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Drivers for international innovation activities in developed and emerging countries

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Abstract This paper aims to shed light on firm-specific drivers that lead firms to internationalise their innovation activities. The paper paints a comprehensive picture of driving forces by including firm capabilities, characteristics of the firm's competitive environment and the influence of innovation obstacles in the home country. In particular the influence of potential driving forces on the probability to carry out different innovative activities abroad is assessed (R&D, design/conception of new products, manufacturing of innovative products and implementation of new processes). In a second stage these driving forces are observed with regard to their impact on the decision to locate innovation activities in various countries and regions (China, Eastern Europe, Western Europe and North America) as well as in groups of countries with similar levels of knowledge ("country clubs"). The analysis is based on the Mannheim Innovation Panel survey which represents the German CIS (Community Innovation Survey) contribution. Two survey waves have been combined, resulting in a sample of about 1,400 firms. The results show that the decision to perform innovation activities abroad is mainly driven by organisational capabilities such as absorptive capacities, international experience and existing technological competences of the respective firm. Innovation barriers at the German home base such as lack of labour and high innovation costs prompt the set-up of later-stage innovation activities abroad while the lack of demand demonstrates a barrier to the internationalisation decision for the development and manufacturing of new products. Location decisions receive the strongest influencing effects from the international experience of the firm. Firms which innovate in developing countries seem to require a more extensive level of international experience through international R&D cooperation.

Keywords Internationalisation of R&D · Innovation · Absorptive capacities · Market structure · China · Asia · Emerging countries

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1 Introduction

Globalisation has been reshaping the business environment of firms. The corporate response to the increased openness of economies is an ongoing trend to internationalise business processes. Foreign markets allow international firms to achieve scale advantages and to source international assets, including knowledge. As a consequence, firms can enlarge their market size and use internationally dispersed knowledge resources to enhance their competitiveness. Internationalising innovation will allow firms to expand their knowledge base by obtaining knowledge, technology and skills from locations beyond their home market, potentially contributing to more ambitious and more efficient innovation efforts.

Approaching new markets often requires innovation designs which are adjusted to their specific environment. Developing or adapting such innovations where potential customers are located may be more effective. Moreover, market success of new products depends not only on technological superiority or customer-tailored solutions but also on price efficiency. The decision to internationalise the innovative activity of firms is likely to be driven by firm capabilities and resources.

Furthermore, firms might not take the risks of shifting business operations away from the centre if their competitive environment and the need to overcome shortcomings in the national innovation environment did not in some way force them to do so. The knowledge base of firms is a function of their internal resources and the assets of the domestic innovation system (Criscuolo et al. 2005). By acquiring knowledge from other places, firms can overcome knowledge constraints in the home country. The national innovation environment often does not possess all the necessary technological assets (Narula 2002).

This paper aims to identify both firm-specific factors and characteristics of the domestic innovation environment and analyse their influence on locating innovation activities abroad. Most of the literature on internationalisation of innovation neglects competitive forces and innovation disadvantages of the domestic location and focuses on host country advantages. Furthermore, existing studies concentrate on R&D and neglect later-stage innovation activities carried out at foreign subsidiaries. This paper attempts to enrich the empirical literature by employing a large data set about the internationalisation decisions of German firms from various sectors by considering different types of innovation activities: R&D, product design, production of new products and services as well as investments in new processes. Closely related to the decision to carry out innovation activities abroad is the location decision since it also reflects firm intentions. The trend to set up corporate innovative capacities in developing countries, especially in the Asian region, has been witnessed in recent studies (UNCTAD 2005). However, developing regions are underrepresented in most of the existing studies. This paper will assist in identifying country effects of the driving forces on the decision to locate research and innovation activities in countries with different levels of knowledge ("country clubs", as proposed by Castellacci and Archibugi 2008) as well as a specific analysis for innovation investments in China, Eastern Europe, Western Europe and North America. Summing up, the paper explores three research questions: To what extent do firm capabilities, the level of domestic market competition and local innovation disadvantages drive a firm's decision to engage in international innovation activities? Do these determinants differ by type of innovation

activity? Do these determinants differ with respect to the stage of economic development of the host country?

In the next section the theoretical background of the topic is presented, while Sect. 3 describes the data and the measuring of model variables. Chapter 4 presents the results of empirical analyses of the drivers of innovation internationalisation whereas the geographic destinations and the impact of driving forces on the location decision of international R&D is shown in Sect. 5. Section 6 summarises the main findings and concludes with management recommendations.

2 Literature review and hypotheses

This paper is built on the stream of literature about internationalisation of R&D including motives, strategies and barriers that affect internationalisation decisions, determinants of internationalising innovation activities as well as the geographic scope of international R&D activities.

2.1 Internationalisation of corporate R&D

The internationalisation of firms is an ongoing trend which is encouraged by the increased openness of economies, the rise of new global players and the firms' need for new sources of competitiveness. It has been pointed out that the pace of internationalising R&D is accelerating and supported by advances in ICT and transport (UNCTAD 2005).

In the internationalisation theory of firms, the internationalisation process itself has been identified as an innovation of the firm (see Andersen 1993). In the process of globalisation the internationalisation of firms is no longer limited to sales activities, which have been the base for the early internationalisation theory models (Johanson and Vahlne 1977, 1990).

The globalisation of firms' innovation activities has been a major research topic for a long time (OECD 2008, 2007; UNCTAD 2006, 2005; Veugelers et al. 2005; Brockhoff 1998; Granstrand et al. 1993; Pearce 1989). One stream relates to the drivers and motives for engaging in innovation activities abroad, in particular with regard to R&D (Dunning 1994; Kuemmerle 1999; Narula and Zanfei 2005; Dunning and Narula 1995; Pearce 1999; Pearce and Papanastassiou 1999; Patel and Vega 1999; Le Bas and Sierra 2002; Hakanson and Nobel 1993; Chesnais 1992).

A firm's decision to internationalise its innovation activities may be related to three motives (Granstrand et al. 1993): knowledge-seeking, market-seeking and efficiency-seeking. Knowledge-seeking firms aim at exploiting a country's possession of certain research capacities or technologies in order to augment its existing knowledge assets. Establishing innovation activities on-site facilitates access to foreign knowledge and its integration into a firm's internal processes (Cantwell and Piscitello 2005). Market seekers aim to access foreign markets in order to sell their innovations, i.e. to exploit their existing knowledge assets. This often requires adaptations of technologies to local environments and preferences, including user-producer interactions (Pearce 1992, 1999; Pearce and Papanastassiou 1999). Innovation activities in the foreign market certainly ease this localisation of product innovations. Efficiency-seeking firms are primarily interested in reducing costs of innovation activities by performing activities in countries with a lower price/productivity ratio for innovation inputs, particularly human capital. It has been shown that firms often have more than one motive and recent studies illustrate the trend towards

R&D intensive subsidiaries abroad (OECD 2008; Alcácer and Chung 2002; Kogut and Chang 1991).

