Discussion Paper No. 05-53

Global Idea Sourcing

An Empirical Investigation into the Mechanisms Behind the Usage of Foreign Business Sources for Innovation

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Non-technical summary

Globalization is on everyone's mind these days. Breakthroughs in technology (telecommunications, logistics, the internet) and ideology (most notably economic and political trends in China and India) are creating exciting opportunities as well as crucial challenges. We focus on the implications of this general trend for the innovation activities of German firms. The focal point of this analysis is a particular innovation strategy: The ability of German firms to "sense" relevant market and technology information through their international value chains (foreign customers, suppliers and competitors) and turn them into valuable sources for innovation at home. In essence we ask: How can such a competitive capability be achieved and sustained.

From its very setup this paper tries to combine two major forces in modern innovation management. On the one hand, it stresses the importance of external sources for innovation. Additionally, it describes the opportunities and challenges globalization presents in the sourcing of ideas and technologies. Internationalizing innovation activities has major advantages: Efficiency (due to economies of scale and comparative advantages leading to higher profits on extended markets), responsiveness (regarding local customer demand) and learning (through access to localized knowledge). On the downside, several studies have shown that transferring knowledge across borders (national and cultural) is difficult and costly as is dealing with liabilities of foreignness abroad. We question whether it is universally advantageous to directly invest abroad and argue instead that a company may use its international value chain (customers, suppliers and competitors) to utilize foreign sources for innovation at home. We suggest a combination of three factors to identify and explain such innovation strategies: Access, need and absorptive capacities. Our empirical analysis rests upon a broad data sample of almost 2,300 German companies from both manufacturing and services.

We find that while the rationales of using foreign customers, suppliers or competitors as sources for innovation differ, the absorptive capacities to leverage them do not. We suggest that, on a personnel and organizational level, these capabilities and competencies are developed domestically and can be transferred across borders if they can be made available (access) and are relevant (need). Our results suggest that demand pull from foreign customers is most important if products are relatively standardized, international exposure is strong and the lead status of domestic customers (business R&D expenditures) is limited. Then again, we find that keeping this market-seeking strategy external from the company works only up to a certain threshold, after which the benefits of internalization outweigh its costs. Relying on foreign suppliers for innovation inputs is largely a risk-sharing but also a technology-seeking strategy, as domestic markets are dynamic and R&D expenditures are relatively more concentrated abroad, and risks and costs increase in less favorable governmental environments. Finally, we suggest a purer technology-seeking strategy if foreign

competitors are used as a source for innovation. This technology push is most beneficial if it can be readily evaluated and attained in the presence of competition on foreign markets and a lack of technological information in self-centered innovation processes.

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Abstract

Globalization has set new paradigms, especially in the business world. Breakthroughs in technology (telecommunications, logistics, the internet) and ideology (most notably economic and political trends in China and India) are creating exciting opportunities as well as crucial challenges. This paper analyses one of the core aspects of competitiveness: a firm's ability to innovate in a globalized environment. We question whether it is universally advantageous to directly invest abroad and argue instead that a company may use its international value chain (customers, suppliers and competitors) to utilize foreign sources for innovation at home. We suggest a combination of three factors to identify and explain such innovation strategies: access, need and absorptive capacities. Our empirical analysis rests upon a broad data sample of almost 2,300 German companies for which we devised a trivariate probit model. In essence, we find a market-seeking strategy for using foreign customers as a source for innovation that is more beneficial to standardized products and becomes more feasible if the lead status of domestic customers is limited. What is more, internalizing this link with foreign customers becomes preferable as their importance as a driver of sales increases. For foreign suppliers we identify a risk-sharing and technology-seeking strategy as a reaction to more dynamic domestic markets and a less favorable domestic environment in both research and regulation. Hence, companies optimize or augment their innovation activities by invoking ideas from foreign suppliers. Then again, companies rely on foreign competitors for technology-seeking as those sources become more readily available and crucial in international competition.

Keywords: innovation strategy, globalization, external sources
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1 Introduction

Globalization is on everyone's mind these days. Some consider it a godsend providing chances and opportunities previously unheard of; others feel trapped in a merciless, worldwide race to the bottom. Or, as the Economist, (2002) puts it, "Globalisation is often described as an irresistible new force that, depending on your perspective, will either wreck or save the planet."

Although definitions vary[1], there appears to be a shared understanding of intensified interactions and interdependencies between globally dispersed locations. This increased interconnection is primarily the result of two driving forces: breakthroughs in technology and shifts in ideology (Govindarajan and Gupta, 2001; Gupta and Westney, 2003): The former is most notably associated with the internet and advanced telecommunications, while the latter is most prominently manifest in supranational (European Union, NAFTA, MERSOCUR, ASEAN) and global (WTO) trade promotion agreements, harmonized currency systems ("euro-/dollarization") and political recalibrations in large countries like China and India away from state-driven economies towards more open, market-driven models. This development has been discussed widely[2] as well as its acceleration during the 1990s.[3]

To clarify the scope of this paper the term globalization will henceforth refer to a more narrow business conception put forward by Govindarajan and Gupta(2001): "Globalization refers to growing economic interdependence among countries as reflected in increasing cross-border flows of three types of entities: goods and services, capital and know-how." The latter will be the focal point of this analysis, the globalization of innovation defined as the increasinglyy international scope of the generation and diffusion of technologies (Archibugi and Iammarino, 2002).

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1 Giddens (1990) offers a rather broad definition of globalization: "the intensification of worldwide social relations which link distant locations in such a way that local happenings are shaped by events occurring many miles away and vice versa."

2 See, for example, Lindsey (2002) or Stiglitz (2002).

3 To present just a few key figures: Global foreign direct investment outflows increased from US$28 billion in 1982 to US$242 billion in 1990 and US$647 billion in 2002; total assets of foreign affiliates rose from US$2.091 trillion in 1982 to US$5.899 trillion in 1990 and US$26.543 trillion in 2002 (UNCTAD, 2003).

In general, there are three major leverage points for a company from internationalization activities (Bartlett and Goshal, 1987; Lessard, 2003): efficiency (due to economies of scale and comparative advantages leading to higher profits on extended markets), responsiveness (regarding local customer demand) and learning (through access to localized knowledge). While the quest for efficiency through international production networks[4] and responsiveness in globalized marketing[5] has been fairly well understood in related international management literature, internationally dispersed innovation activities have to a considerable extent been analyzed for typically large multinational companies and their R&D activities.[6] Although multinational companies play, without a doubt, a major role in the process of globalization (Cantwell, 1989), an overly narrow focus on intra-organisational management solutions would suggest that cross-border know-how transfers in the innovation process are only feasible through intra-firm internalization. Given that most innovation activities are still located close to firms' domestic headquarters (Pavitt and Patel, 1999) and the substantial investments required to shift innovation activities abroad, a more flexible approach to learning from abroad has to be found. This issue is at the very heart of this paper. We analyze the mechanisms within German companies that enable them to use foreign sources for their own innovation projects. Clearly, this would be no unique endeavour had we not the opportunity to distinguish between these sources for innovation. Therefore, in line with the previous argument, we focus on sources that have not been internalized within company and are only connected through the value chain: foreign customers, suppliers and competitors. These particular innovation roots are especially attractive for the development of innovation strategies since they may not be readily leveraged from outside companies (unlike publicly available sources like university research). Hence, a firm with the ability to identify, share and exploit these valuable knowledge assets could generate competitive advantage (Gupta and Govindarajan, 2000; Jensen and Szulanski, 2004; Zander and Kogut, 1995). Further, we rely on a broad empirical base of roughly 2,300 companies of various sizes and industries (both manufacturing and service firms). It should also be clarified from the outset that we consider the term globalization as an intensification of internationalization. Still, both terms are used interchangeably in this analysis with no conceptual difference.

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4 See, for example, Dunning (1981) or DuBois and Toyne (1993).

5 See, for example, Sorenson and Wiechmann (1975), Ayal and Zif (1979), Huszagh et al. (1985) or de Mooij (2000).

6 See, for example, Ridderstrale (1997), Boutellier et al. (1999), Birkinshaw and Fry (1998), or Gupta and Govindarajan (2000).

The paper is organized as follows. The chapter subsequent to this introduction outlines major theoretical terms and concepts in greater detail. Chapter 3 focuses on the empirical implementation of the analysis, while Chapter 4 summarizes the results. The final chapter (5) presents our conclusions.

2 Theoretical framework

2.1 Setup and definitions

From its very setup this paper tries to combine two major forces in modern innovation management. On the one hand, it describes the opportunities and challenges globalization present in the sourcing of ideas and technologies. Additionally, it stresses the importance of external sources for innovation, which in turn leads to the central question: Why do companies use external, foreign sources for their innovation activities? The latter perspective will be outlined first.

