Firms in Integrating Europe:

Innovation, Trade and Productivity

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List of Abbreviations

2SLS	Two-Stage Least Square
AHS	Effectively Applied Tariff
CA	Canada
CEE	Central and Eastern Europe
CTS	Consolidated Tariff Schedules Database
DSF	Downstream Firm
EBDC	Economic Business and Data Center
EPO	European Patent Office
EU	European Union
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
FYR	Former Yugoslav Republic
GDP	Gross Domestic Product
GPTO	German Patent and Trade Mark Office
HS	Harmonized System
IDB	Integrated Database System
IN	Integration
IPR	Intellectual Property Rights
ISIC	International Standard Industrial Classification
IT	Information Technology
IV	Instrumental Variable Approach
IN	Integration
IPR	Intellectual Property Rights
ISIC	International Standard Industrial Classification
IT	Information Technology
IV	Instrumental Variable Approach
NACE	Classification of Economic Activities in the European Community (Nomenclature Générale des Activités Économiques)
NI	Non-Integration

OECD	Organisation for Economic Co-operation and Development
OeNB	Austrian National Bank
OLS	Ordinary Least Squares
PCT	Patent Cooperation Treaty
PIE	PRO INNO Europe
R&D	Research and Development
SIC	Standard Industrial Classification
SII	Summary Innovation Index
SME	Small and Medium-sized Enterprises
TFP	Total Factor Productivity
TRAINS	Trade Analysis and Information System
UN	United Nations
UN COMTRADE	United Nations Commodity Trade Statistics Database
UNCTAD	United Nations Conference on Trade and Development
UK	United Kingdom
US	United States
USD	United States Dollar
USF	Upstream Firm
VIB	Backward Vertical Integration
VIF	Forward Vertical Integration
WIPO	World Intellectual Property Organization
WITS	World Integrated Trade Solution

Chapter 1

Introduction

Integration of the global economy and trade liberalization in the ongoing process of European integration strike both countries and firms. Within this process Germany and Austria are the countries most affected by the eastern enlargement: owing to the increasing competition and new opportunities concerning mobility and attraction of human capital, firms reorganize their structure (Marin 2008). That is, trade policy changes the firm's environment, amongst others, in terms of greater competition (Melitz 2003) and improved access to foreign technology (Grossman and Helpman 1991). It incentivizes further firm investments, international relocation of production, intra-firm trade as well as exporting activities which in turn lead to performance improvements in the corporation.[1]

As most recently stated by the German Federal Statistical Office (2008a), 82 percent of German firms that relocated domestic activities to foreign countries argued that the primary motivations for their relocation are market access and cost reduction owing to labor costs.[2] The report states that product development, foreign knowledge access or a follow-your-customer strategy are

[1] See Holmes and Schmitz 2001, Kunst and Marin 1989, Wagner 2002, Wagner 2007.

[2] Considered period between 2001 and 2006. See German Federal Statistical Office (2008a).

less important. Furthermore, the German Federal Statistical Office (2008a) points out that firms with 100 or more employees experienced a positive impact on their competitiveness (73 percent) as well as reduced labor costs (67 percent).[3] In addition, between 2001 and 2006 almost 60 percent of the considered German firms moved into a country of the new European member states (German Federal Statistical Office 2008a, pp.3).[4] Therefore, the main drivers of the firm performance within the globalization process, especially owing to eastern enlargement, are trade liberalization and the international division of firm activities.[5]

The firm's decision to go abroad is determined, amongst others, by cost saving aspects due to low market wages, off-peak periods, and economies of scale (Abraham and Taylor 1996, p.396ff). Moreover, improved access to higher quality inputs (Grossman and Helpman 1991) as well as ensuring property rights through better protection of intangible assets (Blomström and Sjöholm 1999) play also a significant role. That is, trade liberalization and the international organization of the firm provide additional resources which can be used for further investments increasing the firm's productivity and profitability, respectively. As shown by Glass and Saggi (2001) international outsourcing lowers costs in terms of decreased relative wages and therefore frees resources and increases profits. In addition, the organizational structure itself is influenced by the technology intensity of the firm (Acemoglu et al. 2004). The corporation's innovative endowment due to intellectual property rights determines the ownership structure regarding to an international production within or outside the firm boundaries. Therefore, there exists a link between the organizational structure and firm performance. Moreover, owing to greater competition, enhanced input access, and higher

[3] See German Federal Statistical Office (2008a), p.2ff. For further details see also the German Federal Statistical Office (2008b).

[4] The main driver of this result is the manufacturing industry with 61.9 percent relocating to new EU countries. See the German Federal Statistical Office (2008b), p.7ff.

[5] See, amongst others, Amiti and Konings (2007) and Glass and Saggi (2001).

export values, trade liberalization has a positive impact on productivity.[6] These channels complete the in this thesis compiled relationship between the firm's organization, trade liberalization, and firm-level productivity.

The contribution of my thesis is, on the one hand, to study the association between innovation and the organizational structure and, on the other hand, to analyze the relationship between firm-level productivity and trade liberalization. In more detail, the first analysis tries to answer whether an increasing pool of innovations on the firm level suppresses outsourcing activities owing to hold-up risks. I aim to assess whether German firms relocate their activities within or outside their firm boundaries along with the ongoing process of Eastern European integration. It deals with the following question: How does innovation influence the firm's national and international organizational structure? Second, regarding to the increasing importance of international trade through a rise in intra-firm trade and raising trade openness with new member states (Marin 2008), I consider the impact of tariff reductions on German and Austrian firm-level productivity. Does an improved intra-firm trade environment and therefore easier access to intermediates boost firm-level performance or does competition force the less efficient firms to leave the market?[7] How is firm-level productivity affected by trade liberalization and offshoring? Existing studies show that output and input tariff cuts increase productivity (Amiti and Konings 2007). I analyze whether this also holds true for Austrian and German firms offshoring to Eastern Europe. Third and closely related to this, I focus on the association between German and Austrian firm exports and the underlying performance of the corporation. The analysis shows whether exporting behavior leads to a raise in firm-level productivity and/or whether the productive firms self-select themselves into

[6] See Amiti and Konings 2007, De Loecker 2007b, Grossman and Helpman 1991, Melitz 2003, Wagner 2007.

[7] See Melitz (2003).

the export market.[8] In detail, I answer the question whether participation in the export market of German and Austrian firms causes a rise in productivity growth.

Chapter 2 studies the impact of innovation on the national and international ownership structure of German firms considering their pool of innovations. Following the framework by Acemoglu et al. (2004) the theoretical part develops a model of the firm's decision to offshore or outsource regarding to territorial protected knowledge. The contribution of this analysis is given by the following factors and findings: It links the ownership of patents, investment incentives and the outcome of the organizational structure between German and Eastern European firms in the national and international context, respectively.[9] As a first result and in line with Acemoglu et al. (2004), a larger pool of knowledge on the producer level increases the likelihood of integration; an increasing pool of knowledge on the supplier level raises the probability of non-integration. However, extending the model to an international context where knowledge protection is absent, affects the firm's decision in favor of outsourcing. The chapter shows that non-integration holds *longer* along with an increasing pool of parental knowledge compared with the national case. That is, outsourcing is more likely to maintain the suppliers' active participation in order to increase the relationship's surplus. Using a unique data matching for 2005 on German investment projects in home and in Eastern European countries allows (i) to distinguish between different innovation measures and to study their impact on international outsourcing, (ii) to compare these results with the territorially protected national case, (iii) to test theoretical predictions how the size of the parties' outside options affect the organizational choice, and (iv) to provide robustness for the results.

[8] See Bernard and Jensen (1999).
[9] See also Acemoglu et al. (2004).

Chapter 3 investigates the impact of trade liberalization on firm-level productivity. For this reason I consider the importance of German and Austrian trade openness concerning the pre-eastern enlargement period from 1994 to 2003. Focusing on different types of tariff cuts related to intra-firm trade, this chapter provides, besides a broad overview of related studies, empirical evidence for the micro-impact on total factor productivity (TFP). The data allow a detailed descriptive overview about the mentioned relationship, different kinds of productivity measures as well as a prediction to what extent German and Austrian firm productivity gain owing to cuts in the different types of tariffs. In addition, I determine the channel of decreasing tariffs via intra-firm imports on productivity. Moreover, the data allow to analyze several other parameters and the results' robustness concerning offshoring to Eastern Europe.

Chapter 4 shifts the focus from imports to German and Austrian export behavior. I analyze the association between exporting and firm performance. Using micro-level data from 1994 to 2003 the chapter highlights the main differences between exporters and non-exporters. In detail, I investigate whether exporting firms are more productive compared with their non-exporting counterparts. In addition, I present empirical results revealing that exporting raises the annual average productivity growth.[10] The contribution of this chapter is the following: First, it gives a detailed descriptive analysis about the firm's export intensities and their firm-level performance. Second, it econometrically studies the link between exports and different productivity measures using German and Austrian firm data. Third, it provides robustness for the existing interdependency.

Finally, Chapter 5 concludes this thesis by summarizing the main findings.

[10] The procedure follows Bernard and Jensen (1999).

Chapter 2

Innovation and the International Firm Structure: Theory and Evidence from German Firm-Level Data

2.1 Introduction

In a global economy, the international make-or-buy decision offers firms the option to relocate its activities within its firm environment or outside its firm boundaries, either at home (national integration versus outsourcing) and/or abroad (offshoring versus international outsourcing).[1] Especially due to corporate knowledge and its related risks, this raises the question of whether it is more interesting to outsource or to in-source. On the one hand, outsourcing frees resources and saves labor costs (Glass and Saggi 2001). On the other hand, integration reduces the classical hold-up problem as argued within the "transaction cost economies" (Williamson 1975). Therefore, integration is preferred over outsourcing (non-integration) in order to circumvent the firm-specific hold-up problem. That is, theory creates a link between transaction costs and uncertainty arguing to reduce the ex-post hold-up problem via vertical integration that arises from ex-ante investments and opportunism (Williamson 1975, 1985).[2]

This chapter studies the determinants of the national and international ownership structure of German firms considering their innovational capacities. More precisely, it addresses the following question: How does a pool of knowledge, in particular a pool of patents belonging to the parent firm, influence the organizational relationship within a national as well as international context? Following Acemoglu et al. (2004), the theoretical part develops a relationship between innovation and the organizational structure. It argues that the decision to integrate or not depends on the parties' pool of knowledge and its related territorial environment. Comparing costs and benefits, vertical integration strengthens the position of the firm's owner whereas outsourcing is more likely to maintain the suppliers' active participation.[3] It

[1] See Marin (2006).

[2] See Acemoglu et al. (2004).

[3] The intuition is provided by the "property rights theory" (Grossman and Hart 1986 and Hart and Moore 1990). See also Acemoglu et al. (2004) and Brusoni, Prencipe, and

allows to develop a combination of the parent's and affiliates' innovation pool with the decision for an organizational structure between the two parties for each geographical breakdown.

Against the traditional perception that innovative firms want to protect their knowledge within integration, even highly innovative enterprises are interested in cost savings and therefore non-integrational relationships. Thus, the following Section 2.2 presents a literature review on knowledge in terms of research and development (R&D) and patents. It starts with a broader size of theoretical literature discussing two controversial directions of the influence of innovation on outsourcing. It addresses mainly an contra intuitive empirical finding that a higher R&D intensity is related to more outsourcing (Mol 2005, p.581). The section gives also an short overview about the understanding of inventiveness and innovation and presents the German position within international innovation activities. Section 2.3 develops the general framework beginning in a national context. The underlying model follows Acemoglu et al. (2004), also describing in this section the authors' framework in more detail. It shows that a larger pool of knowledge on the producer level increases the likelihood of integration. The opposite holds if the subsidiaries' pool of innovations increases. Against Acemoglu et al. (2004), the model is also extended to the international context. It is assumed that patent applications granted domestically do not hold in the foreign environment. Despite this characteristic, to a certain threshold the outcome of non-integration is more likely with an increasing pool of knowledge compared with the national case. That is, the changeover from the closed to the open territorially unprotected case delays the probability of integration with an increasing producer's innovation pool. Beside that, the larger the supplier's outside option and the larger the fraction the producer can keep in a potential ex-post break-up, the more likely is non-integration. This holds in

Pavitt (2001) considering aircraft engine manufacturers.

both cases. Section 2.4 describes the underlying data, summary statistic of the employed variables and the basic estimation equation. It presents the empirical results using data on German investment projects in home and in Central and Eastern Europe in 2005. It is based on a unique data matching of the pan-European micro database *Amadeus* provided by the Bureau von Dijk and firm-specific patent data provided by the German Patent and Trade Mark Office.[4] The findings are in line with the theoretical predictions. A German parent firm and its corresponding partner are more likely to be integrated when the German downstream firm (DSF) is highly innovative and the domestic or foreign upstream firm (USF) is less innovative. This holds for the national as well as the international case and for different measures of innovativeness. Moreover, the difference between *Home* and *Foreign* shows a deduction in the likelihood of integration. Intuitively, owing to additional investment incentives outsourcing holds *longer* in the international context than the national case.[5] The following subsection discusses the robustness of the empirical findings. Finally, Section 2.5 concludes and encourages future work in this field of investigation.

2.2 Innovation and the Firm Structure

2.2.1 A Literature Survey

The existing literature yields two controversial aspects of innovation and its association with the organizational relationship between a parent firm and its affiliate.[6] The "traditional view" (Mol 2005, p.572) states that a larger pool

[4] See Bureau von Dijk (2005) and GPTO (2008a, 2008b, 2008c).

[5] The empirical framework is motivated by Acemoglu et al. (2004), McLaren (2000), Antras and Helpman (2004), Marin (2006), and Nunn and Trefler (2007). It is closely related to a wide strand of literature concerning vertical structure, international trade, and growth: Aghion and Tirole (1997), Acemoglu, Aghion, and Zilibotti (2002), Grossman and Helpman (2002, 2003, and 2004), and Bartel, Lach, and Sicherman (2005).

[6] See Mol (2005).

of innovations increases the likelihood of integration. Contrary, innovation also has the potential to increase the likelihood of outsourcing.

The perspective that innovation and knowledge reflect a negative extent of outsourcing is discussed by a huge amount of literature. Stigler (1951) applies it to vertical integration by considering economies of scale. Due to large fixed costs, highly innovative firms decide in favor of integration to exploit economies of scale that can be more easily recuperated by large firms. Moreover, integration raises essential knowledge, makes entry by new firms less likely, and helps to enforce price discrimination (Stigler 1951, p.191). Considering complementary assets, Teece (1986) argues that integration is an important strategic instrument for highly innovative firms. He argues that integration is preferable for obtaining additional assets. The greater the importance of these complementary assets to the innovator and the more critical these assets to the firm's success in terms of time and budget, the more likely integration is from an innovator's perspective.[7] In the chapter's context, the innovator integrates to protect the original innovation as well as to enhance the value of the existing knowledge.[8] Antras and Helpman (2004) present a north-south model of international trade in which final good-producing firms located in the north may decide to keep the input production within their boundaries or to outsource it to an independent supplier. Beside the intermediate good to create the final good, the producer needs headquarter services, which are solely produced by the final-good producer itself at *home* (north). Because investments and output are neither verifiable nor contractible, the outside options determine the organizational structure via ex-post bargaining. As already mentioned, investment incentives are larger for the supplier under non-integration than vertical integration. In contrast, in the case of integration, incentives to invest are larger for the producer because of the in-

[7] See Teece (1986, p.290) calling this outcome "integrating into specialized and cospecialized assets".

[8] See also Mol (2005), p.574.

creased outside option. Hence, the outcome of the organizational structure is defined by the investment incentives of the more important party within the relationship. In the headquarter-intensive sector, Antras and Helpman (2004) show that only the most productive firms choose integration over outsourcing domestically as well as abroad. Following Antras and Helpman (2004), the empirical studies by Marin (2006) and Nunn and Trefler (2007) estimate the determinants of the organizational structure. Both find empirical evidence that knowledge has a positive influence on integration. Marin (2006) finds a significant negative coefficient of the capital-to-labor ratio and a significant positive impact of R&D expenditures on intra-firm imports from Eastern Europe to Germany. That is, her data on German and Austrian firms investing in Eastern Europe suggest that the larger the headquarter intensity and the larger the R&D expenditures, the more likely is integration. Concerning R&D expenditures, the results also hold in probit estimations differing between outsourcing and offshoring in terms of the ownership share. Nunn and Trefler (2007) show that the share of U.S. imports' capital intensity has a positive influence on intra-firm imports. Moreover, patent citations over total value added as a proxy for knowledge have a positive but insignificant impact on integration. Hence, the data affirm the theoretical predictions arguing that a pool of knowledge reduces the likelihood of outsourcing.

The number of empirical analyses presenting a negative impact of innovation on outsourcing is large. Louri, Loufir, and Papanastassiou (2002) report a negative correlation between R&D intensity and the likelihood of outsourcing. For Greek data on 216 multinational firms, the authors show a positive influence of R&D intensity on fully owned affiliates. Distinguishing between an integrated or non-integrated relationship, Monteverde (1995) runs a probit estimation in the semiconductor industry on patents. The number of patents held by each firm is positively correlated with integration. This is in line with the theory's predictions. However, the impact is not

significant. Increasing costs of monitoring as well as technology spillovers are risks that have to be taken into account.[9] From an innovator's perspective, this suggests preferring integration over non-integration. Mugele and Schnitzer (2006) find that technology is the determining variable that increases the investors' ownership share. The authors distinguish between a production-intensive, a technology-intensive, as well as a marketing-intensive sector, whereas the technology-intensive sector is more likely to integrate.

As briefly mentioned at the beginning of this section, there are also arguments in favor of non-integration with an increasing pool of knowledge. A study by Mol (2005) analyzing the impact of R&D intensity on vertical integration within the Dutch manufacturing sector shows that the negative extent of outsourcing at the beginning of the 1990s seems to have shifted. He shows that R&D intensity has a positive impact on changes in the rising external sourcing structure. In more detail, the results refer to international outsourcing, suggesting that the "traditional view" (Mol 2005, p.572) where R&D intensity discourages outsourcing may no longer hold. Mol (2005, p.579) argues that the increasing technological requirements force the firm to outsource. The corporation is not able to develop and implement all the necessary technologies by itself. Moreover, the positive extent of outsourcing is intensified in an environment characterized by rapid technological change (Harrigan 1984, 1985, Balakrishnan and Wernerfelt 1986, Bartel, Lach, and Sicherman, 2005). When a firm has to act in such a frequently changing environment, innovators prefer outsourcing over integration to circumvent perseverative adaptation costs.[10] Bartel et al. (2005) develop a framework that describes the pace of technological change and its impact on the organizational structure. Within their model, a faster pace of technological developments results in more outsourcing to reduce the adaptation costs of

[9] See also Louri et al. (2002), p.33.

[10] For a more detailed discussion of the IT sector, see Bartel et al. (2005).

producing in-house. Therefore, the final good-producing firm can always use the latest technology without incurring additional fixed costs (Bartel et al. 2005, p.12). Within the empirical study, the authors show that, in the case of a great sectoral IT dependency, purchasing services outside is more likely.[11] Hence, outsourcing is a possibility to circumvent fixed costs, avail lower factor prices, and, beside that, to use a potential network offering innovativeness and therefore the chance to follow the technological advance at lower costs.[12]

Thus, outsourcing offers the chance to stay up to date with both the firm's competitive surroundings and the innovative environment. Empey (1988) analyzes that outsourcing of services by manufacturing industries increases faster in sectors where technological change and productivity play a decisive role. Involving the costs of the well-known hold-up problem seems to weigh less than reduced labor costs, costs of technological spillovers, and decreasing supplier's investment incentives. Moreover, Mol et al. (2004) find that product innovation has a positive impact on the scope of international outsourcing and Maskell et al. (2005) argue that even innovative processes are outsourced..[13]

2.2.2 Invention and Innovation

The existing literature reveals different definitions of innovation. As defined in the Oslo Manual by the Organisation for Economic Co-operation and Development (OECD 2005, p.46), innovation is "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations". Thompson (1965, p.2) defines innovation as "[...] the generation, acceptance, and implementation of new ideas,

[11] See Atallah (2002) for a very similar discussion on the IT sector.

[12] See also Quinn (2000).

[13] In contrast, Mol et al. (2005) also argue that innovation is negatively associated with the depth of international outsourcing. However, there is no empirical evidence for this.

processes, products, or services. [...] it implies the capacity to change or adapt." By the Commission of the European Communities (1991), innovation is defined by new products and processes. Damanpour (1991) uses the development and adaption of ideas whereas Drazin and Schoonhoven (1996) define it as a competitive advantage. Moreover, innovation has to be separated from invention. That is, invention in terms of new ideas precedes innovation that turns those ideas into new products and processes (Baddeley and Barrowclough 2009).

Innovation is often measured as R&D expenditures. Becker and Dietz (2002) use the in-house R&D expenditures-to-sales ratio of German corporations for the firm's intensity in inventiveness and developing new products. Their results suggest that R&D cooperation is a significant explanatory factor of innovation in the German manufacturing industry. Marin, Lorentowicz, and Raubold (2003) present R&D expenditures as a percentage of parent sales of German firms during the 1990s to measure technology and innovative activity. They conclude that the highly innovative German segment invests in Eastern Europe to exploit lower wages via foreign direct investment (FDI). Greeve (2003) studies the Japanese shipbuilding industry. Within his study, he employs R&D expenditures as a measure of innovative search activities. Zhang et al. (2005) investigate the link between a firm's knowledge base and its tendency towards collaboration. Using R&D intensity between 1993 and 2002, the authors give evidence for international biotechnology alliances and find, *inter alia*, that firms with intensive technological knowledge are less likely to enter alliances.[14]

R&D covers knowledge and is commonly used as an empirical proxy for innovation input. It is an essential element in the innovative process (Baddeley and Barrowclough 2009). However, R&D is a source or the input of innovation but it does not represent the output of the innovative activity

[14] See also Mol (2005) for a similar discussion.

(OECD 2005). Especially when considering the innovative output, that is new processes, products and upcoming market launches, R&D expenditures are unsatisfying. Therefore, patents are much more suitable for representing fundamental knowledge and inventiveness in terms of evident novelty. Patents form the interface between R&D expenditures and innovations. In addition to that, intellectual property rights determine the corporation's market and technological position (Fattore 1997). Empirical studies like those of Blau and McKinley (1979), Hausman, Hall, and Griliches (1984), Griliches (1990), Crepon, Duguet, and Mairesse (1998), Blind et al. (2003), and Branstetter, Fisman, and Foley (2005) study the number of patents and patent applications to consider the development and impact of inventiveness and knowledge. For instance, Griliches (1990) argues in favor of patents as an economic and innovative indicator. In his overview, he states the importance of patentees considering the value of a firm, its competitiveness, and the technological change.[15]

In general, the objective of a patent is to protect knowledge in terms of new products and processes. It covers for a certain time the ownership of an exclusive right to an invention that can be held by the inventor or assigned by the inventor to his corporation (German Patent and Trade Mark Office (GPTO) 2008a).[16] An efficient patent system gives incentives for further investments and innovations within a protected economic environment (Jaffe and Lerner 2004). In more detail, Fattore (1997) argues that patents encourage inventiveness, allow novelties to be exchanged, offer information on the strength of competitors, and are fundamental to protection and commercialization. Intellectual property rights in terms of patents are one category of a firm's pool of intangible assets ensuring costs and revenues (Greenhalgh and Rogers 2007). Beside that, the European Patent Office (2007a, 2007b) states

[15] See also Baddeley and Barrowclough (2009, p.137ff) discussing underlying problems related to the patent variable in measuring innovative output.

[16] See GPTO (2008a), p.4ff.

the economic importance of patents to an economic area: a larger number of patents is positively correlated with a higher level of innovations.[17] That is, a patent-friendly environment in terms of low and efficient application and process costs incentivizes additional investments. Hence, especially in Germany, innovation has developed to one of the key topics. The Federal Republic engages in a national strategy encouraging innovation policy, called "High-tech Strategy for Germany" (Federal Ministry of Education and Research 2006). Based on the Lisbon Strategy, the objective is a further increase in domestic productivity and inventiveness.[18] Within this program, the patent system will become more efficient, especially concerning translation costs in the international context.[19]

As stated by Baddeley and Barrowclough (2009, p.133) "innovation is essential for economic growth and development [...]." However, beside the benefits on the macro-economy level, there are also impacts on the firms' level as well as to individual people owing to investing in human capital (Baddeley and Barrowclough 2009). Irrespective of their legal form, corporations have the option to protect their invention, increase their market value, and generate additional revenue via patent licensing (Fattore 1997). But, the owner's rights are territorially restricted (GPTO 2008a, 2008b). These characteristics as well as the importance on micro-level justify the study of patents as a output measure of the innovative activities and their impact on the organizational structure in the national as well as the international context. Considering the relationship between a producer and his supplier, the innovator has the exclusive rights over his knowledge and decides solely over its innovative output. This secured environment could lead to the firm's decision to favor outsourcing over integration and therewith benefit from a

[17] See also http://www.epo.org [September, 9th, 2009].

[18] The Lisbon Strategy is a European program adopted in 2000 by the European members with the objective to raise competitiveness of a knowledge society.

[19] See Federal Ministry of Education and Research (2006) and Federal Ministry of Economics and Technology (2007).

reduced cost environment. Therefore, a larger pool of knowledge could result in a positive tenor towards outsourcing. Antras and Helpman (2004) argue that a rise in productivity favors outsourcing abroad over domestic integration. However, only the most productive integrate in foreign countries. As a result, the protection of intellectual rights may induce more outsourcing. [20] The more patents a firm has and the better it is protected by its legal environment, the lower is the innovator's hold-up risk that results in vertical disintegration (Merges 1997, Arora and Fosfuri 1998, Hall and Ziedonis 2001). In contrast, the larger the number of patents and therefore the larger the pool of knowledge, the more unpredictable is the risk of losses and unwanted spillovers. Baye (2006) argues that a firm's position is much improved by stretching out the time of acquiring a patent. During that period, none of the innovation's background is public and therefore the risk of copying or stealing is reduced.[21] The mentioned risks increase through the liability of publishing the patents' content.[22] This in turn raises the probability of integration. Moreover, it is crucial whether the producer's or supplier's investment activities are more important to the outcome of the relationship (Acemoglu et al. 2004). Acemoglu et al. (2004) argue that the larger the producer's technological intensity, the more likely is integration. In this context, the risk of a supplier's ex-post break-up suggests a negative extent to outsourcing and, hence, integration is more likely to sustain the producer's investment incentives. The authors' empirical study shows that the producer's R&D intensity has a positive impact on vertical integration. Hence, the intuition goes in both directions. On the one hand, the larger the pool of knowledge, the more likely is outsourcing because of cost-saving aspects, a protected environment, and the chance of trading novelties. On the other

[20] See also Branstetter et al. (2005) for a detailed discussion about the impact of intellectual property rights on innovation.

[21] See Baye (2006), p.164, based on a study by Richard Levin (1988).

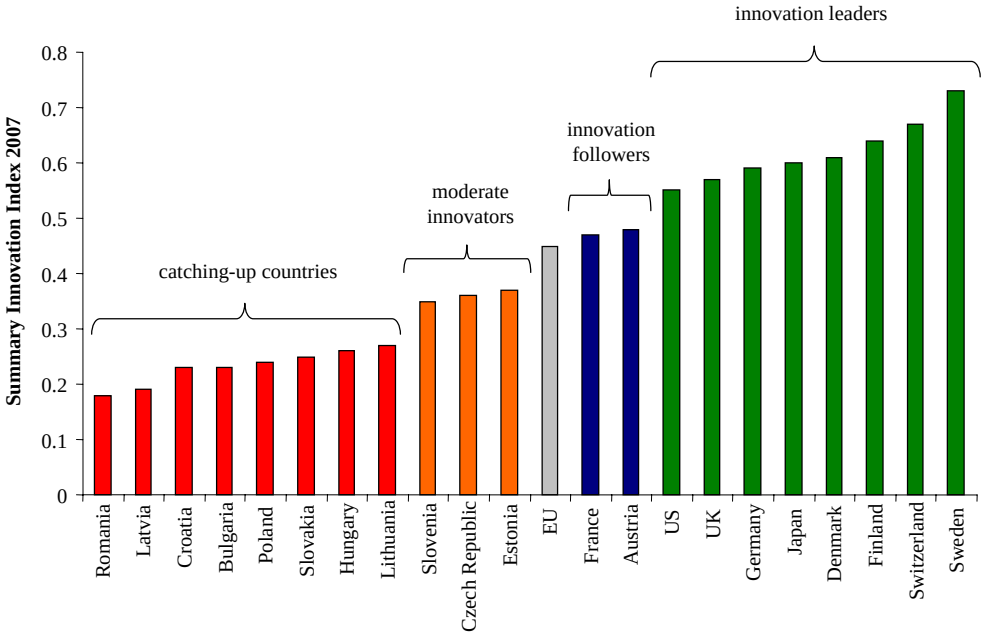
[22] See also Branstetter et al. (2005), p.4ff.

hand, a larger pool of knowledge in the parent firm boosts its importance and sustains investment incentives via integration (Acemoglu et al. 2004).

