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## Intellectual property infringements due to R&D abroad? A comparative analysis between firms with international and domestic R&D activities

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## **Intellectual Property Infringements due to R&D Abroad?**

**A Comparative Analysis Between Firms with  
International and Domestic R&D Activities**

Anja Schmiele

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## **Non-technical Summary**

By internationalising R&D activities, firms can improve their chances to respond to local demands and benefit from local knowledge globally. However, differences in culture and the legal system can challenge firms and lead to higher costs. Furthermore R&D activities abroad are often considered to cause IPR infringements, especially in the case of weak intellectual property protection systems. This paper aims at analysing whether firms with international R&D activities are confronted with a higher risk of intellectual property infringements (IPR) than firms with domestic innovation processes only. The paper differentiates between specific types of infringements: the usage of firms' technical inventions, product piracy and copying of corporate names and designs. The analysis is based both on a qualitative explorative study which consists of six interviews, involving five German companies active in China and a German legal advisor for intellectual property protection as well as on an empirical study. The empirical study is based on the data of the Mannheimer Innovation Panel (MIP).

The explorative study showed that the involved firms disbelieve that R&D activities in China increase the risk of IP infringements, that they all entered the Chinese market with well prepared IP protection and despite the fact that they were all facing IP infringements, these cases turned out to be manageable. The results of the empirical analysis indicate that international innovation activities lead to a higher risk of infringements of technological knowledge. However, firms whose R&D activities are only based in their home countries face an increased risk of product piracy. By differentiating between host countries with weak and strong intellectual property rights, it has been found the effects from both kinds of countries do not vary from each other. A larger scope of innovation processes abroad also causes a higher likelihood of infringements from countries in which the firms innovate abroad. Infringements from countries where the firms do not operate R&D activities are driven by the export intensity of the firm.

## Das Wichtigste in Kürze

Durch internationale Forschungs- und Entwicklungstätigkeiten (F&E) haben Unternehmen nicht nur die Möglichkeit schneller und besser auf lokale Kundenbedürfnisse reagieren zu können sondern auch von lokalen Wissensressourcen weltweit zu profitieren. Allerdings können Unterschiede der kulturellen und rechtlichen Rahmenbedingungen zu einem höheren Risiko für die intellektuellen Eigentumsrechte der Unternehmen führen. In diesem Zusammenhang untersucht diese Forschungsarbeit, ob Unternehmen mit internationalen Innovationstätigkeiten ein höheres Risiko der Verletzung ihrer intellektuellen Eigentumsrechte eingehen, als Firmen, die nur in ihrem Heimatland innovativ tätig sind. Für diese Analyse werden verschiedene Verstöße von ausländischen Wettbewerbern gegen intellektuelle Eigentumsrechte unterschieden: die Nutzung technischer Innovationen, Produktpiraterie und die Imitation des Firmennamens oder –designs. Die Forschungsarbeit basiert zum einen auf einer qualitativen Studie, im Rahmen derer fünf deutsche Unternehmen und ein juristischer Berater, die in China tätig sind, interviewt wurden und auf einer empirischen Studie, die auf Daten des Mannheimer Innovationspanels (MIP) fußt. Die Ergebnisse der qualitativen Studie zeigen, dass die befragten Unternehmen bezweifeln, dass F&E Tätigkeiten in China zu einem höheren Risiko intellektueller Eigentumsrechtsverletzungen führen. Alle Unternehmen waren mit Verletzungen ihres intellektuellen Eigentums konfrontiert, jedoch in kontrollierbarem Ausmaß. Die empirische Analyse zeigt, dass internationale F&E Tätigkeiten das Risiko der Verletzungen von firmeneigenem technologischem Wissen erhöht, während Firmen, die nur in ihrem Heimatland F&E tätig sind, mit einer größeren Wahrscheinlichkeit von Produktpiraterie betroffen sind. Die Effekte von F&E Tätigkeiten in Ländern mit stärkeren Schutzrechten sowie in Ländern mit schwachen Eigentumsrechten unterscheiden sich nicht. Die Produktion von innovativen Gütern im Ausland fördert eher Eigentumsverletzungen aus dem Ausland als F&E Tätigkeiten. Eine größere Bandbreite von Innovationsprozessen im Ausland geht auch einher mit einer höheren Wahrscheinlichkeit von intellektuellen Eigentumsverletzungen aus den Zielländern. Die unerlaubte Nutzung von Unternehmenswissen aus Ländern, in denen die Unternehmen keine Innovationstätigkeiten lokalisiert haben, ist vornehmlich der Exportintensität der Unternehmen zuzurechnen.

# Intellectual property infringements due to R&D abroad? A comparative analysis between firms with international and domestic R&D activities

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## Abstract

This paper aims at analysing the risk of intellectual property (IP) infringements by competitors from abroad and in particular whether this risk is higher for international innovating firms. We distinguish three different types of IP infringements from abroad: the usage of firms' technical inventions, product piracy and copying of corporate names and designs. Our analysis rests on the German data from the Europe-wide Community Innovation Survey (CIS). We use a unique data set of about 900 observations which are retrieved from two survey waves. While the earlier wave contains information about international and domestic innovation activities the later wave reports IP infringements. In a second analysis, the likelihood of infringements from innovation host countries and no innovation host countries abroad is examined. Before the empirical analysis, an explorative study has been carried out in China with interviews of German firms with innovation activities in China and with a legal advisor for small and medium sized German enterprises. The results show that firms with international R&D activities are increasing their chances to lose technological knowledge to their local competitors abroad. R&D activities in countries with weak intellectual property rights increase the risk for all types of infringement. Infringements by competitors from the host country are driven by the production of innovations in this country. Export intensity is the major driver of infringements from no innovation host countries. R&D activities in China and North America also increase the risk of an infringement. However, firms that innovate only in their home country experience significantly more product piracy cases than internationally innovating firms.

**Keywords:** R&D, innovation, internationalisation, intellectual property, infringement

**JEL-Codes:** O32, O34, F23

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# 1 Introduction

The internationalisation of corporate R&D activities enables firms to better serve customers abroad with customised products. R&D activities in customers' countries allow firms to react more quickly to local demands and supply customers in the host country as an authentic 'local' firm (Porter, 1980). Firms with international R&D centres further benefit from internalising foreign talents and expertise into their knowledge base. Many firms have realised the potential of international R&D activities and contributed to the persistent trend to internationalise their innovation strategies (UNCTAD, 2005). This trend is also spurred by emerging economies that have large numbers of university graduates and a growing importance in firms' market portfolios and therefore appear increasingly as desired corporate innovation locations (Rammer and Schmiele, 2008). The internationalisation of corporate R&D activities is often associated with a looser control over technological knowledge and other core competences. Foreign business environments can be very different culturally and legally in comparison to the home country and challenge the operations of international firms. Especially for firms that carry out R&D activities abroad, the weakness of the intellectual property (IP) protection system can hamper their innovative efforts. The intellectual property right (IPR) standards often do not follow the economic development of some emerging states such as China. Firms have to balance the attractiveness of a greater market size with customized innovative products against the risk of knowledge loss from their innovative efforts.

To evaluate this risk, this paper analyses whether firms with innovation activities abroad face a higher risk to experience IP infringements from abroad than firms that have R&D and innovation activities solely in their home country.

The main contribution of this paper is to distinguish between different types of innovation activities abroad (R&D, conception/design of new products, manufacturing of new products, implementation of new processes) and different types of IP infringements (infringement of inventions, product piracy, usage of firm name and designs). In addition, we are able to identify whether the IP infringement by competitors from abroad stems from a firm's innovation host country or from another country abroad. The distinction between host country and non-host country IP infringement can explain whether localized innovation activities, signalling effects or export intensity foster IP infringements.

Prior to the empirical analysis, an explorative study on firms with R&D and business activities abroad was carried out. In interviews, the organisations that hold patents and trademarks told about their experience with IP infringements from abroad. This so-called triangulation approach, the combination of different data sets and research methods, allows gaining a wider and deeper understanding of the topic (Jick, 1979). The qualitative study can lead to conclusions which the empirical analysis would not reveal (Jick, 1979) and can make important contributions to the empirical study.

The outline of this paper is as follows: Section 2 will introduce previous work and related theoretical approaches in this field of research. In section 3, we present results of the explorative study and frame the research questions accordingly. Subsequently, an empirical study which is based on a large sample of firms from Germany investigates in section 5 whether the findings from the explorative study hold for a sample of about 900 innovative firms from Germany of which approximately 500 firms had international innovation activities. Section 6 provides the empirical results and section 7 provides the conclusions and implications of this research work.