The pressure on firms from international competition increases, or as Kleinschmidt and Cooper (1988) put it: "Our domestic market is someone else's foreign market." Moreover, larger innovation investments and shorter product life-cycles have incited companies to reconfigure their technology[7] sourcing from predominantly internal to an increased share of external sources for innovation (Chatterji, 1996; Calantone et al., 1997; Ojah and Monplaisir, 2003). Still, not only does demand for external innovation sources increase - supply does as well. Chesbrough (2003) identifies four interconnected factors that leverage a more open innovation process: The increasing availability and mobility of skilled workers, a venture capital market that endows entrepreneurs with the necessary capital to compete, external options for previously shelved ideas and the increased capabilities of external suppliers. Hence, the boundaries of organizations are blurring and interfaces appear that need to be managed for success (Stock and Tatikonda, 2004). While external, public sources for innovation - notably universities - are certainly also a valuable input in the innovation process, the focus of this analysis is on inputs from the value chain, precisely customers, suppliers and competitors. For a more convenient and simple presentation of the following steps of the analysis, it should be emphasized that for the purpose of this paper, the term "external sources" refers

[7] Within the framework of this paper and in line with Archibugi and Iammarino (2002), the term "technology" is rather broadly defined as "knowledge directed towards the solution of specific human problems."

only to these external business sources. Besides, competitors are accurately defined not as an integral component of a firm's value chain, but as exhibiting only points of contact with it. Therefore, our three types of external sources for innovation should more precisely be described as "in contact with the innovating firm through the value chain" instead of "part of the value chain." Nonetheless, to achieve a more transparent presentation of the core concepts of this paper we will henceforth use the latter term as an abbreviation of the more specific former.

Its country can be considered the natural perimeter of a company's activities (Jensen and Szulanski, 2004). Then again, the central goal of this paper is to take the concept of "external" sources one step further by implying that they are not only external to a company but also to its country. This process of leveraging innovation sources that originate not only outside of the boundaries of the company but also outside of the country and hence national innovation system[8] is especially challenging because there appears to exist a border effect which should be further explored. Given the handicap that knowledge flows usually leave no paper trail a broad stream of research has focused on utilizing patent data. In this field most prominently Jaffe et al. (1993), Eaton and Kortum (1999), Porter and Stern (2000) and Branstetter (2001) find that technology diffusion within countries is significantly stronger than it is internationally. Jaffe and Trajtenberg (1999) find, for example, that a patent applicant is 30 to 80% more likely to cite a domestic inventor than one from abroad. Peri (2005) estimates most recently that only 12% of the initial knowledge can be transferred across country borders. In this context the transfer of codified knowledge might not be the dominant obstacle since these barriers have largely been overcome by modern information and telecommunications technology. Still, especially in the innovation process, tacit knowledge often associated with face-to-face contact and shared experiences is of crucial importance. Moreover, there are cultural barriers[9] to the cross-border transfer of innovation knowledge to overcome as probably best described by the literature on managing globally dispersed teams for innovation (Boutellier et al., 1998; Maznevski and Chudoba, 2000; McDonough III et al., 2001). Hence, the borderless world (Ohmae, 1990) has not

[8] While we usually rely on the term "country" as a reference for the national and cultural environment in which a firm operates and innovates, it might be more precise to call this the "national system of innovation", defined by Freeman (1995) as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies." Still, for the sake of simplicity and transparency in the presentation we will use the term "country" as a substitute.

[9] As Hofstede (1983) shows, nationality can be considered a proxy for culture since "the members of a society share an understanding of the institutional systems, a bond for identity, and experiential understanding of the world."

yet materialized in innovation activities. Therefore, the advantages and challenges of internationalizing innovation activities will be outlined briefly.

2.2 Advantages and disadvantages of globalizing innovation activities

At this point the opportunities and challenges involved in going global in innovation will be outlined without explicitly distinguishing through which operational structure this could best be achieved. This issue will be raised in the subsequent section, but a more general, up-front description should serve as an introduction.

Advantages

Based on Dunning (1981;1992) and Bartlett and Goshal (1987), we identify three major reasons for innovation activities abroad that were recently confirmed by a global survey of 104 senior executives (Economist Intelligence Unit, 2004):

- Product, material or process adaptations/improvements:
  Market, resource or regulatory conditions in foreign markets can make it necessary to adapt products and processes. Firms might only be able to exploit the full market opportunities if they can use all the available information on the foreign market and adapt their offerings accordingly. Bartlett and Goshal (1987) call this factor "responsiveness". Philips coffeemakers that were initially too big for smaller Japanese kitchens or two-liter Coca-Cola bottles which hardly fit in most Spanish refrigerators could serve as two eye-catching examples of a lack of such responsiveness (Kotler, 1986). Additionally, Craig and Douglas (2000) point out that exposure to diverse customers, cultures and competitive practices might enable a firm to develop superior competencies that could be subsequently transferred to other countries.

- Access to localized resources:
  A critical portion of inputs for innovation activities can be transferred neither readily nor at reasonable costs from one country to another. This factor can be physical in nature (e.g., bauxite mining) or, more importantly, embodied in human beings and their unique skills (Kuemmerle, 1999). Local clusters of competitive advantage develop where these resources are ideally combined (Porter, 1990). As Doz et al. (2001) point out, valuable knowledge is increasingly spread in fragmented pockets of specialist expertise around the world and is often subtle, complex and sticky. A firm able to utilize this learning leverage point (Bartlett and Goshal, 1987) might benefit from a sustainable competitive advantage.

- Rationalized research:
  As any other functional component (e.g., production, marketing) of a firm, innovation activities will benefit from being globally placed in the country with the best comparative cost position, which includes economies of both scale and scope. What is more, innovation activities are frequently most promising when performed in close cooperation and exchange with production and marketing. Hence, locating innovation activities at the most efficient site is hardly an independent decision. This might also include simplified access to additional funds as stockholders reward announcements of global product design and development initiatives (Ojah and Monplaisir, 2003). Hence, the leverage point of efficiency could be invoked (Bartlett and Goshal, 1987).

Disadvantages

The term “disadvantage” could be misleading here since it could be misinterpreted as fundamental shortcomings of globalised innovation activities. In fact, it refers to disadvantages in a relative sense, meaning additional challenges not generally associated with domestic innovation activities. Along these lines, Hymer (1976) coined the term “liability of foreignness”, which implies unavoidable costs for a company operating abroad as opposed to firms operating in their domestic environment. These costs include higher costs related to coordination, unfamiliarity with the respective culture and market and a lack of integration in local information and political networks.

Based on this concept, Zaheer (1995) derives four cost factors:

- Costs directly related to spatial distance: travel, transportation, coordination and monitoring over larger distances and different time zones (Hitt et al., 1994; Gomes and Ramaswamy, 1999).

- Costs arising from a lack of roots and experience in the respective local environment, for example, in assessing risks (higher learning costs).

- Costs due to a lack of perceived legitimacy in the respective host country (higher reputation-building costs).

- Costs related to domestic restrictions, e.g., high technology sales to certain countries (special legal restrictions).

The existence and persistence of liabilities of foreignness has been identified in several studies (Hennart et al., 2002; Mezias, 2002b; Miller and Richards, 2002; Zaheer, 1995). Obviously, these costs are highly firm- and country-specific. They may imply an increase in foreign operating costs and investments (e.g.,

recruitment of local managers) as well as higher risks. Firms face the strategic dilemma of balancing the conflicting forces for efficient global integration and coordination on the one hand and the need to adapt products, processes and operations to local tastes, attitudes and regulations on the other (Bartlett and Goshal, 1989; Doz and Prahalad, 1984; Eden and Molot, 2002; Prahalad and Doz, 1987; Rugman and Verbeke, 1998).

2.3 New operational responses

Given the trade-off presented above, the conventional structural response should be to find an intra-organizational solution, i.e., directly investing abroad to secure as broad an information channel as possible while accepting the associated costs and investments. This follows Coase's (1937) seminal argument that using the market mechanism itself has a price and can only be justified if internalisation is more expensive. For R&D operations that primarily tap scarce global pockets of knowledge and marketing operations that adapt products and services to local needs, this might still be an adequate response. Then again, if only the trigger information for an innovation has to be transferred across borders and this transfer is relatively comprehensive and efficient due to advances in information and telecommunications technology (Liesch and Knight, 1999), new organizational responses beyond internalization become feasible. Therefore, an external source for innovation might activate domestic innovation capacities and competencies which are already in place. In addition, no single market can provide the lead status for innovation in most industries for a longer period of time (Doz et al., 2001), raising the risk of betting on the wrong horse with substantial investments.

Accordingly, Doz et al. (2001) suggest a three-layer approach to building a “metanational” advantage:

- Sensing
  Identifying and accessing new competencies, innovative technologies, and lead-market knowledge.

- Mobilizing
  Integrating scattered capabilities and emerging market opportunities to pioneer new products and services.

- Operations
  Optimizing the size and configuration of operations for efficiency, flexibility, and financial discipline.

This framework emphasizes that modern multinational activities do not necessarily imply having comprehensive innovation infrastructures in every country. For the purpose of this paper, we focus on the case where domestic companies “sense” new sources for innovation in the foreign elements of their value chain from home, “mobilize” their complete organizational capabilities and competencies and “operate” through their domestic innovation facilities. Put differently, maybe there is no need to internalize a foreign market if the information on the foreign market can be internalized (Liesch and Knight, 1999). This appears to be a more suitable approach for a number of companies since innovation activities have remained rather domestically focused (Pavitt and Patel, 1999). Therefore, learning from foreign affiliates is an important strategic option in overcoming liabilities of foreignness (Mezias, 2002a). Hence, we essentially ask: Who uses such an approach and what makes it a feasible option?