2.2.3 German and Eastern European Innovation Performance

Within the European Union Germany is one of the most innovative countries: it is far ahead the European average and, in a global context, ahead of the US (PRO INNO Europe 2008). This is shown by PRO INNO Europe (PIE), an initiative induced by the Directorate-General for Enterprise and Industry (European Comission). According to their Summary Innovation Index 2007 (SII) Germany is part of the group of the "*innovation leaders*" (PIE 2008, p.7).[23] For the last five years this result has been relatively stable with a slightly raising German performance (PIE 2008, p.12). Moreover, calculations of years to fall down to the average of the European Union (EU) are greater than 100 years (PIE 2008). In addition, a subgroup of the performance indicator is "*Intellectual property*" measuring innovation output in terms of patents and trademarks per million population (PIE 2008, p.35). The indicator shows that the Switzerland and Germany are the best performers within this dimension (PIE 2008, p.9). Both countries are the most efficient in transforming innovative inputs into intellectual property (PIE 2008, p.23). In contrast, the Eastern European countries perform worse compared to the EU average. These countries are part of the "*moderate innovators*" or "*catching-up countries*" (PIE 2008, p.11ff). However, some of these countries, namely Estonia, Czech Republic, and Lithuania, catch up the EU average in the short run, more precisely in roughly ten years and Slovenia is estimated to catch up in about 15 years (PIE 2008, p.12ff). The

[23] The observed countries are classified into the following four groups: "*innovation leaders*", "*innovation followers*", "*moderate innovators*", and "*catching-up countries*". For the definition of these groups and for further details of the index construction see the European Innovation Scoreboard 2007 report and its appendix (PIE 2008, p.43ff).



Source: European Innovation Scoreboard 2007 (PRO INNO Europe 2008, p.7). Countries selected by author.

Figure 2.1: Summary Innovation Index 2007

report argues that all convergence processes of the other considered Eastern countries will take more than 20 years (PIE 2008, p.13). Figure 2.1 presents the overview of the SII countries for 2007.[24]

Blind et al. (2003) present a conspicuous trend in both German R&D activities and patent applications. Their results show that R&D expenditures of German firms increased slightly in the 1990s. However, patent applications doubled during this time. Using data of the European Patent Office (EPO) from 1991 to 1999, the authors study an average rise of German patent applications by 8 percent per year. Moreover, the steady growth of patent filings by residents and non-residents in Germany suggests the prevailing importance due to a rise in the use of the patent system. From 1995 to 2004,

[24] As stated in the report the data are mainly given for the years 2004, 2005 and 2006 (PIE 2008, p.7).

applications by residents to the German patent offices increased by 27 percent and applications by non-residents increased by 35 percent (World Intellectual Property Organization (WIPO) 2006). Concerning filings by residents, the German growth rate is larger than e.g. France (15 percent), Japan (10 percent), or the United Kingdom (3 percent). The WIPO (2006) also reports larger German growth rates by non-residents than e.g. the United Kingdom with 21 percent. These numbers indicate 2 important findings. First, the German patent system developed an increasing strength and a high importance in the protection of knowledge. Germany is one of the top 6 patent locations, led by Japan and the United States with more than 350,000 and 150,000 applications in 2004 (WIPO 2006). Second, this importance holds for domestic as well as foreign innovators. It reflects that protection is sought not only domestically but also in foreign countries (WIPO 2006).[25]

Figure 2.2 shows the trend of German patent applications published at the GPTO and worldwide from 1996 to 2007. Applications by residents increased from 42,322 in 1996 to 47,853 in 2007. Also total patent applications at the GPTO raised from 51,833 to 60,922. Therefore, despite the drop of applications in 2001 and 2002, these numbers show the continuing importance of German intellectual property rights. Moreover, German patent applications worldwide also increased from 85,008 in 1996 to 130,168 in 2007. This suggests that international protection becomes more important. In addition, German R&D expenditures also raised from 30,447 to 44,410 million euros between 1996 and 2003.[26] Therefore, German patent applications as innovative output closely follow the input R&D expenditures. The WIPO (2006) reports that the ratio of patent applications per million euros of R&D expenditures decreased slightly from 1.39 in 1996 to 1.07 in 2003. However, the

[25] The finding is provided by the WIPO's (2006) calculation of the worldwide ratio of non-resident to resident applications: the ratio increased from 1995 to 2001, followed by a stable outcome until 2004.

[26] Source is the Stifterbund (2003/2004)

global ratio also decreased with a final ratio of 0.81 compared with the German ratio of 0.92 in 2004 (WIPO 2006, p.l7ff).[27] As stated by PRO INNO Europe (2008, p.24ff), this indicates also that Germany is innovation leader due to generating intellectual property.

Moreover, Greenhalgh and Rogers (2007) point out the importance of Germany concerning intellectual property rights. Within their study of patent applications by domestic residents, Japan and the United States have the earliest rise and the largest total values of applications, followed, particularly in the 1990s, only by Germany with rapid rise in patenting. Figure F2.1 in the Appendix shows the graph by Greenhalgh and Rogers (2007, p.542). In addition to that, the WIPO (2006) reports that, with 587 resident patent filings per million population, Germany was the fourth most important country in 2004 after Japan (2,884), the Republic of Korea (2,189), and the United States (654).

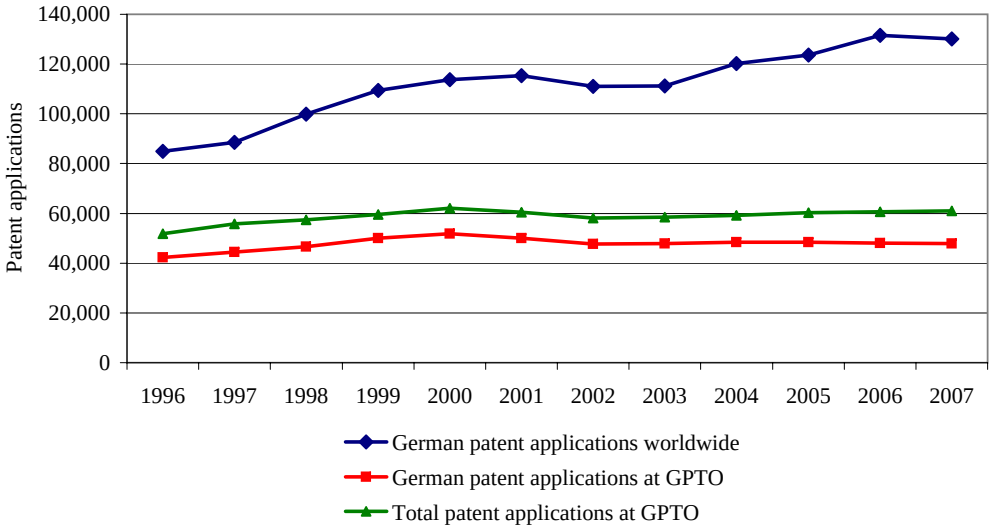
To summarize, the given numbers as well as both figures suggest that Germany is a country that maintains a high level of innovative investments and a significant growth of the protected knowledge pool.

In addition to the raise of German patent applications owing to domestic protection with an annual average growth of 1.2 percent from 1996 to 2007, global protection seeking also increased. The numbers in Figure 2.2 suggest an annual average growth of 6.4 percent from 1996 to 2007. Due to the WIPO Patentreport (2006) 80 percent of all Patent Cooperation Treaty (PCT) applications are designated to the international context.[28]

From a residents' as well as a non-residents' perspective, (German) patents are one of the most important rights to achieve returns on innovative activities. This comes from the fact that in Germany residents at their home

[27] Sources for the calculations are the GPTO (2008b, 2008c), WIPO (2006), and the Stifterbund (2003/2004).

[28] Sources for the author's calculations are the GPTO (2006) Annual Reports 2002-2006 and WIPO (2006, 2008).



Sources: WIPO (2006, 2008), GPTO (2008b, 2008c). Author's calculations.

Figure 2.2: Patent applications

office are the biggest group of filers of patent applications (WIPO 2006). However, due to the fact that filings from foreign applicants as well as German applications in foreign countries have also increased, it suggests that firms are strengthening their search for a global protection. This in turn may also influence investment incentives and the decision about the organizational structure both at home and abroad. Thus, the existence of a pool of knowledge increases the owner's importance as well as the opportunity of enhancing profits within a competitive environment, i.e. with low variation in costs and profits (Aghion and Griffith 2005, Greenhalgh and Rogers 2007).

2.3 Intellectual Property Rights and the Organizational Structure

2.3.1 Theoretical Background

The changing landscape from a labor-based to a knowledge-based economy is a main driver of seeking protection for inventiveness. As mentioned, Grossman and Hart (1986) and Hart and Moore (1990) argue that ownership keeps residual rights and, from a producer's perspective, reduces a potential hold-up raised by declining suppliers' incentives.[29] Therefore, the Property Rights Theory employs the link between a firm's decision to integrate or to outsource a part of its production concerning an existing pool of innovations.

Following Grossman and Hart (1986), Acemoglu et al. (2004) develop a theoretical framework combining technology and the organizational structure between a producer (he) and supplier (she). The authors distinguish between three organizational forms: backward vertical integration, *VIB*, where the producer employs the supplier. In the case of an ex-post break-up, the producer owns all the assets; forward vertical integration, *VIF*, which describes the inverse relationship between both parties; and non-integration, *NI*, where each of the participants is independent. Acemoglu et al. (2004) argue that the relationship between the two parties depends on their individual level of technology. A rise in the producer's technological intensity makes integration more likely. It incentivizes the producer's investments and emphasizes his importance for a higher overall surplus within the relationship. When the supplier is the technology-intensive part in the relationship, non-integration is more likely. If there is an ex-post break-up, her outside option is larger. This increases her incentives to invest, which also results in a larger surplus due to her higher importance within the relationship. Therefore, the greater

[29] See Acemoglu et al. (2004) and Rasmussen (2004).

the technological importance of the producer and supplier, respectively, the more important their corresponding incentives to invest for a higher overall outcome. Summarizing, Acemoglu et al. (2004) propose opposite effects of the producer's and supplier's technology intensity on the probability of vertical integration. The empirical study on British manufacturing plants provides evidence for the theoretical predictions.

The model establishes the fundament for the following theoretical framework, considering a national and international context in the decision about the organizational structure. Employing patents as a pool of knowledge, the model highlights the existence of a threshold between integration and non-integration. The larger the owner's pool of knowledge, the more likely is the owner's preferred parent-affiliate relationship to maximize outcome; moreover, the more likely the supplier is to find an alternative partner the larger is the supplier's outside option and the more likely is non-integration. This follows the predictions by Acemoglu et al. (2004) and McLaren (2000). It holds in the closed as well as the open economy case. However, switching from a national to an international context may reduce the owner's influence on his inventions, e.g. via reduced territorial rights. Intuitively, in both cases, integration becomes more likely with an increase in the parent's pool of patents. However, for a given producer-to-supplier ratio of knowledge, non-integration holds *longer* in the open economy case than in the national consideration. That is, the framework results in a gap between the national and international changeover where the probability of international outsourcing rises by enlarged investment possibilities for the independent supplier. The empirical study on German and Eastern European affiliates provides evidence for the theoretical findings.

2.3.2 The Basic Model in a Closed Economy

Following Acemoglu et al. (2004), the framework consists of a one-period relationship between a risk-neutral producer P (parent firm) and a corresponding risk-neutral supplier S (affiliate). The output and investments are non-verifiable and therefore contracts are incomplete. The timing of incidents is given as follows. The producer offers an ownership structure z, which, in the case of the supplier's acceptance, is followed by the producer's specific investments E and the supplier's specific investments e.[30] Two different organizational forms, namely integration and non-integration, may emerge. This is motivated by the empirical part of the chapter where the German parent firm decides how to invest in Eastern Europe. Integration (IN) means that the producer and supplier are an organizational entity. In the case of an ex-post break-up, the parent firm owns all the assets. Non-integration (NI) means that each of the participants is independent. In the case of an ex-post break-up, each party keeps its own investments with certain deductions due to territorial rights.[31] The revenue is split between the two parties according to symmetric Nash bargaining concerning a given ownership structure z. If there is no agreement between the producer and supplier, the outcome is as in the case of NI. The production function is represented by the following equation:

$$F(x_S, E, e) = \lambda(\sum_{i=1}^{n} s_i e - \sum_{j=1}^{m} p_j E + 1)x_S + (1-\lambda)(\sum_{j=1}^{m} p_j E + 1). \quad (2.1)$$

λ refers to the supplier's fraction in the production function. The larger the value of λ, the more important is the input good. It is assumed that the parent firm's innovation is essential to the output whereas the supplier's im-

[30] See also Acemoglu et al. (2004), p.6.

[31] In the case of an ex post break up Acemoglu et al. (2004) impose transfer payments $T_P(z)$ and $T_S(z)$ depending on the organizational structure z where $T_P(z) + T_S(z) = 0$. This is also assumed here.

portance is restricted.[32] Moreover, due to an increasing rate of technological change, the parent firm does not invest in the affiliate's pool of knowledge.[33] x_S describes the supplier's input in the production, which can be 0 (not supplied) or 1 (supplied). In its most simple form, it is provided at no cost by the supplier.[34] $\sum_{i=1}^{n} s_i$ indicates the supplier's capacity for innovation. The larger the pool and value of knowledge, the larger the outcome of investments e. Beyond the standardized input x_S, the supplier S becomes more important. $j \in [1; m]$ defines the producer's pool of knowledge. The greater his inventiveness, hence the larger $\sum_{j=1}^{m} p_j$, the greater is the output of the producer's investments E.[35] However, the producer's pool of knowledge also restricts the supplier in terms of additional knowledge. Intuitively, each invention of P poses a challenge for S to generate additional surplus beyond her standardized input. That is, equivalent innovations do not raise the relationship's surplus.

In terms of patents as a category of intangible assets, the inventions are protected but published and openly visible (GPTO 2008a, 2008b). Here, it is assumed that P has a pool of innovations protected territorially in the closed economy. That is, within integration, the supplier as a part of the corporation also invests within the protected knowledge according to her incentives. Outside the firm boundaries, a non-integrated supplier either invests within the licensed territory and her own pool of knowledge or she invests within the whole pool of innovations, imitating the ideas outside of their territorial claims. Due to the fact that each party contributes its share, neither of them is able to undertake the other's investment.[36] Additional

[32] The supplier's importance is restricted as follows: $\lambda \in \left(0; \frac{1}{2}\right]$. Acemoglu et al. (2004, p.7) define this ratio as share of costs.

[33] This is also consistent with the assumption that the innovator offers the organizational structure.

[34] This assumption is for simplicity. See also Acemoglu et al. (2004, p.7).

[35] The inventions are ranked from 1 to $k \in \{n; m\}$ where 1 is a simple invention and k a highly innovative idea.

[36] See also the tacit knowledge assumption by Acemoglu et al. (2004, p.6).

surplus from the supplier's investments is given by her own inventiveness $i \in [m; n]$ via x_s.[37] Therefore, the protected capacity of innovation generates no additional revenue for the supplier in a restricted national context. Moreover, if the specialized input is sold outside of the originally intended relationship, the output suffers from a deduction $(1 - \delta)$ where δ is exogenous given and $\delta \in (0; 1)$.[38] The cost function for party $i \in \{P; S\}$ and the corresponding investment activity $h \in \{E; e\}$ is given as follows:[39]

$$C_i = \frac{1}{2} \sum_{j=1}^{m} p_j h^2. \tag{2.2}$$

The utility for each party i, the optimal investment level, as well as the total surplus in each ownership z depend on the individual relationship-specific outside options O_i^z. Following Acemoglu et al. (2004, p.9), this links investment incentives and the organizational structure. Due to a potential ex-post break-up, there are four different outside options. In the case of NI, an ex-post break-up keeps each party independent. That is, the producer does not obtain the supplier's input $x_S = 0$ and therefore the outside option is

$$O_P^{NI} = (\sum_{j=1}^{m} p_j E + 1)(1 - \lambda). \tag{2.3}$$

The supplier sells her specialized input outside the original relationship with a deduction of $(1-\delta)$ where $\delta \in (0; 1]$. Additionally, she is also restricted to the existing territorial protection of the producer's innovations $j = 1...m$. Therefore, within her pool of knowledge, the remaining outside option in the case of an ex-post break-up under NI is

[37] It exactly addresses the question of interest: How does the parent's pool of knowledge influence the organizational form.

[38] See Acemoglu et al. (2004) and McLaren (2000).

[39] The form is mainly for mathematical reasons.

$$O_S^{NI} = \delta(\sum_{i=m}^{n} s_i e + 1)\lambda. \tag{2.4}$$

In the case of an ex-post break-up under integration, the producer keeps all the assets. In more detail, P holds a ratio α with $\alpha \in [0;1]$ of the supplier's input investment. An intuition for this might be that P is not able to use the supplier's innovations as efficiently as S herself can do.[40] The producer benefits due to the ownership of the input good x_S that allows him to sell the innovation more profitably. Hence,

$$O_P^{IN} = (\alpha \sum_{i=1}^{n} s_i e - \sum_{i=1}^{m} p_j E + 1)(\lambda) + (\sum_{i=1}^{m} p_j E + 1)(1-\lambda). \tag{2.5}$$

The supplier's outside option under IN, O_S^{IN}, is assumed to be equal to 0. Because S has no influence on the producer's part of the production, the remaining investments also do not bring the supplier additional value.

Given an ownership structure z, the utility functions U_P^z and U_S^z where $z \in \{NI; IN\}$ are defined as:[41]

$$U_i^z(y_i(E,e)) = y_i^z(E,e) - C_i + T_i(z), \tag{2.6}$$

where $(y_i(E,e))$ is given by

$$(y_i(E,e)) = O_i^z(E,e) + \frac{1}{2}[F(x_s = 1, E, e) - O_P^z(E,e) - O_S^z(E,e)]. \tag{2.7}$$

At least each party $i \in \{P; S\}$ generates its own outside option plus one half of the remaining surplus of the production function. It is certain that

[40] Acemoglu et al. (2004, p. 8) argue that the supplier would not undertake the last effective investment in the case of an ex-post break-up. Here, it might also be an alternative interpretation that S is not able to protect all her knowledge, e.g. because of lower funds.

[41] Following Acemoglu et al. (2004), p.9, according to Nash bargaining for individual revenues.

the larger the outside option of party i, the larger the bargaining position and hence the larger the output y_i (Acemoglu et al. 2004, p. 9). Maximizing the utility functions' output minus costs with respect to the investments for each organizational structure results in

$$E^* = 1 - \frac{3}{2}\lambda, e^* = \frac{1}{2}\lambda(1+\delta) \tag{2.8}$$

and

$$E^* = 1 - 2\lambda, e^* = \frac{1}{2}\lambda(1-\alpha) \tag{2.9}$$

for integration and non-integration, respectively. In both integration and non-integration, E^* depends negatively on λ. The more important the supplier, the less important the producer's incentives to invest.[42] Compared with IN, the total amount of the producer's optimal investments is greater in the case of NI. Intuitively, integration allows the parent firm to participate in the supplier's whole range of knowledge and investments. Moreover, larger technological investments increase adaptation costs. This reduces further investments. In the case of non-integration, the producer is left to his own resources. Due to domestic protected knowledge, the prevailing hold-up problem is reduced. Hence, it allows inefficient low investments by the parent firm under NI due to territorial protection to be circumvented.[43] Regarding the supplier's optimal level of investments in the case of non-integration, e^* is increasing in λ and δ. The larger the outside market and the greater the importance of the supplier, the higher her investments. This is consistent with the existing literature, such as McLaren (2000). Under IN, e^* is reduced by α. The larger α, the larger is the amount of inventiveness P can *keep* and the greater the supplier's ex-post break-up losses.

The sum of the utility functions results in the total surplus for each

[42] See Acemoglu et al. (2004), p.7.

[43] Contrary, Acemoglu et al. (2004, p.10) shows that E^* is largest under IN and e^* is largest under NI.

organizational structure:[44]

$$S^z = F(x_S = 1, E_*(z), e_*(z) - C_P(E_*) - C_S(e_*)), \tag{2.10}$$

where S^z consists of the value function F, the optimal investment levels minus each cost function $C_P(E_*)$ and $C_S(e_*)$. Therefore, the emerging surpluses S^{NI} and S^{IN} allow me to compare the ownership structures for given capacities of innovation:

$$S^{IN} - S^{NI} \geq 0. \tag{2.11}$$

From a social planner's perspective, if the margin is positive, IN generates a larger surplus than NI and it is the preferred relationship. Suppose equation 2.11 is set to 0. It enables me to find a threshold that defines the likelihood of the organizational structure depending on the pool of patents. Computing the threshold it results in a knowledge ratio $\frac{\sum_{j=1}^{m} p_j}{\sum_{i=m}^{n} s_i}$ as follows:[45]

$$\frac{\sum_{j=1}^{m} p_j}{\sum_{i=m}^{n} s_i} = \frac{\frac{1}{4}\alpha + \frac{1}{8}\alpha^2 + \frac{1}{4}\delta - \frac{1}{8}\delta}{\frac{1}{2} - \frac{1}{4}\alpha - \frac{1}{8}\alpha^2} \equiv \Theta. \tag{2.12}$$

If the pool of knowledge ratio is larger than the given threshold Θ, integration is the equilibrium. That is, the larger the parent firm's pool of knowledge - compared with the supplier - the more likely is IN. In more detail, the larger the producer's pool of knowledge, the more important is the producer. Also, the input provided is more effective within this relationship. Therefore, integration raises the producer's outside option, provides additional protection for his pool of knowledge, and allows the producer to participate in the supplier's capacity for innovation. In contrast, the larger the value and number of the supplier's inventiveness, the less likely is IN. Her increased outside option raises investments and the value of her (protected) knowledge.

[44] See Acemoglu et al. (2004), p.9ff.

[45] See Acemoglu et al. (2004, p.27) for the same procedure.

Moreover, equation 2.12 suggests that the derivative of Θ with respect to α is positive. The more P is able to keep of S's innovations due to the input, the less likely is IN. Intuitively, the affiliate's incentives to invest are too low in the case of integration due to a bad outside option. The overall surplus rises via reducing the parent firm's outside option by simultaneously increasing the supplier's incentives via NI. Hence, non-integration is more likely. Computing $\frac{\partial \Theta}{\partial \delta} > 0$ suggests that a larger number of prospective partners decreases the need for the supplier to integrate. Therefore, a higher number of P's competitors also boosts the probability of non-integration.

2.3.3 The Open Economy Case

In terms of knowledge protection, the open economy case compared with the closed economy framework differs in the patents' sphere of control. The assumption is that the protection of knowledge is a territorial right limited to national borders. That is, within this framework, the parent firm applies for patents within its national borders. In the international context, it is assumed that the producer's knowledge is protected within domestic borders. However, out of this area, the protection no longer holds. Therefore, the model addresses differences in the outside options and organizational structure between a domestic and foreign relationship.

Two countries, *Home* H and *Foreign* F, equal in size, are considered. However, they differ from each other in the innovations' territorial protection. FS is defined as a foreign supplier located in the foreign country F. Due to legal protection of the producer's knowledge in H, the foreign supplier has the option to imitate and invest within an existing pool of knowledge. FS is able to increase her individual surplus by selling the input x_s provided by ideas originally belonging to P outside of the protected environment. This affects particularly the NI mode. In contrast to the first case, FS is now by definition allowed to invest within the whole range of ideas i where

$i \in [1; n]$. Additionally, the number of potential partners may change in the new context. Hence, $\delta^{'}$ defines the new exogenous given probability for the foreign supplier to find an alternative partner. Due to the fact that, within the producer's pool of innovations, FS and P are potential competitors in the foreign market, their outside options are defined as the following:

$$O_{FS}^{NI} = \delta^{'}(\sum_{i=1}^{n} s_i e - \sum_{j=1}^{m} p_j E + 1)(\lambda), \tag{2.13}$$

$$O_{P}^{NI} = (\sum_{j=1}^{m} p_j E + 1)(1 - \lambda). \tag{2.14}$$

Maximizing each individual utility of party $i \in \{P; FS\}$ results in the following optimal investment levels: $E^* = 1 - \frac{3}{2}\lambda + \frac{1}{2}\lambda\delta^{'}$ and $e^* = \frac{1}{2}\lambda(1 + \delta^{'})$. Especially the result for the producer - P invests more compared with the non-integration mode in the closed economy context - is affected by two aspects: on the one hand, the loss of territorial protection increases the hold-up problem and therefore decreases the investment incentives. On the other hand, increasing the technological frontier and exploiting the existing pool of knowledge with additional investments allows the producer to boil down the supplier's outside option. The new environment results in inefficient high investments by the producer seeking additional protection. This result affirms the importance as well as the efficiency of a patent protected area. In the international context, e^* differs from the national one in $\delta^{'}$. Even though there is a broader range for FS to invest via an increased $i \in [1; n]$, the investment level e^* depends on the number of potential recipients settled or active in F. For instance, if $\delta^{'} > \delta$, there is no need for integration because of an increased bargaining power.

In the open economy, O_{FS}^{IN} is the same as in the national context. Input good x_s is assumed to be equal to 0. x_S goes over to P. Therefore, the pro-

ducer's production $(1-\lambda)$ plus a deduction $(1-\alpha^{'})$ of the foreign supplier's investments define the outside option,

$$O_P^{IN} = (\alpha^{'} \sum_{i=1}^{n} s_i e - \sum_{i=1}^{m} p_j E + 1)\lambda + (\sum_{i=1}^{m} p_j E + 1)(1-\lambda). \tag{2.15}$$

It is assumed that, in an ex-post break-up, P quits the supplier and sells the whole output. Following the procedure as given in the national case allows me to calculate the knowledge ratio for the new environment:[46]

$$\frac{\sum_{j=1}^{m} p_j}{\sum_{i=m}^{n} s_i} = \frac{\frac{1}{4}\alpha^{'} + \frac{1}{8}\alpha^{'2} + \frac{1}{4}\delta^{'} - \frac{1}{8}\delta^{'2}}{\frac{1}{8} + \frac{1}{4}\delta^{'2} - \frac{1}{4}\alpha^{'} - \frac{1}{8}\alpha^{'2}} \equiv \Theta^{'} \tag{2.16}$$

Comparing the new ratio $\Theta^{'}$ with Θ suggests that again a larger number of domestic patents of P makes international integration more likely. The larger the producer's pool of knowledge, the more important is the producer for the overall surplus. It is important to raise his outside option to ensure that he obtains the input.[47] The reverse intuition holds due to the supplier's importance of investment activity, that is, the more likely is NI. Because of being in a non-restricted environment, the supplier's investments count more in the NI mode compared with IN.[48]

Again, the derivative of $\Theta^{'}$ with respect to $\alpha^{'}$ is positive. An increasing α results in a need for additional incentives for S via non-integration to boost the total surplus. It also holds that a thicker outside market for the supplier raises the probability of non-integration.[49]

[46] The optimal investment levels $E^* = (1-2\lambda)$ and $e^* = \frac{1}{2}\lambda(1-\alpha)$ are unaffected.

[47] This follows from $\frac{\partial S^{IN} - S^{NI}}{\partial \sum_{j=1}^{m} p_j} > 0$.

[48] Increasing the supplier's space for investment from the national to the international context does not necessarily increase his investment incentives. The supplier's outside option under non-integration O_{FS}^{NI} is limited by the producer's innovation pool brought to the market.