Depending on the motives to internationalise innovation activities, a firm's R&D and innovation units abroad will serve different purposes. There are a number of studies that aimed at differentiating between types of R&D activities abroad. Ito and Wakasugi (2007) distinguish between support-orientated R&D and knowledge-sourcing R&D, Dunning and Narula (1995) between asset-seeking and asset-exploiting purposes, whereas Kuemmerle (1997) differentiates between two international R&D strategy categories of R&D sites abroad. The home-base exploiting laboratory is in charge of the transfer of its existing knowledge to the R&D unit abroad for local manufacturing and marketing (market and efficiency seeking). The home-base augmenting laboratory primarily aims to use the the host country's knowledge and transfer it back to the home base (resource seeking). Nobel and Birkinshaw (1998) further distinguish international R&D-active firms into local and international adaptors as well as international creators. While the category "international creators" is linked to the home-base augmenting firm's characteristics following Kuemmerle (1997), the local and international adaptors are both a counterpart to Kuemmerle's home-base exploiting theory. Local adaptors are basically local support units which have a rather limited role in R&D. Their mandate is mainly to facilitate technology transfer from the home base to local manufacture (Nobel and Birkinshaw 1998). Ito and Wakasugi (2007) follow up on this international R&D strategy research with an analysis of the determinants of firms and host countries which adopt one or the other strategy. Related to this research are studies on the management of global R&D activities of multinationals (Gerybadze and Reger 1999; Von Zedtwitz and Gassmann 2002; Dodgson 1993, 2000 Kuemmerle 1997; Ghoshal and Bartlett 1988; Gupta and Govindarajan 2000; Boutellier et al. 2000). Another strand of literature emphasises the role of international co-operation in innovation, including research joint ventures, as a mechanism to exploit global opportunities for a firm's innovation activities (Haagedoorn 1996, 2002; Veugelers 1997; Cassiman and Veugelers 2002). Studies on international technology spillovers are another direction of research capturing internationalisation issues in innovation (Veugelers and Cassiman 2004; MacGarvie 2005; Guellec et al. 2001; Lichtenberg and de la Potterie 1998; Coe and Helpman 1995).

2.2 Driving forces for international innovation activities

A number of studies have been dedicated to observing the question of why some firms carry out innovation activities abroad and others do not. Viewing firms from their resource and knowledge base has been one perspective in the literature to explain firms' international R&D activities (Wernerfelt 1984; Peteraf 1993; Liebeskind 1996; Grant 1996).

However, international innovation activities are also a specific type of foreign direct investment (FDI). Thus, the theory of the international firm and the determinants of FDI occurrence are also relevant for the investigation of a firm's decision to internationalise its innovation activities. The determinants of a firm's decision to internationalise business processes and their location choice for R&D facilities are combined in the OLI-model of Dunning (1981). The "eclectic paradigm" combines ownership-specific (O), location-specific (L) and internalising (I) advantages for a firm's decision to enter into economic activities beyond its domestic market. The ownership advantage refers to competitive advantages, resources and capabilities of a firm which can be capitalised abroad. They can be the result of domestic rivalry which pressures firms to constantly improve their business activities (Porter 1990). Fierce home market competition may result in a high level of product or service quality which makes entering international markets easier.

The location-specific advantages refer to specific factor endowments of potential host countries (such as knowledge or skill resources, raw materials, climate, factor costs) which are difficult or costly to acquire through market transaction and form a location advantage in comparison with home country conditions. Localising their businesses in these host countries allows firms to utilise the country specific potentials. In this analysis we will not employ the advantages of the host country but the innovation-related disadvantages of the home country.

Although it represents a departure from the traditional OLI model, this approach is more appropriate when considering our research question as to the driving forces behind firms' decisions to internationalise their innovation activities.

The internalising advantage of a firm refers to the added value which firms can gain when conducting innovation activities abroad by themselves in comparison with outsourcing or contracting R&D to local firms.

The design of the empirical analysis of the paper will follow the outline of the OLI model and will therefore test the influence of internal resources, capabilities and experience, and business and innovation environment on a firm's likelihood to internationalise its R&D.

2.2.1 Firm internal resources

The internationalisation of corporate R&D brings with it a number of challenges. While many multinational enterprises (MNEs) have acquired experience in foreign markets through exports, sales branches or production activities, managing international innovation processes is likely to be a different task which requires different capabilities (Le Bas and Sierra 2002; Patel and Vega 1999; Ito and Wakasugi 2007). Every firm has a different base of resources, including knowledge and level of experience, and therefore it develops a varying competence level. When it comes to establishing innovation activities abroad, the role of firms' competitive advantages arising from resources and capabilities becomes particularly important. To be able to engage in international innovation activities, innovative firms require certain capabilities to benefit from the knowledge at the host country. Firms firstly need to be able to identify new and relevant knowledge. The absorption and appropriate usage of the new knowledge determines the success of international innovation activities. The decision to internationalise innovation activities will also result from the firm's prior search and selection of host locations which again represents their absorptive capacity (Criscuolo and Narula 2008). Cohen and Levinthal (1989, 1990) argue that these absorptive capabilities are developed while performing R&D activities internally. Only then do firms possess the competence to recognize and to use the relevant knowledge outside their organisation. A high level of skilled employees will facilitate these organisational adaptations. We thus assume a positive relationship between the level of a firm's absorptive capabilities and its likelihood to embark upon international innovation activities:

Hypothesis 1 Firms with absorptive capacity are more likely to decide to internationalise corporate R&D and innovation activities.

In the face of foreign cultures and business practices, technological competences might not be sufficient to cope with foreign business environments. The costs resulting from being a "stranger in a strange land" are summarized in the literature about liabilities of foreignness (Zaheer 1995; Zaheer and Mosakowski 1997; Mezias 2002). International experience of organisations can reduce the uncertainty arising from the exposure to

unfamiliar situations and the distance to the home-base (Zaheer and Mosakowski 1997; Harvey and Novicevic 2000). One way to increase the international experience of an organisation is to serve international markets. It fosters interaction with international customers and understanding of their local requirements and preferences. Moreover it sharpens the view on international competitors and their competencies. In the literature the degree of firm internationalisation is often measured by share of foreign sales to total sales (see Qian et al. 2008 and Sullivan 1994 for an overview). International experience within the firms' innovation processes can be facilitated by joint work with international partners. International R&D collaboration compels employees to adapt to different working environments and to overcome a lack of common understanding due to different firm and cultural habits, values and languages.

Companies can gain the ability to adapt to and cope with local challenges by increasing the organisation's international contacts through engaging in joint innovation projects with international partners, or by exporting. Exporters, in addition, require more sophisticated knowledge than domestic suppliers (Ito and Wakasugi 2007). Therefore, it is anticipated that:

Hypothesis 2 Firms with international experience are more likely to decide to internationalise their R&D and innovation activities.

2.2.2 Competitive environment

The relationship between the competitive firm environment and corporate innovation activities is a field of contradictory research results. Starting from Schumpeter (1943) who finds a negative impact of competition upon innovation, more recent studies (Aghion et al. 2005) show an inverted U-shaped relationship between the level of competition and the innovative activities of firms which might try to escape competition by innovation. These findings confirm the earlier results of Scherer (1967) who also found an inverse U-shaped relationship between the intensity of competition and innovation.

In an era of globalised competition the home market environment is supposed to drive the internationalisation of innovation activities of firms in two ways: On the one hand, the type and quality of competition may force firms to respond by leveraging the location advantages of the home and other countries. This will be particularly relevant in the event that firms experience increased competitive pressure in their home market due to strong price competition or due to the entry of new competitors. Firms that are subject to fierce competitive pressure may be compelled to access additional international knowledge pools in order to sustain or re-develop competitive advantages. Recent evidence by Lewin et al. (2009) found no statistically significant effects of overall competitive pressure on firms' likelihood to offshore R&D. Other findings showed that firms internationalise their innovation activities in fields in which they are competitive at their home location (Bas and Sierra 2002). Firms that operate in a business environment that is characterised by price competition might be more likely to look for efficiency advantages abroad by relocating cost intensive innovation activities to locations with cost advantages. However, on account of the globalisation of competition, domestic firms increasingly face foreign competitors in their home market. These new rivals might have access to resources that firms lack in their own home countries. Therefore it is expected that:

Hypothesis 3 A higher degree of competition in the home market increases a firm's likelihood of deciding to undertake R&D and innovation activities abroad.