The related literature presents several alternative, non-internalized ways of cross-border know-how transfer (Veugelers and Cassiman, 1999): licensing, purchase of equipment, personnel fluctuation, reverse engineering and informal contacts. What is more, we want to distinguish between the different types of knowledge that can be gained from foreign value-chain actors : customers, suppliers and competitors. Each type of input can be valuable at different stages of the innovation process. Schwitalla (1993) identifies six different stages of this process: knowledge, basic research, applied research, industrial development, innovation/imitation and technological/product diffusion. While this suggests a rather sequential process, Kline and Rosenberg (1986) present the chain-linked model, suggesting an ongoing exchange of information among market and research activities. Hence, external sources from abroad could be useful to a company at various stages. Nevertheless, their most prominent value to the company with respect to the innovation process will be outlined briefly as emphasized by Porter (1990) and Von Hippel (1988):

- Customers
  Innovation input from sophisticated and anticipatory customers (“lead users”) allows companies to refine their products and services for future international demand. Although Levitt (1983) suggested most prominently that globalization would ultimately lead to globally homogenous preferences among customers, thereby negating the benefits of international responsiveness, this prediction did not materialise. As globalization lifts income levels, customers look beyond basic daily-life purchases and ask for higher quality products that reflect their culture and personality more deeply, which actually leads to more international diversity in demand and not less (de Mooij, 2000). What is more, even if taste and demand become more homogenous in certain product categories, identifying groups of customers that anticipate

subsequent global demand (lead users) will then generate a competitive advantage through timing.

- Suppliers
  Breakthroughs in related and supporting industries as a source of innovation enable companies to optimize their own operations and subsequently benefit from upstream innovation activities. Eventually, a system of feedback and joint development facilitates learning in the value chain and benefits both partners (Koufteros et al., 2005).

- Competitors
  Their input on innovation is especially valuable since they operate as a potential role model that can propel both new technologies in production and organisation (process innovation) as well as innovative products and services (product innovation) (Craig and Douglas, 2000).

Therefore, we argue that while inputs from each of these three groups open up different opportunities for domestic innovation, we expect to find different innovation strategies. Accordingly, firms will internationalize their innovation activities not only to exploit existing competitive advantages but also to generate new ones through four possible international innovation activities (Le Bas and Sierra, 2002):

- Technology-seeking: selecting a host country that is relatively strong in a specific technology.

- Home-base-exploiting: exploiting firm-specific advantages abroad.

- Home-base-augmenting: complementing a firm-specific advantage in a host country that is also strong in the respective technology.

- Market-seeking: exploiting market (rather than technological) opportunities abroad.

While Le Bas and Sierra (2002) propose this taxonomy for R&D-related FDI, we assume that the motivation for using foreign external sources for innovation should generally not differ. Therefore, we aim to identify and explain them through our analysis. Consequently, an investigation that goes beyond “sources from abroad” and distinguishes instead between foreign customers, foreign suppliers and foreign competitors should yield important insights.

2.4 Factors of using foreign sources for innovation

The previous sections outlined both the disadvantages and advantages of internationalizing innovation activities as well as the organizational possibilities to balance them without internalization. Taking into account these multidimensional facets of our analytical subject, we propose a more viable framework that provides both structure to the problem as well as a base for the subsequent derivation of management implications. In line with Rogers (1995),, we suggest three broad factors that should help explain the usage of foreign external sources for innovation: Access, need and absorptive capacity (ANA). The rationale behind these factors will be outlined in more detail[10].

Access

Having an international value chain is a necessary precondition for using external value chain elements from abroad. The importance of access to foreign technology for local knowledge production has already been empirically established (Veugelers and Cassiman, 1999). Additionally, the richness of transmission channels should propel knowledge flows (Gupta and Govindarajan, 2000). Hence, a company's degree of internationalization should influence the utility it can realize from using these particular sources. Still, we argue, in accordance with a broader stream of literature on the performance effects of internationalization (Hitt et al., 1994; Gomes and Ramaswamy, 1999; Elango, 2004), that the benefits of external sources from abroad follow an inverse u-shaped trend. That is, the advantages outlined above outweigh the costs up to a certain point; then this relationship reverses or the advantages of internalization as opposed to external source usage become dominant. We expect a similar relationship for firm size. While exceedingly small firms might lack the resources to use external sources from abroad, very large firms will likely have the necessary means to internalize them (Liesch and Knight, 1999); or, as former IBM CEO Louis V. Gerstner put it (Prince and Davies, 2004): “Breadth and depth allow for greater investment, greater risk-taking, and longer patience for future payoff.” As a consequence, this should lead to an inverse u-shaped (curvilinear) relationship.

Further, physic and cultural distances should also influence access to foreign sources for innovation. Given the importance of tacit knowledge in the innovation process, the latter should be of especially critical importance. These barriers to knowledge flows have proven to be rather entrenched and persistent in society (Hofstede, 1983; Ghemawat, 2001; Ghemawat, 2003). A number of

[10] Chapter 3 presents additional information on how they were actually operationalized and entered into the empirical investigation as variables.

studies have shown that they actually complicate the flow of innovation knowledge across borders (Maurseth and Verspagen, 2002; Tellis et al., 2003; Yeniyurt and Townsend, 2003). Still, as O'Grady and Lane (1996) show, these distance measures are highly subjective since they can be overcome through organisational configurations, e.g., employees from abroad or with foreign experience in critical positions, and can therefore provide additional points of access. These individuals, frequently called "gatekeepers", (Cohen and Levinthal, 1990) are rather narrowly defined here as being especially able in accessing knowledge across borders by reducing the communication gap and mismatches in "cognitive orientation" (Daghfous, 2004).

Accordingly, we derive two central hypotheses for the influence of access on usage of external sources for innovation from abroad:

- The extent of exposure on international markets makes foreign sources for innovation both more readily available and desirable to compete internationally.

- Sourcing impulses for innovation through the international value chain is preferable up to a certain point; beyond this threshold the benefits of internalization outweigh its costs.

Need

An obvious reason for using external sources from abroad lies in an at least perceived shortage in the quality or quantity of suitable domestic sources. These domestic deficits could originate from three layers in the innovation system: country, industry or firm. All of these can only be ascertained relative to foreign options and as a combination of these three layers. Domestic companies might be both 'pushed' abroad to exploit firm-specific advantages as well as 'pulled' by superior innovation inputs found outside their home borders (Le Bas and Sierra, 2002). Certain domestic paucities might also be based on the fact that important sources for innovation in the value chain have moved abroad (suppliers, customers) or competitors from abroad threaten established market positions (Doz et al., 2001). Indeed, innovation activities are largely not randomly scattered across the globe. The G-7 countries accounted for about 84% of R&D spending in 1995 (Keller, 2004). Hence, the scope of possible target countries for innovation sources appears to be limited. In line with the OLI framework (Dunning, 1981)[11] we suggest that a firm's domestic innovation environment might exhibit disadvantages in the internalization and location sectors of this concept: While the former are either structural (e.g., barriers to competition) or

[11] Dunning (1981) distinguishes between the ownership, location and internalization advantages of internationalization.

cognitive (e.g., high information costs) in nature, the latter arise from non-transferable but superior assets (e.g., skilled labor) abroad. Hence, domestic companies are supposed to make up for shortcomings at home by using external innovation sources from abroad.

What is more, the development stage within the innovation process should not only influence whether a foreign source is suitable but also whether customers, suppliers or competitors should be utilized. As Pearce (1989) and Dunning (1992) suggest, applied R&D activities should more likely be decentralized, while fundamental basic research is better conducted domestically.

Consequently, we propose two central hypotheses for the section concerning need:

- Firms rely on foreign, external sources for innovation to compensate for relative shortcomings in their domestic innovation environments at the country, industry or firm level.
- Using external sources from abroad for innovation is more suitable in applied innovation activities.

Absorptive capacity

Given that companies gain access to external sources for innovation that fit their specific needs, this does not readily imply that they are actually able to leverage this input adequately. The quantity of knowledge flows from abroad does not readily translate into innovation success. As Mansfield and Romeo (1980) show for a sample of US firm subsidiaries in the UK, while more than half of these firms indicated that they were using overseas know-how, only 10 to 15 percent found that 5 percent or more of their innovations were influenced by it. Overcoming this challenge requires absorptive capacities within the firm (Cohen and Levinthal, 1989, 1990): the ability to identify, assimilate and exploit knowledge from the environment, which is developed in performing R&D activities.

Therefore, R&D does not only generate innovations by itself, it also supports the building-up process of knowledge within a company. Since a lot of this knowledge is tacit in nature and rests largely on previous experience, it should not come as a surprise that human resources in the innovation process have been identified as a primary pillar of not only developing internal knowledge stocks but also absorbing them externally (Engelbrecht, 1996).

Subsequently, we formulate two main hypotheses for the absorptive capacity component:

- A firm will be better positioned to leverage external innovation sources from abroad if its employees are well educated and motivated.

- Firms with a comparatively high amount of past R&D investments have better-developed absorptive capacities and can therefore draw larger benefits from foreign innovation impulses.

In conclusion, this framework of access, need and absorptive capacity factors (ANA) for the usage of external business sources from abroad is a theoretical one. The intersections and dependencies among them are obviously significant. Still, we consider it a suitable and workable system of factors one can use to examine why some companies benefit from these foreign innovation sources while others cannot. This allows managers who are interested in this process to pinpoint the central leverage points within their organization. Hence, ANA will provide the blueprint for the following empirical section.