[49] The intuition concerning δ in the international context is twofold. It means if $\delta^{'}$ is above a critical value δ^{TR} the threshold between integration and non-integration is decreasing with respect to an increasing outside market $\delta^{'}$. In this case P would not

To sum up, the value of domestic patents has the same impact on the organizational structure in both contexts. The greater P's inventiveness, the more likely is IN. The reverse effect holds for the affiliate's pool of innovations. The larger $\alpha^{'}$, the more P can keep, and the more likely is outsourcing in the international context according to the national mode. For certain values for α, the outside market δ has a positive impact on non-integration. If δ increases, the effect turns over to incentivize the producer's pool of knowledge. Moreover, further assumptions on the level of the outside parameters allow me to compare both thresholds Θ and $\Theta^{'}$. Assuming $\delta = \delta^{'}$ and $\alpha = \alpha^{'}$ results in a counterintuitive outcome against the traditional view.[50] The following Section 2.3.4 suggests both outcomes, the traditional as well as the the new view where an increasing amount of innovation favors outsourcing.[51]

2.3.4 Implications

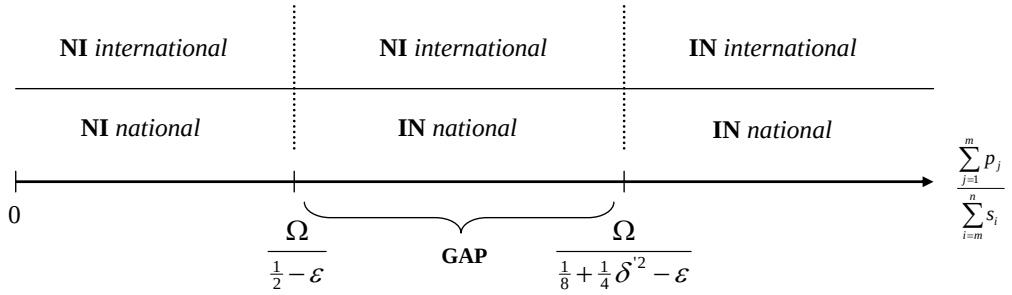
For simplification, it is assumed that $\delta = \delta^{'}$ and $\alpha = \alpha^{'}$. This allows me to compare the derived thresholds in the protected and unprotected contexts. Due to $\delta^{'}$, the comparison of the two ratios shows that the international threshold is always larger than the national one. This results from the difference between *Home* and *Foreign* that is given by $\frac{1}{8} + \frac{1}{4}\delta^{'} < \frac{1}{2}$.[52] It suggests that more patents lead to a greater probability of IN. However, within a certain range, the result also affirms the existence of the opposed outcome. Compared with the national context, despite an increasing pool of the producer's knowledge within this range, non-integration is the dominant relationship. Figure 2.3 shows the result for both cases.

invest anything, which is in terms of an existing pool of innovations, inefficient. The Appendix to Chapter 2 shows the proof.

[50] See Mol (2005), p.572ff.

[51] See Mol (2005), p.572ff and p.575ff, for the description of the two perspectives.

[52] Both ratios show the same nominator Ω as well as the expression $\epsilon = \frac{1}{4}\alpha^{'} + \frac{1}{8}\alpha^{'2}$.



Note: It is assumed that $\alpha = \alpha^{'}$ and $\delta = \delta^{'}$ holds.

Figure 2.3: Domestic vs. foreign relationship

Intuitively, less protection and a larger pool of the parent firm's innovation result in integration. This holds in the national as well as the international context. However, the gap between the two cases shows that non-integration holds *longer* in the unprotected context. The reason is that, in the international context, the supplier is always able to invest within the producer's existing pool of knowledge independently of the organizational structure. For the parent firm as well as the total surplus, it is efficient to use the additional incentives for the supplier's investment to obtain a greater surplus. This holds up to a certain point where the producer's pool of knowledge becomes too important and counteracting investments of the producer are too costly. The equilibrium turns over into integration. That is, the producer is able to exploit the difference between the territorial protection modes. Moreover, the more the parent firm can keep from the affiliate, the lower her incentives to invest. Hence, an increase in a expands the gap between the changeover from non-integration to integration in both cases.[53]

[53] Holding $\delta = \delta^{'}$ constant, an increase in $\alpha^{'}$ with $(\alpha < \alpha^{'})$ results in a rise between Θ and $\Theta^{'}$. A rise in $\delta^{'}$ incentivizes the supplier via outsourcing. However, if $\alpha^{'}$ is sufficiently large, an increase in $\delta^{'}$ results in a total surplus of non-integration below the integrative surplus. In this case $\Theta^{'} < \Theta$ suggests that in the national context the outsourcing mode holds *longer* than in the international framework.

2.4 Empirical Analysis

2.4.1 Dataset

The empirical analysis relies on a data matching for 14,322 Eastern European investment projects of 929 German firms. Data are provided by the pan-European micro database *Amadeus* released by the Bureau van Dijk (Bureau van Dijk, Electronic Publishing 2005). The underlying version covers data for 1.5 million companies in 38 European countries. Beside consolidated and unconsolidated data concerning firm-level information for up to 13 years, it contains the direct ownership share between a parent firm and her subsidiary for 2005. The data do not cover financial institutions and insurance companies. Information on the ownership structure is limited to 2005. All other variables on firm-specific characteristics are available from 1993 to 2005. More precisely, the underlying data cover unconsolidated information on German firms and their corresponding direct affiliates located in Germany and Eastern Europe. Each firm is matched with information about its patent activity. These data are obtained from the German Patent and Trade Mark Office. The unique database is constructed by adjusting all the firm-specific information consisting of the firm name, firm address, founding year, and firm history (like ownership, industry, and products). That is, the data cover a cross-sectional study on the number of patent applications granted of each German parent firm investing in Germany and Eastern Europe.[54] Beside the information about granted patent applications, the data are also matched with information about the severity of imitating the parent firm's products. This addresses the problem of catching a firm's innovation.[55] The data on imitation are provided by a unique survey of the Chair for In-

[54] Eastern Europe covers *Central Eastern Europe*, *Southern Eastern Europe*, the *Baltic States*, and the *Former Soviet Union*. For the whole list of countries, see Table T2.1 in the Appendix.

[55] See also Belenzon and Berkovitz (2007).

ternational Economics, University of Munich, about German firms investing in Eastern Europe.[56]

2.4.2 Descriptives and Estimation Methodology

To study the impact of inventiveness on the organizational structure, the dummy variable IN defines the ownership share within each parent-affiliate pair. The variable is equal to 1 if the ownership share is larger than 50 percent, otherwise it is 0. To find a more proper answer to whether parent companies favor integration over outsourcing due to an increasing pool of innovations (i.e. in terms of reflecting a transaction inside the firm (offshoring) versus an arm's-length transaction (outsourcing)), an alternative measure is constructed that defines the threshold at the 35 percent level.[57] As already mentioned in the literature survey, Antras and Helpman (2004, p.575) argued that only the most productive firms within the headquarter-intensive sectors favor integration over outsourcing. Therefore, the parent firm's working capital-to-labor ratio K/L is included as well as the firm's labor productivity deviation $\dot{Y/L}$ compared with the sample average productivity. Following the theoretical predictions by Antras and Helpman (2004), for both variables a positive coefficient is expected. *AffRat* measures the number of affiliates in the corresponding investment country over the total number of affiliates in the rest of the world.[58] The variable is motivated by Mol (2005). It suggests that a larger number of foreign subsidiaries makes non-integration more likely. On the one hand, parent firms, already having invested in a foreign partner country, are more familiar with potential local suppliers and therefore non-integration is more likely due to lower searching costs.[59] On the other hand, relocating activities outside the firm boundaries

[56] I would like to thank Dalia Marin for providing me these data.

[57] The ownership share in the underlying dataset ranges from 0.01 to 100 percent. See Marin (2006) for a further discussion on the threshold.

[58] The ownership share is at least larger than 25 percent.

[59] See Mol (2005), p.577.

is driven *inter alia* by costs savings related to fixed costs. These are also obtained via outsourcing. The pool of knowledge is measured by intangibles per worker, namely $Intangibles$, and patent applications (granted after 2004) per worker, namely $Patents$. $Intangibles$ can be understood as an objective variable measuring insubstantial values in a firm. The patent variable is closer related with innovations in terms of intellectual property rights. However, contrary to *intangibles*, it does not measure the real value of innovations in a firm. Therefore, this yields the baseline specification, which is described by the following equation:

$$\begin{aligned} IN_{ijk}^{mode} = \beta_0 + \beta_1(K/L)_{ik} + \beta_2(Y/L)_{ik} + \beta_3 AffRat_{ik} \\ + \beta_4 log(L)_{ik} + \beta_5 IPR_{ik} + \vartheta_{ik} + u_{ik} \end{aligned} \tag{2.17}$$

where IN depends on the definition of the 50 or 35 percent modus given for each firm pair between parent company i and the corresponding affiliate j for each investment project k. The variable IPR is replaced by the parent firm's pool of patents and intangibles, respectively. In this context, the null hypothesis $\beta_{IPR} = 0$ means that innovation has no influence on the ownership structure decision. Against the null hypothesis, if $\beta_{IPR} \neq 0$ significantly holds, there is an influence on the left-hand side variable explaining the difference between outsourcing and offshoring. The theoretical model predicts a positive impact of the parent firm's pool on integration. Moreover, depending on the regression specification, parent and affiliate firm characteristics are also included (e.g. number of employees, affiliate's outside option). Unobserved country- and firm-specific factors are controlled for by including a vector ϑ_{ik} representing a set of legal form distinctions, country-specific, and industry-specific dummies, where the industry component is included at a NACE Rev.l 2-digit classification. In the Appendix, Table T2.2 presents the definitions and sample statistics for the underlying investment projects.

The sample statistics shows that the patent variable has a maximum of 8

patents per employee and a standard deviation of 0.2. Excluding firms without any granted inventions shows an average value of 0.03 and a standard deviation of 0.3. The slight increase suggests that the variables' information is reliable without increasing their variance dramatically. This is also confirmed by the average patent application compared with Belenzon and Berkovitz (2007). They find a mean of 4.17 patents per firm whereas the underlying German patents in this study show an average of 7.4 per firm.[60] Table 2.1 delivers a first insight into the relationship between patents and integration. For different samples, namely investments to Eastern Europe, investments to Germany, and overall investments, a larger pool of inventiveness is related to integration. That is, a larger mean of patent applications over all the investment projects in each sample is related to a larger ownership share between parent and affiliate.

Table 2.1: Patent applications and integration

Sample	Non-integration	Integration
CEE	37 (250)	53 (1172)
Germany	73 (1492)	77 (4687)
Total	68 (1742)	72 (5859)

Notes: Mean of German patent applications (granted) over all available firm pairs. Sample sizes are in parentheses. Integration means a ownership share larger than 50 percent.
Sources: Amadeus (Bureau van Dijk 2005), GPTO (2008b, 2008c), and Chair for International Economics, University of Munich. Author's calculations.

Using the whole information on the parent's ownership share instead of the binary variable on integration also suggests that an increasing pool of patents in 2004 boosts the probability of a larger ownership share level. Figure 2.4 presents the finding in each case. For both German affiliates and Eastern European affiliates, it holds that an increasing pool of knowledge

[60] Belenzon and Berkovitz (2007, p.3) study a total of 50,000 patents held by 12,000 European firms.

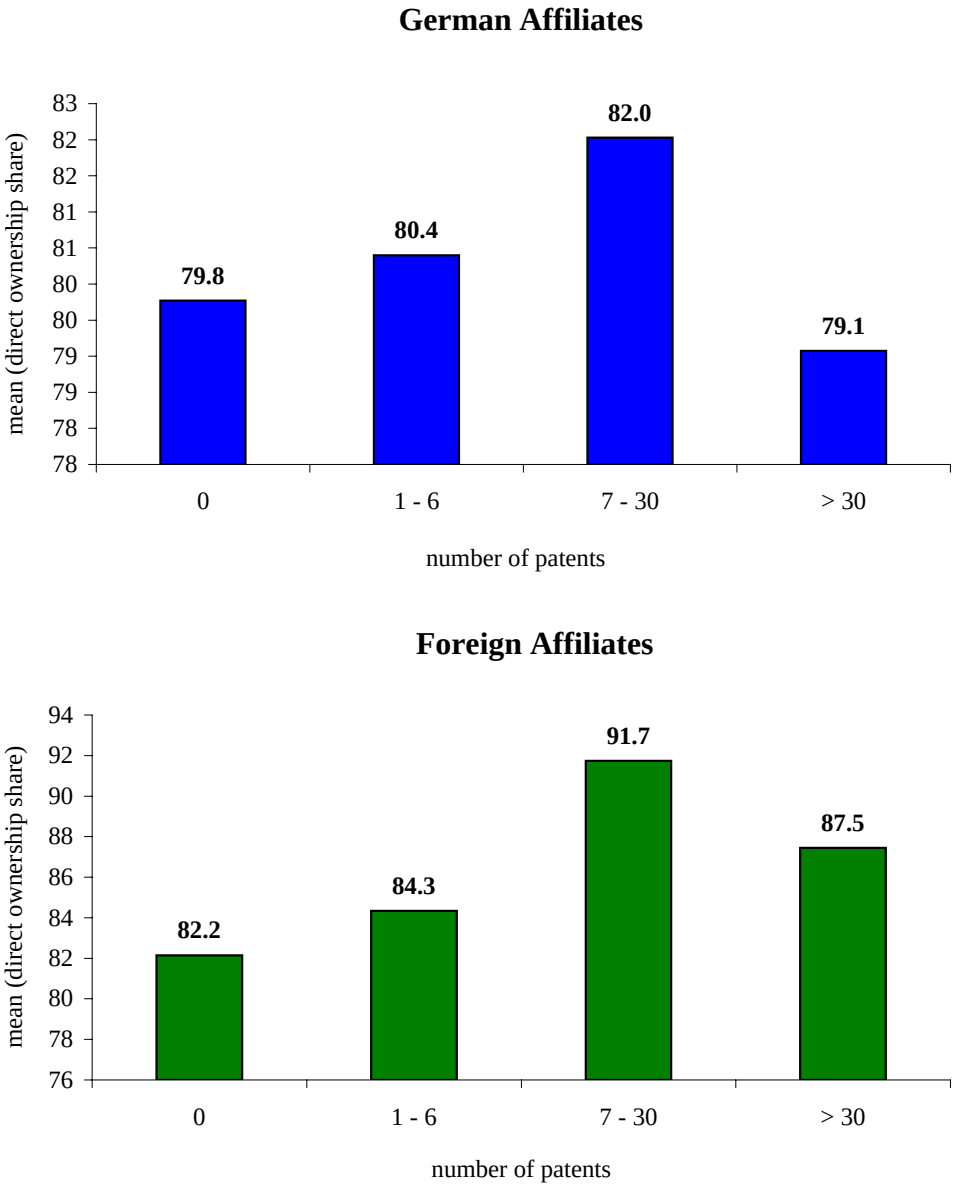
raises the direct ownership share. However, a pool larger than 30 patents lowers the relational share. Intuitively, each patent category shows a greater probability for integration in the foreign context compared with the domestic context.

The result also holds when the data are separated into small and medium-sized firms (SME) with a number of employees smaller than or equal to 500 and firms with an employee number of more than 500 (large firms). Both SMEs as well as large firms are more integrative if they have a higher number of granted patent applications. The distribution of the firm size suggests that the results are driven by both the innovative German SMEs as well as large firms: 55 percent of the parent firms show a size smaller than 500 employees and 45 percent a size larger than 500 employees.

2.4.3 Empirical Results

Equation 2.17 is estimated cross-sectionally with fixed effects to control for omitted variables. Due to the limited dependent variable, regressions are run by the nonlinear method of maximum likelihood estimation. The non-linear regression model (probit) allows me to study the impact of inventiveness on the organizational structure. The sub-samples differentiate between Germany and Eastern Europe to verify the theoretical predictions about domestic and foreign outsourcing. To produce valid statistical inferences, the errors are corrected for heteroskedasticity. Whereas the dependent variable is given for 2005, the independent variables are given for the period t-1.

Table 2.2 presents the results for investments in Germany. The decision to integrate, where the binary variable is equal to 1, is regressed on the parent's pool of intangible-to-employee ratio. Moreover, the affiliate ratio as well as the productivity measure and the firm size are included as controls. Column (1) shows that an increase in the pool of intangibles raises the probability of integration. The coefficient is highly significant and in line



Sources: Amadeus (Bureau van Dijk 2005), GPTO (2008b, 2008c), and Chair for International Economics, University of Munich. Author's calculations.

Figure 2.4: Domestic vs. foreign affiliates

with the theoretical predictions. The capital-to-labor ratio is insignificant, which gives no evidence about the relationship between headquarter intensity and offshoring. However, the most productive choose integration over outsourcing (Antras 2003). This results from the positive and highly significant coefficient on $(Y/L)_{ik}$. Additionally, the larger the number of domestic affiliates and the larger the firm size, the more likely is non-integration. This is suggested by columns (2) to (4). Both coefficients *AffRat* and $log(L)$ are highly significant at the 1 percent level. The results also hold when industry- and firm-specific dummies are included.

Table 2.2: Organizational structure in Germany

Dependent variable: *Integration*				
	(1)	(2)	(3)	(4)
$(K/L)_p$	-0.082	-0.251	0.308	0.133
	[0.271]	*[0.768]*	*[0.819]*	*[0.336]*
$(Y/L)_p$	0.009***	0.019***	0.005	0.013**
	[3.382]	*[4.898]*	*[1.333]*	*[1.943]*
AffRat	-0.111	-0.158**	-0.214***	-0.235***
	[1.565]	*[1.981]*	*[2.774]*	*[2.938]*
$Log\ (L)_p$		-0.063***		-0.05***
		[3.834]		*[2.807]*
$(Intang)_p$	0.009***	0.008***	0.007***	0.006***
	[7.417]	*[6.408]*	*[4.937]*	*[4.276]*
Fixed effects	*no*	*no*	*yes*	*yes*
Observations	3210	3210	3197	3197
Pseudo R2	0.03	0.03	0.06	0.06

Notes: Probit estimation with a constant (not shown), robust z statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 35 percent, otherwise zero. For a detailed definition of the variables, see the descriptive chapter. Fixed effects are defined as a set of industry- and firm-specific dummies. *, **, *** indicate significance at the 10, 5, 1 percent level, respectively.

If an increasing producer's pool of knowledge raises the probability of integration, I expect similar results for the more specific patent variable. For the same set of observations, Table 2.3 presents the results for replacing intangible assets with the firm's pool of patents. Columns (1) and (2) suggest that the positive sign of the coefficient is as expected. Unfortunately, the coefficients on Pat_P are insignificant. The negative sign on the capital-to-labor ratio $(K/L)_P$ is contrary to the expectations. However, in the following more reliable specifications (3) and (4), the coefficient turns its sign and becomes insignificant. The negative sign on the affiliate ratio suggests that an increase in the number of domestic affiliates is accompanied by a fall in the probability of the integrative outcome. The same holds for the firm size, which is intuitive due to cost-saving aspects. Both variables are highly significant. Including fixed effects, column (3) shows a significant coefficient on patents. Again, it has the predicted sign and confirms the theoretical predictions.[61]

[61] All the presented results also hold in the case of a dependent variable differing at a 50 percent threshold instead of a 35 percent threshold.

Table 2.3: Patents and the organizational structure in Germany

Dependent variable: *Integration*				
	(1)	(2)	(3)	(4)
$(K/L)_P$	-0.5354*	-0.5579*	0.1329	0.0629
	[1.670]	*[1.717]*	*[0.340]*	*[0.159]*
$(Y/L)_P$	0.0198***	0.0187***	0.0134***	0.0130***
	[5.256]	*[4.977]*	*[2.674]*	*[2.587]*
AffRat		-0.1558**		-0.2152***
		[2.073]		*[2.824]*
Log $(L)_P$	-0.0857***	-0.0916***	-0.0626***	-0.0675***
	[5.620]	*[5.707]*	*[3.732]*	*[3.930]*
$(Pat)_P$	0.4259	0.1534	1.0269	0.8189
	[0.539]	*[0.194]*	*[1.281]*	*[1.026]*
Fixed effects	*no*	*no*	*yes*	*yes*
Observations	3228	3228	3215	3215
Pseudo R2	0.01	0.02	0.05	0.05

Notes: Probit estimation with a constant (not shown), robust z statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 35 percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. Fixed effects are defined as a set of industry- and firm-specific dummies. *, **, *** indicate significance at the 10, 5, 1 percent level, respectively.

In order to check the theoretical predictions in the international context, Table 2.4 present the familiar set-up for investments in Eastern Europe considering intangibles as a measure of the pool knowledge. Beside the firm and industry dummies, affiliate country dummies are also included. Throughout all the specifications, the coefficient on $Intang_P$ suggests that offshoring is more likely than international outsourcing with an increasing pool of intangibles. The fact that the coefficient on the affiliate ratio is now positive suggests that the more familiar the producer is with the foreign environment, the more likely is an integrated relationship. Therefore, the firm may prefer an employment's relocation to a country where the hold-up risk is high (Marin 2006). In terms of a potential knowledge spillover, the larger the danger of losses to countries with weak property rights, the more likely is integration (Nunn and Trefler 2007). Moreover, *AffRat* could also represent the parent firm's outside option. That is, the larger his outside option, the more likely is his preferred relationship (Acemoglu et al. 2004). The coefficient is significant throughout all the specifications. Although the coefficient on Y/L_P is only significant in specification (3), the direction of the impact is as expected. The capital-to-labor ratio is negative, which suggests a capital-intensive producer is more likely to favor international outsourcing over offshoring.[62]

Turning to the regression results with the pool of patents instead of intangibles affirms the results already given. In the first two sets of specifications, Pat_P is positive but insignificant. Column (3) shows a larger z-statistic whereas the coefficient in column (4) is statistically significant at the 5 percent level. Moreover, the impact of the other variables is as given before. K/L_P suggests that the extent of reducing labor costs via offshoring is higher than in the risky case of outsourcing. The firm's productivity mea-

[62] All the presented results also hold in the case of a dependent variable equal to 1 if the ownership share is larger than 35 percent and equal to 0 if the ownership share is below 35 percent. The coefficients are slightly less significant.

Table 2.4: Organizational structure with Eastern European countries

Dependent variable: *Integration*				
	(1)	(2)	(3)	(4)
$(K/L)_P$	-0.9364**	-0.8884*	-0.3886	-0.3463
	[1.994]	*[1.917]*	*[0.678]*	*[0.601]*
$(Y/L)_P$	0.0296	0.0158	0.0748**	0.0637
	[1.174]	*[0.492]*	*[2.202]*	*[1.440]*
AffRat	0.8536**	0.9163**	0.7694*	0.8212*
	[1.998]	*[2.059]*	*[1.668]*	*[1.686]*
Log $(L)_P$		0.0229		0.0185
		[0.623]		*[0.398]*
$(Intang)_P$	0.0053**	0.0051**	0.0127***	0.0125***
	[2.165]	*[2.172]*	*[3.098]*	*[3.206]*
Fixed effects	*no*	*no*	*yes*	*yes*
Observations	579	579	560	560
Pseudo R2	0.03	0.03	0.12	0.12

Notes: Probit estimation with a constant (not shown), robust z statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 50 percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. Fixed effects are defined as a set of industry- and firm-specific dummies as well as dummies controlling for the Eastern European countries. *, **, *** indicate significance at the 10, 5, 1 percent level, respectively.

sure has the expected coefficient but is insignificant, which results in further specifications without this variable. Again, *AffRat* is positive and significant. $Log(L)_P$ is also positive and significant in the last specification. Marin (2006) argues that labor costs can be reduced most effectively by choosing integration rather than non-integration. Therefore, a labor-intensive firm chooses integration over non-integration. The intuition is given by a typical hold-up risk that increases along with weak property rights the costs of organizing the activity outside the firm boundaries. To obtain an idea of the importance of the affiliates' outside option, columns (3) and (4) also include the variable Oo_A. The coefficient shows a negative sign, which affirms the theoretical predictions by McLaren (2000). The larger the number of similar producers in the Eastern European country and, therefore, the larger the supplier's outside option, the less her hold-up risk in non-integration and the more likely is an arm's-length relationship between the two parties. Moreover, it increases the supplier's incentives to invest (Acemoglu et al. 2004).

The larger the pool of the parent firm's intellectual property rights, the more likely is integration. This result also holds across the whole sample of domestic and foreign German investments. Table 2.6 presents the results using probit and OLS to analyze the marginal effect of innovation on offshoring.

The first two columns in Table 2.6 present a significant coefficient of Pat_P. It indicates that, over all the investments, a larger pool of parental knowledge favors integration. The linear probability model in column (2) suggests that an additional patent increases the probability of integration by 37 percent. Including the affiliate ratio, columns (3) and (4) show a reduced impact of knowledge on the organizational structure. The marginal effect is positive and about 30 percent. The significance is equal or close to the 10 percent level. Following Amemiya (1981) and Camron and Trivedi (2005),

Table 2.5: Patents and organizational structure in Eastern Europe

Dependent variable: *Integration*				
	(1)	(2)	(3)	(4)
$(K/L)_P$	-0.9294**	-0.8853*	-0.7195	-0.2029
	[1.993]	*[1.933]*	*[1.607]*	*[0.388]*
$(Y/L)_P$	0.0221	0.0059		
	[0.881]	*[0.187]*		
AffRat	0.8653**	0.9369**	0.6757*	0.548
	[2.025]	*[2.112]*	*[1.774]*	*[1.357]*
Log $(L)_P$		0.0267	0.03	0.0604*
		[0.756]	*[1.190]*	*[1.905]*
$(Oo)_A$			-0.0005**	-0.0009**
			[1.966]	*[2.022]*
$(Pat)_P$	6.9617	6.4598	3.2887	6.2284**
	[1.506]	*[1.519]*	*[1.642]*	*[2.007]*
Fixed effects	*no*	*no*	*no*	*yes*
Observations	582	582	670	658
Pseudo R2	0.02	0.02	0.02	0.11

Notes: Probit estimation with a constant (not shown), robust z statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 35 percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. Fixed effects are defined as a set of industry- and firm-specific dummies as well as dummies controlling for the corresponding Eastern European countries. *, **, *** indicate significance at the 10, 5, 1 percent level, respectively.

Table 2.6: Organizational structure: Probit vs. OLS

Dependent variable: *Integration*				
	Probit	OLS	Probit	OLS
	(1)	(2)	(3)	(4)
$(K/L)_P$	0.2265	0.0731	0.1801	0.0586
	[0.797]	*[0.874]*	*[0.629]*	*[0.692]*
$(Y/L)_P$	0.0098**	0.0029**	0.0092**	0.0028**
	[2.433]	*[2.535]*	*[2.300]*	*[2.414]*
AffRat			-0.2006***	-0.0681**
			[2.644]	*[2.550]*
Log $(L)_P$	-0.0473***	-0.0138***	-0.0515***	-0.0154***
	[3.508]	*[3.635]*	*[3.760]*	*[3.975]*
$(Pat)_P$	1.2676*	0.3704**	1.0866	0.3167*
	[1.778]	*[2.048]*	*[1.536]*	*[1.745]*
Fixed effects	*yes*	*yes*	*yes*	*yes*
Observations	3770	3783	3770	3783
Adj./Pseudo R2	0.07	0.07	0.07	0.07

Notes: Probit (OLS) estimation with a constant (not shown), robust z (t) statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 50 percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. Fixed effects are defined as a set of industry- and firm-specific dummies (including the firm's legal form as additional control). Country dummies controlling for the corresponding German and Eastern European countries are also included. Similar results are obtained by the 35 percent definition of integration. Here, the patent variable is less significant, equal or close to the 10 percent level. *, **, *** indicate significance at the 10, 5, 1 percent level, respectively.

the variance between OLS and probit is an effect of values with a probability below 0.1 as well as above 0.9. Additionally, all the other variables suggest the expected intuition. Therefore, the presented results affirm the reliability of the estimated coefficients as well as the theoretical predictions as outlined in Section 2.3.[63]

The theoretical part predicts that the changeover from non-integration to integration takes *longer* when the parent firm invests abroad compared with the changeover in purely domestic investments. In order to control for this difference, the starting point is presented by column (1) in Table 2.7. Using a linear probability model, as presented in Table 2.6, the positive sign of the coefficient on the productivity measure suggests that only the most productive integrate (Antras 2003). Considering $log(L)_P$, the larger the firm's endowment of employees, the more likely is outsourcing. Moreover, when investing abroad, the loss of the territorial protection and therefore the increased hold-up risk boosts the probability of integration between the parent firm and the supplier. This is suggested by the included country dummy, which is equal to 1 if the German parent firm invests in Eastern Europe and equal to 0 if the firm invests in the domestic market. All the mentioned variables are significant at the 1 percent level. To test the theoretical prediction of an *increased* likelihood of non-integration in CEE compared with investments in Germany, column (2) includes an interaction between the country dummy and the pool of parental knowledge. All the coefficients show the expected signs. Unfortunately, the coefficient on Pat_P and the interaction term is not significant. However, the negative sign of the coefficient on the interaction term suggests that the theoretical framework is correct in predicting a longer tendency towards non-integration when the inventive parent

[63] Using the 35 percent definition of the integration measure suggests the same impact of each variable. Only the significance of Pat_P is slightly below the given values in Table 2.6.

firm goes abroad. Due to the fact that the impact could be driven by the firm size, column (3) presents the same specification set for the sub-sample of SMEs. This method takes account of the highly inventive medium-sized enterprises, especially in Germany. Whereas the employment measure becomes insignificant, the negative and significant sign of the coefficient on the interaction term gives empirical evidence for the theoretical prediction as outlined in Section 2.3. First, the larger the capacity for innovation, the more likely is offshoring. Second, international outsourcing holds *longer* for a given knowledge ratio when SMEs are investing abroad. Intuitively, due to a limited endowment, SMEs prefer outsourcing to incentivize the supplier additionally to invest within the whole range of innovations. It brings additional surplus that is not available in the national context. However, in the international context, it is also true that a rising knowledge pool increases the producer's hold-up risk and therefore shifts the emphasis to the producer and his need to obtain (a part of) the input.