## **2 Theoretical Framework**

Firms that are investing into R&D seek to appropriate the returns of their efforts. Depending on the nature of the innovation outcome, firms have different possibilities to protect their IP. Technological inventions can be legally protected by applying for a patent grant. Non-technical IP can be protected with industrial designs or trademarks. Each type of IPR requires an application at the public authority which can grant an IPR for the territory it is responsible for. The enforcement of IPR is only possible if they are granted for the region in which the infringement case took place. The following paragraphs will introduce theoretical concepts which explain the occurrence of IP infringements from abroad.

### **2.1 Liabilities of Foreignness**

The internationalisation of business activities such as R&D and other innovation related activities are faced with additional complexity in the business unit abroad. The complexity arises from unfamiliar business environments (Hymer, 1976), which are created by cultural, political and economic differences between home and host country. All costs that are associated with the newness of the foreign firm in the foreign business environment are summarised as the liabilities of foreignness (Zaheer, 1995). The liabilities of foreignness stem



from unexpected situations that lead them to false decisions and hence expose the firm to extraordinary risks (Lord and Ranft, 2000). Social and cultural laws are not codified and therefore especially ambiguous to foreigners and offer great potential to cause liabilities of foreignness (Jensen and Szulanski, 2004). As for international R&D centres, liabilities of foreignness can be too much trust in formal contracts or local R&D partners, the disrespect of the foreign culture and business etiquette which can result in the loss of authority and resignations of important employees. In certain countries, contracts are rather based on personal relationships and the respect of intellectual properties and their legal enforcement is not that embedded (Yang, 2005). The costs from firms' foreignness also comprise the loss of IP to competitors abroad when they have not taken appropriate measures to protect them. Firms have to undertake efforts to learn and employ strategies of the local legal system to work efficiently against counterfeiting.

## **2.2 Signalling Effects of International R&D**

Previous studies have found empirical evidence that firms that innovate both in their home country and abroad are more successful in generating innovative products and achieve higher sales growth due to these new products compared to firms that innovate only domestically (Peters and Schmiele, 2010a; 2010b). This suggests that firms with international R&D units are highly competitive and more successful market actors. From this point of view, it can be assumed that firms are not so much at risk to experience IP infringements because of their international innovation activities abroad itself but from the success the firm gains from these activities.

## **2.3 International R&D Spillovers**

Firms that carry out R&D activities are very likely to generate knowledge spillovers to third parties (Jaffe, 1986, Acs et al., 1992, 1994) which benefit and exploit these assets. International spillovers from innovation activities can occur because of the imperfect appropriability of innovations (Macdissi and Negassi, 2002). International knowledge spillovers can take place via different channels such as trade, foreign direct investment (FDI) or cooperations. FDI seems to play a particular role (Hejazi and Safarian, 1999). Knowledge spillovers from internal R&D activities abroad can be transmitted by reverse engineering, labour market mobility (Görg and Strobl, 2001; Maliranta et al., 2009), user-supplier relations (Javorcik, 2004; Markusen and Venables, 1999) or technology transfer (Macdissi and Negassi, 2002). The geographical proximity increases the chances of knowledge flows

between producers and receivers of spillovers (Marshall, 1920; Jaffe et al., 1993; Branstetter, 2001; Audretsch and Feldman, 1996).

An important aspect for the translation of R&D spillovers into a benefit for the receiving firms is that the receiving entity is able to productively use the information. The receiver requires absorptive capabilities (Cohen and Levinthal, 1989) in terms of pre-existing knowledge in the relevant technology field in order to be able to use the incoming spillovers. If a country or firm does not possess the necessary extent of absorptive capabilities, the knowledge spillovers cannot be fully utilised. For developing countries, the lower level of education can be a barrier to transferring the spillovers into sophisticated products. Spillovers are often used to produce rather crude imitations (Macdissi and Negassi, 2002), simple designs or to copy firm names but rarely to develop competitive products. In this vein, innovation activities in countries with low knowledge levels might be less risky for foreign-owned firms' IP.

The macroeconomic view on spillovers emphasises the positive effects of international spillovers on the economic development of the receiving host country. Host countries benefit twofold from foreign R&D activities. Firstly, the direct benefits result from the learning from new products, materials, processes and the organisation, while indirect benefits stem from the imports of products and services of the foreign firms into the host country (Coe and Helpman, 1995). The incoming knowledge spillovers contribute to the accumulation of the domestic R&D, which is evidently increasing national productivity (Griliches, 1988). The relation of foreign innovation activities and host country productivity growth has also been shown by several scholars (Keller and Yeaple, 2003; Coe and Helpman, 1995). R&D of foreign-owned firms does also stimulate the R&D expenditures in many host countries (Lonmo and Andersen, 2003; Costa and Filippov, 2008; UNCTAD, 2005). Following this perspective, foreign-owned firms can benefit from technological developments that are initiated by international spillovers. The technological development of host countries goes hand in hand with the local market development for foreign-owned firms' products.

To reduce outgoing spillovers, firms invest into knowledge protection mechanisms by applying formal and strategic protection methods (Arbussa and Coenders, 2007). These methods can vary in their efficiency for products and processes as well as across industries (Levin et al., 1987; Mansfield, 1986; Arundel, 2001). While strategic methods such as secrecy enable firms to disclose firm knowledge to outsiders, patents have the unique property to be defensible in court. The extent of knowledge spillovers is not only moderated by corporate

R&D appropriability measures but also by the effectiveness of legal IPR regimes (Belderbos et al., 2008). For R&D activities in developing countries, the usage of formal protection methods can be ineffective since weak IPR systems restrict effective enforcement of the intellectual property rights. A mix of legal, operational and strategic activities (Yang and Jiang, 2007; Yang et al., 2008) or de-facto strategies which make use of cultural laws in host countries (Keupp et al., 2010) can be more effective against IP infringements. The following explorative study reveals some of these strategies implemented in German firms in China.

### 3 Explorative Study

For the explorative study, interviews with five German firms in China from different industries have been carried out as well as one interview with a legal advisor for intellectual property protection from a German public institution. For Germany, as an export-driven economy, China is a very attractive market which often urges firms to adapt their domestic products to Chinese tastes and standards. The adaption of products as well as the development of new products for the Chinese market or for global demand involves innovation and R&D activities. Most of the firms which have been interviewed expressed that they are having localised R&D activities in order to meet customer preferences, being able to react more quickly to local demands and become a ‘total local firm’ which operates all parts of its value chain at the foreign location. Table 3.1 gives an overview of the organisations that participated in the study.

*Table 3.1: Overview of Interviewed German Organisations in China*

Firms	Industry / Products	Firm size	R&D in China
A	Chemistry	>20000	Yes
B	Chemistry	>20000	Yes
C	Oil Processing	< 5000	Yes
D	Machinery	>10000	Yes
E	Machinery	< 5000	No
F	Public institution / Legal Advisory	< 200	-

The interview partners were the General Manager or Managing Directors in smaller firms and heads of patent and trademark functions as well as R&D managers in larger firms. The case F interview partner is a legal advisor predominantly for small and medium sized German firms which are planning business operations in China or are already active in China. Case F explains that the Chinese government wants to improve China’s technological performance

by attracting R&D intensive foreign direct investments. In the past, there have been national rules of local content requirements, which urged foreign firms and their suppliers to produce a larger share of their products within China. Greater corporate investments were connected to the demand for local development centres in China (Schüller, 2006). However, the surveyed firms expressed that they did not set up R&D facilities to meet public requirements but customer demand. Further insights from the interviews are presented in the following paragraphs.

### **3.1 Insights from Interviews**

#### *Corporate IP Protection Strategies*

All firms (cases A-E) have used formal protection methods to be able to carry out legal actions when firm technology, names, logos or designs have been used by competitors. These IP protection strategies have been put into place before the firms entered China. This trend to carefully manage IP and its protection was confirmed by case F. The legal advisor expressed that German firms entered the Chinese market very well prepared in terms of IP protection issues. Not surprisingly, especially firms in the chemical and pharmaceutical industry (A, B) emphasized the importance of patents for the appropriation of IP. For the other firms, the importance of formal strategies was not as high, case C even argued that patents had no additional value to copyrights and trademarks in China. They draw their attention to strategic IP protection methods. An effective way to avoid product piracy has been the import of product parts from the home country or other global centres which are essential to the product but not developed or produced in the host country. In this vein, case B started the initiative to define the ‘crown jewels’ of the firm and develop specific disclosure actions. Following the secrecy method, firms limit the number of people that know all about the product or developed a code system for their suppliers to hide the origins of the ingredients. Once the product is available on the market, firms do not rely on the product solely to win and keep customers. Similarly important is to offer distinct services and infrastructures which are harder to imitate by product pirates. Apart from products, manpower has a great potential for knowledge leakages. To prevent employees from taking firm knowledge from the present firm to direct competitors when leaving the company, firms use anti-compete contracts, extra compensations as well as social pressure to emphasize the employees’ responsibilities towards its previous employer.