3 Empirical Implementation

3.1 Data and Variables

For the empirical part of this paper we use data from a survey on the innovation behavior of German enterprises called the "Mannheim Innovation Panel" (MIP) The survey is conducted annually by the Centre for European Economic Research (ZEW) on behalf of the German Federal Ministry for Education and Research. The methodology and questionnaire of the survey, which is targeted at enterprises with at least five employees, is the same as that used in the Community Innovation Survey (CIS), conducted every four years by Eurostat. For our analysis we use the 2003 survey, in which data was collected on the innovation behavior of enterprises during the three-year period 2000-2002. About 4,000 firms in manufacturing and services responded to the survey and provided information on their innovation activities.[12] We utilized this data to operationalize the concepts presented above. Additionally, we complemented this dataset with international trade data provided by the OECD (ITCS – International Trade by Commodity Statistics 2003 and TIS – Trade in Services 2004) and data on business R&D expenditures (ANBERD - R&D Expenditure in Industry 2003). The following description focuses on a more conceptual perspective of the variables to facilitate readability. Nevertheless, the interested reader may turn to the annex for an in-depth description on how these variables were constructed.

[12] For a more detailed description of the survey see Janz et al. (2001).

Additionally, where not explicitly indicated otherwise, the industry classification here is based on NACE 2 and can be found in Chapter 6.2 of the annex.

As a starting point, the three dependent variables will be introduced: foreigncustomer, foreignsupplier and foreigncompetitor. These were generated from a question on the country of origin of a customer, supplier or competitor which was used as a source for innovation. These dependent variables are in binary format. They take the value 1 if the respondent named a customer (foreigncustomer), supplier (foreignsupplier) or competitor (foreigncompetitor) from a country other than Germany as a source for innovation. It was possible for a respondent to report using all combinations of these sources simultaneously or none. For the sake of transparency the explanatory variables will be presented in accordance with the ANA framework.

Access

The related literature holds several concepts for measuring the degree of a firms' internationalization. Instruments have been suggested to measure structural (e.g., foreign assets as a percentage of total assets), performance-related (e.g., foreign sales as a percentage of total sales) and attitudinal aspects (e.g., international experience of managers) of this concept (Sullivan, 1994). It should be acknowledged up front that we find no suitable item in our data reflecting the latter concept. Nonetheless, as has been pointed out in the theoretical part of this paper, we consider the attitudinal facet - previously described as "gatekeeping" - an important issue in this regard and hope to capture some of its effect through the other two internationalization variables. We use exports as a share of turnover[13] (exonturn01) as a measurement for performance and two dummy variables indicating whether each firm was part of a multinational group with headquarters in Germany (nationalintroup) or abroad (fullforeigngroup), to account for structural internationalization. The distinction between these two types of multinational groups is in line with Veugelers and Cassiman (1999) to account for different levels of international exposure. This set of variables should be interpreted carefully since they can only be considered proxies and have been criticized for not comprehensively reflecting the degree of internationalization, as probably no single variable can (Sullivan, 1994). Still, they represent two major forces in internationalization strategies: exports and foreign direct investment. To test for the supposed curved-linear relationship between the degree of internationalization and derived utility from using external sources from abroad, we additionally introduced the squared export intensity as a separate variable (sqexonturn01).

[13] We use the lagged values for 2001 in this case to achieve clarity in interpretation; for the 2002 data it would be unclear whether an increased export intensity was the result of source usage from abroad or its cause (endogeneity).

To account for firm size we also introduced the logarithm of the number of employees (lnempl) and, for the effect of exceedingly large cooperations, the squared values of this variable (sqlnempl). Additionally, we want to control for a unique German effect resulting from the country's re-unification. Several studies have shown that even fourteen years after this historic event, Eastern Germany exhibits important structural deficits. Hence, we introduce a variable (east) to indicate whether a company is located in the eastern part of Germany or not. This could very well be interpreted as a simple control variable, but it also adds a regional perspective to our model beyond that of firm and industry.

Need

Building upon the deliberations in Chapter 2.4, we here try to capture the effects of actual or perceived deficits within a company or its domestic environment that can be compensated through the use of foreign external sources for innovation. Special consideration is given to the fact that these shortcomings could be due to country-, industry- or firm-specific factors. We tackle this topic empirically from three different perspectives:

1. Domestic environment
   In this field we argue that a German company will not turn to foreign sources if it finds an adequate or superior environment at home. Accordingly, we try to capture the country- and industry-related aspects of this component by invoking the concept of German competitiveness on international markets. We use Germany's revealed comparative advantage (RCA)[14] among OECD countries in 2002 at the industry level (fulllrca) as a measure for competitive performance and the German share of business R&D expenditures (BERD) in the world[15] by industry in 1999 (worldsharernd) as a measure for competitive potential (Buckley et al., 1988). The latter should also account for the question of whether German companies are implementing a technology-seeking strategy by

[14] The strength of the RCA analysis stems from the opportunity to assess how successful a country has been on foreign markets (exports) in comparison to the foothold foreign competitors were able to gain in that country's domestic market (imports). Additionally, this ratio is compared to the overall export/import ratio of a particular country to the world as a whole. To be precise, this concept measures not only whether exports of a specific product have outweighed imports, but also whether the trade position for this particular product has been stronger than the overall trade performance of the country considered. At the same time, its formulation in logarithmic terms yields continuous, unbound and symmetric results (Wolter, 1977).

[15] The OECD ANBERD database covers the business R&D expenditures of Australia, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom and the United States. Hence, it is considered a suitable proxy for global R&D business expenditures. 1999 is the most current year, featuring a high level of data availability.

using external sources from abroad (Kogut and Chang, 1991). Further, openness to new products on domestic markets and domestic market dynamics as measured by share of turnover with market novelties in the industry (indumnovel) was entered into the model.

2. R&D intensity
   We introduce a dummy variable to the model indicating whether the company in question develops its innovations predominantly internally (intdev). This self-reliance in innovation activities would suggest a pronounced need for external sources. Additionally, the share of R&D expenditures on turnover[16] (rndonturn01) is a proxy for the importance of innovation activities for the company. By including the squared value of this variable in the model (sqrndonturn01) we attempt to test whether companies operating with an extreme degree of R&D intensity also utilize external sources from abroad. This follows the idea that applied R&D is better decentralized while fundamental R&D is better performed centrally at home (Dunning, 1992). While high R&D intensity alone can certainly not provide convincing evidence of basic R&D, it should (carefully) be treated as a reasonable indication in that direction.

3. Obstacles to innovation
   Finally, three firm-level dummy variables are introduced to the model to account for obstacles to innovation which might in turn trigger a search process for external innovation sources from abroad. We suggest that high risks and the closely related high costs (hemyescostrisk) of innovation projects let companies turn to foreign sources for innovation in order to ensure that these high risks and costs can be justified and recovered through increased chances of success outside the domestic market. A lack of technological information (hemyestechnologicalinfo) should also encourage firms to look beyond their company and country borders. Additionally, unfavorable conditions in the public sector may force firms to move their innovation sourcing out of Germany. This might be due to regulation or governmental bureaucracy (hemyesgov) (Buckley and Casson, 1998).

Absorptive capacity

As described above, the utility firms gain through the usage of external innovation sources from abroad does not only depend on whether they can get their hands on them (access) and whether they find them fitting their particular

[16] As stated before, at this point it is not totally clear whether an increased R&D intensity is the result of the usage of foreign sources or its cause (endogeniety). To clarify this casual relationship with R&D intensity as the cause we rely on lagged values for 2001.

needs (need); the utility they can derive from these particular sources should primarily depend on how they can actually exploit them. These absorptive capacities are not a tangible concept but rather a combination of different competencies and capabilities. Hence, companies can not be easily surveyed to estimate the degree to which they possess these absorptive capacities. A number of concepts have been suggested in the literature to capture this rather broad concept. A prominent proxy variable is employees' level of education and academic achievement (Rothwell and Dodgson, 1991). Therefore, we introduce the share of employees with higher education degrees (grads) to our model. Secondly, we rely on the basic concept that R&D not only generates innovations but also builds up absorptive capacities itself (Cohen and Levinthal, 1989, 1990). Accordingly, we expand our model with companies' relative strength in R&D (quotrnd01)[17] and successful exploitation of business sources (quotbusispills)[18] compared to the industry average. Additionally, we suggest that absorptive capacities are not a static resource that can be readily exploited. Instead, they have to be activated and supported by management (Lord and Ranft, 2000). Accordingly, we include a variable of the importance management attributes to stimulating innovation (stimindex). This variable includes a broad range of possible incentives for individual employees to propel innovation like monetary or social encouragement. We argue broadly in line with Lane and Lubatkin (1998) that the more importance firms give to promoting innovations, the less organizational barriers they will have to overcome to leverage sources from abroad.

Furthermore, border effects have been found to be less pronounced in certain industries, such as semiconductors (Irwin and Klenow, 1994). Hence, six additional, instrumental industry group[19] variables have been introduced to capture industry-specific aspects that would distort the explanatory power of our other exogenous variables.