2.2.3 *Home country disadvantages for corporate innovation activities*

The different motives for international R&D (knowledge, market and efficiency seeking) are very likely to be the result of deficits of the innovation environment at the firm's home base. Entering foreign countries in order to establish innovation activities may also reinforce the importance of typical barriers such as financial constraints, lack of information, lack of management capabilities, liability of foreignness and lack of abilities to deal with unfamiliar market and regulatory environments (Acs et al. 1997). Lack of innovation-specific resources and services lowers the attractiveness of a domestic location for conducting innovation. With regard to factor markets, this refers on the one hand to the availability and costs of highly qualified labour with skills which a firm requires for conducting a specific innovation project and on the other to the availability of external financial resources and their costs. Kinkel et al. (2007) found that companies which intend to carry out less R&D intensive innovation activities abroad are mostly driven by high costs at home and cost-reducing potentials abroad. Lewin et al. (2009) find that cost savings are the most important motivation for the offshoring of product development tasks but these cost saving motives do not account for labour cost savings. A further "factor market" relates to technology. Trading technology is, however, rather restricted due to its immaterial and tacit character (Polanyi 1966). Therefore, having access to technological information and appropriate partners for collaborating in innovation projects may be an important dimension of a location's attractiveness for innovation. Moreover, the willingness of customers to pay for innovations or, more generally, their responsiveness to innovations may form another important element of location attractiveness. Lewin et al. (2009) find that increased speed to market and access to qualified personnel are important drivers for product development abroad.

Obstacles to innovation in the domestic market can therefore act as a catalyst for firms which aim to compensate home country disadvantages by internationalising corporate innovation (Almeida 1996). Location disadvantages, especially for innovative firms, are characterized by a shortage of qualified personnel, technological information, high costs, lack of potential cooperation partners, and lack of demand for innovation. Political issues such as legal innovation barriers can also hamper innovation projects (Lall 1979). Therefore, we assume that:

Hypothesis 4 Firms which are suffering from innovation-related location disadvantages in their home country are more likely to decide to internationalise their R&D and innovation activities.

2.3 International R&D location decision: the case of developing countries

The geographic decision as to where to locate innovation activities abroad is closely related to the extent and nature of innovation disadvantages of the home country, firms' internationalisation motives and host country attractiveness. In this vein, the search for talent in advanced economies and the rise of new science and engineering clusters in emerging economies are spurring the international sourcing strategies of firms (Manning et al. 2008).

Empirical studies in this field have dedicated their work to regional R&D location analysis within the USA (Audretsch and Feldman 1996; Alcácer and Chung 2007) or concentrated on firm strategies between home and host country (Le Bas and Sierra 2002). Other studies have analysed the location (domestic or abroad) of innovation by patent citation analysis (Jaffe et al. 1993; Frost 2001). Cross-country studies, instead, would

contribute to the literature by demonstrating the influence of location determinants and their different impact on various countries. In this vein, Odagiri and Yasuda (1996) have analysed the impact of firms' capabilities and resources on the probability to innovate in Asia, Europe and the USA.

Knowledge, one of the most valuable resources in business today, is not equally available everywhere. The different geographical allocation of resources creates certain 'pockets of expertise' (Nelson 1993; Porter 1990) globally. Depending on a firm's internationalisation strategy (home base-augmenting and/or home base-exploiting), potential host countries differ in their attractiveness for R&D activities. The importance of host countries' supply and demand factors such as R&D resources for overseas R&D location decision has been pointed out (Odagiri and Yasuda 1996). Firms wishing to perform R&D outside their home country generally look for countries that offer attractive market potential, availability of highly qualified staff, and potential cooperation partners (Thursby and Thursby 2006). Firms normally locate their R&D in countries that are advanced in the same field (Kumar 1996). They prefer to set up R&D centres in nations with technological resources, a supply of low-cost staff, and good communication infrastructure (Kumar 1996). However, it remains unclear whether host countries' supply and demand factors can wholly explain the motivation of firms' overseas R&D location decision and to what extent home country innovation barriers contribute to this decision. It has been argued that international R&D aims to offset home country disadvantages (Almeida 1996; Erken and Gilsing 2005). Therefore, it seems obvious that both the abundance of host and home countries' supply and demand factors impact on the firms' location decision. In this paper we focus on the home country perspective of firms.

Other moderating effects on the location choice include the cultural and geographic distance between home and host country. The more distant the home country is from the host country the higher the propensity for unfamiliar hazards which drive the liabilities of foreignness (Eden and Miller 2004). Firms are aware of these unexpected costs from own experience or from the experience of other firms, and aim to reduce these negative effects. Previous country studies have discussed firms' tendency to follow a national path in their internationalisation innovation strategy (Granstrand 1999). Ambos (2005) found that German firms tend to cross borders initially only within Europe or to the USA and only later adopt innovation activities in Asian countries.

In the case of German MNEs, countries with developed economic status and advanced knowledge levels are the premier location choice, later followed by countries with a less developed economy. By that time firms have accumulated international experience by being exposed to unexpected and different business environment characteristics at their first (developed) international R&D locations. The acquired international experience serves as a qualification to minimise uncertainties at the foreign R&D site. Knowing that developing countries often offer an even more challenging business environment it is expected that:

Hypothesis 5 The effects of firms' international experience on their decision to internationalise R&D and innovation activities are stronger when locating R&D and innovation activities in developing regions.

The rise of such emerging giant countries as China and India has challenged the attractiveness of developed nations. A study by UNCTAD (2005) asked large MNEs about their preferred prospective international R&D location from 2005 until 2009. 62% of the respondents ranked China as premier, the United States (41%) as second and India (29%) as their third most attractive R&D location. The literature has been enriched by studies

about the setup and management of foreign R&D labs in China (Von Zedtwitz 2004; Von Zedtwitz et al. 2007) and the innovation potential of India (World Bank 2007; EIU 2004; Agarwal et al. 2007). Based on the emergence of these not only new big markets but also increasingly large and valuable knowledge pools, the motives and drivers for international R&D activities have been extended. Sachwald (2008) finds that talent at lower costs and the increasing supply of scientists and engineers in emerging countries foster the trend of international dispersion of corporate R&D. Other studies have already set their focus on the differences of doing R&D in developed versus less developed countries (Thursby and Thursby 2006). Gassmann and Han (2004) analysed the motivations behind foreign R&D activities in China based on case studies and found that input-orientated factors (skilled HR, local knowledge) as well as performance factors (low overheads) drive these activities. It has always been argued that lower costs in developing countries are a major pull factor to locate R&D capacities in these countries. However, it is advisable not to consider short-term cost savings as a prominent reason for the decision to internationalise R&D and innovation activities (Gassmann and Von Zedtwitz 1998). A recent study (Demirbag and Glaister 2010) based on 1,722 R&D projects abroad shows that firms also see long-term efficiency gains in developing countries. The authors have found that R&D wage differences increase a firm's likelihood to offshore its R&D projects to India, China, Emerging Asian regions, Eastern Europe, Russia, USA and Canada over the EU15 states. The study also reveals that all considered regions are also more attractive in terms of availability of scientists and engineers than EU15 nations. We have to consider these findings of the role of the host locations' attractiveness for the different firm purposes in formulating our hypotheses. Particularly so if we anticipate that firms' perceptions of disadvantages in the home innovation environment will lead them to a choice of location which offsets these constraints. In this vein, we anticipate that:

Hypothesis 6 Firms with efficiency-seeking motives (high innovation costs and price competition in the home country) or knowledge-seeking motives (lack of labour, lack of technological information) are likely to decide to innovate in countries belonging to the marginalised (e.g. China) or followers country club (e.g. Eastern Europe).