### *Firms' Experience with IP-infringements*

Interview partners denied that their R&D activities in China increased the occurrence of IP infringements. Firm E, which has no R&D activities in China yet, would not expect a rise in IP infringements either if they would establish R&D activities in China. However, all firms (A-E) reported infringements of firm names and trademarks. Patent infringements have been experienced by case A and case B. Further, case B argues that the risk of infringement is most pronounced for their most prestigious and successful products. Firms A and C state that their infringements all stem from local rivals, not from international market players. Firm E, which reported few cases of firm name infringements, assumes that firm reputation is a driving factor for IP infringements and explains: “we are not famous enough to be copied”.

### *Firm Reactions to IP Infringements*

The legal and strategic reactions of firms in case of IP infringements vary according to their level of IP infringements. Firm E, which has few firm name infringements, does not carry out any legal actions. Firms A and B employ a team of lawyers that follow up on patent infringements. Although the compensation from these infringement cases is marginal, each infringement incident in firm C is prosecuted with the aim to keep infringers busy. Firm B also uses press releases about successful patent infringement cases in court in order to discourage potential IP infringers. Firm D tries to get hold of IP infringers with the help of custom raids on fairs in Europe. Strategic decisions and reactions after IP infringements were the relocation of critical business processes back to the home country in firm C, while case A and B did not use backward relocation of operations as a method of IP protection.

### *Importance of IP Infringements and Financial Effects for Firms*

Although most of the firms have experienced IP infringements, the respective firms judge that these cases are manageable and occur in a moderate extent (3 cases per month in firm C). Due to the limited number of cases, IP issues in China are of minor importance to the surveyed firms. Since the costs of legal cases are low, the overall monetary loss is low as well. Firm D, for example, has experienced product piracy for outdated machinery products from which they had received only little sales.

## 4 Research Questions

The conclusions that emerge from the interviews with German firms in China about their experience with IP infringements and local R&D activities are: all firms have experienced IP infringements, firms do not expect a rise of IP infringements due to their R&D activities in China and the majority of the IP infringements concerns the usage of firm names and trademarks.

These interview results oppose in some parts the results from the literature introduced in section 2. The firms reported a manageable extent of IP infringements that cause relatively few costs. From the spillover literature or the liabilities of foreignness perspective, more costs and risks would have been expected to result from international R&D activities. However, one has to keep in mind that infringers from China might not have the technological potential to successfully copy technological inventions which reduces the amount and severity of infringements (low absorptive capabilities) from this particular country. Furthermore, firms which operate internationally are aware of their core competences and the differences in IP rights and their enforcements. They consequently develop and use strategies and methods to protect their products and technologies.

With these results from the explorative study which was carried in a country with weak intellectual property rights (Zhao, 2006; Park, 2008), the following research questions are formulated:

***RQ1:** Do firms which have R&D activities in countries with weak intellectual property rights have a higher probability to be infringed by local competitors than firms which predominantly innovate in countries with strong IPR?*

***RQ2:** Due to lower absorptive capabilities in developing countries: Are IP infringements mainly targeting firm names and designs in these countries?*

Based on the theoretical assumption about the liabilities of foreignness and signalling effects, research question 3 is framed as:

***RQ3:** Are firms with international R&D activities more at risk to experience intellectual property infringements than firms that innovate only in their home country?*

With respect to the signalling theory, research question 4 is put down as:

***RQ4:** Will firms with international R&D activities increase their risk to experience IP infringements from countries in which they do not have R&D units?*

## 5 Empirical Study

The explorative study contributed to the understanding of how firms are affected and deal with IP infringements abroad. The aim of this part of the paper is to analyse the research questions based on a larger number of observations and thus lead to results which are representative and allow generalisations.

The intention of the empirical study is to find statistically significant evidence whether international R&D activities impose a higher risk for firms' intellectual properties. We observe firms with national R&D activities only and firms with international R&D activities and distinguish the type of IP infringement that these two groups of firms experienced. In a second empirical approach, we test whether the host country of a firm's R&D activities abroad itself is the origin of infringement or if firms with international innovation activities have experienced IP infringements from countries in which they do not innovate. The following sections introduce the data and the estimation methods used for the empirical analysis.

### 5.1 Data

For the empirical investigation of our research questions, we need firm-level information about corporate R&D activities in the home and host countries and data about the infringement of firms' intellectual properties abroad. An appropriate data source for our purposes is the German innovation survey, called Mannheim Innovation Panel (MIP). This cross-sectional firm panel survey has been conducted since 1993 by the Centre of European Economic Research (ZEW) in Mannheim, Germany. For this study we use the survey waves 2006 and 2008 since these two waves contain relevant data for the research questions. Table 5.1 gives an overview of the employed single data samples and the sample size after merging the two survey waves.

*Table 5.1: Overview of the Employed Data Samples*

	<b>MIP 2006</b>	<b>MIP 2008</b>	<b>Combined Sample</b>
Gross Sample	17,395	18,109	n.a.
Net sample	5,187	6,624	5,166
thereof: innovators	2,843	3,484	2,018
thereof: international innovators	842	n.a.	552
thereof: infringements from abroad	n.a.	444	94

The survey questionnaires are sent out annually to 20,000 firms in Germany and inquire about innovation efforts, innovation success and other innovation related topics. A response rate of

about 35% is achieved. The MIP targets firms with more than 5 employees in manufacturing and service sectors located in Germany. This data set is the German contribution to the Europe-wide Community Innovation Surveys (CIS). The MIP usually goes beyond the standard CIS and includes additional questions. The following paragraphs will further describe the survey information that is used to compute the estimation variables.

### *Dependent Variables*

The aim of the paper is to analyse the factors that influence the probability that a firm's IP is being infringed by competitors from abroad. We focus on IP of firms from Germany. In the 2008 MIP survey, firms were asked whether they had experienced infringements of their IP in the years 2005-2007. The respondents had the opportunity to specify whether the kind of IP infringement targeted technological inventions, product or business model piracy or the usage of firm names or designs. For each kind of IP infringement, the respondents could declare whether the origin of the infringing firm resulted from national or foreign firms. The countries from which the infringements originated had to be specified in a free text field. Based on this information a total of five dependent variables have been defined. The definitions of the dependent variables are shown in Table 5.2 below.

*Table 5.2: Definition of Dependent Variables*

<b><i>Dependent variables</i></b>	<b><i>Definition / Data years: 2005-07</i></b>
<b><i>1st analysis</i></b>	
Technology infringements	1 if firm experience copying of technological inventions from abroad
Product piracy	1 if firm experienced product piracy or piracy of business models from abroad
Usage of firm names or designs	1 if firm's name, logo, designs have been used by foreign firms
<b><i>2nd analysis</i></b>	
Infringements from host countries	1 if firm's innovation host countries are also the origin of IP infringements
Infringements from no-host countries	1 if IP infringements stem from other than firm's innovation host countries

In order to answer all research questions two different analyses will be carried out. For the first empirical analysis, the kind of foreign IP infringement is of primary interest, therefore, three kinds of foreign IP infringement from abroad are distinguished as dependent variables: *technology infringements, product or business model piracy and the usage of firm names or designs*. The descriptive results illustrate that about 9% of the sample firms had foreign technological infringements while 7% experienced the piracy of products or business models from foreign infringers and about 8% of the firms reported that foreign firms used their firm name or designs. The specification for the first empirical analysis consists of three-equations (the estimation method section will elaborate further in this matter):



$$[1] \quad \text{Type of Infringement}_{ik} = \alpha_k + \beta_k X_i + \chi_k Y_i + \varepsilon_{ik} \quad \text{for } k = \{1,2,3\}$$

$$\text{Cov}(\varepsilon_1, \varepsilon_2) = \rho_1$$

$$\text{Cov}(\varepsilon_1, \varepsilon_3) = \rho_2$$

$$\text{Cov}(\varepsilon_2, \varepsilon_3) = \rho_3$$

where X is the vector for the explanatory variables and Y the vector for the control variables.