Table 2.7: Gap in the organizational structure

Dependent variable: *Integration*			
	all firms		SME
	(1)	(2)	(3)
$(K/L)_P$	0.0089	0.0122	-0.0063
	[0.117]	*[0.148]*	*[0.066]*
$(Y/L)_P$	0.0029***	0.0029***	-0.2322
	[3.072]	*[3.071]*	*[1.608]*
Log $(L)_P$	-0.0108***	-0.0108***	-0.0003
	[3.411]	*[3.408]*	*[0.023]*
$(Pat)_P$	0.2359	0.246	0.8081***
	[1.531]	*[1.422]*	*[2.672]*
Country	0.1235***	0.1239***	0.064
	[8.641]	*[8.548]*	*[1.572]*
$(Pat)_P$ * country		-0.0893	-0.7252*
		[0.370]	*[1.938]*
Fixed effects	*yes*	*yes*	*yes*
Observations	3821	3821	916
Adjusted R2	0.04	0.04	0.06

Notes: Linear probability estimation with a constant (not shown), robust t-statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 35 percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. The country dummy is equal to one when the parent firm invests in Eastern Europe and it is equal to zero when the firm invests in Germany. Fixed effects are defined as a set of industry- and firm-specific dummies. Fixed effects also include affiliate country dummies controlling for the corresponding Eastern European countries. Similar results are obtained by the 50 percent definition of integration. In the 50 percent set-up, the variables present a even higher significance level. *, **, *** indicate significance at the 10, 5, 1 percent levels, respectively.

2.4.4 Robustness

This section discusses the robustness of the empirical findings. To address the potential problem of endogeneity, the following tables report a number of alternative measures and methods. The results affirm the theoretical predictions as well as the empirical findings.

Table 2.8 starts with a probit estimation in the German sub-sample. Instead of dividing the innovation measure by the number of employees, it reports the results for the coefficient on the knowledge variable per firm's value added. Column (1) presents the results for the firm's intangible assets $IntangVA$. The coefficient is as expected and significant at the 1 percent level. The larger the ratio of the assets, the greater is the pool of intangibles within the parent firm's added value. Therefore, as the theoretical framework predicts, the more likely is integration. Columns (2) to (4) also suggest that this holds for both the patent measure as well as for the decision about the organizational structure in Eastern Europe. Moreover, all the other variables present the expected coefficients, which suggests that the results are not sensitive to the inclusion of value added. Again, the sign of the coefficient on productivity is positive, suggesting that only the most productive choose offshoring over outsourcing. Columns (5) and (6) show the results using probit and OLS over all the investments, respectively. Both coefficients on $PatVA_P$ are significant and positive: the larger the pool of knowledge within the value added, the more likely is integration.

Running the same specifications including the interaction term between foreign investments and knowledge presents the predicted impact. However, the coefficients are less significant. Additionally, the same set of specifications is run on firms with a value of patents larger than 0. Again, the coefficients show the predicted signs but they are less significant (below the 15 percent level). In order to control for the fact that a parent firm owns an existing

Table 2.8: Robustness: organizational structure

Dependent variable: *Integration*						
	Germany		Eastern Europe		Whole sample	
	(1)	(2)	(3)	(4)	(5)	(6)
$(K/L)_p$	-0.0631	0.095	-0.4484	-0.5248	0.1145	0.0347
	[0.157]	*[0.277]*	*[0.755]*	*[0.916]*	*[1.405]*	*[1.591]*
$(Y/L)_p$	0.0151***	0.0113**	0.1011**	0.0885*	0.0103**	0.0030**
	[2.827]	*[2.483]*	*[2.065]*	*[1.854]*	*[2.473]*	*[2.536]*
AffRat	-0.2158***	-0.2138***	0.5821	0.7875	-0.1815**	-0.0630**
	[2.828]	*[2.689]*	*[1.191]*	*[1.573]*	*[2.413]*	*[2.407]*
Log $(L)_p$	-0.0765***	-0.0686***	-0.0206	0.0116	-0.0519***	-0.0153***
	[3.925]	*[4.231]*	*[0.415]*	*[0.235]*	*[3.588]*	*[3.744]*
$(IntangVA)_p$	1.1348***		2.6092*			
	[2.963]		*[1.849]*			
$(PatVA)_p$		2.539**		4.1282	2.5127**	0.5435**
		[2.119]		*[1.159]*	*[2.215]*	*[2.469]*
Fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	2959	2977	472	475	3457	3469
Adj./Pseudo R2	0.06	0.07	0.13	0.11	0.07	0.07

Notes: Probit estimation with a constant (not shown), robust z-statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 35 percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. Fixed effects are defined as a set of industry- and firm-specific dummies. Fixed effects also include a country dummy controlling for the corresponding countries in Eastern Europe and Germany. The underlying estimation method from columns (1) to (5) is probit; for comparison reasons in column (6) the underlying method is OLS. The parent firms' intangible assets and patents are divided by the firms' value added. *, **, *** indicate significance at the 10, 5, 1 percent levels, respectively.

pool of innovations, the patent measure's information is reduced to a binary variable. It is equal to 1 if the firm owns at least one filled patent and 0 otherwise. The regressions are run for probit and OLS as well as for the sub-sample of SMEs. Throughout all the specifications, the patent dummy is positive and significant at least at the 5 percent level. There is only weak empirical evidence for the theoretical prediction that outsourcing holds *longer* in the international context. The coefficient on the interaction term is, close to the 15 percent level, not significant. Moreover, the dependent variable is also changed from a binary to a continuous variable ranging between 0 and 100 percent. Despite low significance in the Eastern European sub-sample, all the variables show the right impact and an underlying significance as presented before.

In the literature, it is argued that innovation is influenced by various determinants.[64] Additionally, it is possible that the organizational structure has an influence on inventive activities. Moreover, freed resources could also be useful for further investments in costly patent proceedings. It could be the case that outsourcing frees resources and these in turn are used for further innovation (Glass and Saggi 2001). This would imply that the knowledge variable is correlated with the error term. Therefore, the coefficient on the knowledge variable is biased due to simultaneous causality. The following results take account of this problem.

The patent variable is instrumented by a measurement of the possibility to imitate the parent firm's products. The variable *copy* ranges from 1, which means that the products can be easily imitated, to 3, which means that extraordinary efforts are necessary for imitation. The variable is reconstructed by a binary code that is equal to 0 if imitation is easy and 1 otherwise, hence large or extraordinary efforts are necessary.[65] To obtain reliable results, a

[64] See Griliches (1990, 1992), who gives a survey of the empirical literature addressing innovation.

[65] The variable comes out of a unique data survey of 660 global corporations in Austria

valid instrument must be correlated with the problematic patent variable and must be exogenous, that is, uncorrelated with the error term. The instrument's relevance can be tested in the first stage of the instrumental variables regression:

$$\begin{aligned} Pat_P = \beta_0 + \beta_1 copy_{ik} + \beta_2 (K/L)_{ik} + \beta_3 (Y/L)_{ik} \\ + \beta_4 AffRat_{ik} + \beta_5 log(L)_{ik} + \vartheta_{ik} + v_{ik}, \end{aligned} \tag{2.18}$$

where the binary patent variable is regressed on the instrument $copy_{ik}$. Table 2.9 reports the first-stage results. The sign of the coefficient on $copy_{ik}$ is negative and significant. Intuitively, the easier the possibility to imitate (costly) products, the more likely is seeking patent protection. If it is difficult to imitate the product, it is protected by itself and the less likely is territorial protection. From this perspective, *copy* appears to be a relevant instrument. Because equation 2.18 is exactly identified, exogeneity cannot be tested. From an intuitive perspective, the decision about the organizational structure has no influence on the existing pool of knowledge of the parent firm. The variable measures the active evaluation of the possibility to imitate an existing product before the decision about patenting investments is made. Therefore, the assumption of exogeneity is fulfilled. Table 2.9 presents the results.

Columns (1) and (2) suggest that an increasing pool of knowledge boosts the probability of integration. The coefficient is significant for both thresholds. Moreover, the capital-to-labor ratio is also positive and significant in column (1). Unfortunately, the sign of the coefficient on productivity turns. Contrary to the previous results, the impact is negative. However, it becomes insignificant in column (2). It is noticeable that the number of observations falls by more than 50 percent. This is induced by the limited availability of the variable copy. Columns (3) and (4) study the effect of the second theoret-

and Germany, University of Munich. For further information see Marin et al. (2003).

Table 2.9: 2SLS regressions: organizational structure

Dependent variable: *Integration*				
	50% threshold	35% threshold	50% threshold	35% threshold
	(1)	(2)	(3)	(4)
$(K/L)_p$	0.3268**	0.1363	0.2523*	0.1273
	[1.97]	*[0.95]*	*[1.759]*	*[0.935]*
$(Y/L)_p$	-0.0083**	-0.004	-0.0095***	-0.0060***
	[2.09]	*[1.35]*	*[3.360]*	*[2.936]*
AffRat	0.0452	0.033	0.0606*	0.0551**
	[0.97]	*[0.98]*	*[1.663]*	*[2.150]*
Log $(L)_p$	0.0091	0.0074	0.003	0.0058
	[0.85]	*[0.82]*	*[0.340]*	*[0.727]*
$(Pat)_p$	0.4469***	0.2236**	0.5618***	0.3466***
	[2.80]	*[1.94]*	*[4.495]*	*[3.853]*
Country			0.1505**	0.1306**
			[2.135]	*[2.276]*
$(Pat)_p$ * country			-0.2693***	-0.1726**
			[2.682]	*[2.099]*
First-stage results	-0.302***	$R^2 = 0.44$	-0.279***	$R^2 = 0.64$
	[6.73]		*[7.92]*	
Fixed effects	*yes*	*yes*	*yes*	*yes*
Observations	1179	1179	1179	1179
Adj./Pseudo R2	0.07	0.05	0.04	0.03

Notes: 2SLS estimations with a constant (not shown), robust t-statistic in brackets. The dependent variable is equal to one if the direct ownership share is larger than 50(35)percent, otherwise zero. For a detailed definition of the variables, see the descriptive Section 2.4.2. Fixed effects are defined as a set of industry- and firm-specific dummies. Fixed effects also include a country dummy controlling for the corresponding countries in Eastern Europe and Germany. Patents are instrumented by copy, a variable that is equal to zero if parent firm goods can be easily copied and one if imitation is not possible or only with extraordinary efforts. *, **, *** indicate significance at the 10, 5, 1 percent level, respectively.

ical prediction about the difference between domestic and foreign investments on the organizational structure. The results provide empirical evidence for the theoretical predictions. A larger pool of inventiveness increases the probability of integration. However, outsourcing holds *longer* when the parent firm invests abroad. This is suggested by the negative coefficient on the interaction term, which is significant.[66]

2.5 Conclusion

This chapter studies the determinants of the organizational structure of German firms investing in Eastern Europe. Following Acemoglu et al. (2004), the theoretical framework predicts that a larger pool of parental knowledge increases the probability of integration. This holds in both the national *and* international contexts. However, in the foreign case, the decision to outsource holds *longer*. In more detail, there are three key predictions within the theoretical framework. First, the larger the domestic pool of knowledge at the parent firm's level, the more likely is integration. Second, this finding holds in the national as well as in the international context. Along with Acemoglu et al. (2004), the carrier with the higher capacity for inventiveness has to be incentivized by his preferred organizational form. Third, territorial protected knowledge also increases the likelihood of international outsourcing. That is, the outcome of outsourcing holds "longer" with an increasing parental pool of innovations in the international context compared with the territorially protected national case. Moreover, the framework suggests that (i) the larger the number of potential partners for the supplier, the more likely is non-integration, which is also in line with McLaren (2000); (ii) the

[66] As stated by Acemoglu et al. (2004, p.23), some problems may occur because of treating both the patent variable and the concerning interaction simultaneously as endogenous.

larger the parent firm's possibility of keeping knowledge of the supplier, the more likely is outsourcing.

The empirical analysis provides evidence for the theoretical predictions using (i) the European micro database *Amadeus*(Bureau van Dijk 2005) matched with (ii) data from the German Patent and Trade Mark Office (2008) and (iii) a unique data set from German firms investing in Eastern Europe. The results indicate that, for German parent firms investing in Germany and Central and Eastern Europe, integration is more likely the larger their pool of knowledge. This holds for both measures given by intangibles and the number of patents. Beside that, productivity is positively related to the change from outsourcing to offshoring (Antras and Helpman 2004). Because of an obvious existence of specification problems, robustness checks are run to confirm the obtained empirical findings. An instrumental variable regression also suggests that the results are consistent with the theoretical predictions. It confirms the existence of a gap in the outsourcing decision between home and abroad. Because the empirical findings are based on the definition of innovation, different measures are conceivable. Therefore these provide the further proceeding in future research, especially in the international context of the drivers of the decision on the organizational structure.

Appendix to Chapter 2

I. Proof

Proof of the outside market due to the international case

The first derivative of $\theta^{'}$ with respect to $\delta^{'}$ is

$\frac{\partial\theta^{'}}{\partial\delta^{'}} = \frac{(\frac{1}{4}-\frac{1}{4}\delta^{'})(\frac{1}{8}+\frac{1}{4}\delta^{'2}-\epsilon)-(\epsilon+\frac{1}{4}\delta^{'}-\frac{1}{8}\delta^{'2})\frac{1}{2}\delta^{'}}{(\frac{1}{8}+\frac{1}{4}\delta^{'2}-\epsilon)^2}$

$\frac{\partial\theta^{'}}{\partial\delta^{'}} = \frac{1}{32} - \frac{1}{16}\delta^{'2} - \frac{1}{4}\epsilon - \frac{1}{4}\delta^{'}\epsilon - \frac{1}{32}\delta^{'}$ with $\epsilon = \frac{1}{4}\alpha^{'} + \frac{1}{8}\alpha^{'2}$

iff $\alpha^{'} \to 0 \Leftrightarrow \epsilon \to 0 \Rightarrow \frac{1}{32} - \frac{1}{16}\delta^{'2} - \frac{1}{32}\delta^{'}$

iff $\delta^{'} < \frac{1}{2} \Rightarrow \frac{\partial\theta^{'}}{\partial\delta^{'}} > 0$

iff $\delta^{'} > \frac{1}{2} \Rightarrow \frac{\partial\theta^{'}}{\partial\delta^{'}} < 0$

Therefore concerning to $\frac{\partial\theta^{'}}{\partial\delta^{'}}$:

iff $\alpha^{'} \to 1 \Rightarrow \delta^{'TR} \downarrow$

iff $\delta^{'} \in]0; \delta^{'TR}[\to \frac{\partial\theta^{'}}{\partial\delta^{'}} > 0$

iff $\delta^{'} \in]\delta^{TR}; 1[\to \frac{\partial\theta^{'}}{\partial\delta^{'}} < 0.$ q.e.d.

The intuition is given as follows. The larger the affiliate's likelihood to find an alternative partner outside the intended relationship, the larger her investments. However, the investments on the producer level are also larger under non-integration than integration. This results from the production function in the firms' legally protected environment: the producer is able to increase the supplier's space for value-creating investments via reducing his investments and therefore costs in the integration mode. Outside the relationship, the producer's outside option is solely increasing his investments. Therefore, to increase his output and to reduce the foreign supplier's outside option using parental innovation, the parent firm increases her investments counteracting the supplier's investment. Hence, the greater the incentives for the supplier, the larger the producer's efforts to limit the independent supplier. These efforts are strengthened in the international context because the foreign supplier is legally allowed to invest in the whole pool of innovations. This restriction of the supplier increases the costs of investments and reduces the total surplus compared with integration. Therefore, the likelihood of integration is increasing in a greater $\delta^{'}$.

Appendix to Chapter 2

II. Tables and Figures

Table T2.1: Central and Eastern European countries

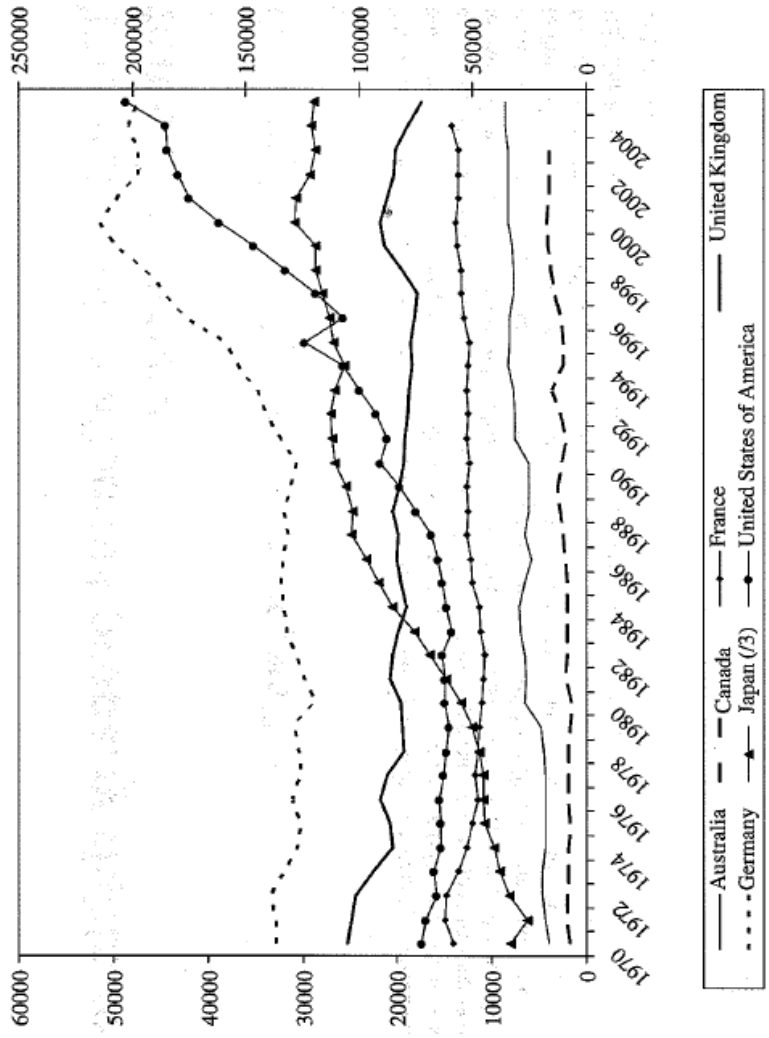
Albania	Macedonia, FYR
Belarus	Moldova
Bosnia and Herzigovina	Poland
Bulgaria	Romania
Croatia	Russian Federation
Czech Republic	Serbia and Montenegro
Estonia	Slovak Republic
Hungary	Slovenia
Latvia	Ukraine
Lithuania	

Source: Amadeus (Bureau van Dijk 2005) and Chair for International Economics, University of Munich.

Table T2.2: Definition of variables and sample statistics

Variable	Obs.	Definition	Mean	Min.	Max.	Stand. Dev.
L	11038	Number of employees	2,975.93	1	208,199	14,208.66
Y/L	7592	Deviation of productivity among German parent firms.	3.61	-0.999	38.6	9.65
K/L	9075	Parent firm's capital-to-labor ratio (th USD)	1,476	0	55,737	3,177
Intang	9158	Parent firm's intangibles-to-labor ratio (th USD)	22.7	0	2,218	91.2
Pat	11159	Granted patent applications per employee	0.01	0	8	0.19
AffRat	14318	Ratio of the parent firm's number of affiliates in German (CEE) to the rest of the world.	0.56	0.003	9	0.41
Sh	13524	Number of recorded shareholders of the parent firm	19.91	0	74	19.56
Oo	2259	Affiliate's outside market: Equal producers working in the same sector and market as the prevailing parent firm	164.21	1	577	242.36
IN	7602	Dummy equal to one if parent's ownership share is greater than 50 (35) percent, otherwise zero.	Dummy=1, 5860 (6534) obs.			
Imitat	4852	Dummy equal to zero if imitation of the parent firm's product is easy, otherwise equal to one if imitation is not possible or only with extraodinary efforts	Dummy=1, 2273 obs.			
Country	14322	Dummy equal to one if investment project is located in CEE, equal to zero if it is located in Germany	Dummy=1, 4107 obs.			

Sources: Amadeus (Bureau van Dijk 2005), GPTO (2008b, 2008c), and Chair for International Economics, University of Munich. Author's calculations.



Source: Greenhalgh and Rogers (2007), p.542.

Figure F2.1: Patent applications by domestic residents

Chapter 3

Tariff Rates, Offshoring and Productivity: Evidence from German and Austrian Firm-Level Data

3.1 Introduction

The ongoing process of trade liberalization has removed much protectionism. Worldwide it has gone so far that the Economist Intelligence Unit[1] has found that business executives' fear of protectionism is relatively low compared with, for example, worries about a recession (*The Economist* 2008). *The Economist*'s article (2008) reports that the Doha round and trade barriers are seen as increasingly unimportant. On the one hand, it justifies the question whether there is additional need to study the impact of liberalized trade. On the other hand, trade liberalization is important. Conversely, owing to a new threat of protectionism, *The Economist* (2008, p.30) also argues that "multilateralism matters more than ever": inter alia, it mentions the "symbolic importance" (The Economist 2008, p.30) of Doha, restricted investments (Marchick and Slaughter 2008), as well as raised food demand, oil production quotas and relative scarcity (Mattoo and Subramanian 2008). Moreover, a recent study by Amiti and Konings (2007) focus on the importance of tariffs and the firm's international value chain, analyzing the impact of liberalized trade on intermediate inputs and productivity. Marin (2008) points out the importance of international trade through a rise in intra-firm trade and the development of international value chains. There is continuing importance of trade liberalization and its broad impact on micro as well as macro perspectives.

Trade liberalization and its impact on firm productivity are studied in different ways and for a wide span of countries. On this note there are different definitions of liberalized trade and its link to productivity. As stated by Amiti and Konings (2007), however, only a few papers study the effect on productivity of liberalized trade in terms of both output and input tariffs. Moreover, there is, to the best of my knowledge, no study about German and

[1] A sister company to *The Economist*; see *The Economist* (2008).

Austrian trade liberalization with regard to Eastern Europe. That is, there is no empirical evidence about liberalized offshoring via tariff cuts which distinguishes between different kinds of tariff rates and their impact on total factor productivity.

Particularly in the case of Germany and Austria, however, this topic is of paramount interest. First, because of the German unification in 1990 there are significant productivity differences among regions and firms, especially between the services and manufacturing sectors (Temouri et al. 2008). Second, as argued by Marin (2008), a fact of increased global competition is that Germany and Austria are the countries most affected by Eastern enlargement. They are the most important investors in Eastern European countries. Up to two-thirds of total imports within the European Union (EU27) can be ascribed to intra-firm imports between old and new EU member states. The German Federal Statistical Office (2008b) indicates that 60 percent of German companies undertaking offshoring decide in favor of the new EU member states. Within this group of firms more than 60 percent relocate their core functions and auxiliary functions, respectively. Third, within these offshoring activities firms reorganize their structure towards flatter hierarchies resulting in easier communication, greater responsibility and greater firm productivity (Marin 2008, Marin and Verdier 2008). Fourth, Germany and Austria are internationally the most integrated countries within the European Union (Marin 2008). For instance, Germany's medium-sized firms are the greatest exporters compared with other European countries like France or Italy (Mayer and Ottaviano 2007a). Moreover, Marin (2008) shows that trade openness with new member states - measured in imports plus exports over GDP - increased from 1994 to 2006 in Austria by 7.2 percentage points and in Germany by 5.4 percentage points. Fifth, there are considerable effects of trade liberalization in terms of tariff cuts the firms may respond to.[2] This

[2] More details on this follow in Section 3.4.3.

promotes intra-industry competition which in turn boosts productivity and therefore GDP growth (Mayer and Ottaviano 2007a).

This study deals with the analysis of tariff reductions and their impact on German and Austrian productivity. Motivated by theoretical papers like those of Grossman and Helpman (1991), Feenstra et al. (1992), Acemoglu and Zilibotti (2001), Melitz (2003), and Luong (2008), the findings are in favor of supporting trade liberalization. That is, as argued by Melitz (2003), liberalized trade exposes domestic firms to increased competition which forces inefficient establishments to exit the market. This in turn shifts the average productivity up. The described selection effect (Melitz 2003), however, does not raise within-firm productivity. Productivity growth within each firm is provided by improved access to cheaper inputs, higher quality, foreign technology (Grossman and Helpman 1991) and a greater variety of intermediates (Dixit and Stiglitz 1977, Feenstra et al. 1992, Acemoglu and Zilibotti 2001). As argued by Luong (2008) the impact of improved access to foreign inputs via tariff cuts depends on both the affected tariff rate (output vs. input tariffs) and the elasticity of substitution between existing and newly available intermediate inputs. The effects of tariff cuts on productivity gains are estimated by Amiti and Konings (2007). Section 3.2 gives an extensive overview of existing empirical studies and their main differences.

Following Amiti and Konings (2007), the results of this chapter are presented in two steps. In the first step I estimate the firm-specific TFP for each two-digit ISIC sector using different dependent variables and regression methods for Austria and Germany separately. The second stage presents the estimation results of productivity on tariff rates. In contrast with Amiti and Konings (2007), intra-firm tariffs are included that capture the offshoring relationship between parent firms and their Eastern European affiliates. The results of this step are obtained at plant level. The underlying sources are the *Amadeus* database provided by the Bureau van Dijk (Bureau van Dijk,

Electronic Publishing 2005), the *WITS* database (World Bank and UNCTAD 2008) and a unique set of German and Austrian investments in Eastern Europe matched for the years 1994 to 2003.[3]

The study finds empirical evidence for a significant negative impact of tariffs on firm-level total factor productivity. In line with the small amount of existing literature which distinguishes between different kinds of tariffs, the effect of input tariffs exceeds that of intra-firm as well as output tariffs. The impact for a ten percentage point decrease in the tariff rates raises firm productivity between 0.3 and 2.0 percent depending on the type of tariff and country. Reducing tariffs on output goods by ten percentage points can lead to productivity gains at firm-level of 0.4 percent, whereas reducing tariffs on intermediate inputs by ten percentage points can lead to productivity gains of up to 1.6 percent. The results of reducing intra-firm tariffs by ten percentage points suggests productivity gains of 0.7 percent. The effect of liberalized trade is greater for Austria than for Germany. Moreover, foreign-owned firms located in Germany and Austria seem to benefit more from tariff cuts compared with domestic firms. Their total factor productivity gains are greater by 0.2 to 0.5 percentage points. The results also suggest that a fraction of the positive impact of offshoring on productivity is induced by reduced tariff rates. Comparison of the results with the existing literature about Brazil or Indonesia shows that the effect of Eastern European trade liberalization for Germany and Austria is much smaller. This can be traced back to some quite intuitive facts. First, Indonesia is a developing country far from the technological frontier, suggesting larger marginal effects. Second, liberalized trade with Eastern Europe explains only part of German and Austrian trade activities.