3 Database and empirical analysis

In this section, the database, variables and methods used to test the hypothesis empirically are introduced. A set of explanatory variables is used to analyse two types of decisions for internationalising innovation: firstly, a firm's decision to engage in certain types of innovation activities abroad and, secondly, a firm's decision to engage their innovation activities in different regions and countries.

3.1 Data: the German innovation survey

This paper employs data from the German Innovation Survey, which represents the German contribution to the EU's Community Innovation Survey (CIS). The German Innovation Survey follows the methodological recommendations for CIS surveys and adopts the standard CIS questions. The German Innovation Survey is conducted annually by the Centre for European Economic Research (ZEW) in Mannheim, Germany and is called the Mannheim Innovation Panel (MIP). The survey has been carried out on behalf of the German Federal Ministry of Education and Research (BMBF) since 1993. The overall aim

of the survey is to capture information about corporate innovation activities. The survey targets all firms in Germany with at least five employees. The study incorporates all industry sectors including mining, energy and water supply, knowledge-intensive services and other services. The innovation survey is designed as a panel. The same sample of firms is surveyed in this manner each year. Sample firms that drop out due to liquidation, reduced firm size or change of industry sector are substituted every other year with new firms.

The MIP sample is stratified by firm size, industry classification and location within Germany. The MIP survey is, alternately, a longer and a shorter data collection. While short surveys contain mainly core innovation indicators about innovation activities and firm figures, the long surveys additionally include questions about specific innovation related topics. Core innovation indicators comprise firm efforts for R&D in terms of R&D spending, the share of highly skilled employees, continuity of R&D behaviour or non-R&D efforts such as the acquisition of machines to name a few. The outcome of these innovation efforts is captured by surveying successful product and process innovation projects and the termination of unsuccessful projects. The core innovation indicators are complemented with additional questions where each survey wave has a special thematic focus which is repeated for certain topics in different survey waves.

The questionnaires address the head of research and development departments in larger firms and the general manager in smaller firms. Participation in the survey is voluntary.

The MIP survey follows the recommendations for definitions and methodologies provided in the Oslo Manual by the OECD and Eurostat.

3.1.1 Explanatory variables

The paper employs information from two survey waves of the Mannheim Innovation Panel: 2005 and 2006. The 2005 survey contributes all core innovation variables which will be used to characterise a firm's innovation environment, its competitive conditions as well as its internal resources, capabilities and innovation activities, i.e. the supposed drivers of internationalising innovation activities. The variables of the 2005 survey refer to the situation in the 2004 financial year. Table 1 summarises the indicators used.

As proposed in hypothesis 1, the empirical analysis will consider the absorptive capabilities of the firms by using two variables: the share of high skilled employees and a dummy variable whether the firm has continuous in-house R&D activities. Both variables are supposed to capture the pre-existing level of expertise of firms. They do not only enable them to benefit from international innovation activities but also represent the intellectual resources that can foster the firms' decision for the internationalisation of their innovation activities.

Hypothesis 2 posits that firms' international experience is a driver for engaging in international innovation activities. In our analysis international firm experience is measured by two indicators: one indicator measures whether a firm has had any experience in collaborating with foreign partners (outside Germany) in innovation projects between 2002 and 2004, while the other one measures whether the firm is selling its products abroad.

In addition, we complement the analysis of internal firm resources and their influence on firms' decisions to internationalise their innovation process with three other variables: the firms' ability to protect their knowledge against infringement, the firms' level of technological advance and corporate financial resources.

A firm is regarded as having accumulated experience in successfully protecting intellectual property (IP) when it has been able to use at least one formal or strategic protection measure (patents, trademarks, utility patterns, industrial designs, copyrights, secrecy,

Table 1 Explanatory variables

No.	Model variable	Indicator
	Firm capabilities and resources	
1	Continuous R&D	1 if a firm conducted in-house R&D continuously in 2002–2004; 0 otherwise
2	High-skilled employees	No. of graduate employees versus total number of employees in 2004
3	Experience in innovation cooperation with foreign partners	1 if a firm co-operated in innovation between 2002 and 2004 with a partner located outside Germany which is at the same time not part of the same enterprise group the firm might belong to; 0 otherwise.
4	Export experience	1 if a firm had any exports from 2002 to 2004; 0 otherwise
5	Experience in successful protection of IP	1 if firm had used at least one formal or strategic protection method for IPR (choose from patents, trademarks, utility patterns, industrial designs, copyrights, secrecy, complex innovation designs, lead time over competitors) from 2002 to 2004 which was highly important for protecting its IP; 0 otherwise
6	Financial resources	Firm reported a profit margin in 2003 and 2004; ordered variable (7 values: 6 categories ranging between 0 and 15%; 1 for more than 15%)
7	Technology advantage	1 if a firm has applied for at least one patent and/or (for service sector firms) registered trade mark between 2002 and 2004; 0 otherwise
	Home competitive environment	
8	Dominating price competition	1 if price competition is the most important factor of competition in a firm's main product market in 2004; 0 otherwise
9	Competitive pressure due to market entries	1 if a firm stated that its product market environment (in 2004) is characterised by strong competitive pressure due to market entries; 0 otherwise
10	Unstable competitive environment	1 if a firm judges the behaviour of competitors as very difficult to foresee in 2004; 0 otherwise
11	High number of competitors	1 if a firm had more than 6 main competitors in 2004; 0 otherwise
	Home innovation environment	
12	Lack of technological information	1 if a firm stated that the lack of technological information was an important obstacle to innovation between 2002 and 2004 (answers 2 or 3 on a 0–3 Likert scale); 0 otherwise
13	Lack of customer response/demand for innovation	1 if a firm stated that the lack of customer response or demand for innovation was an important obstacle for innovation from 2002 to 2004 (answers 2 or 3 on a 0–3 Likert scale); 0 otherwise
14	Lack of qualified labour	1 if a firm stated that the lack of qualified personnel was an important obstacle to innovation between 2002 and 2004; 0 otherwise
15	Lack of external sources of finance	1 if a firm stated that the lack of appropriate external financing was an important obstacle to innovation between 2002 and 2004; 0 otherwise
16	High innovation costs	1 if a firm stated that excessive innovation costs were an important obstacle to innovation between 2002 and 2004; 0 otherwise

Table 1 continued

No.	Model variable	Indicator
17	Lack of appropriate partners	1 if a firm stated that the lack of appropriate partner for innovation was an important obstacle to innovation between 2002 and 2004; 0 otherwise
18	Regulation as barrier to innovation	1 if a firm stated that regulation and long administrative procedures were an important obstacle to innovation between 2002 and 2004; 0 otherwise
19	Cooperation with home universities	1 if a firm had R&D cooperation with universities, universities of applied sciences, other higher education academies, public or nonprofit research institutions in Germany between 2002 and 2004; 0 otherwise
	Control variables	
20	Size	ln(No. employees at FTE in 2004)
21	Age	ln(time between the year of market entry and 2005)
22	East German location	1 if a firm was located in East Germany in 2004; 0 otherwise
23	Manufacturing Industry	1 if a firm belongs to an industry whose NACE classification code is larger than 500

FTE Full time equivalents, *NACE* EU industry classification, rev. 1.2, *FSO* Federal statistical office of Germany

complex innovation designs, lead time over competitors) in a way that it has made a high contribution to IP protection.