3.2 Descriptive statistics

Complete data for the variables described above were available for 2,284 companies. This is the basis for all of the following elaborations. 415 of these

[17] Measured as a firm's R&D expenditures divided by the industry average.

[18] Measured as an index value indicating how much turnover a firm could generate by using external business sources divided by the industry average.

[19] These industry groups are more broadly defined as "other", "medium high-tech" manufacturing, and "distributive", "knowledge-intensive" and "technological" services. The base group in all cases is "other" manufacturing.

firms had used one or more sources for innovation in the form of a foreign customer (321 observations), supplier (114) or competitor (136). The following section gives a brief overview of the average company characteristics and the differences among them. Table 6.8 of the annex provides a more detailed and complete list of all the means and standard deviations for the variables presented above found for the complete sample, for the control group of companies that had used no foreign external sources for innovation, and for each of the three foreign groups.

Judging from the descriptive statistics in the access field, firms that use foreign business sources for innovation are typically two to three times as large in terms of employees as firms that do not. The same is true for export intensity. While the average firm evincing no foreign source usage generates only 10% of its turnover from exports, its foreign usage counterparts are much more export-reliant, with values between 24 and 36%. They are also more frequently part of multinational groups.

In the need section, firms using foreign sources (foreign customers and foreign competitors) operate in more internationally competitive industries but also on more dynamic domestic markets. More than 60% of them rely primarily on internal competencies and capabilities to generate innovations, while only 24% do so in the control group. Additionally, they invest a higher share of their turnover in R&D and are also more sensitive to obstacles to innovation across the board (technological information, cost and risk, government intervention).

Focusing on absorptive capacities, on average, firms that use external sources from abroad for innovation employ roughly 10% more employees with higher education. They are typically also far ahead of the industry average when it comes to R&D expenditures and turning knowledge spillovers into sales revenues. The control group is on both accounts below the industry average. Additionally, they appear to be more active in stimulating innovation than companies that use no foreign innovation sources.

These first results suggest that firms using external sources from abroad are better off on almost all fronts. Still, this descriptive analysis cannot capture the interconnections among these factors and could therefore be misleading. Accordingly, we want to base the main focus of our discussion and argumentation on the following multivariate analysis.

3.3 Econometric model and method

The decisions to use a foreign customer, supplier or competitor as a source for innovation are not independent of one another. It is quite conceivable that firms

choose multiple sources at the same time, such as when they are operating in multiple industries (we found some of these cases in the data). To model this link between the three decisions adequately, we used a trivariate probit model instead of estimating the equations for each source separately.[20] Within our empirical framework, the trivariate probit is superior to multinomial logit models since it allows us to reflect simultaneous multiple-source usage. The trivariate probit model is directly derived from the standard probit model, but allows more than one equation with correlated disturbances. This technique is quite comparable to the seemingly unrelated regressions model. Estimating three equations simultaneously allows us to improve the estimated sampling precision and subsequently facilitate a more complete usage of the available information. In essence, each probit equation holds information on factors that influenced the decisions on all three possible foreign sources. Estimating these equations simultaneously utilizes this information for the complete system. The specification for our three-equation model is

$$
\begin{aligned}
foreigncustomer^{*} &= \beta_1' x + \varepsilon_1, \quad foreigncustomer = 1 \; if \; foreigncustomer^{*} > 0, 0 \; otherwise, \\
foreignsupplier^{*} &= \beta_2' x + \varepsilon_2, \quad foreignsupplier = 1 \; if \; foreignsupplier^{*} > 0, 0 \; otherwise, \\
foreigncompetitor^{*} &= \beta_3' x + \varepsilon_3, \quad foreigncompetitor = 1 \; if \; foreigncompetitor^{*} > 0, 0 \; otherwise. \\
Cov(\varepsilon_1, \varepsilon_2) &= \rho_1 \\
Cov(\varepsilon_1, \varepsilon_3) &= \rho_2 \\
Cov(\varepsilon_2, \varepsilon_3) &= \rho_3
\end{aligned}
$$

where x is the vector of explanatory variables presented above.

Estimating trivariate or more generally multivariate probit regression models using maximum likelihood methods involves some unique challenges. Normal probability distribution functions have to be calculated in the evaluation of probit-model likelihood functions. While algorithms for the bivariate case exist, more highly dimensional normal distributions are still challenging. Hence, we turned to a simulation-based technique: the Geweke-Hajivassiliou-Keane (GHK) simulator.[21] This simulator relies on sequentially conditioned, univariate normal distribution functions, through which multivariate normal distribution functions can be expressed. The following chapter provides the results.

[20] On this topic see Greene (1993).

[21] The GHK simulator is part of the triprobit procedure developed by Antoine Terracol in the STATA statistical software package.

4 Results

The estimation results of our investigation yield some interesting insights. Table 6.9 of the annex presents a complete overview of the results. Empirical testing (Rho in Table 4.4) validates that the choice of a trivariate probit setup instead of three separate probit estimations is justified. That said, we find that the correlation between the decisions to use foreign customers or suppliers as a source is not significant (the correlations between customers/competitors and suppliers/competitors are positive and significant). We argue that this is due to their differing positions in the value chain (upstream and downstream, respectively). Hence, we conclude that demand-pull or technology-push factors in knowledge sourcing from abroad do not trigger identical (or closely related) innovation processes within innovating firms, a rationale that is in line with findings on domestic sources for innovation. Nevertheless, incorporating the correlation among these three equations did in fact increase the precision of the estimation. In addition, the significant correlations with foreign competitors as a source for innovation give a first indication of the importance of international competition for the usage of external sources from abroad.

As stated previously, Table 6.9 presents the complete estimation results. Nevertheless, for the argumentative purpose of this section and the subsequent conclusions we find it more fitting and convenient to discuss our findings in three steps. Hence, we return to the ANA framework. The results for the access variables will described first, followed by the need variables and the absorptive capacity variables. However, this should not be misinterpreted as three different model specifications; these are merely three parts of the same trivariate probit estimation. Furthermore, the control variables for the industry group variables were part of the estimation. Given that a considerable part of the explanatory variables were aggregated at an industry level, their analytical contribution could be questionable. Nevertheless, they will be briefly outlined at the end of this chapter.

Access

Table 4.1 shows the estimation results for the access variables. Interestingly enough, we find a significant regional effect beyond the expected firm and industry layers: Companies from the eastern part of Germany are increasingly more likely to use foreign competitors as a source for innovation. We argue that firms from Eastern Germany are still trying to catch up with domestic and international competition. They may be more inclined to imitate tried and proven products and processes on international markets instead of incurring the risks of betting on the wrong horse in venturous first moves (Sofka and Schmidt, 2004).

Table 4.1: Results for trivariate probit estimations of probability of using a foreign customer, supplier or competitor as a source for innovation: Access variables

Definitions	*Variable*	*Foreign customer*	*Foreign supplier*	*Foreign competitor*
Company is located in Eastern Germany (Dummy)	east	0.111	-0.020	0.311**
		(0.098)	(0.121)	(0.129)
Number of employees (log)	lnempl	0.132	0.109	0.157
		(0.105)	(0.123)	(0.144)
Squared number of employess (log)	sqlnempl	-0.013	-0.007	0.003
		(0.010)	(0.011)	(0.013)
Share of exports in turnover 2001	exonturn01	0.041***	-0.005	0.015*
		(0.006)	(0.007)	(0.008)
Squared share of exports in turnover 2001	sqexonturn01	-0.0003***	0.0001	-0.0001
		(0.000)	(0.000)	(0.000)
Company is part of multinational group with foreign headquarters (Dummy)	fullforeigngroup	-0.178	0.194	-0.034
		(0.153)	(0.179)	(0.184)
Company is part of multinational group with German headquarters (Dummy)	nationalintgroup	0.086	0.068	-0.025
		(0.134)	(0.171)	(0.163)

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Measurements of fit will be provided in Table 4.4.

For the utilization of external sources from abroad, size does not matter. We find neither a linear nor a curvilinear relationship. In contrast, the export intensity shows the expected inverse u-shaped relationship with usage of foreign customers as a source for innovation. The likelihood of using this source increases as the share of exports on turnover increases up to a certain threshold, after which it declines.[22] This result yields two important insights: First, relying on foreign customers as an innovation source is not especially favorable for companies which depend either heavily or negligibly on exports to drive their sales. Secondly, simple derivation shows that the climax in the benefits of foreign customer innovation inputs is reached when exports represent roughly 68% of turnover; any less and the pay-offs are suboptimal, but a greater share is met with declining benefits. An internalization strategy may provide a better cost-benefit ratio.

For foreign competitors we find a linear relationship between export intensity and their value as sources for innovation. This leads us to believe that with

[22] The fit of the curvilinear probit models is also higher than the fit of its linear counterparts.

growing exposure on international markets, firms may find learning from foreign competitors is not only easier but also more critical to surviving in competition.

Our variables for structural internationalization (indicating whether a company is part of a multinational group) show no significant impact at all. We argue that already established intra-organizational links to foreign elements of the value chain will lead to access through subsidiaries abroad, thus turning external sources from abroad into internal ones.

One more thing sticks out here: Access seems to be no valid concept for using foreign supplier sources. None of the explanatory variables presented show a significant impact. However, suppliers are distinctly different from the other two prospective sourcing partners. Suppliers are located upstream in the value chain. Hence, an established, contracted channel already exists between these two companies and information flows have been established towards the innovating company, embodied in the product or service provided by the supplier.