The chapter is structured as follows. Section 3.2 gives a review, by no means exhaustive, of the related empirical literature to which the chapter

[3] A more detailed description of the underlying datasets follows in Section 3.3.

refers. In particular, this section emphasizes the study and underlying estimation method of Amiti and Konings (2007), which provides the main motivation for this analysis. Section 3.3 gives an overview of the data. Section 3.4 describes the underlying estimation methodology, illustrates the construction of the total factor productivity and tariff variables in more detail, and gives some descriptive facts about tariff rates and the firms' productivity. Section 3.5 presents the estimation results of liberalized trade in terms of reduced tariffs on TFP. Section 3.6 gives evidence for the robustness of the empirical findings. Section 3.7 concludes.

3.2 Literature Review

This section summarizes the existing literature on the relationship between liberalized trade and firm productivity. More precisely, it cites empirical studies about the impact of trade liberalization on firms' total factor productivity. After considering this set of empirical literature arranged by country and underlying samples, the section focuses on the Indonesian study by Amiti and Konings (2007).

3.2.1 Related Literature

Beside the theoretical papers mentioned in the introduction a huge amount of empirical literature has addressed, both directly and indirectly, the relationship between trade liberalization and productivity.

An important strand of literature studies empirically the relationship of imports and exports with productivity. For Japanese firms, Tomiura (2007) finds that corporations investing abroad are the most productive firms. Similarly, Sjoholm (1999) argues that Indonesian firms in the manufacturing industry show increased productivities with an increasing amount of exports. Moreover, Muuls and Pisu (2007) find that not only exports count. Their

data for Belgium suggest that firms that export and import are the most productive. The same evidence for Italian firms is provided by Castellani et al. (2008). German plant level data studied by Wagner (2002) suggest that exporting firms are associated with higher labor productivity.[4] Moreover, Vogel and Wagner (2008) also give evidence for an existing self-selection in Germany. They find a positive impact of firms' productivity on their import activities.[5] In terms of Eastern Europe, Hagemejer and Kolasa (2008) find within their study on Polish data that internationalized firms are the most productive. Halpern et al. (2005) study the contribution of imports to Hungarian productivity. Their results on firm-level data show productivity boosted through access to a larger variety and different qualities of imported intermediate inputs as well as reallocation of output-determining input variables. Within the theoretical framework it is implied that the access to foreign inputs, the relative quality, and the reallocation of capital and labor can raise productivity. Using the Olley-Pakes approach (1996), Halpern et al. (2005) enhance the unobserved productivity function by the number of varieties imported. This circumvents the problem of zero investment report.[6] Halpern et al. (2005) find that from 1992 to 2001 a ten percentage point increase in the share of imports raised TFP by 1.8 percent. Aggregating the firm-level data the authors find that imports explain 30 percent of aggregated productivity growth. One half of the whole effect can be separated into the reallocation of inputs, and the other half can be traced back to import activities.

All these studies explain possible productivity boosts and related problems mainly in terms of an underlying self-selection problem. None of them, however, takes account of potential triggers for rising import and export ac-

[4] See also Bernard and Wagner (1997) and Bernard and Jensen (1999), p.2ff.

[5] See also Altomonte and Bekes (2008), who find that self-selection holds for both importing and exporting firms.

[6] The authors point out that 25 percent of the firm data report zero investments.

tivities. That is, none of them studies the effect of liberalized trade on total factor productivity in terms of quotas, reduced tariffs or other trade policy variables.

Kasahara and Lapham (2008) consider the link between trade liberalization and intermediates, exports and productivity. Reduced trade restrictions allow for a larger amount of imported intermediates. This in turn raises productivity within the firm, which itself allows for exports. A greater demand for labor forces the less efficient firms to exit the market. De Loecker (2007a) finds that relaxing product-specific level and quota restrictions leads to productivity gains in the Belgian textile industry. Using an enhanced Olley-Pakes methodology (1996) for the production function estimations that additionally controls for unobserved price variable biases (De Loecker 2007a, p.22ff), the author finds productivity gains of 4 percent. Liberalized trade forces the inefficient producers to exit, which leads to an increase in average productivity (De Loecker 2007a, p.3ff). In Bernard et al. (2006) reduced trade costs, measured by changes in tariff and freight costs, have a positive impact on productivity growth, a negative effect on plant death and are positively associated with a switch from being a non-exporter to being an exporter as well as export growth.

A positive effect of trade liberalization on productivity is also found by Pavcnik (2002). Her data on Chilean plants in the manufacturing industries yield an aggregated rise in total factor productivity of 19 percent. On the plant level she argues that there is a difference between producers acting in import-competing sectors and plants acting in non-traded goods sectors. The effect of liberalized trade on non-traders and traders ranges between 3 and 10.4 percent, respectively, and is because of "reshuffling (of) resources from the less to more efficient plants [...]." (Schor 2004, p.261). Plants with inefficient production are forced to close down owing to foreign competition

(Schor 2004, p.265).[7] Another study on Chilean manufacturing is presented by Alvarez and Crespi (2007). Their study does not give direct evidence of liberalized trade effect on productivity. The authors study the determinants of the convergence of low-productivity firms on the technological frontier for Chilean plant-level data under (almost) free trade policy from 1979 to 1998 (Alvarez and Crespi 2007, p.3). Using the Levinsohn-Petrin technique (2003) for the productivity estimations at the three-digit industry level shows that the plant-specific productivity gap interacting with the share of foreign firms has a significant positive effect on productivity growth. Therefore it suggests that domestic firms benefit from access to foreign technology. This positive effect of importing intermediate inputs in the Chilean manufacturing industry is more precisely studied by Kasahara and Rodrigue (2008). Using a wide range of estimation techniques their results suggest that importing foreign inputs increases firm productivity by at least 2.6 percent.

Empirical results for trade liberalization in terms of a Free Trade Agreement (FTA) and reduced tariffs on productivity are more precisely studied by the following authors. Head and Ries (1999) study the impacts of FTA on output. After introducing their theoretical part, which considers different models of imperfect competition, the authors test their predictions on Canadian industry data. At industry level Canadian tariff reductions of ten percentage points reduce output by at least 11.3 percent. In contrast, a reduction of the same amount in US tariff rates increases output by 16 percent. Summarizing their findings, Head and Ries (1999, p.309ff) show that both tariff reductions offset each other in their impact on outputs. The impact of the Canadian-U.S. FTA on productivity is studied by Trefler (2004). His study offsets the short-run costs with the long-run benefits of the country-specific changes in FTA-mandated tariff concessions. Estimates of tariff concession effect on employment growth and labor productivity shows

[7] See also Luong (2008), p.2ff.

an employment loss between 12 and 24 percent for Canada and a loss of 3 percent for the US in the short run. In contrast, tariff concessions show long-run gains owing to increasing labor productivity ranging between 8 and 15 percent for Canada and between 4 and 14 percent for the US.[8] The largest, 15 percent, rise in labor productivity can be ascribed to import competition effects (Trefler 2008, p.880).

Tybout and Westbrook (1995) find that Mexican tariff rates are on the one hand positively correlated with costs and on the other negatively correlated with productivity growth. Therefore liberalized trade shifts the average cost curve downward and raises sector-specific efficiency. Fernandes (2007) explores the impact of nominal tariffs on Colombian plant productivity. Calculation of TFP in accordance with Levinsohn and Petrin (2003) shows that a 10 percentage point tariff cut raises productivity between 0.8 and 2.9 percent. Because the effect is greater for firms with higher imports of intermediate inputs, the author argues that one channel is the access to foreign innovations (Fernandes 2007, p.68). All these studies present results for the impact of output tariffs. The measurement and potential link of input tariffs with productivity are still missing.[9]

Schor (2004) studies the impact of nominal output and input tariff rates on TFP of 27 Brazilian sectors at the two-digit SIC level. Her estimates for manufacturing firms from 1986 to 1998 show a significant negative effect of both tariff measures on productivity. With the Olley-Pakes technique (1996) adding input tariffs reduces the coefficient of nominal tariffs and yields predicted impact of the input tariffs' coefficient, which gives between 1.5 and 2.7 percent productivity gains for a ten percentage point tariff cut. Schor (2004) argues that the results give evidence of two effects. The first one is the import competition effect reflected by the estimates for nominal tariffs. The

[8] The results depend on the estimation methods as well as on the underlying data (industry versus plant-level data).

[9] See also Luong (2008), p.2.

second effect is the improved access to foreign technology derived from the negative coefficient for input tariff rates (Schor 2004, p.390). These links for the Brazilian manufacturing sectors are more precisely studied by Muendler (2004). He finds that the effect of increasing foreign competition on the product market raises firm productivity enormously. The impact of foreign inputs is not, however, as large as expected; it is more the effect of inefficient firms leaving the market which leaves the internal productivity untouched.

A famous example of trade liberalization effect on productivity is the case of India. Beside the more recent studies by Goldberg et al. (2008) and Topalova (2004), Krishna and Mitra (1998) find evidence that the trade reform in India has a positive association with productivity growth. Their dummy model of liberalized trade in 1991 shows between 3 and 6 percent productivity growth. Topalova (2004) finds average productivity gains of 0.5 percent induced by a ten percentage point tariff cut. Similarly to Krishna and Mitra (1998), apart from the mentioned outcome she also finds a faster productivity growth rate using manufacturing industry and plant level data from 1986 to 1993. Goldberg at al. (2008) put more emphasis on the role of input tariffs. Their findings of a reduction in the input tariff rates in India suggest that trade liberalization makes imported intermediates cheaper and gives firms access to a greater variety of new inputs and foreign technology. This in turn increases domestic variety. To sum up their findings, lower tariff rates raise imported varieties in intermediate as well as in final good sectors. Lowering input tariffs by ten percentage points increases, among other things, total factor productivity by 4.5 percent.

Amiti and Konings (2007) find empirical evidence of plant productivity gains for Indonesian firms because of trade liberalization. A cut in both output and input tariffs raises productivity via increasing competition and variety as well as quality effects. The particular role of the growth of input tariffs is shown by the study. The productivity gains of tariff reductions on

intermediate inputs is significantly negative and ranges from 3 percent for non-importing firms to 12 percent for importing firms. These findings as well as the underlying methodology are the subject of the following subsection. Closely related is Luong's (2008) study about Mexican data. Similarly to Amiti and Konings (2007), Luong (2008) distinguishes between output and input tariffs but additionally shows that there is a difference between high and low differentiated products. There is a rise in firm total factor productivity owing to lower input tariffs if inputs are highly differentiated. Productivity also increases owing to lower output tariffs if intermediate inputs are not highly differentiated. Therefore his results are driven by the elasticity of substitution among inputs (Luong, 2008, p.11ff).

To the best of my knowledge, there is no study about the relationship between German or Austrian trade liberalization and Eastern European countries and firm-level total factor productivity. Temouri et al. (2008) estimate German total factor productivity from 1995 to 2004. In their second step, however, they show productivity differences owing to foreign affiliates and parent multinationals. Unfortunately, they do not link this with trade liberalization. As stated in the introduction, however, for Germany and Austria in particular it would seem to be very valuable to study the impacts.

3.2.2 Study by Amiti and Konings (2007)

Amiti and Konings (2007) give empirical evidence that Indonesian firms benefit from trade liberalization. Their study provides information about Indonesian plants between 1991 and 2001 on, inter alia, revenue, labor, investments and imported inputs. Information on intermediate inputs is available for each firm in 1998. This measurement is used for creating input tariffs. It allows the authors to distinguish between the impacts of both output tariff rates and input tariff rates on firm productivity. Whereas the benefits of reduced output tariffs are realized via import competition, the gains of input tariff

cuts are realized by learning, variety effects and foreign technology.[10] The output tariff is measured by the average of all HS nine-digit product codes for each five-digit ISIC sector. The input rate is constructed as a weighted average of the output tariff. In this context the weights are given by the sectoral cost shares of one input good over all imported intermediate inputs per parental sector.[11] The authors point out that the tariff rates are given at the industry level to avoid endogeneity problems (Amiti and Konings, 2007, p.1620). Importantly, Amiti and Konings (2007, p.1612) observe that the input weights are only available for 1998 with the consequence of a constant technology assumption over time.

To test the impact of trade liberalization on productivity, Amiti and Konings (2007) run an OLS regression with fixed effects. Assuming a Cobb-Douglas production function the authors estimate the total factor productivity for each three-digit ISIC sector via an enhanced Olley-Pakes technique (1996) to avoid unobserved productivity impacts on the input coefficients. The estimation method takes account of the problem of simultaneous causality between the error term, including the productivity shock and the dependent variable within the firm's decision on input factors. To control for the correlation between the inputs and the error term a strict positive correlation between investments and the unobserved productivity shock is assumed (Olley and Pakes 1996). It controls for the simultaneity problem and provides a consistent coefficient for labor. Moreover, the method also takes account of a selection bias resulting from firms leaving the market. The semi-parametric estimation method also controls for this problem by estimating survival probabilities (Yasar et al. 2008). It allows me to obtain in a second step a consistent coefficient for capital.[12] Besides controlling for

[10] See Amiti and Konings (2007), p.1613ff.

[11] See Amiti and Konings (2007), p.1619ff.

[12] For a detailed discussion of the underlying estimation method see Amiti and Konings (2007), p.1635, Olley and Pakes (1996) and Section 3.4.2 about the total factor productivity.

unobserved productivity shocks and exits of firms, the authors modify the Olley-Pakes (1996) technique by controlling for the firm's import and export decision (Amiti and Konings 2007, p.l635ff). The Olley-Pakes (1996) method implies that investment function depends on trade, productivity shock and capital. Hence, within the underlying data the existence of data on firm investments and the import and export decision allows estimation of consistent values for the input coefficients. In a further step the authors run a fixed-effect regression to estimate how trade liberalization affects TFP.

Their estimation results show a negative impact of output tariffs on productivity. The coefficient in terms of absolute values ranges from 0.7 percent to 6.4 percent with a ten percentage point change in output tariffs. The value as well as the significance depends strongly on the underlying specification. A larger and significant negative effect is provided by the results for input tariff rates. For a ten percentage point decrease the coefficient for input tariffs ranges from 1.8 percent to 7.9 percent for non-importing plants and from 4.1 to 11.8 percent for importing firms. Therefore the effect for firms importing intermediate inputs is much larger than the gains for firms that compete with foreign inputs (Amiti and Konings, 2007, p.l621ff). In this context, Amiti and Konings (2007, p.1614) argue that trade liberalization and therefore lower tariff rates can be thought of as lowering the price of international outsourcing and therefore raising firm productivity.

The findings are robust owing to a large number of alternative specifications and estimation methods. They show that in terms of a potential omitted variable bias problem it is necessary to include input tariff rates when estimating the effect of trade liberalization on firm productivity (Amiti and Konings 2007, p.1621). Due to the coefficient's value and significance the impact of input tariffs is existent and even larger than the impact of import competition itself.

3.3 Dataset

The empirical analysis relies mainly on the matching of two datasets. The first is a detailed cross-sectional dataset of 660 global corporations based in Germany and Austria. The survey was conducted from 1990 to 2001 by the Chair of International Economics at the University of Munich. The sample represents 80 percent of German total investments in Eastern Europe and 100 percent of total Austrian investments in Eastern Europe. As a whole it consists of 2,123 German and Austrian investment projects. The employed version provides firm-level information on the parent investors in Austria and Germany, their corresponding affiliates in Eastern Europe and the actual investment and the parties' relationship. The survey reports, inter alia, detailed information on parent and affiliate firm-specific measures like capital stock, labor endowments, research and development investments and skill endowments. It also includes detailed information on underlying relationships like ownership share, investments and imports. Out of the unique data this study uses measures about intra-firm imports, more precisely, the type and amount of intermediate inputs between the parent firm and her corresponding Eastern European affiliate.[13]

The second dataset is the pan-European micro database *Amadeus* released by the Bureau van Dijk (Bureau van Dijk, Electronic Publishing 2005). The version used includes firm-level data for more than 1.5 million national and multinational establishments in 38 European countries for up to 13 years, finishing in 2005. I use unconsolidated data provided on tangible assets, employees, material costs, and revenue as well as added value and the ultimate owner for over 209,000 German and more than 30,000 Austrian firms.[14] In addition to that I match the cross-sectional dataset on Eastern European

[13] See Marin (2004, 2008) for further description of the data.

[14] For further information on the *Amadeus* dataset (Bureau van Dijk 2005) available online see http://www.bvdep.com/en/Amadeus.html [September, 16th, 2009].

investment projects with *Amadeus* (Bureau van Dijk 2005) to obtain an enhanced panel structure. It results in an unbalanced panel of 417 German and Austrian firms covering a period of ten years from 1994 to 2003. Data are collected until the end of 2003 to avoid potential bias by the eastern enlargement from the beginning of 2004.

To answer the question how trade liberalization affects firm-level productivity I take the simple average of effectively applied tariff rates for each three-digit Eastern European affiliate industry provided by the World Integrated Trade Solution database (*WITS*) (World Bank and UNCTAD 2008).[15] In the period 1994 to 2003 these data are merged for each year with the outcome of the first two matchings mentioned above. The new dataset allows me to identify the impact of tariff rates on productivity between Eastern Europe and the old European members Germany and Austria. A detailed description of the variables and the procedure follows in the next section.

3.4 Estimation methodology

3.4.1 Basic Estimation Equation

The empirical analysis studies the question whether liberalized trade has a significant positive impact on German and Austrian firm-level total factor productivity. Considering the related literature, I expect different contributions owing to the kind and character of the observed tariff rates. Therefore I expect a negative sign for all tariff rates raising firm-level productivity in the following ascending order: a decrease in output tariff raising productivity less than a cut in intra-firm tariffs; the largest contribution is expected from a cut in input tariff rates. The reason behind this expectation is access to

[15] *WITS* (World Bank and UNCTAD 2008) gives access to the major trade and tariff data from the *UN COMTRADE* database, the *TRAINS* database, and the *IDB* and *CTS* databases. For these and further information on *WITS* (World Bank and UNCTAD 2008) see http://wits.worldbank.org/witsweb [September, 16th, 2009].

foreign inputs as well as the mentioned competition effects. This should hold for both Austria and Germany, whereas the impact of a tariff reduction for Austrian firms is expected to be larger than for German corporations. Moreover, the study tries to answer whether foreign-owned and importing firms benefit more than purely domestic and non-importing firms. I expect multinationals that are more familiar with foreign environments to enjoy greater productivity effects from tariff reductions than domestic firms (Temouri et al. 2008, p.44ff). The estimation strategy also suggests that trade liberalization makes offshoring cheaper and this in turn is positively linked with productivity.[16]

Thus, the main estimation equation of interest is

$$\begin{aligned} TFP_{it}^{k} = \beta_0 + \beta_1 (Outtr)_t^k + \beta_2 (Inttr)_t^k + \beta_3 (Inptr)_t^k \\ + \beta_4 \delta_t^k + \eta_i + \eta_j + \eta_t + \epsilon_{it}, \end{aligned} \tag{3.1}$$

where $(Outtr)_t^k$ is the average of the effectively-applied output tariffs with which each parent firm's three-digit ISIC sector level is confronted. $(Inttr)_t^k$ and $(Inptr)_t^k$ are weighted averages of the sectoral output tariffs. $(Inttr)_t^k$ measures intra-firm tariffs, that is, nominal tariffs at the affiliates' sectoral product level weighted with intra-firm imports from industry j to the parent industry k over all intra-firm imports of sector k. This measure contains all kinds of offshored products. $(Inptr)_t^k$ weights tariff rates with the amount of each intermediate input imported from a three-digit affiliate sector j over all imports of sector k. I also include a set of variables δ_t^k containing the number of shareholders, foreign ownership, a dummy for importing firms and their related interaction terms with tariff rates. The number of shareholders and the nationality of the owner are provided by the *Amadeus* dataset (Bureau van Dijk 2005). In this context a foreign owner is defined as the firm's global ultimate owner who is not of German (or Austrian) nationality and holds

[16] See Amiti and Konings (2007), p.1614.

directly or indirectly at least 50.01 percent. The results are estimated by ordinary least square (OLS) with robust standard errors. Firm, industry and year fixed effects are included to avoid endogeneity problems owing to time-invariant and time-variant effects given by η_i, η_j and η_t.

3.4.2 Total Factor Productivity

Following the methodology of Amiti and Konings (2007), in a first step I estimate the firm's total factor productivity. It is defined as the residual of the production function, and hence the difference between the actual value Y_{it} and the estimated value $\hat{Y_{it}}$. Therefore I consider a simple Cobb-Douglas production function in the following way:

$$Y_{it} = A_{it}(\tau) L_{it}^{\gamma_l} K_{it}^{\gamma_k}, \tag{3.2}$$

where Y_{it} is measured by the value added of firm i at time t, L_{it} is the number of employees in i at time t and K_{it} is the capital endowment of firm i at time t. Except for labor, all variables are deflated.[17] I estimate the following log-log specification,

$$y_{it} = \gamma_0 + \gamma_1 l_{it} + \gamma_2 k_{it} + u_{it}, \tag{3.3}$$

for each country and each sector separately. It allows identification of the firm's TFP as mentioned above. For comparison, I proceed with the same specification with revenue as dependent variable. Thus, the specification is

$$y_{it} = \gamma_0 + \gamma_1 l_{it} + \gamma_2 k_{it} + \gamma_3 m_{it} + v_{it}, \tag{3.4}$$

where m_{it} measures applied materials. All variables are given in natural logs.

[17] I deflate in two different ways. On the one hand manufacturing and service sectors are deflated by the producer price index and the consumer price index, respectively. On the other hand I include year dummies while estimating TFP. The methods result in similar outcomes, especially in the second step when the impact of tariffs on productivity is considered.

To obtain unbiased coefficients for the input variables the ordinary least square (OLS) procedure is not very reliable (Olley and Pakes 1996, Levinsohn and Petrin 2003, Ackerberg et al. 2005). Yasar et al. (2008) show that an estimation technique not controlling for simultaneity and the mentioned selection bias provides upwards-biased coefficients for labor, capital, and materials. That is, the residuals u_{it} in Equation 3.3 and v_{it} in Equation 3.4 contain an unobserved productivity shock which has an impact on the firm's decision on the input factors. Unfortunately, the impact is unobserved by econometricians. Firms, however, take the shock within their productivity process into account. The so-called transmitted component results in a simultaneous causality problem between the explained and the explanatory variables. This in turn induces biased coefficients by OLS related to a correlation, especially between capital and the error term as stated by Levinsohn and Petrin (2003, p.319ff).[18] Owing to this problem the coefficients $\hat{\gamma}_l$, $\hat{\gamma}_k$, and, in the case of revenue as dependent variable, $\hat{\gamma}_m$, are estimated for each two-digit ISIC classification by use of the Levinsohn-Petrin (2003) approach. This estimation method avoids the simultaneity problem via intermediate inputs in order to control for the unobserved productivity shock. Hence, contrary to Olley and Pakes (1996), the Levinsohn-Petrin (2003) technique does not require any measurement of investments. This is important because the underlying data within this study report many zero investments or provide insufficient data on firm-level investments. In addition, Levinsohn and Petrin (2003) argue that investments do not entirely catch productivity shocks owing to adjustment costs. Therefore the authors suggest intermediate inputs as proxy to circumvent data-specific problems and to solve the endogeneity problems. Similarly to the investment proxy, by assuming a strictly monotonous relationship between the proxy (intermediate inputs),

[18] See also Olley and Pakes (1996), Ackerberg et al. (2005), and Alvarez and Crespi (2007).

capital accumulation and the unobserved shock, the approach controls for the transmitted component which has an influence on the firm's decision itself (Olley and Pakes 1996, Pakes 1996). Hence, it is part of the error term in Equations 3.3 and 3.4, respectively. Thus, the transmitted component ν_{it} is specified by $\nu_{it} = f_t(k_{it}, m_{it})$. It allows me to estimate a consistent $\hat{\gamma}_l$ by approximating the relationship between materials, capital and productivity shock via a fourth-order polynomial in k_{it} and m_{it}. Considering value added as dependent variable the estimation equation can be written as:

$$y_{it} = \gamma_1 l_{it} + \theta_t(k_{it}, m_{it}) + u_{it} \tag{3.5}$$

defining

$$\theta_t(k_{it}, m_{it}) = \gamma_0 + \gamma_2 k_{it} + f_t(k_{it}, m_{it}). \tag{3.6}$$

In a first step the elasticity of labor is obtained by approximating $\theta_t(k_{it}, m_{it})$ by a fourth-order polynomial. The consistent results provided in the first stage allow me estimating a consistent coefficient on capital in a second step by again approximating an unknown function of lagged values of θ_t.[19] That is, the following equation is estimated:

$$y_{it} - \gamma_1 l_{it} = \gamma_2 k_{it} + g(\theta_{t-1} - \gamma_2 k_{i,t-1}) + u_{it} + \tau_{it}. \tag{3.7}$$

Following the described procedure I implement overall material costs as proxy to estimate a reliable production function. I concentrate more on value added as dependent variable than firm revenue. The reason is that value added is expected to give more serious results owing to the fact that within the value added specifications material costs are used as pure proxy compared with the revenue estimates where an additional coefficient is estimated for materials. This avoids the danger of collinearity problems.[20] Tangible fixed

[19] In the case of revenue as dependent variable the elasticity of material inputs m_{it} is also obtained in the second step.

[20] See also Ackerberg et al. (2005).

assets are used for capital measurement and labor is measured by the number of employees. Owing to the fact that the number of observations per sector in the underlying panel of the 417 German and Austrian firms is very low, I do not expect to obtain reliable results on industry level. For this reason I run the Levinsohn-Petrin technique (2003) in two different ways. First, I do not distinguish between each industry, using the whole underlying sample of 417 firms in the period from 1994 to 2003 to estimate the designated elasticities. This method relies on the assumption that there are no productivity differences between the sectors. Owing to this weakness I alternatively estimate the TFP in each two-digit sector for each country separately for over 209,000 German and more than 30,000 Austrian firms from 1994 to 2003. These results are obtained from the *Amadeus* dataset (Bureau van Dijk 2005). For comparative reasons the coefficients are also estimated by simple OLS. Tables T3.2 and T3.3 in the Appendix report the results obtained by OLS and Levinsohn and Petrin (2003) with value added as dependent variable Y_{it} for Germany and Austria.[21]

3.4.3 Tariff Rates: Construction and Descriptives

The data on tariff rates between parent firms and their Eastern European affiliates are provided by the *WITS* database (World Bank and UNCTAD 2008). As shown by Mattoo and Subramanian (2008) it is important to consider applied tariff rates.[22] Output tariff rates are translated from the product level into the four-digit ISIC industry classification as a simple average for each parent sector. Following Amiti and Konings (2007), to obtain

[21] Owing to the fact that a huge amount of literature exists which criticizes Olley and Pakes (1996) as well as Levinsohn and Petrin (2003) (e.g. Ackerberg et al. 2005, Wooldridge 2005) I have to point out that this discussion is beyond the scope of my analysis.

[22] Contrary to bounded tariff rates the by countries effectively applied tariff rates show an significant decrease from 1986 to 2006. This accompanies with increasing trade in goods. See Mattoo and Subramanian (2008) as well as *The Economist* (2008).

intra-firm and input tariff rates the effectively applied tariffs are weighted as follows. The sample of 417 firms provides information on intra-firm imports as well as intermediate inputs directly imported mainly for one year in the period from 1997 to 2001. Therefore the sector-specific intra-firm weights, $v_{jk}^{1997/2001}$, are calculated by the ratio of industry k's imported products from industry j to all imported products by industry k.[23] Similarly, input tariffs are calculated by weighting nominal tariff rates with the aggregated ratio of imported inputs between each parent-affiliate relationship. That is, the value of imported inputs of industry j in the production of a good in the parent sector k over all inputs imported by sector k. This procedure allows me to estimate the relationship between trade liberalization in terms of tariff cuts at industry level and firm productivity. Formally, the weights are:

$$(Inttr)_t^k = \sum_j v_{jk}^{1997/2001} * (Outtr)_t^j, \tag{3.8}$$

$$(Inptr)_t^k = \sum_j w_{jk}^{1997/2001} * (Outtr)_t^j. \tag{3.9}$$

The intuition is as follows. The most important import industry for a parent firm in sector k over all existing affiliate industries is weighted the most.[24] Following Amiti and Konings (2007), tariff rates are calculated at an aggregated industry level. The larger the tariff rate on a core good the larger is its importance in analyzing the impact of trade liberalization.

