&D index on technological leadership is only weakly significant in Portugal while the main effect remains unchanged. Hence, we are confident that our results are not confined to the specific industry compositions of Portugal and Germany.

6 Conclusions

Our study investigates the choices of MNC subsidiary managers with regard to knowledge protection strategies including not only formal methods (patents, copyrights, trademarks) but also strategic ones (secrecy, lead time, complex design). We conceptualize a firm’s breadth and depth of knowledge protection strategies and their unique relevance for MNCs compared to domestic firms. Moreover, we argue that these approaches differ with regard to host country challenges and opportunities.

Two main conclusions can be drawn from our results based on empirical tests that were put forward using the harmonized databases for Germany and Portugal. First, MNC subsidiaries have deeper and broader knowledge protection strategies that go beyond patents. Secondly, MNC knowledge protection strategies are less restrictive with regard to breadth in host country environments with more opportunities for knowledge sourcing. The latter result only came to light thanks to our cross country study based on a harmonized survey. Interpretations based on only one host country (Germany) would have been misleading. Interestingly, we find that managers of MNC subsidiaries choose deeper knowledge protection strategies in technology advanced host countries such as Germany. We conclude that the insignificant result for breadth in these countries does not imply that MNC managers rely solely on reciprocity in host country knowledge exchanges. Instead, they deploy deep knowledge protection strategies relying on selective protection methods with high intensity.

Our findings extend existing research, which has found that opportunities for host country knowledge spillovers are an important driver for MNC engagements (e.g. Almeida and Phene, 2004). We are able to show that this is not only reflected in MNC location choices but also in the way in which they protect their knowledge. Multinationals seem to come to countries with more opportunities for knowledge sourcing, such as Germany, to capture knowledge spillovers. We suspect that they opt for less restrictive knowledge protection strategies in order to facilitate host country knowledge exchanges by demonstrating reciprocity selectively and combine it with selective, high intensity methods of protection (depth). In Portugal, a country with fewer opportunities for knowledge sourcing, subsidiaries of multinationals seem to be more focused on preventing their knowledge from spilling over to local firms, since they have fewer opportunities to receive valuable knowledge in exchange.

Our findings provide opportunities to derive both management and policy recommendations. On the management side, we find evidence that firms need to develop knowledge protection strategies that are not limited to formal methods like patenting. This seems to be especially relevant if they expand their activities to other countries, i.e. turn multinational. Then again, a “zero spillover” approach that limits all knowledge flows has its downside in host countries where firms hope to benefit from knowledge spillovers. MNCs cannot expect commitments from host country institutions for knowledge sharing if they do not share themselves. This line of reasoning provides a link to the derivation of policy recommendations. Federal and regional governments have invested heavily into attracting MNC engagements in recent years but the measurable effects on efficiency and productivity spillovers have been mixed (Keller, 2004). Our findings suggest that MNCs play a much more active role not only in sharing but also in protecting their knowledge than previous studies, based on patent statistics and limited to a single (often highly developed) host country, have been able to show. In that sense, governments should not limit the goals of their financial support to attracting MNCs. Instead, incentive schemes should become part of policy proposals that propel MNC subsidiaries to engage in local knowledge flows and become fully embedded.

7 Future research

Our study has certain limitations which may provide fruitful paths for future research projects. First, we trace actual instead of best practices of MNC subsidiary knowledge protection. Additional studies may be able to reveal the contribution of each subsidiary and its knowledge protection strategy for the MNC as a whole. Secondly, we find relatively few Portuguese MNC subsidiaries in our existing German dataset and vice versa. A dedicated study may reveal important differences or similarities between MNC headquarter and subsidiary knowledge protection strategies. In addition, comparisons with other countries, especially in the developing world, could provide further insight into the mechanisms behind MNCs’ knowledge protection strategies.

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9 Appendices

Appendix A: Industry breakdown

Low-tech manufacturing	NACE 15-22, 36, 37
Medium-tech manufacturing	NACE 23, 24(excl.244), 25-29, 31, 34, 35(excl.353)
Hi-tech manufacturing	NACE 244, 30, 32, 33, 353
Low knowledge-intensive services	NACE 51, 60, 63
Knowledge-intensive services	NACE 61, 62, 64, 65, 66, 67, 72, 73, 74.2, 74.3

Appendix B: Descriptive statistics: Dataset

Variable	Portugal		Germany	
	Mean	SD	Mean	SD
Breadth of knowledge protection strategies	1.18	1.52	2.24	1.93
Depth of knowledge protection strategies	-	-	1.19	1.39
Foreign group (d)	0.13	0.34	0.10	0.30
Domestic group (d)	0.26	0.44	0.32	0.47
RDI of technological leadership at industry level (index)	-0.37	0.52	0.20	0.55
Exports as share of sales (ratio)	0.22	0.32	0.21	0.25
Share of empl. with college educ. (ratio)	0.12	0.16	0.23	0.24
R&D activities (d)	0.65	0.48	0.78	0.41
Innovation spend as share of sales (ratio)	0.07	0.27	0.07	0.12
Explorative innovation strategy (index)	0.53	0.32	0.65	0.28
Exploitative innovation strategy (index)	0.49	0.25	0.49	0.26
No of employees	252.40	962.05	299.84	638.27
No of employees (log)	4.40	1.33	4.66	1.41
Location in East Germany (d)	-	-	0.35	0.48
Low tech manufacturing (d)	0.32	0.47	0.13	0.34
Medium tech manufacturing (d)	0.31	0.46	0.47	0.50
High tech manufacturing (d)	0.05	0.22	0.08	0.28
Distributive services (d)	0.13	0.34	0.10	0.30
Knowledge intensive services (d)	0.18	0.38	0.22	0.41
Av. industry share of total inward FDI between 1994 and 1998 (ratio)	0.04	0.06	0.01	0.06
No of observations	747		1,095	