Need

Table 4.2 shows the estimation results of the need variables. Again, this should not be misinterpreted as a separate estimation; it is only a part of the full estimation presented in Table 6.9.

Table 4.2: Results for trivariate probit estimations of probability of using a foreign customer, supplier or competitor as a source for innovation: Need variables

Definitions	***Variable***	***Foreign customer***	***Foreign supplier***	***Foreign competitor***
Revealed comparative advantage in industry, 2002 (NACE2; in logs; multiplied by 100)	fulllrca	0.001	0.001	0.001
		(0.001)	(0.001)	(0.001)
German share of global business R&D in industry, 1999	worldsharernd	-0.029***	-0.035***	-0.014
		(0.009)	(0.009)	(0.011)
Industry share of turnover with market novelties	indumnove	0.022	0.056***	-0.005
		(0.016)	(0.018)	(0.022)
Company develops innovations primarily internally (dummy)	intdev	0.517***	0.064	0.303**
		(0.100)	(0.123)	(0.138)
Share of R&D expenditures in turnover, 2001	mdontum01	0.043***	-0.000	0.014
		(0.012)	(0.014)	(0.015)
Squared share of R&D expenditures in turnover, 2001	sqrndonturn01	-0.001***	-0.000	-0.000

Definitions	*Variable*	*Foreign customer*	*Foreign supplier*	*Foreign competitor*
		(0.000)	(0.000)	(0.000)
Obstacle - lack of technological information (dummy)	hemyestechnologicalinfo	0.137	0.015	0.381**
		(0.139)	(0.169)	(0.156)
Obstacle - innovation costs or risk (dummy)	hemyescostrisk	0.126	0.512***	0.156
		(0.095)	(0.112)	(0.117)
Obstacle regulation or bureaucratic red tape (dummy)	hemyesgov	0.184	0.246*	0.192
		(0.119)	(0.133)	(0.138)
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

Note: Measurements of fit will be provided in Table 4.4.

While the competitive performance of German companies on international markets (measured by the industry RCA) does not significantly influence the decision to use foreign sources for innovation, competitive potential (Germany's share of global business R&D expenditures) does. We find that foreign customers and suppliers become less valuable as innovation sources if the domestic innovation environment is strong compared to the rest of the world. Hence, we do actually find a trade-off between domestic and foreign inputs for innovation.

Then again, as domestic markets become more dynamic in terms of market share with novel products and services, German companies become more likely to turn to foreign suppliers for ideas in innovation. We argue that German companies which face an increased pressure of seeing their products become obsolete on dynamic markets focus on their core competencies and rely on foreign suppliers to provide them with the necessary technology push to compete with new products and services. The fact that increased costs and risks in innovation activities also drive the use of foreign suppliers substantiates this argument. Still, a less favorable public-sector environment due to regulation or bureaucracy makes German companies also more likely to source their innovation ideas from suppliers abroad, which could be the result of a broader outsourcing strategy. In essence, turning to foreign suppliers can be both a technology-seeking and a risk-avoiding strategy.

As expected, a more pronounced self-reliance in innovation activities increases the value foreign sources for innovation from customers and competitors. Firms that refrain from outsourcing innovation activities need this input from abroad as some sort of reality check for their own developments. Additionally, as R&D intensity increases, so does the value of sources for innovation from foreign customers. We find no significant relationship for competitors or suppliers. On the other hand, firms turn to foreign competitors if they experience deficits in technological know-how. Independent of the knowledge intensity of their

production, firms might try to both reduce the risks of innovating in the wrong direction and “free-ride” on their competitors' innovation investments.

For foreign customers, however, we find the previously explained curvilinear relationship. If a company’s R&D expenditures are below 21%, they benefit from using foreign customers as a source for innovation; beyond that threshold, the rewards decline. This finding supports the earlier hypothesis that applied R&D (e.g., adapting existing products to international demand), indicated by relatively low R&D expenditures, benefits more from the inputs of foreign customers as opposed to fundamental, more expensive research that is better served by circumventing the border effect and investing directly abroad. Therefore, using foreign customers as a source for innovation might be a more appropriate market-seeking (or in other words demand-pull) strategy for established products, while technology-seeking strategies might better be targeted at foreign suppliers.

Absorptive capacity

The estimation results for the absorptive capacity variables are presented in Table 4.3. It comes as a surprise that having well-educated employees only increases the likelihood of using foreign customers as sources for innovation and not that of suppliers or competitors. We argue that this is due to the fact that knowledge exchange with the latter two might rely more on professional experience than on formal education. Firms with highly qualified personal (in terms of formal education) might also be more likely to offer complex and sophisticated products and services that require close interaction with customers.

Table 4.3: Results for trivariate probit estimations of probability of using a foreign customer, supplier or competitor as a source for innovation: Absorptive capacity variables

Definitions	***Variable***	***Foreign customer***	***Foreign supplier***	***Foreign competitor***
Share of graduates in employees	grads	0.005**	-0.002	0.000
		(0.002)	(0.003)	(0.003)
Relative position to industry average in R&D, 2001	quotmd01	-0.009	0.003	-0.024*
		(0.007)	(0.007)	(0.014)
Relative position to 2001 industry average in absorbing business spillovers	quotbusispills	0.162***	0.164***	0.218***
		(0.018)	(0.019)	(0.023)
Index value of management stimulation for innovation	stimindex	1.002***	0.817**	0.832***
		(0.267)	(0.341)	(0.316)

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Measurements of fit will be provided in Table 4.4.

What is more, firms that are relatively strong in extracting and leveraging valuable know-how from customers, suppliers and competitors on a domestic scale are also better prepared to leverage these capabilities and competencies on an international scale. This appears to be a central organizational trait, which does not distinguish between the sources of origin in the value chain. In line with what has been stated above in the section regarding need, we find that if German companies spend less than the industry average on R&D, they are more inclined to rely on foreign competitors to compensate for this deficit. Moreover, if employees are encouraged to innovate they turn to sources from abroad at all stages of the value chain.

Industry variables and measurements of fit

As stated previously, the following presentation of the industry group variables may be questionable because the variables predominantly serve as instrument variables to account for industry effects not covered by other variables. Nevertheless, they basically represent certain technological characteristics of the industries (and hence products) under consideration and will be outlined briefly.

Table 4.4: Results for trivariate probit estimations of probability of using a foreign customer, supplier or competitor as a source for innovation: Industry group variables and measurements of fit

Definitions	***Variable***	***Foreign customer***	***Foreign supplier***	***Foreign competitor***
Industry group medium high-tech manufacturing	indugroup2	0.449***	0.052	0.708***
		(0.145)	(0.204)	(0.216)
Industry group high-tech manufacturing	indugroup3	0.263	0.207	0.893***
		(0.175)	(0.227)	(0.255)
Industry group distributive services	indugroup4	-0.006	0.211	-2.627***
		(0.206)	(0.192)	(0.505)
Industry group knowledge-intensive services	indugroup5	-0.632**	-0.553*	0.286
		(0.286)	(0.294)	(0.292)
Industry group technological services	indugroup6	0.006	0.517***	1.019***
		(0.183)	(0.199)	(0.248)
Constant	constant	-3.195***	-2.935***	-4.288***
		(0.293)	(0.364)	(0.455)
Observations		2284		
Wald chi2(78)		857.00		
Prob > chi2		0.000		
Log-likelihood		-1141.59		
Aldrich Nelson Pseudo R2		0.57		

Definitions	*Variable*	*Foreign customer*	*Foreign supplier*	*Foreign competitor*
	Rho	(1,2) -.0186	(1,3) 0.4***	(2,3) 0.261***

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

In the manufacturing sector, foreign competitors become a more valuable source for innovation as the industry becomes more reliant on high technology. This supports our argument concerning technology-seeking abroad. The input of foreign customers is only cherished at the medium high-tech level of manufacturing (e.g., the automotive industry). Therefore, at this technology level in manufacturing we find a combination of market-seeking through foreign customers and technology-seeking through foreign competitors (but not suppliers).

In the service sector we find a negative relationship between distributive services (e.g., wholesale) and sources for innovation from foreign competitors. The same is true for the relationship between knowledge-intensive services (e.g., financial intermediation) and sources from foreign competitors or foreign suppliers. This leads us to believe that in these sectors, the products are and have to be tailor-made for domestic customers; not much is gained from foreign sources for innovation. Then again, when it comes to technological services (e.g., ICT services) we find a technology-seeking strategy targeting foreign suppliers and competitors. This in turn underscores our argument that these two groups provide valuable innovation input from abroad (technology push) as services become more sophisticated and less standardized.

5 Summary

So far, the results have been analyzed and organized along the factor dimension (ANA). The following section will choose a different format by opening up a different perspective along the sources.

Foreign customers

Customers are arguably the most important external factor for the success of any company. Therefore, it should not come as a surprise that the input from foreign customers for innovation is a crucial item in the innovation process. International customers clearly become more important as companies explore growth opportunities beyond the borders of their home countries. Our results on the curvilinear relationship between share of exports in turnover and usage of foreign customer sources suggest that the benefits of global integration, i.e.,

relying on domestic operations and ensuring international responsiveness through external sources, work up to a certain point. Beyond this threshold the importance of foreign customers - and hence, the costs and risks of the liability of foreignness - may become dominant. Subsequently, companies finding themselves in such a position may be forced to internalize their previously external channels for providing responsiveness outside domestic markets. This not only protects their access to these particular sources for innovation but also enables a broader and richer stream of information - albeit one that requires substantial investments.