For the second empirical analysis, it is tested whether the location of international innovation activities of the infringed firms are linked to the location of the infringing competitor. Two dependent variables are defined: infringements by competitors from host countries and infringements from competitors located in countries where the infringed firm has no innovation activities (no-host countries). These variables were created by linking infringement information from the 2008 survey with information on a firm's innovation activities abroad which are collected in the 2006 survey. In this survey firms were asked to provide a list of countries with main innovation activities in 2005, differentiated by the type of innovation activity (R&D, conception/design of new products, manufacturing of new products, new process implementation).

The second analysis comprises two equations which are specified as follows:

$$[2] \quad \text{Origin of Infringement}_{ij} = \alpha_j + \beta_j X_i + \chi_j Y_i + \varepsilon_{ij} \quad \text{for } j = \{1,2\}$$

where X is also the vector for the explanatory variables and Y the vector for the control variables. The descriptive results show that among firms which have innovation activities abroad, about 3% experienced infringements from their innovation host countries and about 10% reported infringements from no-host countries. Table 9.1 and Table 9.3 in the annex section display all descriptive results.

### *Explanatory Variables*

The 2006 survey contains information to construct the explanatory variables employed in both empirical analyses. Table 5.3 lists the variables and their measurement. The most interesting explanatory variables to answer the research question in this paper are those that capture the location of corporate R&D activities. There are the two basic categories: firms that concentrate their R&D activities in their home country and firms which also have international R&D activities.

The first analysis also investigates whether certain countries drive the occurrence of IP infringements. The host countries were grouped to the following regions, each of them is represented by an indicator in analysis [1]: China, India, Western Europe, Eastern Europe, North America. In a further variant, the host countries of firms' foreign R&D activities have been categorised into countries with weak or strong IPRs, following the Park (2008) index<sup>1</sup>. Since some firms had specified more than one R&D location abroad, variables were created that express the relation of the number of weak and strong IPR countries in the total number of host countries where a firm conducts R&D abroad.

In the second analysis [2], the aim is to analyse the influence of the host countries of innovation activities on IP infringements. For this model, more information about innovation-related activities abroad is used. Beside R&D activities abroad, the conception and design of new products as well as the production of new products and the implementation of new processes are considered as further types of innovation activities in the host country, since these activities might increase the effect of international IP infringements, too. The descriptive statistics demonstrates that 55% of the sample firms have R&D activities abroad, 66% have design activities abroad and 82% produce innovations abroad. Different interaction terms between these three types of international R&D activities are included to observe likely complementary effects of different innovation activities abroad. For a country specific view of IP infringements from host or no-host countries, we distinguish international innovation activities by host country. The descriptive results show that 16% of firms have innovation activities in China, 5% in India, 25% in Eastern Europe, 30% in North America and nearly every second firm with innovation activities abroad operated them in the Western European region. The results of the descriptive statistics are presented in Table 9.3 in the annex section.

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<sup>1</sup> Countries with a Park (2008) index greater than 4.10 have been declared as strong IPR countries. The considerations behind this numeric range was that China has an index of 4.08 and is frequently mentioned as a country with low IPR protection system while Norway, which is characterized as a strong IPR regime by Zhao (2006), has an index of 4.17.

Table 5.3: Definition of Explanatory and Control Variables

<b>Explanatory variables</b>	<b>Definition / Data year: 2005</b>
<b>Explanatory variables 1st analysis</b>	
Domestic R&D only	1 if the firm has R&D labs in Germany only
Domestic R&D and abroad (iR&D)	1 if the firm has R&D labs in Germany and at least one R&D lab abroad
R&D in China	1 if firm has R&D activities in China
R&D in India	1 if firm has R&D activities in India
R&D in Western Europe	1 if firm has R&D activities in Western Europe
R&D in Eastern Europe	1 if firm has R&D activities in Eastern Europe
R&D in North America	1 if firm has R&D activities in North America
R&D in Rest of the World	1 if firm has R&D activities in the Rest of the world
R&D in Countries with weak IPR	Relation of number of R&D locations in countries with weak IPRs to total sum of R&D locations abroad
R&D in Countries with strong IPR	Relation of number of R&D locations in countries with strong IPRs to total sum of R&D locations abroad
<b>Explanatory variables 2nd analysis</b>	
Innovation conception/design abroad (iKON)	1 if firm undertakes design/conception activities of new products abroad
Innovation production abroad (iPROD)	1 if firm manufactures innovations abroad
iR&D x iKON	1 if firm has R&D and design/conception activities abroad
iR&D x iKON x iPROD	1 if firm has R&D, design/conception and innovation manufacturing activities abroad
iR&D x iPROD	1 if firm has R&D and innovation manufacturing activities abroad
iKON x iPROD	1 if firm has conception/design and innovation manufacturing activities abroad
Innovation active in China	1 if firm has one of the observed innovation activities* located in China
Innovation active in India	1 if firm has one of the observed innovation activities* located in India
Innovation active in Eastern Europe	1 if firm has one of the observed innovation activities* located in Eastern Europe
Innovation active in Western Europe	1 if firm has one of the observed innovation activities* located in Western Europe
Innovation active in North America	1 if firm has one of the observed innovation activities* located in North America
<b>Control Variables for both empirical models</b>	
Intern. Group with German HQ	1 if firm is an international group headquartered in Germany
Intern. Group with HQ abroad	1 if firm is an international group headquartered abroad
High-Skilled Employees	No. of graduated employees per total number of employees
Export intensity	Share of exports to total sales
Firm age	ln (time between the year of market entry and 2005)
Firm size	No. of employees (in log)
Firm in East Germany	1 if firm is located in Eastern Germany
Competition: Technology	Average importance of technological advantage as indicator of competition (at NACE 3 industry level)
Industry: Knowledge-intensive Manufacturing	1 if firm belongs to the industry classification of Knowledge-intensive manufacturing sectors following Legler and Frietsch (2007)
Industry: Other Knowledge-int. Manufacturing	1 if firm belongs to the industry classification of Other (than the previous category) Knowledge-intensive manufacturing sectors following Legler and Frietsch (2007)
Industry: Other Manufacturing	1 if firm belongs to the industry classification of not knowledge intensive manufacturing sectors following Legler and Frietsch (2007)
Industry: Knowledge-intensive Services	1 if firm belongs to the industry classification of Knowledge-intensive Services sectors following Legler and Frietsch (2007)

\* innovation activities: R&D, Conception/design of new products, Manufacturing of new products, New process implementations

### Control Variables

For both empirical analyses, the same set of control variables is included. They include firm size, firm age, the share of graduated employees, export intensity and the firm location within Germany. Furthermore, a variable is included that captures the importance of technology rivalry in the firm's business environment. Other control variables are the firms' ownership structure and industry variables. We distinguish five types of industries according to their level of R&D intensity and knowledge intensity following Legler and Frietsch (2007).

## 5.2 Estimation Method

### *International R&D and Different Types of IP Infringements*

For the first empirical analysis, firms were included in the sample that reported either domestic or international innovation activities and provided information on IP infringements (including firms that stated that none of their IP was subject to infringements from abroad). The sample size amounts to 908 observations. Since the occurrence of infringements of different types of IP (technology, products, names and designs) can be correlated, a trivariate probit estimation was carried out. The correlation coefficients between the equations for the three dependent variables support this assumption, they are highly significant. The estimation strategy comprises three model variants. Model (1), the base model, estimates the effects of domestic and international R&D activities on the likelihood to experience different IP infringements. Model (2) substitutes the variable for international R&D activities by two variables that indicate the share of low and strong IPR-countries among the R&D host countries. In model (3), different host countries and regions of firms' R&D activities abroad are included as dummy variables and replace the variables for strong and weak IPR host countries.

### *International Innovation Activities and Infringements from Host Countries*

To observe the influence of international innovation activities on the likelihood of IP infringements from firms' host countries and no-host countries, the sample has been restricted to firms with at least one innovation activity abroad. The observable innovation activities abroad hereby comprise R&D, design and production of innovations and the implementation of new process technology abroad.

For this second empirical analysis, country information of firms' innovation locations abroad have been matched with the country information of IP infringements by competitors from abroad. Each time a firm's innovation host country was identical with the country of the reported IP infringement the dependent dummy variable *infringement from host country* has been set 1 (otherwise: 0). The same approach has been done to compute the dependent variable *infringement from no-host country*. Hereby, this variable is 1 for each innovation host country that is not on the list of countries from which the firm reported IP infringements. Firms naming more than one host country of innovation activities or more than one country from which their IP have been infringed were duplicated in the data set each time the different

host countries and infringement origins matched. The number of duplications has been used as a frequency weight for a weighted probit estimation.