The existence of a technological advantage of the firm is measured by patent applications (in the absence of information on granted patents); for firms from the service sectors we also consider applications of trademarks since many service innovations, even if they are entirely new to the market, cannot be protected by a patent while trademarks tend to serve as an effective way to protect radically new service innovations (Schmoch 2003).

The availability of internal financial resources is measured by the profit margin. Firms reporting a significantly positive profit margin in the years prior to the decision to expand innovation activities abroad are regarded as having sufficient internal funding to engage in a high-risk activity such as establishing innovative activities in foreign locations. From the survey we could not obtain further variables that gave insights into the financial situation of the firm. However, we included a variable capturing whether the lack of external sources of finance is a barrier to firms.

Hypothesis 3 assumes an influence of competitive business environment on firms' likelihood to offshore innovation activities. The variables characterising the competitive environment, i.e. the significance of price competition and the degree of competition concentration (number of main competitors) were measured by means of a firm's own assessment with reference to their main product market. This measure of competition from a firm's own perception has the advantage of capturing the effect of firm-specific competition and explaining why some firms undertake more innovation activities than others in the same product market (Tang 2006).

Hypothesis 4 expects that the innovation environment in the home country increases firms' likelihood to look for better innovation conditions abroad. The attractiveness of Germany as a location for conducting innovation is measured by a firm's assessment on the relevance of various obstacles to innovation. We consider six such obstacles, each being measured on a 4-point Likert scale: lack of demand for a firm's innovations, lack of

qualified personnel, lack of external sources of finance, very high innovation costs, lack of appropriate partners for innovation, and legal innovation barriers. Firms stating that one of these obstacles was medium or very important for impeding their innovation activities from 2002 to 2004 are considered to be facing difficulties with the innovation environment at their domestic location. Cooperation partners are essential in a firm's innovation system. Universities or other research institutes have been found to be valuable cooperation partners (Cassiman and Veugelers, 2002; Adams et al., 2001). The availability and engagement into science-industry innovation cooperations might prevent firms from looking for further knowledge sources abroad. Thus we incorporate a variable that captures firms' university collaborations in the innovation process.

3.1.2 Control variables

In the estimations in the first and second empirical analyses we check the size of the firm, the age of the firm, whether the firm is located in the eastern part of Germany and if the firm is active in the industrial sector or in the services sector (reference category). Larger firms tend to be more likely to offshore their innovation activities while smaller firms might have difficulties gathering the management competence and capacities. Firms in Eastern Germany, the former communist part of Germany, have shown a dissimilar R&D investment behaviour and lower innovative outcomes (Czarnitzki and Kraft 2006) and might thus be less likely to offshore their innovation activities abroad.

3.1.3 Dependent variables

The paper aims to assess the influence of firm capabilities, home innovation and competition environment on (i) firms' likelihood to internationalise R&D and later-stage innovation activities and (ii) the location choice in firms' international innovation decision. For this reason two empirical analyses are needed.

In the first empirical analysis, the effect of firm capabilities, home innovation and competition environment on four types of innovation related activities is tested. The relevant data to construct the dependent variables are taken from the 2006 MIP survey which included a thematic focus on firms' international innovation engagements. The types of innovation activities that firms are planning to take up in the future comprise the *planned* R&D, design/conception of new products, production of new products and the implementation of new processes abroad of firms for the years 2006 and 2007.

In order to avoid endogeneity, we do not consider actual innovation activities abroad (which may refer to firm decisions a long time ago) but we consider currently planned internationalisation of innovation activities in the respective year. Each of the planned activity is a binary dependent variable in analysis 1 (dependent variable is one if firm is planning to take up the respective type of innovative action abroad, zero otherwise). Hypotheses 1–4 will be tested in analysis 1.

The second empirical analysis does not split the data set by innovation activity as empirical model 1 does but by the foreign innovation location. In this vein, the dependent variables are capturing whether the firm is planning to innovate in a specific continent, country or technology club. Hereby, the analysis does not consider the type of innovation activity. The dependent variable is 1 when a firm plans to take up any innovation activity in the respective continent, country or technology club or 0 otherwise. The location information stems from the 2006 survey where firms stated in which countries (free text field for country specifications) they plan to perform each of the four different innovation activities

predominantly. However, due to data constraints it is not possible to observe the driving factors for both the type of innovation activity and its location abroad, e.g. the manufacturing of innovations in China. The sample size would be too small to run estimations.

The second empirical analysis thus examines influences on innovation location decision. The formulation of dependent variables that capture the geographic location (continents and countries) does not explicitly account for country differences in economic development or technological progress. To address these important facts, three dependent variables were defined which capture the level of knowledge in the innovation host countries. Technology clubs, as proposed by Castellacci and Archibugi (2008), demonstrate the most recent categorization of countries concerning their levels of technological advance. For the clustering of 131 countries the two scholars used eight indicators: patents per capita, scientific articles, internet and telephone penetration, electricity consumption, literacy rate, average years of schooling and the proportion of tertiary students in science and engineering. The resulting three clusters are the advanced technology club which comprises more technologically advanced countries with high skills, the followers technology club with lesser technological abilities, and the marginalised country club which is the largest group of countries due to low infrastructure, low skills and low innovation (for a detailed list of countries and their respective category see Table 2). China is in the same technology club (marginalised countries) as African countries, but considering its greater attractiveness for firms in terms of market size, speed of economic growth and absolute numbers of graduates it might have a different priority than other countries. Therefore, we have used the firms' internationalisation decision with regards to China, North America, Western Europe and Eastern Europe as separate dependent variables to measure the influence of internationalisation drivers for these countries and regions of interest (without considering their different technology club classifications). Hypotheses 5 and 6 will be subjected to testing in the second empirical analysis of the paper.

3.2 Empirical analysis

3.2.1 Sample selection

The two MIP survey waves from 2005 to 2006 are merged by using the unique company identifying number. The resulting sample has then been restricted to firms with innovation activities at their home location and firms with foreign ownership have been excluded. The definition of innovation active firms is in line with the Oslo Manual (OECD and Eurostat 2005). Innovation active firms are not only firms which have successfully brought their innovation activities to fruition with product or process innovations but also firms which have ended their innovation projects without innovative output and firms which have not yet completed their innovation projects.

The sample for the second empirical analysis has been initially further restricted to firms that carry out at least one of their R&D and innovation activities abroad in order to be able to compare the effects of the internationalisation drivers for different countries and regions. However, for the reader, the usage of a uniform sample for both empirical analyses seemed easier to follow and the results from the restricted sample and from the sample used in empirical analysis 1 do not vary substantially. Therefore, the choice of the sample was made in favour of one uniform sample for the R&D abroad and R&D location decision.