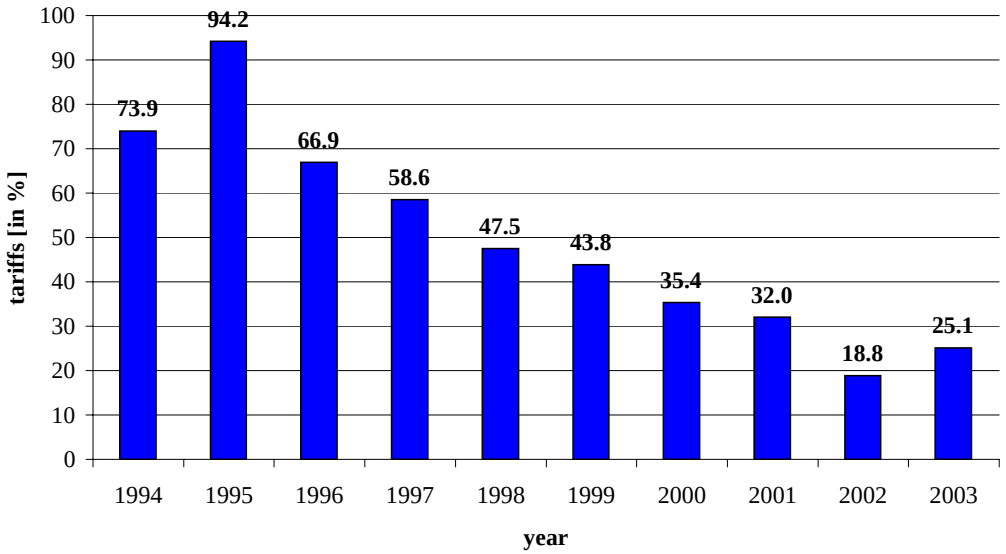
The underlying data show that there are significant tariff reductions between Germany, Austria and Central and Eastern European region.[25] Significant reductions are important because firms may respond to the liberalized environment and this could lead to a change in the productivity structure,

[23] All values are aggregated from plant level up to industry level and measured in Euros.

[24] See Amiti and Konings (2007), p.1620.

[25] See Appendix, Table T3.4 for the whole list of Eastern European countries considered in this study.

outside the firm as well as within the firm boundaries. From 1994 to 2003 the maximum rates of nominal tariffs for all reported products between the parent EU countries (Germany and Austria, respectively) and Eastern Europe fell from 74 percent to 25 percent, a reduction by roughly 50 percentage points. Figure 3.1 shows how the maximum values of effectively-applied tariff rates change over time.



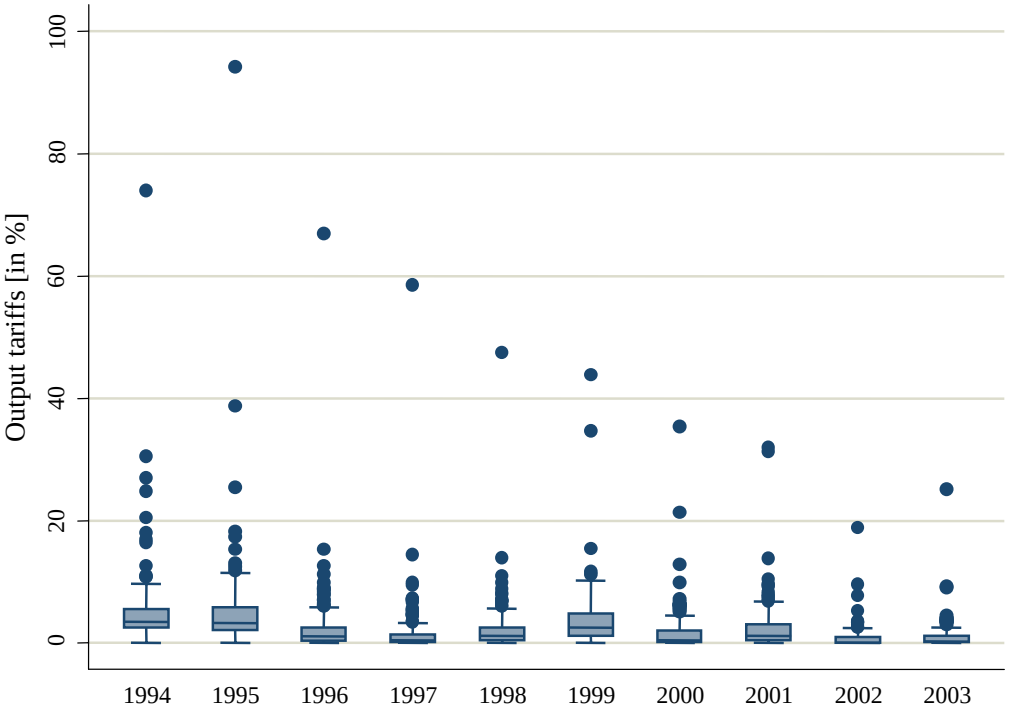
Notes: Values are maximum applied tariff rates (AHS) in percent, calculated as simple average of each three-digit affiliate level for a total of 70 industries.
Source: WITS database (World Bank and UNCTAD 2008).

Figure 3.1: Change in output tariffs (1994 - 2003)

This general finding also holds for an additional range of descriptive summaries. As presented in Figure 3.2, the median, the interquartile range, and the maximum values are also decreasing over time. The firms may respond to this variation over all products in terms of access to foreign technology and greater variety, and therefore a change in their productivity. Owing to liberalized trade, tariff variation is reduced over time.[26] In this case partic-

[26] See also Luong (2008), p.16ff.

ularly, firms respond to these tariff cuts, when the parent industry imports from more than one affiliate industry. In the underlying data a parent industry at the three-digit classification imports on average from three different three-digit affiliate sectors.

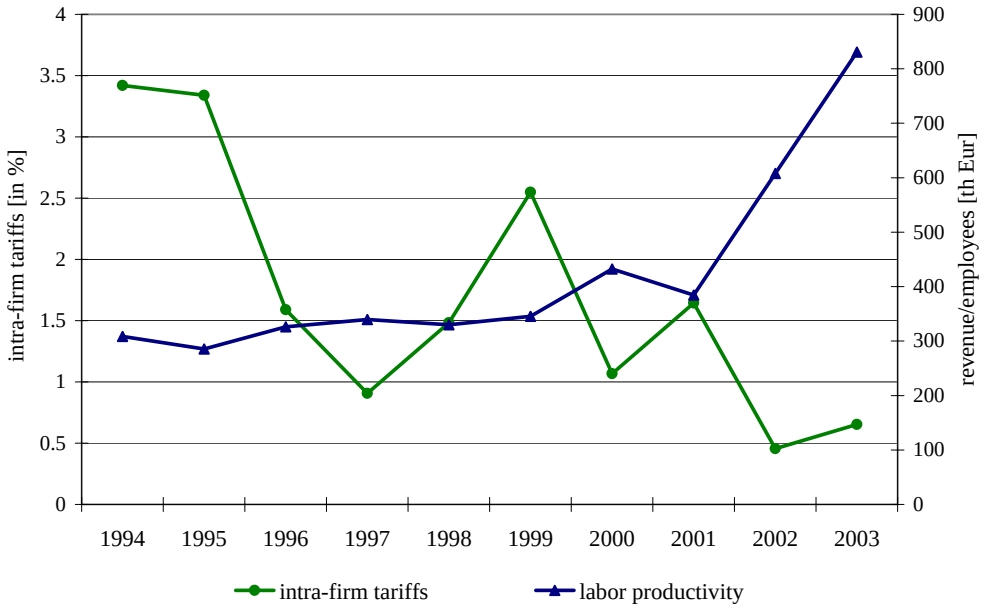


Source: WITS database (World Bank and UNCTAD 2008). Author's calculations.

Figure 3.2: Output tariff variation over time (1994 - 2003)

Tariff rates with the largest initial level in 1994 incur the greatest cut from trade liberalization compared with 2003. Figure F3.1 in the Appendix shows the graph on all existing three-digit industry levels. There is a significant negative correlation which affirms the large tariff reductions of initial tariff rates. Moreover, all tariffs are close to the 45-degree line. This confirms that almost all industries show considerable tariff cuts by at least 50 percent

within the considered period.

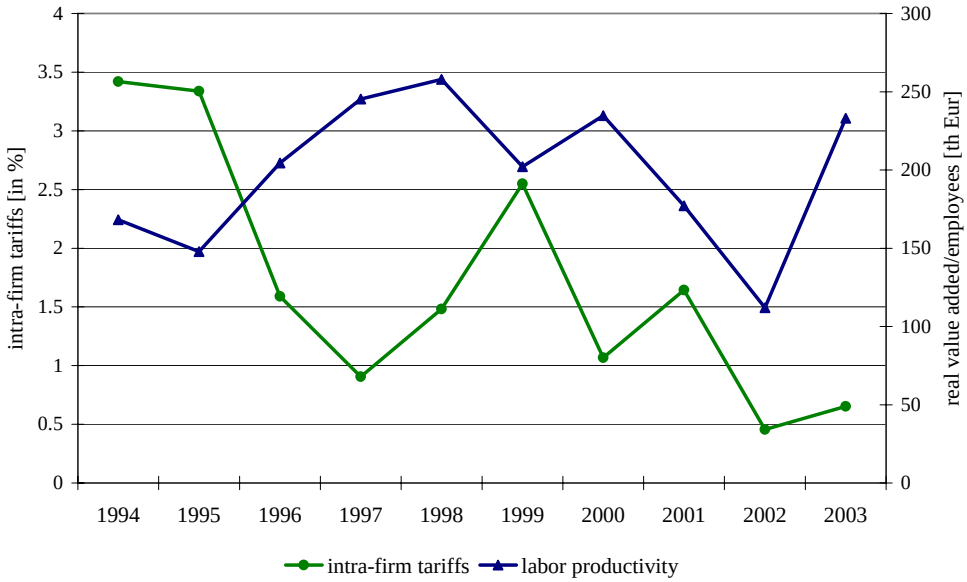


Notes: Values are given on a three-digit parent-industry level. Owing to large outliers the upper 5th percentile firms related to the revenue variable is excluded.
Sources: WITS database (World Bank and UNCTAD 2008), Amadeus database (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 3.3: Tariff rates and labor productivity

These findings suggest a relationship between tariff cuts and a productivity boost on the firm level. Figure 3.3 shows a negative link between tariffs and productivity. In the sample period from 1994 to 2003 intra-firm tariff rates decreased while labor productivity of German and Austrian firms investing in Eastern Europe mainly increased during these phases. The same finding is obtained by considering tariff rates and productivity measured in real value added per employee. Figure 3.4 presents the outcome.[27]

[27] The findings hold also for both countries Germany and Austria separately. Values are deflated by the corresponding producer price index provided by the German Federal Statistical Office (2008c) and Austrian National Bank (OeNB 2008), respectively.

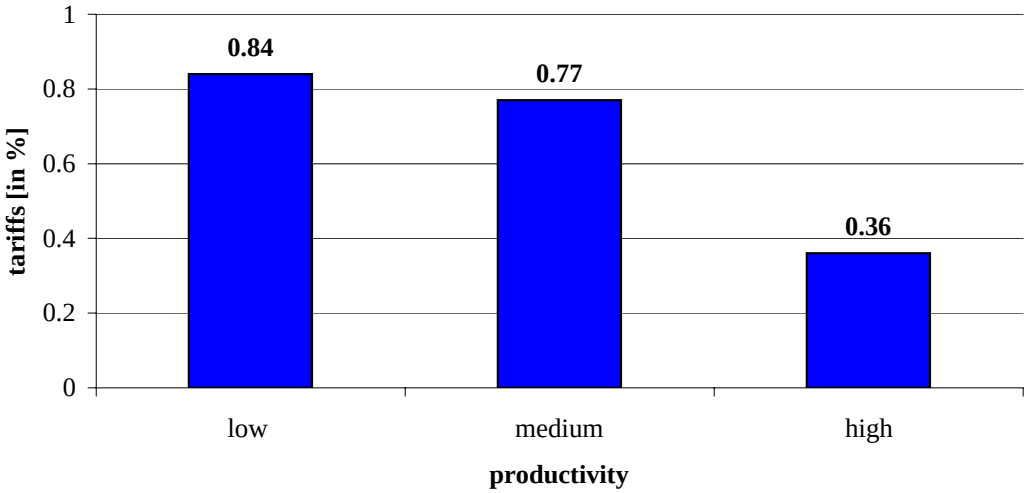


Notes: Values are given at a simple average over all parent firms on a three-digit industry level per year. Owing to large outliers the upper 5 percent quantile of the value added distribution is excluded.
Sources: WITS database (World Bank and UNCTAD 2008), Amadeus database (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 3.4: Tariff rates and real value added

Another aspect of the relationship between increasing productivity and decreasing input tariffs is documented in Figure 3.5. Firms are ranked by their labor productivity, whereby a low-level firm is in the lower 25th percentile, a medium firm ranges between 25 and 75th, and a high productivity is in the upper 25th percentile. The figure shows that more productive corporations are confronted with, on average, lower input tariff rates. Hence, German and Austrian parent firms have liberalized access to foreign technology, greater variety and lower-priced intermediate inputs which in turn may boost their productivity.

Highly productive corporations are confronted with lower tariff rates compared with low-productive firms. Whether this in turn incentivizes intra-firm imports is shown in Figure 3.6. Low versus high productivity is determined

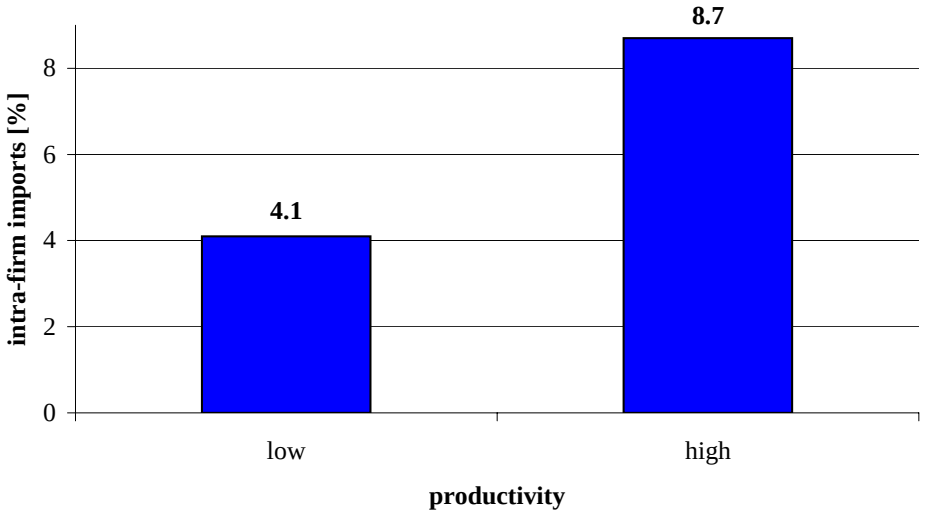


Notes: Productivity is measured by firms' revenue-employee ratio for all given parent firms in each three-digit industry. Low productivity means firms in the lower 25th percentile, high productivity firms in the upper 25th percentile. Tariffs on inputs are the weighted sum of the sectoral average tariff rates on imported inputs from all corresponding Eastern European industries affiliated to the parent industry (three-digit ISIC classification).
Sources: WITS database (World Bank and UNCTAD 2008), Amadeus database (Bureau van Dijk 2005) and Chair for International Economics, University of Munich. Author's calculations.

Figure 3.5: Input tariffs and labor productivity

by the firm's median labor productivity measured in real value added per employee. The figure suggests that less productive corporations have lower intra-firm imports in percent of parent sales compared with firms in the highly productive segment. It suggests that corporations practicing offshoring via significant tariff cuts play an important role in determining the impact of trade liberalization on productivity. Therefore, liberalized trade in terms of lower tariff rates lowers the price of offshoring and boosts productivity.[28] These effects take place outside the firm boundaries and within the firm.

[28] See Amiti and Konings (2007), p.1614ff.



Notes: Intra-firm imports are given at parent firm level as a percentage of parent sales. Productivity is low if the firm's real value added per worker is equal or below the median firm. Contrary, it is high if the firm's real value added per employee is equal or larger than the median corporation.
Sources: WITS database (World Bank and UNCTAD 2008) and Chair for International Economics, University of Munich. Author's calculations.

Figure 3.6: Tariff rates and offshoring

3.5 Empirical Results

This section analyzes the impact of trade liberalization on firm-level productivity. The total factor productivity having been obtained, Equation 3.1 is estimated by simple OLS with fixed effects. The dependent variable is the natural log of TFP calculated by using the firm's real value added. In this first set of calculations the productivity estimations are not run for each sector separately. That is, the coefficients for labor and capital are calculated using the set of 417 firms. To produce valid statistical inferences, the errors are corrected for heteroskedasticity.

Table 3.1 reports the results. Column (1) suggests that an increase in the output tariff reduces the firm productivity. The sign of the coefficient for tariffs is negative and significant. A decrease of ten percentage points in the tariff rate improves productivity by 0.54 percent. Column (2) additionally includes intra-firm tariffs. The coefficients for both tariff rates are negative

and highly significant. The coefficient for output tariff falls, however, when the intra-firm tariff is included. It seems that the productivity effect through access to foreign technology has an important impact. Ignoring this variable would lead to a biased coefficient for the output tariff measure. The outcome suggests the existence of both effects: the competition effect described by Melitz (2003) as well as productivity-improving effects of foreign quality (Grossman and Helpman 1991), greater variety (Feenstra et al. 1992) and access to products at a reduced rate. The negative impact is larger for foreign-owned firms as reported in column (3). The largest negative effect on productivity is given by the coefficient for the input tariff rate. The positive impact of trade liberalization on productivity is smaller in the final market compared with intermediate inputs. The coefficient for input tariff is, however, not significant. Column (5) also reports an insignificant coefficient for input tariff rates but the impact of input tariff and the interaction with importing firms IM is as expected. In line with Amiti and Konings (2007), the effect is greatest for importing German and Austrian parent firms.

Table 3.2 uses the more reliable natural log of the productivity measure TFP calculated separately for each industry over 209,000 and 30,000 firms located in Germany and Austria, respectively. The set of the first four specifications shows an insignificant coefficient for the output tariff. This insignificant impact is in line with Amiti and Konings (2007) and can be explained by the framework described by Luong (2008). Inclusion of the intra-firm tariff rate, however, shows a negative and significant impact. A ten percentage point decline in the tariff rate raises productivity by 0.55 percent. Controlling for foreign-owned firms FO, column (4) suggests that having easier access to foreign products increases productivity. This impact is stronger for foreign-owned firms by 0.4 percent.[29] It indicates that a ten percentage point increase in the intra-firm tariff rate results in almost a 1

[29] A ten percentage point increase in intra-firm tariff rate is assumed.

Table 3.1: Tariff rates and TFP

	Dependent variable: tfp_{it} (real value added)				
	(1)	(2)	(3)	(4)	(5)
$tariffs_j$	-0.0540***	-0.0518***	-0.0513***	-0.0518***	-0.0544***
	[0.0051]	*[0.0050]*	*[0.0050]*	*[0.0050]*	*[0.0050]*
intra-firm $tariff_j$		-0.0537***	0.0418	-0.0535***	-0.0666***
		[0.0197]	*[0.0317]*	*[0.0198]*	*[0.0218]*
input $tariff_j$				-0.0587	0.0047
				[0.0744]	*[0.0880]*
FO			0.2460*		
			[0.1265]		
FO * intra-firm $tariff_j$			-0.0968***		
			[0.0299]		
IM					0.0066
					[0.0251]
IM * input $tariff_j$					-0.1244
					[0.1357]
fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*
Adj. R2	0.9	0.9	0.9	0.9	0.9
Observations	2083	2079	2079	2079	1745

Notes: A constant term as well as year, country, and firm fixed effects are included throughout all the specifications. Robust standard errors are in brackets. The dependent variable is the total factor productivity at the plant level i in industry j and year t. TFP is obtained by Levinsohn and Petrin (2003) with real value added as dependent variable. A constant technology for all industries is assumed. *Tariffs* are sectoral tariff rates at the parent industry level j. *Intra-firm tariff* is the sum of sectoral average tariffs weighted with imported goods from each related affiliate industry. *Input tariff* is the sum of the sectoral average tariff rates weighted with the industries' mean of imported inputs in percent of parents' sale. IM is a dummy equal to one if the value of imported goods between the parent firm and its affiliate is greater than zero. FO is a dummy equal to one if the global ultimate owner is a foreigner. The number of the corporate shareholders worldwide is included as control throughout all the specifications. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

percent boost in the firm productivity. At this time inclusion of the input tariff rate shows a negative and significant coefficient. If input tariff rates are reduced by ten percentage points the access to foreign intermediates raises productivity by more than 1.2 percent. Column (7) reports a greater impact of reducing input tariff rates compared with intra-firm tariffs. Although the impact for importing firms is larger than for non-importing firms column (8) reports only insignificant results. That is, contrary to Amiti and Konings (2007), there is unfortunately no single evidence of productivity gains from greater variety or learning effects controlled for by the interaction between importing firms IM and the intra-firm tariff rate. An F-test showing that all variables controlling for any type of tariff rates are different from zero is, however, significant.

Table 3.2: Tariff rates and sectoral TFP

Dependent variable: sectoral tfp_{it} (real value added)								
	basic estimations				input estimations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$tariffs_j$	-0.0213		0.0381	0.0371		-0.0211	0.0376	0.0859***
	[0.0143]		*[0.0272]*	*[0.0279]*		*[0.0143]*	*[0.0272]*	*[0.0302]*
intra-firm $tariff_j$		-0.0389**	-0.0552***	-0.0552***			-0.0545***	-0.0754***
		[0.0154]	*[0.0207]*	*[0.0207]*			*[0.0208]*	*[0.0223]*
input $tariff_j$					-0.1593**	-0.1626**	-0.1234*	-0.0906
					[0.0678]	*[0.0822]*	*[0.0717]*	*[0.1036]*
FO				2.9744***				
				[0.0477]				
FO * intra-firm $tariff_j$				-0.0391**				
				[0.0190]				
IM								0.0091
								[0.0941]
IM * intra-firm $tariff_j$								-0.0126
								[0.0162]
fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Adj. R2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Observations	1364	1364	1352	1352	1364	1352	1327	1090

Notes: A constant term as well as year, country, and firm fixed effects are included throughout all the specifications. Robust standard errors are in brackets. The dependent variable is the total factor productivity at the plant level i in industry j and year t. TFP is obtained by Levinsohn and Petrin (2003) for each 2-digit ISIC classification with firms' real value added as dependent variable for Germany and Austria, respectively. *Tariffs* are the simple average of sectoral tariff rates in all corresponding affiliates' industries on a three-digit level for each parent industry. *Intra-firm tariff* is the sum of the weighted average of tariffs aggregated up to the three-digit parent industry level. *IM* is a dummy equal to one if the firm's intra-firm imports are greater than zero. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Owing to the fact that the data consist of German and Austrian firms, Table 3.3 reports the results for the country differences. The country dummy is equal to one if the firm is located in Germany and zero if the observation relates to Austria. All three specifications show that productivity gains from liberalized trade are greater for Austria than for Germany. This holds for all three types of tariff rates. Again, the impact of reducing intra-firm tariff rates is greater compared with the output tariff coefficients.

Amiti and Konings (2007) give an additional interpretation for trade liberalization. They argue that reduced tariff rates "lower the price of international outsourcing" (Amiti and Konings 2007, p.1614, fn 11). In this context, lower tariffs increase offshoring and this in turn boosts firm productivity. Görg et al. (2008) also study the impact of international outsourcing on productivity.[30] In order to investigate the effect the results obtained stepwise for the offshoring channel are reported in Table 3.4.

In columns (1) to (3) offshoring measured as intra-firm imports in percent of parent sales is regressed on tariffs. Including controls, column (3) of Table 3.4 shows that a falling output tariff rate raises the offshoring activities. Column (4) suggests that offshoring in turn is positively linked with firm productivity. Increasing intra-firm imports significantly raises the firm's real value added. If increasing firm-level productivity is explained by greater offshoring and therefore by greater variety of and easier access to foreign goods, the coefficient for tariff rates is expected to be insignificant or equal to zero. Column (5) suggests that both offshoring and trade liberalization have a significant impact. The sign of the coefficient for intra-firm imports is positive, as expected. The impact, however, is reduced. That is, trade liberalization incentivizes offshoring and this in turn raises productivity. Besides that, a positive effect of reduced output tariffs on productivity remains. This is also

[30] For a detailed discussion on the existence of further empirical studies, see Görg et al. (2008), p.671ff.

Table 3.3: Country differences

Dependent variable: sectoral tfp_{it} (real value added)			
	(1)	(2)	(3)
$tariffs_j$	-0.2183***	-0.0837**	-0.0838**
	[0.0397]	*[0.0364]*	*[0.0366]*
$tariffs_j$ * country	0.1831***	0.0800**	0.0803**
	[0.0298]	*[0.0379]*	*[0.0380]*
intra-firm $tariff_j$		-0.1603***	-0.1602***
		[0.0388]	*[0.0389]*
intra-firm $tariff_j$ * country		0.1210***	0.1215***
		[0.0434]	*[0.0436]*
input $tariff_j$			-0.1432
			[0.1153]
input $tariff_j$ * country			0.0682
			[0.1226]
country	0.3156***	0.1349	0.2219**
	[0.0680]	*[0.0902]*	*[0.0971]*
fixed effects	*yes*	*yes*	*yes*
Adj. R2	0.8	0.8	0.8
Observations	1669	1665	1665

Notes: A constant term as well as year, industry, and firm fixed effects is included throughout all specifications. Robust standard errors are in brackets. The dependent variable is the sectoral total factor productivity at the plant level i in industry j and year t. TFP is obtained by Levinsohn and Petrin (2003) for each sector separately with real value added as dependent variable. *Tariffs* are sectoral tariff rates at the parent industry level. *Intra-firm tariff* is the sum of sectoral average tariff rates weighted with imported goods from one affiliate industry over all imported goods. *Input-tariff* is the sum of the sectoral average tariff rates weighted with the intermediate inputs ratio imported from one Eastern European affiliate industry over all corresponding intermediates. *Country* is a dummy equal to one if the parent firm is German and, contrary, equal to zero if the parent firm is Austrian. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 3.4: Channel of tariff rates and offshoring on productivity

	dependent variable: intra-firm imports			dependent variable: ln (real value added)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
intra-firm imports	-	-	-	0.0035***	0.0030**	0.0031**	0.0031**	0.0030***
				[0.0011]	*[0.0012]*	*[0.0013]*	*[0.0012]*	*[0.0011]*
$tariffs_j$	-0.1183	-0.1730**	-0.1644*		-0.0152**	-0.0127*	-0.0127*	-0.0116
	[0.0865]	*[0.0868]*	*[0.1023]*		*[0.0071]*	*[0.0074]*	*[0.0075]*	*[0.0083]*
intra-firm $tariff_j$						-0.0119	-0.0118	-0.0141
						[0.0147]	*[0.0210]*	*[0.0177]*
ln (L)		-1.6533***	-1.5245***				-0.0109	-0.0028
		[0.4596]	*[0.5140]*				*[0.0150]*	*[0.0259]*
ln (K)			0.2654					0.0123
			[0.3237]					*[0.0167]*
industry fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Adj. R2	0.02	0.03	0.04	0.02	0.02	0.03	0.03	0.01
Observations	783	743	481	1262	586	561	529	331

Notes: A constant term as well as a country dummy and firm fixed effects is included throughout all the OLS specifications. Robust standard errors are in brackets. The dependent variable in the first set is intra-firm imports in percent of parent sales. The dependent variable in the second set is the real value added at plant level i in industry j. The data are on project level for the year 1999. Therefore the number of observations can be larger than 417 firms. *Tariffs* and *Intra-firm tariff* are the average and weighted average tariff rate, respectively, for each parent-affiliate relationship on the Eastern European investment level. *Ln(L)* is the natural log of the number of parent employees. *Ln(K)* is the log of the parent firm's capital stock. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 3.5: Contribution of trade liberalization (in percent)

tariff rate	$\widehat{\beta}$	$\widehat{\beta}_{Austria}$	$\widehat{\beta}_{Germany}$
output tariff	0.3 - 0.4	0.3 - 0.8	0.03 - 0.4
intra-firm tariff	0.5 - 0.7	0.6 - 1.6	0.4 - 0.6
input tariff	0.6 - 1.6	1.4 - 2.1	0.8 - 1.2

Notes: The table summarizes the average effect of a ten percentage point reduction of each mentioned tariff rate on firm-level productivity. Author's calculations.

affirmed by the following specifications (6) to (8). Inclusion of the intra-firm tariff variable suggests that a reduced tariff rate incentivizes offshoring and raises productivity. The impact of the intra-firm tariff itself is insignificant. The coefficient for offshoring is positive and significant whereas the impact of tariffs is reduced.