A previous test of correlation between the estimation equations for “infringements from host countries” and “infringements from no-host countries” resulted in non-significant correlation coefficients, therefore, the estimations for the dependent variables were performed separately. For each of the two dependent variables, seven model variants with different perspectives on international R&D activities were estimated. Model (1) is the base model and includes variables that indicate whether firms have only domestic R&D activities or both domestic and international R&D activities. The second model further incorporates variables that capture other innovation related activities abroad. Models (3) to (6) include interaction terms between international R&D activities and other international innovation activities to observe likely complementary effects of e.g. innovation production activities and R&D activities on the probability to receive IP infringements from the host country. Model (7) adds country dummies of international R&D and innovation activities.

## **6 Results**

### **6.1 International R&D and Different Types of IP Infringements**

In the theory section, it has been anticipated that international R&D activities will lead to an increased risk of IP infringements in comparison to firms conducting R&D only in their home country (in our sample: Germany). The estimation results in Table 6.1 show that this is the case for infringements that target technological inventions of the firm. This finding partly answers research question 3 in which we were questioning the influence of foreign R&D activities on the occurrence of IP infringements in comparison with firms that conduct R&D only in their home country. Most importantly, international R&D activities foster infringements of technological knowledge which is critical for firms’ competence. The test of statistical equivalence between the marginal effects of only domestic and also foreign R&D activities is statistically significant. However, this weak significant effect is the only significant influence of international R&D activities on IP infringements.

Firms that conduct their R&D activities only in the home country are more likely to suffer from product or business model piracy. This result indicates that also purely domestic innovators have to fear counterfeiting of their products. Results with stronger statistical significance are achieved in the second trivariate estimation model. Here, firms that have their

international R&D activities in a higher share of countries with weak IPR protection increase their chances of all observed IP infringements. A higher share of strong IPR countries among firms' innovation locations abroad increases the risk of technological infringements significantly. It leads to the conclusion that strong IPR regimes, which are established in countries with elaborate absorptive capabilities, impose a stronger risk on technological firm knowledge. This finding answers the first research question of the paper. The effect of R&D activities in strong IPR regimes on technology infringements is lower than for the share of weak IPR host countries but both effects do not vary statistically from each other. However, both significant effects differ statistically from the effects retained for national innovating firms.

The country specific effects on the different types of IP infringements from abroad are neglectable. Only firms which have R&D activities in China show a higher probability to be subject to illegal usage of their firm names and designs. This weak significant effect supports our second hypothesis, namely that developing nations with limited technological capabilities are more likely to use foreign trademarks. The significant effect of R&D in China varies also statistically from the effect of domestic R&D activities.

Among the control variables, export intensity shows strong and robust significant effects for all three kinds of IP infringements. Firms that have strong export activities mirror their success with products or services on foreign markets. Their international competitiveness may result in signalling effects which, as indicated by the estimation results, foster any kind of IP infringement from abroad.

Firm size shows a positive influence on technology infringements. A technology driven business environment also increases the probability of technology infringements by foreign competitors. Firms which are headquartered in Eastern Germany or abroad are significantly less likely to experience infringements of their technological inventions.

Table 6.1: Marginal Effects from the Influence of International R&D on Different Types of IP Infringements

	Technology Infringement			Product Piracy			Firm name/design usage		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Domestic R&D only	0.018 (0.018)	0.017 (0.017)	0.013 (0.016)	0.032 * (0.019)	0.034 * (0.018)	0.016 (0.017)	0.020 (0.018)	0.016 (0.017)	0.012 (0.016)
Domestic R&D and abroad	0.084 * (0.046)	-	-	0.065 (0.043)	-	-	0.065 (0.042)	-	-
R&D in weak IPR countries	-	0.070 ** (0.030)	-	-	0.080 ** (0.033)	-	-	0.076 ** (0.030)	-
R&D in strong IPR countries	-	0.050 ** (0.024)	-	-	0.040 (0.028)	-	-	0.024 (0.026)	-
R&D in China	-	-	0.254 (0.173)	-	-	-0.036 (0.022)	-	-	0.374 * (0.212)
R&D in India	-	-	0.281 (0.406)	-	-	0.335 (0.290)	-	-	0.469 (0.411)
R&D in Western Europe	-	-	0.028 (0.037)	-	-	-0.015 (0.024)	-	-	0.003 (0.027)
R&D in North America	-	-	0.101 (0.078)	-	-	0.094 (0.086)	-	-	0.034 (0.054)
R&D in Eastern Europe	-	-	0.036 (0.051)	-	-	0.009 (0.042)	-	-	-0.020 (0.021)
R&D in RoW	-	-	-0.020 (0.029)	-	-	-0.016 (0.045)	-	-	0.112 (0.145)
Export intensity	0.109 *** (0.027)	0.106 *** (0.027)	0.109 *** (0.027)	0.116 *** (0.028)	0.103 *** (0.028)	0.116 *** (0.028)	0.114 *** (0.028)	0.119 *** (0.028)	0.114 *** (0.028)
Intern. Group with German HQ	0.004 (0.015)	0.004 (0.015)	0.009 (0.016)	-0.001 (0.016)	-0.001 (0.016)	0.006 (0.018)	0.001 (0.015)	0.001 (0.015)	0.010 (0.016)
Intern. Group with HQ abroad	-0.027 ** (0.012)	-0.027 ** (0.012)	-0.023 * (0.013)	-0.005 (0.021)	-0.005 (0.021)	-0.000 (0.023)	-0.014 (0.017)	-0.015 (0.016)	-0.009 (0.017)
High-Skilled Employees	0.021 (0.036)	0.022 (0.036)	0.021 (0.036)	-0.044 (0.043)	-0.047 (0.043)	-0.044 (0.043)	-0.057 (0.041)	-0.065 (0.042)	-0.057 (0.041)
Firm size	0.010 *** (0.004)	0.010 *** (0.004)	0.009 ** (0.004)	0.002 (0.004)	0.002 (0.004)	0.002 (0.005)	0.005 (0.004)	0.006 (0.004)	0.005 (0.004)
Firm age	-0.001 (0.007)	-0.001 (0.007)	-0.001 (0.007)	-0.008 (0.008)	-0.009 (0.008)	-0.010 (0.008)	-0.010 (0.008)	-0.011 (0.007)	-0.010 (0.007)
Competition: Technology	0.035 ** (0.014)	0.036 ** (0.014)	0.036 *** (0.014)	0.013 (0.015)	0.013 (0.015)	0.018 (0.015)	0.008 (0.014)	0.009 (0.013)	0.007 (0.013)
Firm in East Germany	-0.032 ** (0.013)	-0.034 ** (0.013)	-0.032 ** (0.014)	-0.022 (0.015)	-0.022 (0.015)	-0.023 (0.015)	-0.020 (0.015)	-0.021 (0.014)	-0.021 (0.014)
Ind: Knowledge-int. Manu.	0.044 (0.071)	0.044 (0.071)	0.054 (0.086)	-0.013 (0.029)	-0.011 (0.029)	-0.024 (0.024)	0.108 (0.094)	0.120 (0.101)	0.187 (0.158)
Ind: Other Knowl.-int. Manu.	0.085 (0.087)	0.083 (0.087)	0.106 (0.107)	0.011 (0.038)	0.014 (0.039)	0.004 (0.035)	0.169 (0.108)	0.184 (0.115)	0.274 (0.175)
Ind: Other Manufacturing	0.070 (0.050)	0.071 (0.050)	0.085 (0.059)	-0.007 (0.026)	-0.004 (0.027)	-0.012 (0.026)	0.074 (0.047)	0.082 * (0.050)	0.117 (0.073)
Ind: Knowledge-int. Services	0.031 (0.057)	0.031 (0.057)	0.047 (0.071)	-0.036 (0.024)	-0.035 (0.024)	-0.042 * (0.022)	0.021 (0.053)	0.026 (0.056)	0.051 (0.084)
No. of observations	908	908	908	908	908	908	908	908	908
Athanhro for (1), (2), (3) equ.	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***	0.000 ***

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 6.2 International Innovation Activities and Infringements from Host Countries

The aim of a second analysis was to estimate the risk of infringement by competitors from the host countries of firms' innovation activities abroad. Table 6.2 presents the marginal effects of the probit estimations. The corresponding tests between the effects for statistical equality are presented separately in Table 9.4 in the annex section.