Additionally, we find that customer input is rather valuable when the share of R&D in turnover is limited, indicating, according to our reasoning, that R&D may be more directed towards adapting and extending existing products and services, which makes an international division of labor less beneficial. Highly R&D-intensive activities do not benefit as much from foreign customers as a source for innovation; they more likely require a technology push instead of a demand pull. This argument could probably be readily extended to innovation impulses from domestic customers. That said, Germany's high share of global business R&D expenditures indicates that German customers exhibit a certain lead status in that market, which obviously makes innovation inputs from foreign customers less attractive.

Following this line, we find that when companies exhibit excellent capabilities and competencies in exploiting external business sources they can extend these assets across borders. We argue that this is the combined result of skilled employees and an organizational system that supports and encourages innovation instead of raising barriers.

Foreign suppliers

As expected, we find that the position of foreign sources for innovation in the value chain influences their utility as a source for innovation. Obviously, access to foreign suppliers as such a source does not appear to be an issue. A broad exchange of information is already established with the supplier, whose value as a source for innovation is for the most part embodied in its products and services.

While access is not an issue in dealing with foreign suppliers, need is. As German companies are less favorably positioned in global R&D, market pressures, costs and risks are high and the public-sector environment is less supportive: They look upwards in the value chain to share the burden. In addition, we may also find some effects of conventional outsourcing activities to foreign suppliers, which should in turn produce innovation-relevant information streams to the home country. In essence, we identify a risk-sharing and technology-seeking strategy with foreign suppliers, indicating that projects with

considerable risks in difficult environments are better performed with outside expertise from abroad. The combination of these two strategies might also point towards a home-base-augmenting strategy. We also find, as in the case of customers, that the utility derived from foreign suppliers is considerable when firms are strong in leveraging external business sources towards turnover, particularly through a supportive management and incentive system.

Foreign competitors

Foreign competitors are primarily a source for innovation as companies intensify their international exposure. Not surprisingly, this is a strictly linear relationship. Innovation inputs from foreign competitors become more readily available as internationalization in sales intensifies, but also become more crucial for competing on foreign markets. Additionally, we find an interesting regional effect for firms from Eastern Germany. They are significantly more inclined to learn from foreign competitors than their Western German counterparts.

The fact that foreign competitors become all the more valuable as innovation activities are predominantly performed internally and technological information remains scarce is also quite revealing. That is, at increasing degrees of internalization (access) companies are more and more confronted with foreign competitors and benefit from this exposure by participating in some of their competitors' innovation activities (need). Apparently, this represents a technology-seeking strategy. As stated for the other two groups, a company’s particular expertise in exploiting external business opportunities propels usage of foreign competitors as a source for innovation. What is more, encouraging innovation throughout companies leads to significantly increased imitation attempts of foreign competitors.

Conclusion

Our analysis did benefit from a broad representative sample of German firms. Admittedly, it was not primarily designed for the particular purpose of this research project and, consequently, interpretation of the empirical results has to be conducted carefully. In essence, we find that while the rationales of using foreign customers, suppliers or competitors as sources for innovation differ, the absorptive capacities to leverage them do not. We suggest that, on a personnel and organizational level, these capabilities and competencies are developed domestically and can be transferred across borders if they can be made available (access) and are relevant (need).

Our results suggest that demand pull from foreign customers is most important if products are relatively standardized, international exposure is strong and the lead status of domestic customers (business R&D expenditures) is limited. Then again, we find that keeping this market-seeking strategy external from the

company works only up to a certain threshold, after which the benefits of internalization outweigh its costs. Relying on foreign suppliers for innovation inputs is largely a risk-sharing but also a technology-seeking strategy, as domestic markets are dynamic and R&D expenditures are relatively more concentrated abroad, and risks and costs increase in less favorable governmental environments. Hence, this could be a home-base-augmenting strategy. Finally, we suggest a purer technology-seeking strategy if foreign competitors are used as a source for innovation. This technology push is most beneficial if it can be readily evaluated and attained in the presence of competition on foreign markets and a lack of technological information in self-centered innovation processes.

Eventually, it has to be acknowledged that we examine actual and not best practices. While one could certainly argue that competition would eventually force inadequate companies out of business, we cannot ascertain that our dataset reflects such a long-term optimal situation. Hence, a logical next step would be to focus on the outcomes of firms that use these sources and whether they witness any performance impact. In addition, including a regional perspective to this framework would help to explain whether the relevant innovation system for a company is best described by national borders or by the regional cluster in which it operates. Perhaps we can increase our own international exposure through this paper and rely more on foreign research competitors to lead the way.

6 Annex

6.1 Variables

Table 6.5: Definition of dependent variables

Variable	***Definition***
Foreign customer	Dummy variable is 1 if the company indicated that it used at least one customer as a source for innovation from a country other than Germany.
Foreign supplier	Dummy variable is 1 if the company indicated that it used at least one supplier as a source for innovation from a country other than Germany.
Foreign competitor	Dummy variable is 1 if the company indicated that it used at least one competitor as a source for innovation from a country other than Germany.

Table 6.6: Definition of exogenous variables

Variable	***Definition***
east	Dummy variable is 1 if the company is located in Eastern Germany.
lnempl	Natural logarithm of number of employees in the year 2002.
sqlnempl	Squared natural logarithm of number of employees in the year 2002.
exonturn01	Share of exports in turnover, 2001.
sqexonturn01	Squared share of exports in turnover, 2001.
fullforeigngroup	Dummy variable is 1 if the company is part of multinational group with foreign headquarters.
nationalintgrou	Dummy variable is 1 if the company is part of multinational group with German headquarters.
fulllrca	The quotient between exports and imports in an industry (NACE2) divided by the quotient between overall German exports and imports in 2002; in logs, multiplied by 100.
worldsharernd	German share of business expenditures on R&D among reporting OECD countries in current PPP USD in 1999 by industry (NACE2).
indumnove	Industry (NACE2) share of turnover with market novelties, 2002.
intdev	Dummy variable is 1 if the company develops its innovations predominantly internally.
mdontum01	Share of R&D expenditures in turnover, 2001.
sqrndonturn01	Squared share of R&D expenditures in turnover 2001.
hemyestechnologicalinfo	Dummy variable is 1 if the company indicated that a lack of technological information obstructed its innovation projects.
hemyescostrisk	Dummy variable is 1 if the company indicated that high economic risks or costs obstructed its innovation projects.
hemyesgov	Dummy variable is 1 if the company indicated that regulation or government bureaucracy obstructed its innovation projects.
grads	Share of graduates on employees, 2002.
quotmd01	The quotient between the firm's R&D expenditures and the industry (NACE2) average in 2001.
quotbusispills	The quotient between the index value of a company for absorbing business

Variable	*Definition*
	spillovers divided by its industry (NACE2) average. The index was generated as follows: Companies rated on a five-point scale according to what share of turnover they were able to generate from their use of customers, suppliers or competitors as sources for innovation. A principal component factor analysis was performed on these three categories, yielding a single factor with an eigenvalue larger than one (1.63). The index represents these factor loadings after Varimax rotation rescaled between 0 and 1.
stimindex	Index value of management stimulation for innovation. The index was derived as follows: Companies indicated on a four-point scale according to what importance their company assigned to nine different measures of stimulating innovation, ranging from targeted recruiting to immaterial incentives and monetary bonuses. A principal component factor analysis was performed on these nine categories, yielding a single factor with an eigenvalue larger than one (5.94). The index represents these factor loadings after Varimax rotation rescaled between 0 and 1.

Table 6.7: Definition of instrument variables

Variable	*Definition*
Indugroup1	Dummy variable is 1 if company operates in other manufacturing.
Indugroup2	Dummy variable is 1 if company operates in medium high-tech manufacturing.
Indugroup3	Dummy variable is 1 if company operates in high-tech manufacturing.
Indugroup4	Dummy variable is 1 if company operates in distributive services.
Indugroup5	Dummy variable is 1 if company operates in knowledge-intensive services.
Indugroup6	Dummy variable is 1 if company operates in technological services.