Appendix C: Descriptive statistics: Share of firms with knowledge protection strategy

	Portugal	Germany	Portugal		Germany	
			Domestic	Foreign group	Domestic	Foreign group
Patent	9%	36%	8%	17%	35%	48%
Design pattern	7%	27%	5%	19%	26%	29%
Trademark	25%	26%	22%	44%	25%	34%
Copyright	4%	9%	3%	11%	9%	9%
Secrecy	22%	47%	22%	27%	46%	53%
Complex design	14%	25%	13%	23%	25%	27%

	<i>Portugal</i>	<i>Germany</i>	<i>Portugal</i>		<i>Germany</i>	
			<i>Domestic</i>	<i>Foreign group</i>	<i>Domestic</i>	<i>Foreign group</i>
Lead time	28%	55%	28%	32%	54%	59%

Appendix D: Variance Inflation Factors (VIF)

<i>Variable</i>	<i>Portugal</i>	<i>Germany</i>
Foreign group (d)	1.34	1.21
Domestic group (d)	1.48	1.25
RDI of technological leadership at industry level (index)	1.74	1.50
Export share of sales (ratio)	1.32	1.39
Share of empl. with college educ. (ratio)	1.92	1.93
R&D activities (d)	1.18	1.27
Innovation expend. as share of sales (ratio)	1.08	1.19
Explorative innovation strategy (index)	1.24	1.23
Exploitative innovation strategy (index)	1.13	1.24
No of employees (log)	1.60	1.57
Location in East Germany (d)	-	1.16
Medium tech manufacturing (d)	2.11	2.95
High tech manufacturing (d)	1.75	1.80
Distributive services (d)	2.24	1.67
Knowledge intensive services (d)	2.89	3.12
Mean VIF	1.63	1.62

Appendix E: Estimation results of negative binomial models for Portugal and Germany including FDI and interaction effects

	<i>Germany</i>		<i>Portugal</i>
	Depth of knowl. prot. strategy	Breadth of knowl. prot. strategy	Breadth of knowl. prot. strategy
MNC with HQ abroad (d)	0.29** (0.14)	0.13 (0.09)	0.42** (0.20)
Domestic group (d)	0.13 (0.09)	0.05 (0.06)	-0.09 (0.13)
RDI of technological leadership at industry level (index)	0.05 (0.08)	-0.00 (0.06)	0.01 (0.12)
Exports as a share of sales (ratio)	0.24 (0.16)	0.38*** (0.11)	-0.01 (0.16)
Share of empl. with college educ. (ratio)	0.57*** (0.20)	0.56*** (0.14)	0.78** (0.39)
R&D activities (d)	0.95*** (0.14)	0.77*** (0.09)	0.39*** (0.12)
Innovation exp. as a share of sales (ratio)	1.22*** (0.30)	0.97*** (0.21)	-0.14 (0.28)
Explorative innovation strategy (index)	0.93*** (0.16)	0.48*** (0.11)	0.81*** (0.18)
Exploitative innovation strategy (index)	0.31* (0.16)	0.22* (0.11)	0.35* (0.20)
No of employees (log)	0.12*** (0.03)	0.12*** (0.02)	0.19*** (0.04)
Location in East Germany (d)	-0.12 (0.08)	-0.22*** (0.06)	
Medium tech manufacturing (d)	0.15	0.23**	-0.02

	Germany		Portugal
	Depth of knowl. prot. strategy	Breadth of knowl. prot. strategy	Breadth of knowl. prot. strategy
High tech manufacturing (d)	(0.16) 0.22	(0.11) 0.26**	(0.15) 0.13
Distributive services (d)	(0.18) 0.09	(0.13) 0.06	(0.25) -0.54**
Knowledge intensive services (d)	(0.23) -0.03	(0.16) 0.09	(0.23) -0.10
Interaction: Foreign MNC * RDI	(0.18) -0.13	(0.13) -0.11	(0.20) 0.33*
Interaction: Foreign MNC * FDI	(0.15) -3.25	(0.11) -2.01	(0.20) 0.16
Av. industry share of total inward FDI between 1994 and 1998 (ratio)	(2.09) 1.42	(1.46) 1.25	(2.09) 0.11
Constant	(1.19) -2.46***	(0.80) -1.32***	(1.05) -1.68***
Ln alpha	(0.25) -1.45***	(0.17) -2.59***	(0.25) -0.61***
Pseudo R2	(0.25) 0.09	(0.38) 0.10	(0.18) 0.07
N	856	856	630
LR/Wald chi2	241.13	340.95	128.65
P-value	0.00	0.00	0.00

Significance levels: * p<0.10, ** p<0.05, *** p<0.01.
d: Dummy variable. Standard errors in parentheses.

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