The results of the base model show that firms with international R&D activities have no significant effects on infringements from their R&D host countries. The addition of further innovation related activities leads to strong positive results for the production of innovations abroad. In model (3), the interaction of international R&D and the design of new products abroad lead to weak significant effects. However, the tests of statistical equivalence between the effects from this interaction term and the effect from domestic R&D activities are significant and therefore differ from each other. Firms which have R&D, innovation production and design capacities abroad show mild positive significant effects and also differ significantly from the effects for domestic R&D activities. The combination of R&D and innovation production facilities abroad leads to a higher probability of IP infringements from host countries. Firms with innovation design and innovation production activities abroad have a weaker but positive significant effect. Overall, the results lead to the impression that the more innovation processes the firms has located overseas, the more they experience infringements of their intellectual assets from host country competitors.

The last model incorporates tests how innovation activities in various countries and regions contribute to the occurrence of IP infringements from these host countries. Hereby, innovation activities in China and North America significantly increase the probability of IP infringements by competitors from these locations. The effects of innovation activities in China or North America are significant but do not vary statistically from the effects of domestic R&D activities.

Export intensity has a low significant or even no effect in this empirical analysis. This indicates that IP infringements from countries in which the firm operates innovation activities are fostered particularly by these operations. The results for the influence of technology driven business environments are also not robust across the different models variants. Firms with headquarters in Germany show a significant negative probability to experience IP infringements from their innovation host countries. Knowledge intensive and other manufacturing sectors are also significantly less likely to be infringed from innovation host countries than firms in the service sectors.



Table 6.2: Marginal Effects: Infringements from Innovation Host Countries

	Dep. Var.: IP infringements from host country						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Domestic R&D only	-0.016 (0.029)	0.007 (0.038)	0.030 (0.035)	0.022 (0.027)	0.018 (0.029)	0.006 (0.042)	-0.003 (0.010)
Domestic R&D and abroad (iR&D)	0.011 (0.031)	0.040 (0.040)	-	-	-	0.025 (0.041)	-
Inno. conception/design abroad (iKON)	-	0.008 (0.019)	-	-	0.002 (0.021)	-	-
Innovation production abroad (iPROD)	-	0.051 *** (0.014)	0.043 *** (0.013)	-	-	-	-
iR&D x iKON	-	-	0.090 * (0.046)	-	-	-	-
iR&D x iKON x iPROD	-	-	-	0.111 ** (0.044)	-	-	-
iR&D x iPROD	-	-	-	-	0.083 ** (0.040)	-	-
iKON x iPROD	-	-	-	-	-	0.041 * (0.022)	-
Innovation active in China	-	-	-	-	-	-	0.169 *** (0.052)
Innovation active in India	-	-	-	-	-	-	0.070 (0.052)
Innovation active in Eastern Europe	-	-	-	-	-	-	-0.004 (0.011)
Innovation active in Western Europe	-	-	-	-	-	-	-0.003 (0.009)
Innovation active in North America	-	-	-	-	-	-	0.060 ** (0.029)
Export intensity	0.052 * (0.028)	0.045 (0.028)	0.039 (0.025)	0.048* (0.028)	0.046 (0.030)	0.045 (0.031)	0.035 ** (0.017)
Intern. Group with German HQ	-0.045 *** (0.015)	-0.033 ** (0.015)	-0.030 ** (0.014)	-0.034 ** (0.016)	-0.037 ** (0.017)	-0.039 ** (0.017)	-0.017 * (0.009)
Intern. Group with HQ abroad	0.006 (0.023)	-0.003 (0.019)	-0.006 (0.015)	-0.003 (0.020)	-0.002 (0.021)	0.004 (0.023)	0.017 (0.020)
High-Skilled Employees	0.008 (0.043)	0.034 (0.041)	0.039 (0.036)	0.036 (0.042)	0.026 (0.044)	0.033 (0.046)	-0.023 (0.024)
Firm age	0.004 (0.008)	0.007 (0.008)	0.007 (0.007)	0.007 (0.008)	0.007 (0.009)	0.008 (0.009)	0.003 (0.005)
Firm size	0.005 (0.004)	0.002 (0.004)	0.001 (0.003)	0.001 (0.004)	0.003 (0.004)	0.004 (0.004)	-0.005 * (0.003)
Firm in East Germany	-0.016 (0.019)	-0.006 (0.020)	-0.005 (0.018)	-0.009 (0.020)	-0.007 (0.022)	-0.004 (0.024)	-0.004 (0.011)
Competition: Technology	0.033 ** (0.016)	0.028 * (0.016)	0.023 (0.014)	0.026 (0.016)	0.029 * (0.017)	0.026 (0.017)	0.012 (0.009)
Ind: Knowledge-int. Manu.	-0.048 *** (0.015)	-0.038 ** (0.019)	-0.033 ** (0.017)	-0.035 * (0.021)	-0.040 * (0.021)	-0.040 * (0.023)	-0.027 *** (0.010)
Ind: Other Knowl.-int. Manu.	-0.072 *** (0.021)	-0.056 ** (0.025)	-0.048 ** (0.024)	-0.053 ** (0.026)	-0.061 ** (0.027)	-0.061 ** (0.028)	-0.041 *** (0.016)
Ind: Other Manufacturing	-0.065 *** (0.025)	-0.048 * (0.027)	-0.038 (0.025)	-0.040 (0.029)	-0.049 * (0.030)	-0.049 (0.031)	-0.037 ** (0.016)
Ind: Knowledge-int. Services	-0.036 * (0.021)	-0.014 (0.030)	-0.012 (0.027)	-0.013 (0.032)	-0.015 (0.033)	-0.015 (0.034)	-0.014 (0.011)
Observations	579	508	508	516	508	508	579

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### **6.3 International Innovation Activities and Infringements from No-Host Countries**

When comparing the results from the analysis of IP infringements from innovation host countries with the results of IP infringements from countries in which the firm has no innovation some differences are obvious. The empirical results in Table 6.3 show that international R&D activities have a weak significant effect in model variant (2). This finding answers the last research question in which we were asking if signalling effects are created by corporate R&D activities abroad and lead to infringements from no-host countries.

In models (3) and (4), further significant marginal effects are retrieved for the interaction effects from international R&D and the design of new products abroad as well as from firms that have R&D, the design and production of new products located abroad. Table 9.4 shows that these two interaction terms vary both statistically from the effects for domestic R&D activities. In addition to the results for the innovation host country IP infringements, the results from model (7) indicate that firms which innovate in China, North America or India are significantly more at risk to be infringed from others but these innovation host countries than firms that innovate in the rest of the world. Contrary to the results of the analysis about innovation host country infringements, innovation activities and in specific the production of innovative goods abroad do not have similarly strong significant effects as for the innovation host country infringements.

The estimation results show that export intensity plays a major role as a driver for infringements from countries in which the infringed firms did not have innovation activities. The marginal effects for export intensity are robust across all estimation models. The signalling assumption can serve here as a possible explanation. Firms ease the way for competitors to learn about their products by exporting even if the firm itself is not innovation active in the country where the infringing party stems from.

Firms whose business environment is characterised by technological product competition are more at risk to receive IP infringements from no-host countries. These results are more robust than for host country infringements. Firms which are headquartered in the eastern part of Germany are significantly less at risk to be infringed from innovation no-host countries. The results from the industry sectors are somewhat less robust. Firms in the knowledge intensive manufacturing sector seem to have a lower probability to lose intellectual properties to firms from countries where they have no firm internal innovation activities.