6.2 Industry breakdown

Industry	NACE Code	Industry Group
Mining and quarrying	10 – 14	Other manufacturing
Food and tobacco	15 – 16	Other manufacturing
Textiles and leather	17 – 19	Other manufacturing
Wood / paper / publishing	20 – 22	Other manufacturing
Chemicals / petroleum	23 – 24	Medium high-tech manufacturing
Plastic / rubber	25	Other manufacturing
Glass / ceramics	26	Other manufacturing
Metal	27 – 28	Other manufacturing
Manufacture of machinery and equipment	29	Medium high-tech manufacturing
Manufacture of electrical machinery	30 – 32	High-tech manufacturing
Medical, precision and optical instruments	33	High-tech manufacturing
Manufacture of motor vehicles	34 – 35	Medium high-tech manufacturing
Manufacture of furniture, jewellery, sports equipment and toys	36 – 37	Other manufacturing
Electricity, gas and water supply	40 – 41	Other manufacturing
Construction	45	Other manufacturing
Retail and motor trade	50, 52	Distributive services
Wholesale trade	51	Distributive services
Transportation and communication	60 – 63, 64.1	Distributive services
Financial intermediation	65 – 67	Knowledge-intensive services
Real estate activities and renting	70 – 71	Distributive services
ICT services	72, 64.2	Technological services
Technical services	73, 74.2, 74.3	Technological services
Consulting	74.1, 74.4	Knowledge-intensive services
Other business-oriented services	74.5 – 74.8, 90	Distributive services

6.3 Descriptive statistics

Table 6.8: Descriptive statistics: means, standard errors in parentheses

Definition	*Variable*	*Complete sample*	*No foreign sources*	*Foreign customers*	*Foreign suppliers*	*Foreign competitors*
Access						
Company is located in Eastern Germany (Dummy)	east	0.35	0.36	0.35	0.33	0.38
		(0.48)	(0.49)	(0.49)	(0.47)	(0.49)
Number of employees	empl	653.48	553.96	1151.38	1444.30	1645.07
		(9933.63)	(10531.84)	(6923.53)	(9786.88)	(6325.15)
Number of employees (log)	lnempl	3.93	3.77	4.70	4.72	5.23
		(1.77)	(1.70)	(1.84)	(1.96)	(2.05)
Squared number of employess (log)	sqlnempl	18.59	17.14	25.49	26.04	31.48
		(16.48)	(15.22)	(20.06)	(20.86)	(23.45)
Share of exports in turnover 2001	exonturn01	14	10.16	36.28	23.57	34.32
		(22.91)	(19.75)	(27.10)	(28.21)	(29.13)
Squared share of exports in turnover 2001	sqexonturn01	720.49	492.99	2048.58	1344.37	2019.74
		(1636.26)	(1366.96)	(2307.42)	(2196.67)	(2408.41)
Company is part of multinational group with foreign headquarters (Dummy)	fullforeigngroup	0.07	0.06	0.12	0.14	0.16
		(0.25)	(0.23)	(0.33)	(0.35)	(0.37)
Company is part of multinational group with German headquarters (Dummy)	nationalintgroup	0.1	0.08	0.21	0.18	0.24
		(0.3)	(0.27)	(0.41)	(0.38)	(0.43)
Need						
Revealed comparative advantage in industry 2002 (NACE2; in logs; multiplied by 100)	fulllrca	9.69	8.36	17.77	9.32	19.73
		(66.31)	(70.52)	(40.39)	(54.02)	(34.95)
German share of global, business R&D in industry 1999	worldsharernd	10.16	10.34	9.61	7.99	9.56
		(6.66)	(6.94)	(5.03)	(5.51)	(5.15)
Industry share of turnover with market novelties	indumnove	2.81	2.46	4.66	4.02	4.38
		(3.23)	(3.04)	(3.62)	(3.35)	(3.36)
Company develops innovations primarily internally (Dummy)	intdev	0.33	0.24	0.76	0.64	0.75
		(0.47)	(0.43)	(0.42)	(0.48)	(0.43)
Share of R&D	mdontum01	2.83	1.76	7.89	6.45	8.20

Definition	*Variable*	*Complete sample*	*No foreign sources*	*Foreign customers*	*Foreign suppliers*	*Foreign competitors*
expenditures on turnover, 2001						
		(8.07)	(6.28)	(11.97)	(11.89)	(13.04)
Squared share of R&D expenditures in turnover, 2001	sqrndonturn01	73.08	42.57	205.03	181.63	235.91
		(380.29)	(290.78)	(572.24)	(621.46)	(724.22)
Obstacle - lack of technological information (Dummy)	hemyestechnologicalinfo	0.05	0.04	0.13	0.14	0.20
		(0.23)	(0.20)	(0.33)	(0.35)	(0.37)
Obstacle - innovation costs or risk (Dummy)	hemyescostrisk	0.23	0.18	0.45	0.59	0.50
		(0.42)	(0.38)	(0.50)	(0.49)	(0.50)
Obstacle - regulation or bureaucratic red tape (Dummy)	hemyesgov	0.12	0.09	0.23	0.32	0.29
		(0.32)	(0.29)	(0.42)	(0.47)	(0.45)
Absorptive capacity						
Share of graduates in employees	grads	22.81	20.94	30.85	27.86	32.44
		(26.54)	(26.10)	(26.43)	(25.73)	(25.99)
Relative position to industry average in R&D, 2001	quotmd01	0.63	0.45	1.19	1.89	1.32
		(5.36)	(4.36)	(7.05)	(10.14)	(3.56)
Relative position to industry average in 2001 in absorbing business spillovers	quotbusispills	1.16	0.65	3.29	4.88	4.52
		(2.45)	(1.82)	(3.32)	(4.33)	(4.10)
Index value of management stimulation for innovation	stimindex	0.36	0.32	0.51	0.51	0.53
		(0.17)	(0.15)	(0.18)	(0.17)	(0.17)
Number of observations		2284	1869	321	114	136

6.4 Regression results

Table 6.9: Results for trivariate probit estimations of probability of using a foreign customer, supplier or competitor as a source for innovation

Definitions	*Variable*	*Foreign customer*	*Foreign supplier*	*Foreign competitor*
Access				
Company is located in Eastern Germany (Dummy)	east	0.111	-0.020	0.311**
		(0.098)	(0.121)	(0.129)
Number of employees (log)	lnempl	0.132	0.109	0.157
		(0.105)	(0.123)	(0.144)
Squared number of employess (log)	sqlnempl	-0.013	-0.007	0.003
		(0.010)	(0.011)	(0.013)
Share of exports in turnover, 2001	exonturn01	0.041***	-0.005	0.015*
		(0.006)	(0.007)	(0.008)
Squared share of exports in turnover, 2001	sqexonturn01	-0.0003***	0.0001	-0.0001
		(0.000)	(0.000)	(0.000)
Company is part of multinational group with foreign headquarters (Dummy)	fullforeigngroup	-0.178	0.194	-0.034
		(0.153)	(0.179)	(0.184)
Company is part of multinational group with German headquarters (Dummy)	nationalintgroup	0.086	0.068	-0.025
		(0.134)	(0.171)	(0.163)
Need				
Revealed comparative advantage in industry, 2002 (NACE2; in logs; multiplied by 100)	fulllrca	0.001	0.001	0.001
		(0.001)	(0.001)	(0.001)
German share of global, business R&D in industry, 1999	worldsharernd	-0.029***	-0.035***	-0.014
		(0.009)	(0.009)	(0.011)
Industry share of turnover with market novelties	indumnove	0.022	0.056***	-0.005
		(0.016)	(0.018)	(0.022)
Company develops innovations primarily internally (Dummy)	intdev	0.517***	0.064	0.303**
		(0.100)	(0.123)	(0.138)
Share of R&D expenditures in turnover 2001	mdontum01	0.043***	-0.000	0.014
		(0.012)	(0.014)	(0.015)
Squared share of R&D expenditures in turnover 2001	sqrndonturn01	-0.001***	-0.000	-0.000
		(0.000)	(0.000)	(0.000)

Definitions	*Variable*	*Foreign customer*	*Foreign supplier*	*Foreign competitor*
Obstacle lack of technological information (Dummy)	hemyestechnologicalinfo	0.137	0.015	0.381**
		(0.139)	(0.169)	(0.156)
Obstacle innovation costs or risk (Dummy)	hemyescostrisk	0.126	0.512***	0.156
		(0.095)	(0.112)	(0.117)
Obstacle regulation or bureaucratic red tape (Dummy)	hemyesgov	0.184	0.246*	0.192
		(0.119)	(0.133)	(0.138)
Absorptive capacity				
Share of graduates in employees	grads	0.005**	-0.002	0.000
		(0.002)	(0.003)	(0.003)
Relative position to industry average in R&D, 2001	quotmd01	-0.009	0.003	-0.024*
		(0.007)	(0.007)	(0.014)
Relative position to industry average in 2001 in absorbing business spillovers	quotbusispills	0.162***	0.164***	0.218***
		(0.018)	(0.019)	(0.023)
Index value of management stimulation for innovation	stimindex	1.002***	0.817**	0.832***
		(0.267)	(0.341)	(0.316)
Instruments				
Industry group medium high-tech manufacturing	indugroup2	0.449***	0.052	0.708***
		(0.145)	(0.204)	(0.216)
Industry group high-tech manufacturing	indugroup3	0.263	0.207	0.893***
		(0.175)	(0.227)	(0.255)
Industry group distributive services	indugroup4	-0.006	0.211	-2.627***
		(0.206)	(0.192)	(0.505)
Industry group knowledge-intensive services	indugroup5	-0.632**	-0.553*	0.286
		(0.286)	(0.294)	(0.292)
Industry group technological services	indugroup6	0.006	0.517***	1.019***
		(0.183)	(0.199)	(0.248)
Constant	constant	-3.195***	-2.935***	-4.288***
		(0.293)	(0.364)	(0.455)
Observations	2284			
Wald chi2(75)	857.00			
Prob > chi2	0.000			
Log-likelihood	-1141.59			
Aldrich Nelson Pseudo R2	0.57			
Rho		(1,2) -.0186	(1,3) 0.4***	(2,3) 0.261***

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

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