Table 2 Definition of dependent variables

No.	Model variable	Indicator
	Planned research and innovation activities abroad	
A–D	Planned internationalisation of innovation activities of type *k*	1 if a firm plans to take up or expand type *k* innovation activity outside Germany in 2006 or 2007; 0 otherwise (*k*: R&D [A], design/preparation of innovations [B], manufacturing of new products [C], implementation of new processes [D])
	Planned research and innovation activities in different countries and regions	
E	Planned internalisation of any innovation activities of type *k* in country *c*	1 if a firm plans to take up or expand type *k* innovation activity outside Germany in 2006 or 2007 in one of the *c* countries or technology clubs (c: advanced, followers, marginalised, China, North America, Western Europe, Eastern Europe); 0 otherwise
F	Advanced countries	Northern Europe, Scandinavia, Switzerland, Netherlands, Norway, Denmark, UK, Sweden, Finland, Western Europe, Iceland, Japan, USA, Canada, Australia, Israel
G	Follower countries	Austria, Belgium, Benelux, France, Luxembourg, Poland, Romania, Slovakia, Czech Republic, Hungary, Slovenia, Serbia/Kosovo, Croatia, Bulgaria, Bosnia, Spain, Italy, Turkey, Greece, Cyprus, Portugal, Ireland, Malta, Latvia, South Korea, South East Asia, Singapore, Malaysia, Hong Kong, Thailand, Philippines, South America, Brazil, Chile, Mexico, Argentina, Peru, Columbia, Russia, Ukraine, Georgia, Baltic, Belarus, Lithuania, Saudi Arabia, Lebanon, Libya, UAE, Middle East, Near East, Dubai, South Africa
H	Marginalised countries	China, India, Pakistan, Vietnam, Taiwan, Sri Lanka, Indonesia, Mongolia, Iran, Macao, Montserrat, Africa (except for South Africa)
I	China	China
J	Eastern Europe (EastEU)	Middle and Eastern European countries (CEE, MEE, MOE)
K	Western Europe (WestEU)	Switzerland, Netherlands, Norway, Denmark, UK, Sweden, Finland, Iceland, Austria, Belgium, Benelux, France, Luxembourg, Spain, Italy, Portugal, Ireland, Malta
L	North America (NA)	USA, Canada

3.2.2 *Estimation method*

Initially, separate probit models for each decision (by type of innovative activity abroad and location abroad) have been estimated, with marginal effects for both estimation models. However, for the second model, the decision to carry out innovation activities in certain regions can be a simultaneous decision process. Therefore, the location-specific effects of international innovation drivers have been estimated with two multivariate probit models with marginal effects. One multivariate probit estimation was prepared for the advanced, follower and marginalised country classification and a second one for the regions of Western Europe, Eastern Europe, North America and China.[1]

[1] Thanks to input from Otto Toivanen at the Zvi Griliches Research Summer School in Barcelona, July 2009, a rare event logit model (King and Zeng 2001) has been estimated to capture the effects of the observable driving forces for rare events such as planned innovation activities of German firms in North America (3%). However, no varying results have been achieved by this analysis.

4 Drivers of internationalising innovation activities

In the retrieved sample of 1,439 innovative firms which are headquartered in Germany, about 23% of the companies plan to set up or expand international innovation activities abroad. 16% want to manufacture innovations outside Germany, 11% intend to develop new products and about 9% to implement new processes abroad. In the sample, 7% of the firms plan to set up internal research capacities abroad which makes it the least internationalised of the observed innovation activities (the detailed descriptive statistics is provided in Table 3). Analysing the drivers of internationalising decisions for innovation activities the results in Table 4 clearly shows that the most prominent forces in setting up R&D capacities abroad are the firm's own capabilities and resources. Previous international experience and absorptive capacity show the strongest influence on the decision to internationalise any kind of corporate innovation activity. The home innovation environment also indicates a positive stimulus; in particular, the lack of information and high innovation costs spur the internationalisation decision for any observed innovation activity. For each type of planned innovative activity abroad, previous export experience is found to bring strong influence to bear, especially upon the internationalisation of manufacturing innovative products abroad as well as on the design of new products (Hypothesis 2 supported). Export experience seems to provide knowledge about market conditions, demand and location advantages which might increase the likelihood to set up the manufacturing of innovative products and new processes abroad. This is in line with findings from Ito and Wakasugi (2007) stating a positive relationship between export activities and overseas R&D. However, as with previous studies, the causality between export and international R&D activities remains ambiguous. This study has tried to circumvent this causality problem by relating existing exporting activities in the year 2004 to the intention of firms to internationalise their R&D activities in 2006. Surprisingly, previous international experience gathered by international research cooperation has no significant effect on the decision to locate single innovation activities overseas but it increases the likelihood for the decision to internationalise any innovation activities by 11%. Firms which plan to internationalise their R&D activities show stronger effects on continuously performed in-house R&D and a high share of skilled labour. These indicators reflect the importance of absorptive capabilities for international research activities (Hypothesis 1 partly supported) and the design of very innovative firms are supported by the positive effect of technological advantages of these firms on their likelihood to decide upon international Research and Design. Surprisingly, the share of highly skilled employees has a slight negative effect on the decision to implement new processes abroad. Other firm resources which promote the decision of later stage innovation activities such as the manufacturing of new products and the implementation of new processes abroad are the experience in intellectual property rights use. It seems that the potential loss of knowledge is greatest when it is embodied in products and services. Firms with pronounced financial resources are also more likely to manufacture their products abroad.

Regarding the influence of competition on the likelihood to perform innovation activities abroad, varying results are retrieved. While the quality of competition, namely price competition, in the home market has a negative effect on the manufacture of innovative goods the quantity of competition shows positive effects. Firms that face price competition are very likely not to operate at the leading edge of technology, thus explaining the lesser likelihood of carrying out innovation activities abroad. As for the quantity of competition in the home market, the results show that firms which face competition from new market players are 3% more likely to implement new processes abroad. Therefore, a more intense

Table 3 Correlation matrix of explanatory sample variables and descriptive statistics (by #, see Tables 1 and 2)