Table 6.3: Marginal Effects: Infringements from No-Host Countries

	Dep. Var.: IP infringements from no-host country						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Domestic R&D only	0.036 (0.060)	0.074 (0.076)	0.046 (0.051)	0.006 (0.038)	0.007 (0.041)	0.071 (0.076)	-0.015 (0.028)
Domestic R&D and abroad (iR&D)	0.080 (0.055)	0.119 * (0.070)	-	-	-	0.114 (0.070)	-
Inno. conception/design abroad (iKON)	-	0.023 (0.034)	-	-	0.022 (0.035)	-	-
Innovation production abroad (iPROD)	-	0.035 (0.032)	0.021 (0.034)	-	-	-	-
iR&D x iKON	-	-	0.125 ** (0.054)	-	-	-	-
iR&D x iKON x iPROD	-	-	-	0.090 * (0.046)	-	-	-
iR&D x iPROD	-	-	-	-	0.067 (0.047)	-	-
iKON x iPROD	-	-	-	-	-	0.026 (0.032)	-
Innovation active in China	-	-	-	-	-	-	0.131 ** (0.053)
Innovation active in India	-	-	-	-	-	-	0.212 ** (0.094)
Innovation active in Eastern Europe	-	-	-	-	-	-	0.004 (0.030)
Innovation active in Western Europe	-	-	-	-	-	-	-0.003 (0.027)
Innovation active in North America	-	-	-	-	-	-	0.074 * (0.043)
Export intensity	0.138 *** (0.047)	0.149 *** (0.053)	0.148 *** (0.052)	0.156 *** (0.052)	0.153 *** (0.053)	0.149 *** (0.052)	0.141 *** (0.045)
Intern. Group with German HQ	-0.005 (0.029)	-0.004 (0.033)	-0.004 (0.033)	-0.001 (0.032)	-0.003 (0.033)	-0.004 (0.033)	0.032 (0.031)
Intern. Group with HQ abroad	-0.032 (0.033)	-0.038 (0.035)	-0.040 (0.035)	-0.035 (0.035)	-0.037 (0.036)	-0.037 (0.036)	-0.002 (0.038)
High-Skilled Employees	-0.060 (0.077)	-0.039 (0.084)	-0.023 (0.083)	-0.020 (0.082)	-0.030 (0.084)	-0.042 (0.085)	-0.094 (0.075)
Firm age	0.020 (0.014)	0.024 (0.016)	0.024 (0.016)	0.022 (0.016)	0.023 (0.016)	0.024 (0.016)	0.022 (0.014)
Firm size	-0.002 (0.007)	-0.002 (0.008)	-0.003 (0.008)	-0.002 (0.008)	-0.002 (0.008)	-0.001 (0.008)	-0.015 ** (0.007)
Firm in East Germany	-0.086 *** (0.027)	-0.073 ** (0.032)	-0.072 ** (0.032)	-0.079 ** (0.031)	-0.077 ** (0.032)	-0.074 ** (0.032)	-0.077 *** (0.026)
Competition: Technology	0.081 *** (0.027)	0.075 ** (0.030)	0.073 ** (0.030)	0.078 *** (0.030)	0.079 *** (0.030)	0.075 ** (0.030)	0.067 ** (0.026)
Ind: Knowledge-int. Manu.	-0.099 *** (0.037)	-0.095 * (0.052)	-0.090 * (0.053)	-0.078 (0.056)	-0.083 (0.057)	-0.094 * (0.053)	-0.096 *** (0.033)
Ind: Other Knowl.-int. Manu.	-0.096 ** (0.048)	-0.075 (0.068)	-0.063 (0.070)	-0.055 (0.070)	-0.060 (0.071)	-0.074 (0.068)	-0.082 * (0.046)
Ind: Other Manufacturing	-0.090 * (0.050)	-0.066 (0.067)	-0.052 (0.068)	-0.042 (0.069)	-0.050 (0.069)	-0.064 (0.068)	-0.073 (0.048)
Ind: Knowledge-int. Services	-0.069 (0.049)	-0.029 (0.074)	-0.020 (0.077)	-0.016 (0.078)	-0.016 (0.079)	-0.030 (0.075)	-0.044 (0.053)
Observations	579	508	508	516	508	508	579

Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 7 Conclusions

This paper investigated the relationship between international innovation activities and their propensity to provoke intellectual property infringements from foreign firms. The literature offers a stream of research studies about how R&D creates international spillovers and that the foreign business environment inhibits extraordinary risks which lead to higher costs due to foreign-owned firms' foreignness.

In an explorative study in China we found that firms are experiencing IP infringements but that these cases are manageable. The results from two empirical analyses have shown that international R&D activities of firms have only weak significant effects and only for technology infringements. Of course, technological knowledge is most important in many sectors but can also not be avoided by carefully choosing the host innovation countries. Weak intellectual property regimes significantly ease the way to all kinds of IP infringements while strong IPR countries are territories for technology infringements. But even firms which have only national innovation activities are significantly more at risk to experience foreign product piracy. China, Russia and India are worldwide the main sources of counterfeit and pirated products (OECD, 2008). And also in our empirical analysis, the foreign-owned R&D activities in China lead to firm name infringements while innovation activities in China but also in North America lead to infringements from these host countries.

A larger scope of international R&D and other innovation related activities abroad has significantly stronger effects on IP infringements from innovation host countries than single innovation activities. Following the results, one conclusion that can be drawn is that firms which only have R&D centres abroad to develop new technologies and products are less at risk to be infringed than firm that embody their innovative knowledge in products abroad. About 10% of the firms with international innovation activities in our data set experienced IP infringements from countries in which they have localised innovation activities. The results of this paper explain this occasion with the strong effects of firms' export intensity.

The paper has some limitations. An interesting aspect within this research framework would have been to analyse different types of IP infringements from certain countries and how they are influenced by R&D and innovation activities in these countries. However, due to data constraints, it is not possible to split the data set by two dimensions, location and type of IP infringement. Another limitation is that some firms reported international R&D and innovation activities but did not specify the foreign locations. Consequently, the direct match

between foreign innovation locations and the origin of IP infringements is often not possible and leads to smaller numbers of dependent variables for the second analysis. The survey information does not allow to draw conclusions about the type of R&D, in the sense of knowledge augmenting or knowledge exploiting (Kuemmerle, 1997) activities that have been carried out in the foreign R&D departments.

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## 9 Annex

Table 9.1: Descriptive Statistics of First Data Sample: Types of Foreign IP Infringements

No.	Dependent and Explanatory Variables	Mean	Std. Dev.	Min	Max
	Technology Infringement	0.088	0.283	0	1
	Product Piracy	0.069	0.254	0	1
	Firm name/design usage	0.081	0.274	0	1
1	Domestic R&D only	0.558	0.497	0	1
2	Domestic R&D and abroad	0.151	0.358	0	1
3	R&D in China	0.011	0.106	0	1
4	R&D in India	0.007	0.086	0	1
5	R&D in Western Europe	0.068	0.252	0	1
6	R&D in North America	0.042	0.200	0	1
7	R&D in Eastern Europe	0.022	0.146	0	1
8	R&D in RoW	0.016	0.125	0	1
9	R&D in strong IPR countries	0.099	0.295	0	1
10	R&D in weak IPR countries	0.036	0.181	0	1
11	Intern. Group with German HQ	0.259	0.438	0	1
12	Intern. Group with HQ abroad	0.102	0.303	0	1
13	High-Skilled Employees	0.230	0.244	0	1
14	Export intensity	0.227	0.291	0	1
15	Firm size	4.526	1.956	0	13.041
16	Firm age	2.699	0.871	-0.693	6.378
17	Competition: Technology	3.434	0.731	1	6
18	Firm in East Germany	0.313	0.464	0	1
19	Industry: Knowledge-int. Manu.	0.111	0.314	0	1
20	Industry: Other Knowl.-int. Manu.	0.150	0.357	0	1
21	Industry: Other Manufacturing	0.393	0.489	0	1
22	Industry: Knowledge-int. Services	0.222	0.416	0	1