A summary of all findings for a ten percentage point reduction in the studied types of tariffs is provided by Table 3.5. First, the contribution of trade liberalization to productivity is smaller for Germany than for Austria for all tariff types. Second, in both countries, Germany and Austria, the contribution of a reduction in intra-firm and input tariffs is larger compared with lowering output tariffs. This means that lowering the intra-firm tariff rate by ten percentage points increases German productivity on average by 0.5 percent and Austrian productivity by more than 1 percent. Finally, the effect is greater for multinationals in both countries.

3.6 Robustness

Owing to robustness concerns of the empirical findings, several measurement and specification issues can be presented in this section. The results reported in Table 3.6 are estimated by use of the real value added per employee as measurement for the firm's productivity. Beside the impact of output tariffs all coefficients for trade liberalization have the expected influence. Again, the impact of input tariffs is greater compared with lowering intra-firm tariff rates. Multinationals benefit more from lowering tariff rates than domestic firms. However, inserting the input tariff rate to the specification including output and intra-firm tariffs, show a statistically insignificant coefficient on the input variable.

Changing the dependent variable through the firm's operating revenue suggests that lower tariff rates increase the firm's revenue. Throughout all specifications the capital-to-labor ratio, the firm size, and intermediate materials are included to analyze the impact on an alternative productivity measure. The results suggest that trade liberalization has a positive impact. The effect is largest for the input tariff rate, followed by intra-firm rates and the output tariffs. Again, the coefficient for the input tariff rate itself is insignificant. Table 3.7 presents the estimates.

Tables 3.8 and 3.9 affirm the finding that there are significant differences between Germany and Austria. It holds for both measures real value added per employee and real revenue per employee, respectively, that generally the effect for Austria is larger. The exception in both tables, however, is given by a larger impact of lower input tariffs in Germany than in Austria. The F-test on all included tariff variables in both columns (3) suggests that the impacts are significantly different from zero. Moreover, Table 3.9 reports that the difference in lower intra-firm tariff rates is not as large as shown before. Nevertheless, reducing the tariff rates increases labor productivity.

Table 3.6: Tariff rates and labor productivity

Dependent variable: *real value added per employee*								
	basic estimations				input estimations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$tariffs_j$	0.0069	0.0132**	0.0132**	0.0134**		0.0071	0.0132**	0.0132**
	[0.0062]	*[0.0066]*	*[0.0066]*	*[0.0066]*		*[0.0063]*	*[0.0066]*	*[0.0066]*
intra-firm $tariff_j$		-0.0692***	-0.0692***	-0.0237			-0.0685***	-0.0683***
		[0.0176]	*[0.0176]*	*[0.0492]*			*[0.0177]*	*[0.0177]*
input $tariff_j$					-0.1797**	-0.1771**	-0.1196	-0.0179
					[0.0720]	*[0.0721]*	*[0.0738]*	*[0.1048]*
FO			0.8122***	0.8360***				0.8128***
			[0.0731]	*[0.0768]*				*[0.0732]*
FO * intra-firm $tariff_j$				-0.0456				
				[0.0435]				
FO * input $tariff_j$								-0.1958
								[0.1341]
fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Adj. R2	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Observations	1852	1848	1848	1848	1866	1848	1848	1848

Notes: A constant term as well as year, country, and firm fixed effects is included throughout all the specifications. Robust standard errors are in brackets. The dependent variable is the firms' real value added per employee for Germany and Austria, respectively. *Tariffs* are the simple average of sectoral tariff rates in all corresponding affiliates' industries on a three-digit level for each parent industry. *Intra-firm tariff* is the sum of the weighted average of tariffs aggregated up to the three-digit parent industry level. *Input tariff* is the aggregated sum of the input weighted average of the output tariffs. *FO* is a dummy equal to one if the firm's owner is a foreigner. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 3.7: Robustness: Trade liberalization and operating revenue

Dependent variable: *ln (revenue)* $_{it}$				
	(1)	(2)	(3)	(4)
$tariffs_j$	-0.0379***	-0.0359***	-0.0378***	-0.0359***
	[0.0053]	*[0.0052]*	*[0.0053]*	*[0.0052]*
intra-firm $tariff_j$		-0.0677***		-0.0674***
		[0.0218]		*[0.0220]*
input $tariff_j$			-0.1054	-0.0647
			[0.0763]	*[0.0794]*
ln $(K/L)_i$	0.4020***	0.3914***	0.4027***	0.3920***
	[0.0536]	*[0.0537]*	*[0.0536]*	*[0.0537]*
ln $(L)_i$	0.6345***	0.6307***	0.6357***	0.6315***
	[0.0530]	*[0.0526]*	*[0.0531]*	*[0.0527]*
ln $(materials)_i$	0.1723***	0.1686***	0.1712***	0.1680***
	[0.0340]	*[0.0344]*	*[0.0341]*	*[0.0345]*
fixed effects	*yes*	*yes*	*yes*	*yes*
Adj. R2	0.9	0.9	0.9	0.9
Observations	1527	1523	1523	1523

Notes: A constant term as well as year, country, and firm fixed effects are included throughout all the specifications. Robust standard errors in brackets. The dependent variable is the natural log of real revenue at the plant level i in industry j and year t. *Tariffs* are sectoral tariff rates at the three-digit ISIC parent industry classification. *Intra-firm tariff* is the sum of sectoral average tariff rates weighted with imported goods from one affiliate industry over all imported goods. *Input tariff* is the sum of the sectoral average tariff rates weighted with intermediate inputs imported from one Eastern European affiliate industry over all corresponding intermediates. *Ln(K/L)* is the log of capital over employees. *Ln(L)* is the natural log of the number of employees in the parent firm, and *Ln(materials)* is the log of imported goods in th euros. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

In general the effect is lower compared with the results of Table 3.3.

The findings also hold when the data are separated into a manufacturing and services classification. The results reported in Table T3.5 in the Appendix show a significant and positive impact of falling tariffs on productivity in the manufacturing sector. A ten percentage point decrease raises productivity by 0.34 percent. As shown before, the impact is greater for intra-firm tariff rates. Trade liberalization increases firm productivity by more than 0.6 percent. The coefficient for the input tariff is not significant. Moreover, column (4) presents a negative link between the number of shareholders and the firm's productivity. Column (5) suggests that multinationals benefit more from trade liberalization than purely domestic firms. This also holds for the service sectors. The output tariff rate, however, is no longer significant. The coefficients for the intra-firm tariff variable suggest that tariffs falling by ten percentage points raise productivity by more than 2 percent. Unfortunately, in the service sector subsample the number of observations drops significantly.

Table 3.8: Robustness: Country differences and value added

Dependent variable: *ln(real value added/L)* $_{it}$			
	(1)	(2)	(3)
$tariffs_j$	-0.1267**	-0.0361	-0.0361
	[0.0529]	*[0.0540]*	*[0.0540]*
$tariffs_j$ * country	0.1078**	0.0222	0.0222
	[0.0514]	*[0.0525]*	*[0.0526]*
intra-firm $tariff_j$		-0.1560**	-0.1561**
		[0.0629]	*[0.0630]*
intra-firm $tariff_j$ * country		0.1008*	0.1025*
		[0.0598]	*[0.0598]*
input $tariff_j$			-0.2109*
			[0.1133]
input $tariff_j$ * country			-0.0247
			[0.1567]
country	-0.2237***	-0.3692**	-0.3698**
	[0.0765]	*[0.1660]*	*[0.1661]*
fixed effects	*yes*	*yes*	*yes*
Adj. R2	0.8	0.8	0.8
Observations	1851	1847	1847

Notes: A constant term as well as year, industry, and firm fixed effects are included throughout all the specifications. Robust standard errors are in brackets. The dependent variable is the firm's real value added per employee. *Tariffs* are sectoral tariff rates at the parent industry level. *Intra-firm tariff* is the sum of sectoral average tariff rates weighted with imported goods from one affiliate industry over all imported goods. *Input tariff* is the sum of the sectoral average tariff rates weighted with intermediate inputs imported from one Eastern European affiliate industry over all corresponding intermediates. *Country* is a dummy equal to one if the parent firm is German and equal to zero if the parent firm is Austrian. Additionally, the natural log of turnover is included as a control variable in each specification. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 3.9: Robustness: Country differences and operating revenue

Dependent variable: *ln(real revenue/L)* $_{it}$			
	(1)	(2)	(3)
$tariffs_j$	-0.1063***	-0.1019***	-0.1027***
	[0.0223]	*[0.0304]*	*[0.0303]*
$tariffs_j$ * country	0.0738***	0.0719**	0.0727**
	[0.0219]	*[0.0305]*	*[0.0304]*
intra-firm $tariff_j$		-0.0635*	-0.0636*
		[0.0363]	*[0.0363]*
intra-firm $tariff_j$ * country		0.0001	0.0007
		[0.0397]	*[0.0398]*
input $tariff_j$			-0.109
			[0.0739]
input $tariff_j$ * country			-0.0286
			[0.1317]
ln (K/L)	0.2954***	0.2907***	0.2911***
	[0.0432]	*[0.0432]*	*[0.0432]*
ln (L)	-0.2664***	-0.2661***	-0.2655***
	[0.0378]	*[0.0378]*	*[0.0378]*
country	-0.6329***	-0.0243	-0.0285
	[0.1503]	*[0.1820]*	*[0.1811]*
fixed effects	*yes*	*yes*	*yes*
Adj. R2	0.8	0.8	0.8
Observations	2083	2079	2079

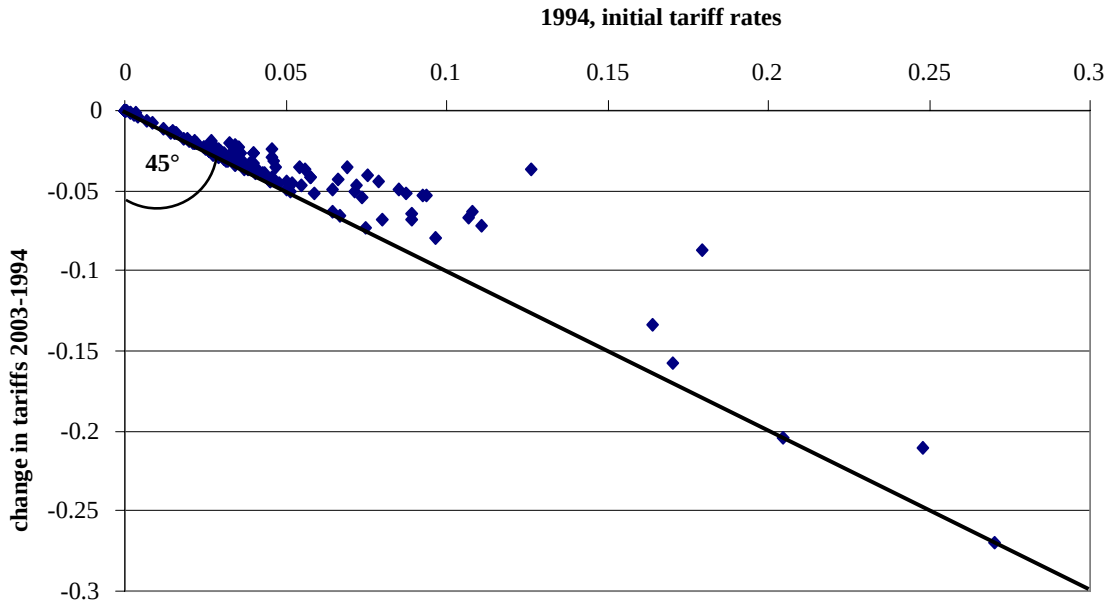
Notes: A constant term as well as year, industry and firm fixed effects are included throughout all the specifications. Robust standard errors are in brackets. The dependent variable is the natural log of real revenue over employees. *Tariffs* are sectoral tariff rates at the parent industry level. *Intra-firm-tariff* is the sum of sectoral average tariff rates weighted with imported goods from one affiliate industry over all imported goods. *Input-tariff* is the sum of the sectoral average tariff rates weighted with intermediate inputs imported from one Eastern European affiliate industry over all corresponding intermediates. *Country* is a dummy equal to one if the parent firm is German and, contrary, equal to zero if the parent firm is Austrian. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

3.7 Conclusion

Even though there is a huge amount of literature on trade liberalization, empirical studies on liberalized trade in terms of both output and input tariffs in firm productivity are rare. Moreover, there is no detailed study on the relationship between intra-firm tariffs and productivity in Germany and Austria which considers the directly preceding periods of the Eastern European enlargement. This chapter argues, however, that it is important, especially for Germany and Austria as two of the countries most affected by the eastern enlargement. Therefore, the underlying analysis tries to say to what extent tariff reductions for Central and Eastern Europe lead to a boost in German and Austrian firm-level productivity. More precisely, following Amiti and Konings (2007), the chapter considers the determinants of firm-level total factor productivity. Obtaining productivity by using the Levinsohn and Petrin technique (2003) that corrects for unobserved productivity shocks, a unique matching of intra-firm import data finds that tariff reductions significantly increase total factor productivity. The size of the coefficient depends strongly in both countries on the type of tariffs: input tariff rates show the largest effects, followed by intra-firm and output tariff rates. The impact of a ten percentage point tariff cut ranges between 0.3 and 2 percent. The effect for Austria is larger than for Germany. The results also suggest that trade liberalization makes offshoring cheaper and this in turn increases productivity. This channel, among others, is hypothesized by Amiti and Konings (2007) for Indonesian firms. This study is the only one using data relating to Germany, Austria and Eastern Europe. Moreover, it is the only one which distinguishes between tariffs on intra-firm imports and tariffs on intermediate inputs. The results are in line with findings for other country studies and robust to a wide range of tests varying the dependent variable and the underlying estimation specifications.

Appendix to Chapter 3

Tables and Figures



Source: WITS database (World Bank and UNCTAD 2008). Author's calculations.

Figure F3.1: Change in initial tariff levels

Table T3.1: Overview of empirical literature on trade liberalization and productivity

literature	countries	period	observations	estimation method	productivity measures	**results** of	
Amiti and Konings (2007)	Indonesia	1991 - 2001	plant-level	Olley-Pakes (1996)	total factor productivity	*10%-points decrease in*	
						output tariffs	[1%; 6%]
						input tariffs	[2%;12%]
De Locker (2007)	Belgium	1994 - 2002	firm-level	Olley-Pakes (1996), enhanced by ommited price variable bias	total factor productivity	*relaxing*	
						avg. quota restriction	4%
Fernandes (2003)	Colombia	1977 - 1991	plant-level	Levinsohn-Petrin (2003)	total factor productivity	*10%-points decrease in*	
						nominal tariffs	[0.7%; 2.9%]
Goldberg et al (2008)	India	1989 - 2003	firm-level	Topalova (2004)	amongst others: total factor productivity	*10%-points decrease in*	
						input tariffs	4.5%
Head and Ries (1999)	Canada	1987 - 1994	industry-level, plant-level	semi-log OLS, fixed effects	output per plant	*tariff cuts*	
						Canadian tariffs	-8.5%
						US tariffs	9.8%
Krishna and Mitra (1998)	India	1986 - 1993	firm-level	Harrison (1994), extended	total factor productivity	*liberalized trade*	
						trade reform (1991)	[3%; 6%]
Luong (2008)	Mexico	1984 - 1990	plant-level	factor share method, OLS, Olley-Pakes (1996)	total factor productivity	*10%-points decrease in*	
						output tariffs	[−1.6%; −3.9%]
						input tariffs	[−1.4%; 9.7%]
						output tariffs*rank	[0.4%; 0.6%]
						input tariffs*rank	[− 0.4%; − 0.7%]
Halpern, Koren and Szeidl (2005)	Hungarian	1992 - 2001	product-level	Olley-Pakes (1996)	total factor productivity	*10%-points increase in*	
						import share	1.8%

Table T3.1 (continued): Overview of empirical literature on trade liberalization and productivity

literature	countries	period	observations	estimation method	productivity measures	**results** of	
Muendler (2004)	Brazilia	1986 - 1998	firm-level	Olley-Pakes (1996), extended	total factor productivity	*10%-points decrease in*	
						nominal tariffs	[1.3%; 6.1%]
Pavcnik (2002)	Chile	1979 - 1986	industry-level, plant-level	Olley-Pakes (1996)	total factor productivity	*trade orientation*	
						sectoral (aggregated)	19%
						plant level difference between traders and non traders	[3%;10%]
Schor (2004)	Brazilia	1986 - 1998	plant-level	Olley-Pakes (1996)	total factor productivity	*10%-points decrease in*	
						nominal tariffs	[0.4%;1.3%]
						input tariffs	[1.5%; 2.7%]
Topalova (2004)	India	1986 - 1993	industry-level, plant-level	Levinsohn-Petrin (2003)	total factor productivity	*10%-points decrease in*	
						nominal tariffs	[0.2%;1.6%]
Trefler (2004)	US, Canada	1980 - 1996	industry-level, plant-level	differences-in-differences		*change in FTA-mandated tariff concessions*	
					employment growth	CA: [−12%; − 24%]	US: [− 3%; 9%]
					labor productivity	CA: [8%;15%]	US: [4%;14%]

Table T3.2: German productivity estimations (industry level)

Dependent variable: *real added value* $_{it}$				
	OLS		Levpet	
industry	capital	employees	capital	employees
14: Other mining and quarrying	0.242	0.766	0.591	0.201
15: Manufacturing - food products and beverages	0.281	0.709	0.275	0.608
17: Manufacturing - textiles	0.158	0.709	0.49	0.588
20: Manufacturing - wood and products of wood	0.095	0.931	0.056	0.591
21: Manufacturing - pulp, paper and paper products	0.232	0.72	0.469	0.41
22: Publishing, printing, reproduction of rec. media	0.182	0.734	0.179	0.701
24: Manufacturing - chemicals and chemical products	0.114	0.886	0.028	0.607
25: Manufacturing - rubber and plastic products	0.321	0.554	0.069	0.542
26: Manufacturing - non-metallic mineral products	0.248	0.625	0.281	0.596
27: Manufacturing - basic metals	0.27	0.685	0.342	0.527
28: Manufacturing - fabricated metal products	0.212	0.71	0.1	0.534
29: Manufacturing - machinery and equipment n.e.c.	0.161	0.776	0.382	0.695
31: Manufacturing - electrical machinery	0.151	0.815	0.402	0.685
32: Manufacturing - radio, television, communication	0.4	0.6	0.257	0.706
33: Manufacturing - medical, precision, optical instruments	0.204	0.758	0.065	0.733
34: Manufacturing - motor vehicles, trailers, semi-trailers	0.286	0.668	0.381	0.648
35: Manufacturing - transport equipment	0.188	0.745	0.404	0.593
36: Manufacturing - furniture, n.e.c.	0.182	0.753	0.242	0.751
40: Electricity, gas and water supply	0.308	0.571	0.395	0.367
45: Construction	0.223	0.733	0.186	0.738
50: Sale, repair of motor vehicles and motorcycles	0.256	0.633	0.28	0.43
51: Wholesale trade and commission trade	0.155	0.672	0.165	0.669
52: Retail trade	0.201	0.731	0.068	0.705
60: Land transport, transport via pipelines	0.423	0.395	0.311	0.585
62: Air transport	0.09	0.973	0.444	0.011
64: Post and telecommunications	0.186	0.818	0.387	0.921
67: Activities auxiliary to financial intermediation	0.267	0.369	0.587	0.192
72: Computer and related activities	0.23	0.744	0.196	0.784
74: Other business activities	0.23	0.424	0.135	0.608
90: Sewage and refuse disposal	0.175	0.54	0.004	0.6

Note: The dependent variable is the firm's real added value at plant level i in industry j and year t. All variables are given in natural logs. A constant term as well as year dummies are included throughout all the specifications. The coefficients for each industry are obtained from simple OLS estimations and Levinsohn-Petrin estimations (2003), respectively. Calculations run at a two-digit ISIC industry level. *Source:* Amadeus (Bureau van Dijk 2005). Author's calculations.

Table T3.3: Austrian productivity estimations (industry level)

Dependent variable: *real added value* $_{it}$				
	OLS		Levpet	
industry	capital	employees	capital	employees
15: Manufacturing - food products and beverages	0.438	0.638	0.215	0.702
17: Manufacturing - textiles	0.093	0.924	0.619	0.691
20: Manufacturing - wood and products of wood	0.01	0.393	0.456	0.609
26: Manufacturing - non-metallic mineral products	0.152	0.864	0.559	0.654
27: Manufacturing - basic metals	0.333	0.647	0.711	0.631
28: Manufacturing - fabricated metal products	0.116	0.903	0.51	0.724
29: Manufacturing - machinery and equipment n.e.c.	0.049	0.893	0.376	0.813
32: Manufacturing - radio, television, communication	0.236	0.665	0.585	0.809
36: Manufacturing - furniture, n.e.c.	0.19	0.864	0.657	0.322
40: Electricity, gas and water supply	0.688	0.268	0.49	0.597
45: Construction	0.26	0.699	0.206	0.502
50: Sale, repair of motor vehicles and motorcycles	0.26	0.614	0.419	0.36
51: Wholesale trade and commission trade	0.179	0.671	0.423	0.113
52: Retail trade	0.15	0.806	0.309	0.886
60: Land transport, transport via pipelines	0.181	0.921	0.398	0.663
63: Supporting and auxiliary transport activities	0.146	0.797	0.607	0.028
67: Activities auxiliary to financial intermediation	0.442	0.27	0.502	0.123
74: Other business activities	0.165	0.476	0.504	0.425

Note: The dependent variable is the firm's real added value at plant level i in industry j and year t. All variables are given in natural logs. A constant term as well as year dummies are included throughout all the specifications. The coefficients for each industry are obtained from simple OLS estimations and Levinsohn-Petrin estimations (2003), respectively. Calculations run at a two-digit ISIC industry level.
Source: Amadeus (Bureau van Dijk 2005). Author's calculations.

Table T3.4: Baltic, Central and Eastern European countries

Albania	Latvia
Armenia	Lithuania
Azerbaijan	Macedonia, FYR
Belarus	Moldova
Bosnia and Herzigovina	Poland
Bulgaria	Romania
Croatia	Russian Federation
Czech Republic	Serbia and Montenegro
Estonia	Slovak Republic
Georgia	Slovenia
Hungary	Tajikistan
Kazakhstan	Ukraine
Kyrgyz Republic	Uzbekistan
Latvia	

Source: University of Munich, Chair for International Economics.

Table T3.5: Robustness: Manufacturing vs. services

Dependent variable: tfp_{it} (revenue)										
	Manufacturing					Services				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$tariffs_j$	-0.0353***	-0.0342***	-0.0342***	-0.0342***	-0.0339***	-0.1896*	-0.001	0.0047	-0.001	0.0692
	[0.0044]	*[0.0043]*	*[0.0043]*	*[0.0043]*	*[0.0043]*	*[0.1082]*	*[0.0689]*	*[0.0706]*	*[0.0689]*	*[0.0749]*
intra-firm $tariff_j$		-0.0642***	-0.0642***	-0.0642***	-0.012		-0.2380**	-0.2417**	-0.2380**	-0.0605
		[0.0210]	*[0.0210]*	*[0.0210]*	*[0.0319]*		*[0.1114]*	*[0.1125]*	*[0.1114]*	*[0.0734]*
input $tariff_j$			-0.0320					-0.1509		
			[0.1123]					*[0.1409]*		
FO				0.7044***	0.8462***				1.6788***	2.3142***
				[0.0845]	*[0.0918]*				*[0.3041]*	*[0.4236]*
FO * intra-firm $tariff_j$					-0.0525*					-0.2275**
					[0.0316]					*[0.0907]*
#(SH)				-0.0223***	-0.0222***				0.0428***	0.0581***
				[0.0012]	*[0.0012]*				*[0.0082]*	*[0.0107]*
fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Adj. R2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Observations	1136	1136	1136	1136	1136	391	387	387	387	387

Notes: A constant term as well as year, country, and firm fixed effects is included throughout all the specifications. Robust standard errors are in brackets. The dependent variable is the sectoral total factor productivity at the plant level i in industry j and year t. TFP is obtained by the Levinsohn-Petrin-technique (2003) with revenue as dependent variable. *Tariffs* are sectoral tariff rates at the parent industry level. *Intra-firm tariff* is the sum of sectoral average tariff rates weighted with imported goods from one affiliate industry over all imported goods. *Input tariff* is the sum of the sectoral average tariff rates weighted with intermediate inputs imported from one Eastern European affiliate industry over all corresponding intermediates. FO is a dummy equal to one if the global ultimate owner is a foreigner. $\#(SH)$ is the number of the firms' shareholders worldwide. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Chapter 4

Exports and Productivity: An Empirical Analysis of German and Austrian Firm-Level Performance

4.1 Introduction

Investigating the causal relationship between exports and productivity is not new. However, there is a crucial difference between past and more recent studies. The early literature considers comovement between exporting and productivity on the macro-level using aggregate data. For instance, Kunst and Marin (1989) and Marin (1992) analyze for Germany and Austria, respectively, whether exports Granger cause productivity or productivity has an impact on exports. For Germany, Kunst and Marin (1989) find that export growth causes productivity gains, whereas for the Austrian analysis, Marin (1992) has to reject the mentioned link.

More recent literature on the interaction between exporting and firm performance argues that there is interdependence between the two of them on the micro-level. That is, the literature reveals that only the most productive firms self-select themselves into the export market and that exporting improves firm performance. From a theoretical point of view, Clerides et al. (1998) argue that only the highly productive firms are able to cover their sunk costs and this in turn allows them to export. This well-known relationship between exporting and firm-level productivity is also modeled by Melitz (2003). He shows that, due to fixed costs, only the most productive firms start to export. This in turn raises productivity at the industry level because less efficient firms have to leave the market. The results suggest that a higher productivity increases the probability of exporting due to additional distribution, marketing, or production costs (Wagner 2007). Therefore, causality runs from productivity to exports.

However, exporting can also generate higher firm-level productivity via learning-by-exporting (Clerides et al. 1998). For instance, derived from the management and policy literature, Arnold and Hussinger (2005, p.223) mention that technological and managerial inputs from foreign contacts boost

firm performance. Closely related to this argument, Wagner (2007) states that an international knowledge flow increases the exporter's performance. Involvement in export markets and therefore serving a larger market offers the possibility to exploit additional economies of scale and to overcome domestic reductions in demand (Wagner 2002). Further, intense competition may lead exporters to faster improvements (Wagner 2002), force firms to keep costs low (Kunst and Marin 1989), and give greater incentives to innovate (Holmes and Schmitz 2001, Kunst and Marin 1989). In other words, exporting boosts firm-level productivity.

This chapter tries to find empirical evidence of the association between exporting and firm performance. That is, it deals with the question of an underlying causality. It focuses on the causal effect that exporters become more productive compared with non-exporters. For this study, a unique matching of micro-level data for German and Austrian firms in the period from 1994 to 2003 is employed. The results suggest that German and Austrian exporters are more productive by on average 40 percent compared with non-exporters. Moreover, contrary to other prominent empirical findings in the literature, the study reveals that exporting additionally raises the annual average productivity growth by approximately 1 to 1.5 percent. The robustness of the results relies, beside other techniques, mainly on an instrumental variable approach. This analysis suggests that exporting as well as the export intensity (export-to-sales ratio) boost labor productivity and total factor productivity (TFP) significantly. In this context, estimating TFP follows Levinsohn and Petrin (2003) to circumvent endogeneity problems as a result of unobserved productivity shocks. Therefore, the results allow the conclusion that both directions hold: more productive firms self-select themselves into export markets and exporting to foreign markets boosts firm-level productivity.