#	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
A	0.074	0.262																							
B	0.108	0.310																							
C	0.156	0.363																							
D	0.094	0.292																							
E	0.234	0.424																							
F	0.056	0.229																							
G	0.124	0.330																							
H	0.058	0.234																							
I	0.047	0.213																							
J	0.067	0.250																							
K	0.051	0.219																							
L	0.026	0.160																							
1	0.431	0.495	1.000																						
2	0.238	0.253	0.201	1.000																					
3	0.123	0.329	0.354	0.193	1.000																				
4	0.574	0.495	0.324	-0.018	0.201	1.000																			
5	0.490	0.500	0.461	0.137	0.287	0.373	1.000																		
6	0.471	0.499	0.001	-0.085	-0.030	-0.032	0.004	1.000																	
7	0.346	0.476	0.472	0.135	0.381	0.314	0.527	-0.022	1.000																
8	0.449	0.498	-0.150	-0.172	-0.115	-0.098	-0.145	-0.057	-0.087	1.000															
9	0.503	0.500	-0.064	-0.023	-0.080	0.045	-0.017	-0.008	-0.027	0.117	1.000														
10	0.444	0.497	-0.089	-0.092	-0.041	-0.057	-0.079	-0.036	-0.053	0.117	0.186	1.000													
11	0.398	0.490	-0.058	0.006	-0.005	-0.091	-0.058	0.049	-0.056	0.102	0.039	0.168	1.000												
12	0.082	0.274	0.053	0.043	0.042	0.050	0.059	-0.041	0.045	0.001	0.036	0.028	0.007	1.000											
13	0.118	0.323	0.086	0.063	0.068	0.002	0.043	-0.003	0.050	-0.029	0.009	0.037	0.015	0.404	1.000										
14	0.126	0.332	0.069	-0.007	0.022	-0.004	0.025	0.026	0.025	-0.034	0.001	0.020	0.001	0.363	0.222	1.000									
15	0.168	0.374	0.101	0.112	0.056	0.026	0.072	-0.118	0.033	0.034	-0.037	0.011	-0.037	0.255	0.224	0.211	1.000								
16	0.266	0.442	0.084	0.081	0.034	0.029	0.033	-0.044	0.050	0.009	0.017	0.007	0.038	0.325	0.355	0.302	0.559	1.000							
17	0.077	0.266	0.049	0.051	0.049	0.000	0.026	-0.071	0.018	0.021	-0.010	0.005	-0.012	0.323	0.276	0.246	0.369	0.328	1.000						
18	0.169	0.375	0.076	0.046	0.078	-0.017	0.066	-0.004	0.073	0.004	0.023	0.031	0.006	0.281	0.335	0.286	0.370	0.460	0.295	1.000					
19	0.226	0.419	0.426	0.272	0.525	0.225	0.293	-0.048	0.368	-0.134	-0.016	-0.069	-0.083	0.091	0.092	0.050	0.131	0.125	0.087	0.111	1.000				
20	4.185	2.009	0.278	-0.221	0.295	0.200	0.246	0.106	0.355	0.033	-0.060	-0.069	0.010	-0.012	0.037	-0.008	-0.132	-0.051	-0.072	-0.006	0.185	1.000			
21	2.677	0.859	0.011	-0.153	-0.011	0.049	-0.044	0.048	0.026	0.047	0.037	0.002	0.025	0.010	0.028	0.000	-0.070	-0.031	0.003	-0.049	-0.034	0.268	1.000		
22	0.350	0.477	0.002	0.170	-0.072	-0.098	-0.084	-0.047	-0.105	0.066	0.026	0.019	0.010	-0.013	-0.022	-0.029	0.074	0.100	-0.002	0.062	0.059	-0.233	-0.271	1.000	
23	0.040	0.196	0.186	-0.005	0.353	0.133	0.189	0.073	0.240	-0.034	-0.022	-0.032	0.014	-0.031	0.014	-0.054	-0.071	-0.038	-0.013	-0.003	0.209	0.441	0.113	-0.143	1.000

Table 4 Drivers to internationalise innovation activities of German MNEs (by innovation activity): marginal effects of probit models

	Planned innovation activities abroad				
	Any innov. activitiy	Research	Design/ conception	Manu-facturing	New Processes
Internal resources and capabilities					
Continuous R&D	0.074***	0.050***	0.034	0.019	0.009
High-skilled employees	0.068	0.064***	0.035	−0.009	−0.049*
Innovation coop. with intl. partners	0.107***	0.024	−0.006	0.048	0.014
Export experience	0.133***	0.043***	0.082***	0.116***	0.059***
Experienced usage of IPR	0.033	0.010	0.013	0.048**	0.027*
Financial resources	0.007	0.002	0.003	0.011**	0.001
Technological advantage	0.027	0.031*	0.035*	0.005	0.015
Home competitive environment					
Price competition	−0.023	−0.002	−0.004	−0.035*	−0.008
Unstable competitive situation	−0.011	−0.001	−0.002	0.001	−0.006
Competition from new competitors	0.010	0.012	0.026	0.031	0.027**
High number of competitors	−0.010	−0.016	0.007	−0.007	−0.015
Home innovation environment					
Lack of technological information	0.102**	0.022	0.005	0.033	0.016
Lack of customer response	−0.045	−0.013	−0.055***	−0.048**	−0.014
Lack of qualified labour	0.022	−0.011	0.026	0.057*	−0.009
Lack of ext. sources of finance	0.005	0.002	−0.001	0.024	0.014
High innovation costs	0.064**	0.004	0.027	0.090***	0.025
Lack of appropriate partners	0.007	0.027	0.042	0.003	−0.002
Regulation as barrier for innovation	−0.020	0.017	0.021	−0.028	0.006
Coop. with home universities	−0.034	−0.020**	0.011	−0.010	0.002
Control variables					
Firm size	0.017***	0.003	0.004	0.019***	0.015***
Firm age	−0.014	−0.004	−0.023**	−0.017	−0.013**
Firm located in East Germany	−0.066***	−0.005	−0.045***	−0.061***	−0.035***
Manufacturing Industry	0.028	0.042	0.041	0.171**	0.100*
Pseudo R-squared	0.145	0.210	0.123	0.198	0.299
No. of observations	1439	1202	1198	1200	1193

* 10% Significance; ** 5% Significance; *** 1% Significance

competition seems to work as a driver for the decision to carry out later stage innovation activities abroad (Hypothesis 3) and to escape competition by innovation. However, competition has no effect on the likelihood to carry out R&D intensive activities at foreign locations.

The influence of firms' home country innovation environment on their innovation performance abroad shows positive and negative effects. It was argued before that firms which are hindered by home country specific innovation barriers will be more motivated to change their R&D location (Hypothesis 4). In terms of the general decision to internationalise innovation activities, the lack of information and high innovation costs demonstrate significant positive incentives. As for the decision to expand single innovative activities abroad, the lack of labour and high innovation costs in the home country—the often mentioned forces which make firms locate their R&D abroad—in fact only have a positive effect on the decision to set up innovation manufacturing capacities abroad. However, the lack of customer response in the home country makes firms less likely to design and manufacture innovative products abroad, indicating that firms do not try to take advantage of different demands worldwide. Firms that cooperate with higher education institutions such as universities in the home country are less likely to internationalise their R&D activities, confirming our assumptions that the availability of knowledge reduces firms' incentives to search for foreign knowledge pools.

The results for firm size show that larger firms tend to be more likely to decide in favour of the manufacture and development of new products and processes abroad. Firm age and firm location (in Eastern Germany) are negatively associated with the decision to internationalise innovation activities. Firms that belong to the manufacturing sector are more likely to internationalise later-stage innovation activities like the manufacture of innovative goods and the implementation of new processes.

5 Drivers for international R&D and innovation activities by host country, region and technology club

The regional analysis of international innovation activities aims to observe country-specific effects of driving forces to internationalise innovation. In this regard the host countries of a firm's (any type) innovation activities abroad are the central point of interest in this analysis. The descriptive results show that for innovative German firms planning to internationalise their R&D the most popular region (for 12% of the sample firms) are nations with medium developed knowledge levels (follower countries). Nations with advanced or marginalised knowledge infrastructure account for 6% of the firms in the sample as their preferred prospect innovation locations (for detailed descriptive statistics refer to Table 3, see also Rammer and Schmiele 2008).