Table 5: Correlation Matrix of Explanatory Variables for Data Sample [1](by No., see previous table)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1	1.000																						
2	-0.427	1.000																					
3	-0.120	0.260	1.000																				
4	-0.088	0.192	0.178	1.000																			
5	-0.288	0.642	0.070	0.086	1.000																		
6	-0.225	0.487	0.181	0.189	0.272	1.000																	
7	-0.165	0.357	0.052	0.080	0.049	0.064	1.000																
8	-0.128	0.277	0.161	0.224	0.210	0.262	0.079	1.000															
9	-0.365	0.806	0.055	0.062	0.777	0.581	0.320	0.187	1.000														
10	-0.154	0.464	0.449	0.294	0.020	0.028	0.202	0.262	-0.018	1.000													
11	0.009	0.044	0.014	-0.017	0.037	-0.016	0.027	-0.047	0.024	0.049	1.000												
12	-0.003	0.101	0.029	-0.004	0.092	0.031	-0.013	0.008	0.115	0.011	-0.198	1.000											
13	0.062	0.072	0.033	0.013	0.048	0.052	0.020	0.019	0.070	0.026	-0.069	-0.038	1.000										
14	0.079	0.278	0.094	0.069	0.201	0.223	0.086	0.104	0.267	0.123	0.076	0.172	-0.026	1.000									
15	-0.015	0.284	0.089	0.107	0.233	0.295	0.083	0.100	0.292	0.045	0.233	0.204	-0.236	0.301	1.000								
16	-0.057	0.042	0.032	0.013	0.031	0.063	0.019	0.021	0.035	0.020	0.028	-0.013	-0.172	0.064	0.216	1.000							
17	0.652	0.176	0.061	0.056	0.131	0.143	0.068	0.090	0.168	0.053	-0.067	0.120	0.207	0.329	-0.011	-0.112	1.000						
18	0.065	-0.102	-0.020	-0.025	-0.093	-0.078	0.001	-0.028	-0.098	-0.001	-0.035	-0.090	0.187	-0.152	-0.244	-0.238	0.038	1.000					
19	0.059	0.079	0.025	0.077	0.073	0.091	0.028	0.062	0.084	0.021	-0.039	0.068	0.076	0.147	0.034	-0.054	0.315	0.001	1.000				
20	0.051	0.160	0.037	0.041	0.111	0.126	0.039	0.080	0.141	0.058	0.012	0.100	-0.068	0.318	0.135	0.036	0.422	-0.033	-0.147	1.000			
21	0.067	-0.095	-0.027	-0.050	-0.074	-0.086	-0.002	-0.046	-0.083	-0.024	0.036	-0.003	-0.340	-0.004	-0.003	0.010	-0.220	-0.005	-0.285	-0.339	1.000		
22	-0.039	-0.017	-0.021	-0.010	-0.019	-0.028	-0.026	-0.027	-0.019	-0.027	-0.062	-0.078	0.513	-0.223	-0.148	-0.022	-0.069	0.003	-0.186	-0.221	-0.430	1.000	

Table 9.3: Descriptive Statistics of Second Data Sample: IP Infringements from Host and No-Host Countries

No.	Dependent and Explanatory Variables	Mean	Std. Dev.	Min	Max
	Infringements from Hostcountries	0.032	0.175	0	1
	Infringements from No-Host countries	0.098	0.297	0	1
1	Domestic R&D only	0.327	0.470	0	1
2	Domestic R&D and abroad (iR&D)	0.550	0.498	0	1
3	Innovation conception/design abroad (iKON)	0.664	0.473	0	1
4	Innovation Production abroad (iPROD)	0.823	0.382	0	1
5	Interaction term: iR&D x iKON	0.468	0.499	0	1
6	Interaction term: iR&D x iKON x iPROD	0.405	0.491	0	1
7	Interaction term: iR&D x iPROD	0.441	0.497	0	1
8	Interaction term: iKON x iPROD	0.541	0.499	0	1
9	Innovation active in China	0.160	0.367	0	1
10	Innovation active in India	0.054	0.225	0	1
11	Innovation active in Eastern Europe	0.254	0.435	0	1
12	Innovation active in Western Europe	0.489	0.500	0	1
13	Innovation active in North-America	0.302	0.460	0	1
14	Intern. Group with German HQ	0.252	0.434	0	1
15	Intern. Group with HQ abroad	0.157	0.364	0	1
16	High-Skilled Employees	0.249	0.242	0	1
17	Export intensity	0.434	0.327	0	1
18	Firm age	2.804	0.994	-0.693	5.173
19	Firm size	6.144	2.419	1.099	13.041
20	Firm in East Germany	0.180	0.385	0	1
21	Competition: Technology	3.585	0.751	1	6
22	Industry: Knowledge-int. Manu.	0.146	0.354	0	1
23	Industry: Other Knowl.-int. Manu.	0.256	0.437	0	1
24	Industry: Other Manufacturing	0.348	0.476	0	1
25	Industry: Knowledge-int. Services	0.173	0.379	0	1

Table 9.4: Tests of Statistical Equality between the Marginal Effects of National and International Innovation Activities for Host and No-Host Country Infringements

Tests between marginal effects	Host country infringements	No-host country infringements
dom. R&D=iR&D	0.167	0.112
dom.R&D=iKON	0.540	0.973
dom.R&D=iPROD	0.660	0.134
dom.R&D=iR&D x iKON	0.031 **	0.011 **
dom. R&D=iR&D x iKON x iPROD	0.032 **	0.004 ***
dom. R&D=iR&D x iPROD	0.144	0.032
dom. R&D=iKON x iPROD	0.581	0.467
dom.R&D=Innovation active in China	0.007 ***	0.000
dom.R&D=Innovation active in India	0.004 ***	0.031
dom.R&D=Innovation active in WEU	0.709	0.962
dom.R&D=Innovation active in N. America	0.047 **	0.006
dom.R&D=Innovation active in E. Europe	0.619	0.971

Table 8: Correlation Matrix of Explanatory Variables for Second Data Sample [2](by No., see table 9.3)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1	1.000																									
2	-0.802	1.000																								
3	-0.282	0.345	1.000																							
4	0.070	-0.107	-0.001	1.000																						
5	-0.651	0.812	0.618	0.081	1.000																					
6	-0.549	0.685	0.521	0.375	0.843	1.000																				
7	-0.596	0.744	0.410	0.407	0.759	0.920	1.000																			
8	-0.259	0.322	0.735	0.529	0.525	0.708	0.617	1.000																		
9	-0.061	0.120	0.054	0.151	0.140	0.186	0.190	0.146	1.000																	
10	-0.111	0.159	0.161	0.017	0.191	0.197	0.174	0.147	0.233	1.000																
11	0.036	-0.021	0.015	0.073	0.004	0.012	0.031	0.038	0.031	0.057	1.000															
12	-0.256	0.309	0.119	0.008	0.255	0.213	0.261	0.114	-0.059	0.050	-0.052	1.000														
13	-0.216	0.282	0.138	0.099	0.268	0.299	0.318	0.195	0.207	0.178	-0.016	0.094	1.000													
14	0.022	-0.024	-0.021	0.022	-0.029	-0.005	-0.019	0.009	-0.014	-0.093	-0.019	-0.030	-0.048	1.000												
15	-0.120	0.168	0.101	-0.015	0.180	0.135	0.153	0.058	0.030	-0.003	-0.006	0.082	0.014	-0.273	1.000											
16	-0.069	0.109	-0.078	-0.208	-0.009	-0.064	-0.033	-0.159	-0.011	0.006	-0.046	-0.012	0.110	-0.065	-0.076	1.000										
17	-0.018	0.137	0.149	0.056	0.178	0.163	0.180	0.151	0.072	0.087	0.069	0.029	0.240	0.078	0.160	-0.049	1.000									
18	-0.030	0.040	-0.035	0.117	0.058	0.113	0.129	0.049	0.109	0.059	0.049	0.049	0.075	-0.021	0.064	-0.107	0.132	1.000								
19	-0.159	0.271	0.195	0.221	0.334	0.412	0.409	0.313	0.198	0.181	0.096	0.213	0.404	0.109	0.136	-0.209	0.323	0.219	1.000							
20	0.080	-0.117	-0.140	-0.077	-0.169	-0.153	-0.153	-0.132	-0.069	-0.040	0.039	-0.067	-0.123	0.026	-0.105	0.161	-0.090	-0.220	-0.307	1.000						
21	0.019	0.128	0.067	-0.074	0.129	0.055	0.050	0.016	0.119	0.076	0.055	-0.011	0.207	-0.035	0.126	0.178	0.201	0.024	0.056	0.023	1.000					
22	-0.052	0.109	0.030	0.070	0.130	0.106	0.108	0.054	0.095	0.040	0.020	0.069	0.131	-0.070	0.071	0.049	0.078	-0.035	0.083	0.049	0.259	1.000				
23	0.011	0.088	0.130	0.020	0.133	0.131	0.120	0.128	0.038	0.123	0.025	-0.025	0.152	0.014	0.085	-0.116	0.229	0.077	0.145	-0.005	0.444	-0.265	1.000			
24	0.109	-0.164	-0.120	0.114	-0.176	-0.135	-0.110	-0.051	-0.027	-0.100	0.097	-0.023	-0.165	0.048	-0.023	-0.379	-0.038	0.023	-0.037	-0.059	-0.416	-0.306	-0.446	1.000		
25	-0.046	0.034	-0.057	-0.240	-0.042	-0.090	-0.099	-0.163	-0.095	-0.051	-0.114	0.001	-0.025	-0.053	-0.083	0.594	-0.223	-0.096	-0.191	0.022	-0.068	-0.195	-0.284	-0.328	1.000	