The results of the regional analysis of innovation internationalisation drivers are shown in Table 5 stating that the main factors which lead firms to innovation activities in certain countries and regions are company capabilities and resources and only to a lesser extent location disadvantages in the home country. Competition rather hinders the location of innovation to one of the observed countries and regions. The results illustrate that the effects of firms' international experience are more pronounced for firms planning to set up or expand innovation capacities in follower countries than in advanced and marginalised countries. The direct comparison between the effects of international experience (exports) between advanced and marginalised host countries shows slightly stronger effects for the marginalised group of countries (Hypothesis 5). Furthermore, the effect of a firm's technological advantage on its decision to innovate is lower in North America than it is in China. Firms which have continuous in-house innovation activities are more likely to decide upon Western European locations or more importantly upon follower countries such as the Eastern European countries. The observed firm capability to use intellectual property

Table 5 Drivers to internationalise innovation activities (by region): two multivariate probit models with marginal effects

	1 China	2 EastEU	3 NA	4 WestEU	I Advanced	II Followers	III Marginal
Internal resources, capabilities							
Continuous R&D	0.000	0.027 *	0.001	0.026 **	0.009	0.042 **	0.010
High-skilled employees	−0.020	0.018	0.005	0.024	0.015	0.051	−0.007
Innovation coop. with intl. partners	0.029	−0.003	0.009	0.027	0.028	0.034	0.022
Export experience	0.014 **	0.042 ***	0.005	0.015	0.024 ***	0.060 ***	0.028 ***
Experienced usage of IPR	0.001	−0.003	0.005	0.021 *	0.029 ***	0.020	0.002
Financial resources	0.003 ***	−0.002	0.001	0.003	0.001	0.001	0.004 **
Technological advantage	0.018 *	−0.009	0.013 *	−0.009	0.004	−0.003	0.018
Home competitive environment							
Price competition	−0.012 **	−0.005	−0.002	−0.010	−0.007	−0.008	−0.005
Unstable competitive situation	0.000	−0.004	0.001	−0.002	−0.006	−0.009	0.006
Competition from new competitors	−0.004	−0.001	0.003	0.011	0.019 **	−0.001	−0.003
High number of competitors	−0.005	−0.002	−0.003	0.008	0.006	0.009	0.002
Home innovation environment							
Lack of technological information	0.012	0.019	−0.003	0.007	0.007	0.028	0.023
Lack of customer response	0.015	−0.014	−0.003	−0.005	−0.004	−0.015	0.025
Lack of qualified labour	−0.005	0.011	0.000	0.016	0.011	0.001	0.003
Lack of ext. sources of finance	−0.005	−0.012	0.005	0.009	0.020	−0.011	−0.011
High innovation costs	0.010	0.031	−0.005	−0.015	−0.025 ***	0.044 *	0.013
Lack of appropriate partners	−0.006	−0.002	0.004	0.014	0.007	−0.023	−0.022 ***
Regulation barrier for innovation	−0.017 ***	−0.005	0.008	−0.001	0.009	−0.015	−0.024 ***
Coop. with home universities	−0.001	−0.000	−0.002	−0.012	−0.001	−0.015	0.001

Table 5 continued

	1 China	2 EastEU	3 NA	4 WestEU	I Advanced	II Followers	III Marginal
Control variables							
Firm size	0.004 **	0.007 **	0.001	−0.002	0.003	0.006	0.003
Firm age	−0.002	0.007	−0.001	−0.002	−0.003	0.008	−0.003
Firm located in East Germany	−0.005	−0.005	−0.002	−0.018 *	−0.006	−0.038 **	−0.015 *
Manufacturing Industry	0.015	0.008	−0.000	0.006	−0.005	0.093 *	0.017
	rho1	rho2	rho3	rhoI		rhoII	
rho2/rhoII	0,044			0,246**			
rho3/rhoIII	0,019	0,068		0,201		0,616***	
rho4	0,346**	0,304**	0,099				
LL	−812,026			−868,509			
No. of observations		1439		1439			

* 10% Significance; ** 5% Significance; *** 1% Significance

rights is pronounced for firms with planned innovation activities in advanced knowledge countries such as Western EU nations. From this result one can make the assumption that firms use these IP protection strategies to prevent technology competition or IP infringements from developed regions (Table 5).

The last hypothesis concerned the motives which make firms set up or expand their innovation activities into countries with developing knowledge levels. The results show that the innovation-related location disadvantages of the home country, namely regulation barriers and the lack of appropriate partners, show negative significant coefficients. It demonstrates that firms which are affected by these two innovation barriers are less likely to plan innovation activities in marginalised countries, particularly in China. High innovation costs such as the anticipated drivers for R&D in follower and marginalised countries show negative significant results for countries with advanced knowledge levels and weak positive significance for follower countries. In this vein, the results for firms' financial resources show positive influence on the decision to innovate in marginalised countries in particular China.

Similar results are found regarding the effect of the competitive environment as location choice driver. A high number of competitors as well as unforeseeable competitive behaviour do not have an effect on the likelihood of carrying out innovation activities in a specific region of the world. For China, a significant negative effect is found in the quality of competition. Firms which face price competition in the home country are less likely to move their innovative capacities to China. This result partly supports hypothesis 6. Competition from new market entries leads firms to internationalise their innovation activities to countries with advanced knowledge infrastructure.

Other results which describe the nature of firms with plans to build up innovation capacities overseas show that firm size turns out to be a relevant characteristic for firms planning to innovate in China and in the East European countries. The manufacturing industry indicates a slightly positive likelihood to innovate in follower countries while firms from Eastern Germany are less likely to innovate in marginalised and follower countries as well as in Western Europe.

6 Discussion

This paper aimed to shed light on driving forces from firms' local business and innovation environment as well as on the influence of firms' capabilities and resources to perform innovation activities abroad. Moreover, this study went beyond the term R&D abroad which is the state of the art in the literature of internationalisation of R&D. In this vein, the contribution of this paper was that it paid attention to the nature of the innovation activities that firms plan to offshore. The paper gave insights on how the influence of internationalisation drivers varies for research-intensive innovation activities and later-stage innovation activities. This was explicitly shown by initially combining all company innovation information into one 'any innovation activity abroad' variable which was then broken down into the different types of planned international innovation activities. While we saw significant effects for some internationalisation drivers on the accumulated 'any innovation activity abroad' variable, this effect can diminish (such as lack of technological information) or is significant mainly for only one single observed planned innovation activity abroad (such as high innovation costs).

The empirical study considered firm capabilities, firms' competitive environments and home country location disadvantages as drivers for firms' decisions to set up innovation

activities in developed and developing countries as well as in country groups with different levels of technology knowledge.

It could be shown that firm capabilities and resources, in particular absorptive capacities and international experience, are most important for the decision to internationalise innovation activities. High innovation costs and the lack of qualified labour propel only the later stage innovation activities abroad while firms which are confronted with innovation obstacles are not seeking to overcome these constraints by innovating abroad. Companies performing R&D abroad are not driven by high competition either. The overall picture from the analysis demonstrated that firms use R&D activities abroad rather to continue strengthening their existing capabilities and business success than to escape intensive competition.

Firms which plan to innovate abroad have accumulated experience with foreign markets by exporting. Firms with the decision to innovate in developing countries like China in the near future have shown that more elaborate international contacts via innovation collaborations are necessary. R&D in developing countries is still a very open field in the literature and the results achieved in this paper help to clarify the conditions driving firms to innovate in countries with 'marginal' knowledge stocks. Again, it becomes obvious that firms which undercut price competition are not pushed to developing countries to manufacture innovative goods or to carry out other innovation activities in Asia and in marginalised countries.

The results indicate that firms wishing to internationalise their R&D activities should have developed absorptive capacities and international experience. If the choice of location is a country belonging to the group of countries with lower developed knowledge levels or Asian countries, additional cultural competence should be gathered by engaging in partnerships with international innovation partners. Policy implications can be directed to foster international innovation projects for firms to create international innovation experience or generally to set incentives to perform R&D on a continuous basis and overcome innovation disadvantages domestically. Furthermore, it was shown that the trend to move innovative capacities to emerging regions can be blocked by legal innovation regulation.

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