The underlying methodology is based on empirical studies focusing on the distinction between causality and a simple correlation of export status

and productivity. The first to mention here is that of Bernard and Jensen (1999). They use labor productivity as well as TFP to find differences between exporters and non-exporters. The underlying technique is based on a feasible chronological dependency between exporting and productivity.[1] The authors argue that their results suggest that there is more evidence of self-selection than of productivity growth by exports. A similar result is found in another study by Bernard and Jensen (2004). They give indirect evidence of the existence of sunk costs because of the greater importance of existing exporters than new entrants for raising US exports between 1987 and 1992. In this context, Roberts and Tybout (1997, p.559) quantify the presence of sunk costs as exporting activities raise the probability of further exporting by approximately 60 percentage points. Against these findings, De Loecker (2007b) gives evidence for the learning-by-exporting hypothesis. Employing micro data for Slovenia from 1994 to 2000, the author uses a matching technique comparing exporting firms with similar non-exporting firms. The estimations show that the instantaneous impact of export starters on productivity is 8.8 percent whereas the effect is larger for exports to high-income regions than exports to low-income regions (De Loecker 2007b, p.86). The study by Hahn (2004) provides evidence of both effects of the relationship between exporting and, amongst others, TFP. Using annual plant level data for Korean firms from 1990 to 1998, especially entry into the export market raises TFP whereas exporters are more productive before they start exporting. As the author mentioned, this result is in contrast to the findings by Aw, Chung, and Roberts (1998). Their results suggest that for South Korea as well as for Taiwan self-selection is much more supported than learning-by-exporting. Baldwin and Gu (2003) analyze the Canadian manufacturing sector from 1974 to 1996. They find that both export starters are more productive by around 21 percent and exporting improves annual labor pro-

[1] See also Lachenmaier and Wößmann 2006, p.318ff.

ductivity growth and TFP by 6 and 2 percent, respectively.[2]

The balance of this chapter is organized as follows. Section 4.2 gives a short overview of German and Austrian export behavior within the considered period from 1994 to 2003. It emphasizes German and Austrian trade openness and the potential link of exporters becoming more productive, which provides the main motivation for this analysis. Section 4.3 gives an overview of the data and the underlying methodology, illustrating the basic estimation equations. Following Levinsohn and Petrin (2003), it also presents some data-related intuition about the simultaneity bias concerning the input and output variables within the TFP calculations. Section 4.4 gives a more detailed descriptive analysis of the underlying data. Section 4.5 presents the empirical results of the causality analysis between exporting and productivity. The following Section 4.6 provides robustness from an instrumental variable approach to give evidence of the existence of a causality running from exports to productivity. Finally, Section 4.7 concludes.

4.2 Exports and Productivity in Germany and Austria

As mentioned in the first section, Kunst and Marin (1989) find for Germany a causal relationship running from exports to productivity. This finding does not hold for Austria (Marin 1992). Considering more recent German firm-level studies on the causal relationship between exporting and productivity suggests that mainly one direction holds: firm performance determines the

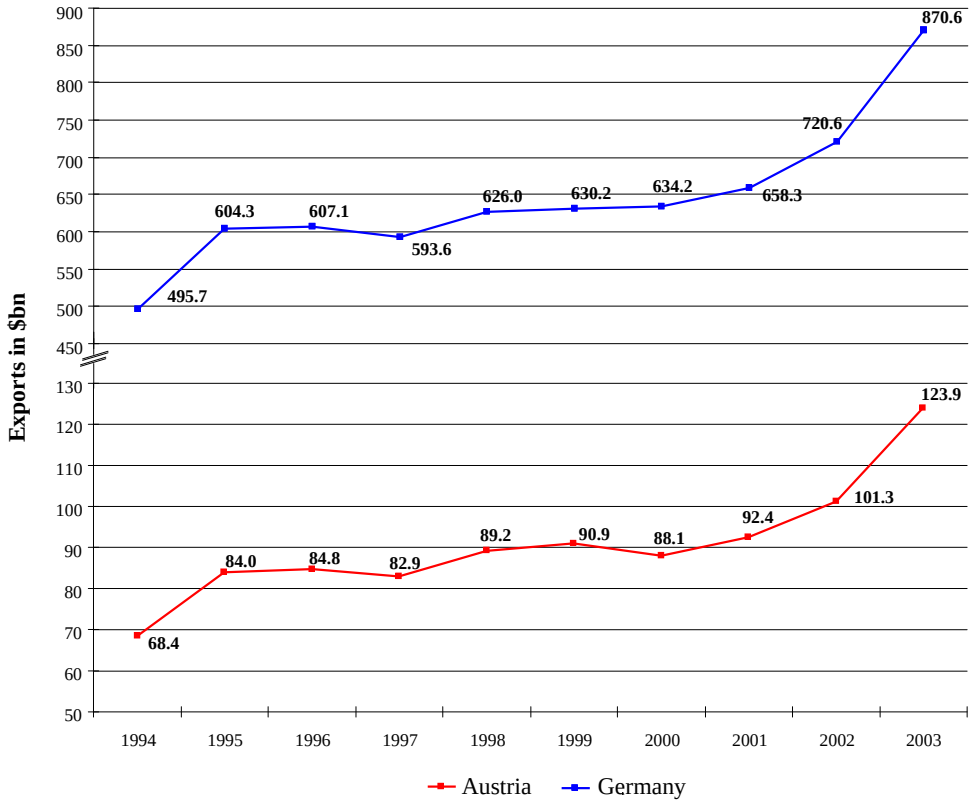
[2] A more extensive summary and evaluation of the literature on the causal relationship between exports and productivity is given by Greenaway and Kneller (2007) and Wagner (2007, 2008). Also closely related, another set of literature studies the relationship between exports and innovation, e.g. Lachenmeier and Wößmann (2006). They show a causality running from innovation to exports. Using an instrumental variable approach, the authors conclude that innovation raises the export share by an additional 7 percentage points.

export status (Arnold and Hussinger 2005, Bernard and Wagner 1997, 2001, Wagner 2007). For instance, employing data of the Statistical Office of Lower Saxony, Wagner (2002) uses a matching approach comparing export starters with non-starters. Beside the well-known fact that exporters are *better* in a range of different firm characteristics, the author finds only weak evidence of the impact of exporting on labor productivity. Arnold and Hussinger (2005) use 389 German firm-level data from the Mannheim Innovation Panel between 1992 and 2000. Applying a propensity score matching approach, the authors conclude that productivity causes exports and therefore self-selection is existent; however, the other way round does not hold. The only analysis that finds empirical evidence of causality running from exporting to productivity in Germany is the study by Fryges and Wagner (2008). Allowing for continuous treatment, the authors apply the generalized propensity score methodology to German micro-level data in Lower Saxony from 1995 to 2005. Their results show that only within different sub-intervals of the exports-to-sales ratio does exporting raise labor productivity growth.

The existing literature on Germany finds empirical evidence that exporters are more productive than non-exporters. However, empirical evidence of the impact of German exporting on firm performance is weak. This finding as well as the undoubted importance of trade liberalization and, in the true sense, exports motivate this analysis.

Marin (2008) accounts for the importance of Germany and Austria. She shows that the two countries are most integrated into the world economy compared with other European countries (Marin 2008, p.3): from 1994 to 2006, exports plus imports as a percentage of GDP (trade openness) increased in Germany from 37 to 69 percent and in Austria from 49 to 85 percent. Figure 4.1 and 4.2 demonstrate in this context the increasing importance of exports in Germany and Austria, separately. From 1994 to 2003, the total exports almost doubled in both countries. Within this period, exports as

a percentage of GDP increased by 14.9 percentage points in Austria, from 33.6 to 48.5 percent, and by 12.5 percentage points in Germany, from 23.1 to 35.6 percent. Moreover, this rise can be ascribed to a small number of top firms. Mayer and Ottaviano (2007a, 2007b) show that in Germany the top 10 percent of exporters account for 90 percent of exports.[3]

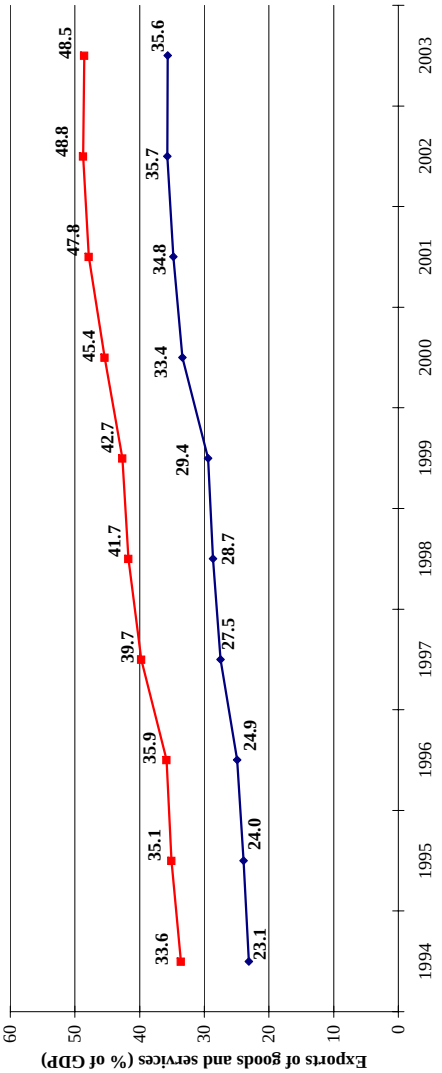


Source: The World Bank Group (2009), World Development Indicators.

Figure 4.1: Total exports in Austria and Germany (1994 - 2003)

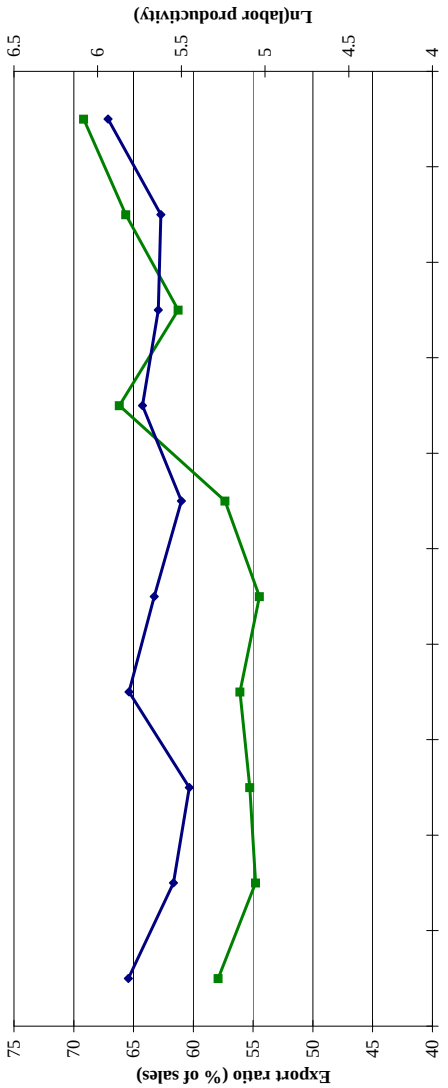
[3] This fact also motivates the study of the potential relationship with a small number of roughly 380 firms over 10 years. See Section 4.3 for more details.

Moreover, Mayer and Ottaviano (2007a, 2007b) present that German employment and wage premia are larger for exporters than purely domestic firms. The authors conclude that exporters show a better firm performance than non-exporters. These results are also supported by Figures 4.3 and 4.4. Both figures show, for Austria and Germany separately, movements of the export ratio (as a percentage of sales) and the related firm's labor productivity from 1994 to 2003. In general, an increase in the export ratio is associated with an increase in productivity. In more detail, an increase in the export ratio in period t is linked with an increase in productivity in period $t + 1$. In Austria, this holds true for five out of eight periods. The other periods in Austria generally illustrate a comovement in the same period. In Germany, the lagged relationship is more precise. For instance, a rise in the export ratio in 1996 is linked with an increase in labor productivity one period later. A decrease in the export ratio in 1997 is followed by a decrease in the firm-level productivity in 1998. This relationship can be found from 1994 to 2002, that is, in seven out of eight possible periods. In addition, owing to the Asian and Russian crises occurring in 1997 and 1998, respectively, and the subsequent falling export ratios, the data seem to be reliable. These facts, from German data more than from Austrian data, allow us to infer gently that exporting may promote productivity.



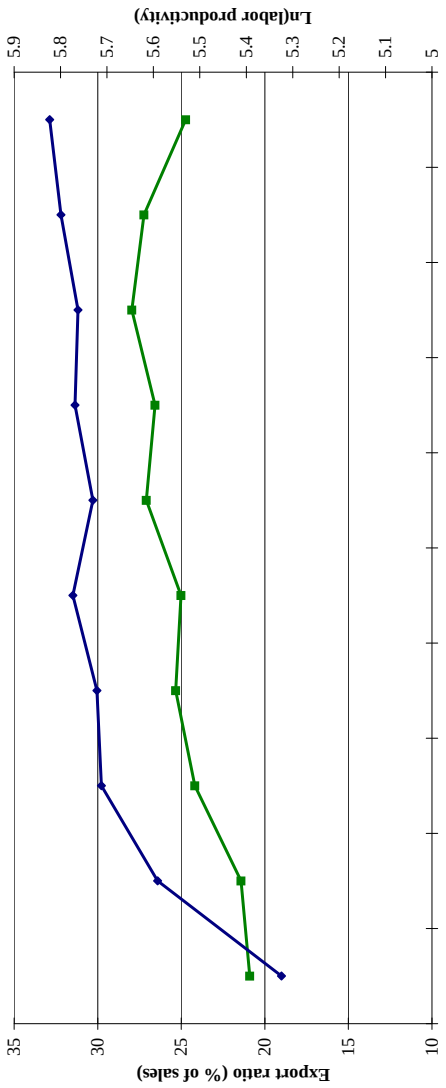
Source: The World Bank Group (2009), World Development Indicators.

Figure 4.2: Austrian and German export evolution as a percentage of GDP (1994 - 2003)



Notes: Labor productivity is the revenue-to-employee ratio.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 4.3: Austrian export ratio and labor productivity (1994 - 2003)



Notes: Labor productivity is the revenue-to-employee ratio.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 4.4: German export ratio and labor productivity (1994 - 2003)

4.3 Data and Methodology

4.3.1 Dataset

The dataset is built on a matching for 660 German and Austrian firms investing in Central and Eastern European countries. That is, the sample of the empirical study relies mainly on a survey between 1997 and 2001 by the Chair of International Economics at the University of Munich. It provides information on the micro-level for the investors as well as for the corresponding affiliates covering firms of all size classes. For this period, the sample represents 80 percent of the German total investments in Eastern Europe and 100 percent of the total Austrian investments in Eastern Europe.[4]

To enhance the underlying data, the cross-sectional firm information is matched with the pan-European micro database *Amadeus* released by the Bureau van Dijk (Bureau van Dijk, Electronic Publishing 2005). The underlying version includes firm-level data for more than 1.5 million national and multinational establishments in 38 European countries for up to 13 years, finishing in 2005.[5] This results in an unbalanced panel of 417 German and Austrian firm-level data covering a period of 10 years from 1994 to 2003. Unfortunately, this database gives information on the export turnover neither for Germany nor for Austria. However, it offers values for the peer group's export turnover. This group is defined as companies with information on their export turnover, being active in the parent firm's same first two-digit industry classification (ISIC), and having a similar capital as well as labor endowment. The obtained peers' export turnover is the simple average per employee over all comprised peers available for the sample period from 1997 to 2003.[6] This variable is used for the instrumental regressions to circumvent

[4] See Marin (2004, 2008) for a further description of the data.

[5] For further information on the *Amadeus* dataset (Bureau van Dijk 2005) available online see http://www.bvdep.com/en/Amadeus.html.

[6] It contains firm information from Croatia, France, Hungary, United Kingdom, and

the endogeneity problem prevailing and discussed in the literature.

The measure for German and Austrian export activities is provided by *Hoppenstedt* (Hoppenstedt 2009) and *Thomson ONE Banker* data (Thomson Reuters 2009).[7] It allows the matching out of a total of 417 firms of 367 German (65 percent) and Austrian (35 percent) corporations with information on the global export status as well as exporting ratio as a percentage of firm sales. Therefore, it results in an unbalanced panel on the micro-level for each year from 1994 to 2003.

In a final step, effectively applied export tariff rates are merged for each four-digit German and Austrian firm's industry and year. The data are provided by the World Integrated Trade Solution database *(WITS)* (World Bank and UNCTAD 2008), which is fully available for the research period.[8] Beside the peers' export turnover mentioned above, this variable is also used to avoid the underlying endogeneity problem via an instrumental approach.

4.3.2 Total Factor Productivity and Simultaneity Bias

To study the underlying relationship between exporting and productivity, in a first step, I estimate the firm's TFP. Owing to the low number of observations, this approach is estimated for each 2-digit industry classification (ISIC) over all 209,000 German and 30,000 Austrian firms available in *Amadeus* (Bureau van Dijk 2005). TFP is defined as the difference between the natural log of the actual value Y_{it} and the natural log of the estimated value $\hat{Y_{it}}$ considering a Cobb-Douglas production function:

Switzerland.

[7] I would like to thank the Economic Business and Data Center (EBDC) for giving me access to this data. For further information on the EBDC and the mentioned datasets see http://www.cesifo-group.de/portal/page/portal/ifoHome/_EBDC_root/EBDC_Intro/EBDC_000_Intro, http://www.hoppenstedt.de and www.thomsonreuters.com/products_services/financial [August, 3rd 2009].

[8] *WITS* (World Bank and UNCTAD 2008) gives access to the major trade and tariff data from the *UN COMTRADE* database, the *TRAINS* database, and the *IDB* and *CTS* databases. For these and further information on *WITS* (World Bank and UNCTAD 2008) see http://wits.worldbank.org/witsweb

$$Y_{it} = A_{it}(E) L_{it}^{\gamma_l} K_{it}^{\gamma_k}, \tag{4.1}$$

where Y_{it} is the firm's value added of firm i at time t, L_{it} is the number of employees of firm i at time t, and K_{it} is the capital endowment of firm i at time t. All the variables are deflated.[9] Calculating TFP allows us to analyze whether firm-level productivity $A_{it}(E)$ is influenced by exports E. Beside ordinary least square (OLS) with fixed effects, the estimation procedure follows Levinsohn and Petrin (2003). Due to a productivity shock unobserved by econometricians, OLS is not very reliable (Ackerberg et al. 2005, Levinsohn and Petrin 2003, Olley and Pakes 1996). That is, the residuals in the production function specification contain an unobserved shock that has an impact on the firm's input factors capital and labor. The so-called transmitted component results in a simultaneous causality problem between the explained and the explanatory variables, especially between capital and the error term as stated by Levinsohn and Petrin (2003, p.319ff).[10]

Contrary to Olley and Pakes (1996), the Levinsohn and Petrin (2003) technique does not require a measurement of investments to proxy the unobserved shock. Due to zero investment observations and insufficient data on firm-level investments, Levinsohn and Petrin (2003) suggest intermediate inputs m_{it} as a proxy to solve the endogeneity problem. Assuming a strictly monotonous relationship between the proxy, the capital accumulation, and the unobserved shock allows me to estimate consistent beta coefficients on the input variables specifying the transmitted component as part of the error term by $f_t(k_{it}, m_{it})$ (Levinsohn and Petrin 2003, Olley and Pakes 1996,

[9] The manufacturing and service sectors are deflated by the producer price index and the consumer price index, respectively. Additionally, year dummies are included while estimating total factor productivity. The measures are obtained by the Austrian National Bank (OeNB 2008) and German Federal Statistical Office (2008c).

[10] See also Ackerberg et al. (2005), Alvarez and Crespi (2007), and Olley and Pakes (1996).

Pakes 1996).[11] Therefore, the following equations are estimated.[12] First, the elasticity of labor is obtained by

$$y_{it} = \gamma_1 l_{it} + \theta_t(k_{i,t}, m_{i,t}) + u_{it}, \tag{4.2}$$

where

$$\theta_t(k_{it}, m_{it}) = \gamma_0 + \gamma_2 k_{it} + f_t(k_{it}, m_{it}). \tag{4.3}$$

Second, the coefficient on capital is empirically calculated by

$$y_{it} - \gamma_1 l_{it} = \gamma_2 k_{it} + g(\theta_{t-1} - \gamma_2 k_{i,t-1}) + u_{it} + \epsilon_{it}. \tag{4.4}$$

The proxy variable is measured by material costs, labor is measured by the number of employees, tangible fixed assets measure capital endowment, and the dependent variable is the firm's real value added. All the variables are from the *Amadeus* database (Bureau van Dijk 2005). As already mentioned, owing to the fact that the number of observations is restricted to 367 firms per year, TFP is calculated in each 2-digit sector for Germany and Austria separately over a total of more than 239,000 firms from 1994 to 2003.

A comparison of the TFP calculations following Levinsohn and Petrin (2003) with TFP estimations by simple OLS for a two-input production function allows the determination of the simultaneity bias (Levinsohn and Petrin 2003, p.319). As argued by Levinsohn and Petrin (2003, p.319), one of the most relevant cases is a positive correlation of labor and capital with the unobserved productivity shock. However, labor is assumed to correlate more than capital, resulting in an overestimation of the $\hat{\beta}$-coefficient on labor and an underestimation of the $\hat{\beta}$-coefficient on capital. This is exactly what the production function estimations applying OLS and Levinsohn and Petrin

[11] The relationship between materials, capital, and productivity shock is approximated by a fourth-order polynomial in k_{it} and m_{it} (Levinsohn and Petrin 2003).

[12] See Levinsohn and Petrin (2003, p.321), Olley and Pakes 1996, Pakes 1996).

(2003) to Germany and Austria report.[13]

4.3.3 Estimation methodology

The starting point of the empirical estimation procedure is based on the approach by Bernard and Jensen (1999). This methodology is widely employed by various empirical studies as a common approach and beginning to investigate the causal relationship between exports and productivity. [14] Therefore, the basic estimation equation of interest is

$$\begin{aligned} Ln(Prod)_{it} = \beta_0 + \beta_1 Export_{it} + \beta_2 Ln(size)_{it} \\ +\beta_3 Ln(K/L)_{it} + \beta_4 \Phi + \epsilon_{it}, \end{aligned} \tag{4.5}$$

where $Ln(Prod)$ is the natural log of labor productivity and TFP, respectively, of firm i at period t. $Export$ is either a dummy for the firm's export status equal to 1 if the firm is exporting in period t or it measures the firm's export-to-sales ratio in period t. All the specifications include the corporation's turnover $Ln(size)$, the firm's capital-to-sales ratio $Ln(K/L)$, as well as industry, firm, and year dummies as controls (vector Φ) to avoid endogeneity problems owing to time-invariant and time-variant effects. Ignoring these effects, estimations with simple OLS would lead to biased coefficients owing to unobserved heterogeneity in the error term. To detect whether exporting improves productivity or not, the initial specification is modified by lagged values for the export variable estimating its impact on the next period's productivity level and average annual productivity growth rate, respectively (Bernard and Jensen 1999, p.6ff and p.14ff). That is, the main specification 4.5 gives the simple export premium for exporting compared with non-exporting behavior whereas the modification reflects more a causal

[13] See Tables T4.1 and T4.2 in the Appendix comparing OLS and Levinsohn and Petrin (2003) with value added as the dependent variable Y_{it} for Germany and Austria separately.

[14] See Wagner (2007), p.61ff.

relationship from the initial export activity on subsequent productivity levels and growth rates in percentage points, respectively.[15]

Therefore, following Bernard and Jensen (1999, p.14) the impact of the export status in year $t-y$ with a period of y years has the following form:

$$\begin{aligned} \%\Delta(Prod)_{it} &= 1/t\left[Ln(Prod)_{it} - Ln(Prod)_{i,t-y})\right] \\ &= \beta_0 + \beta_1 Export_{i,t-y} + \beta_2 Ln(size)_{i,t-y} \\ &\quad + \beta_3 Ln(K/L)_{i,t-y} + \beta_4 \Phi_{i,t-y} + \epsilon_{it}. \end{aligned} \tag{4.6}$$

Equation 4.6 detects causality running from exporting to productivity by indicating a chronological impact of export behavior on the performance growth rate.[16] Within this specification, the β-coefficient on the export variable explains the annual average growth rate of firm productivity by a change in the initial export status $t-y$.[17]

Furthermore, it is necessary to verify the robustness of the estimated impact of exporting. To address the simultaneity problem between exporting and productivity, the regressions are re-estimated with an instrumental variable approach (IV). For this procedure, exports are instrumented by the peer group's export ratio. A detailed description of this proceeding is given in Section 4.6.[18]

4.4 Descriptive results

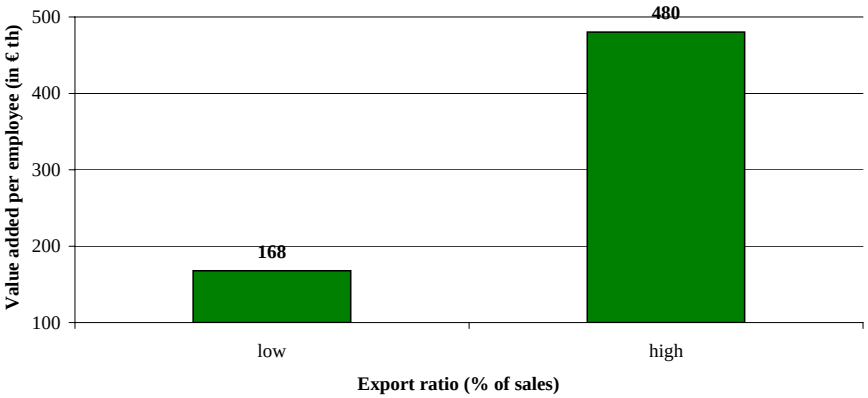
The following section documents a descriptive overview of the underlying data, focusing on the association between exporting and firm-level productivity for Germany and Austria. It illustrates how rising global integration

[15] See Bernard and Jensen (1999), p.14ff.
[16] See Lachenmaier and Wößmann (2006), p.318ff.
[17] See Bernard and Jensen (1999), p.14.
[18] See Section 4.3 for the definition of the peer variable.

and firm performance are linked. The question evolves from the fact that increasing trade openness contributes to German and Austrian firms developing flatter firm hierarchies and a better performance in terms of, amongst others, firm-level productivity (Marin 2008). As a result of the underlying data matching, starting with the Figures F4.1 and F4.2 in the Appendix suggests rather a comovement between the export ratio and TFP. Therefore, both figures again indicate a relationship between those two variables. However, contrary to Figures 4.3 and 4.4 showing labor productivity, plotting exporting and TFP does not present an unambiguous indication of causality running from exporting to productivity.

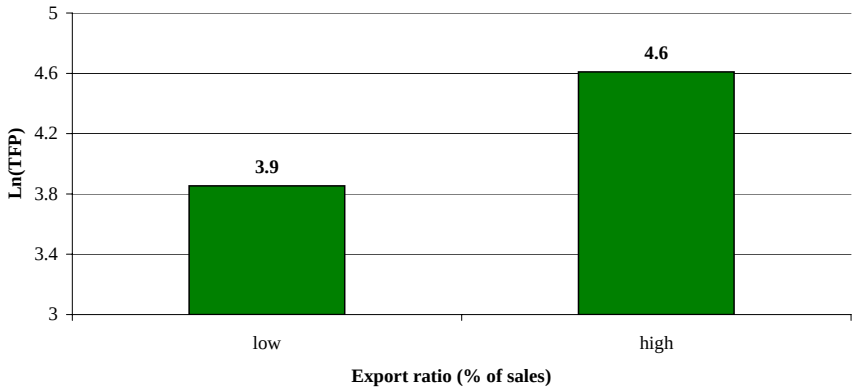
Further evidence of a present relationship is given by Figures 4.5 and 4.6. Both illustrate the association between the export ratio and productivity as a simple average over all firms in both countries from 1994 to 2003. The *export ratio* is split up into *low* and *high* values whereas a low export ratio is defined as a value below or equal to the median's export ratio and, controversially, a high export ratio is on hand when the firm is above the median. The figures show that export-intensive firms have a higher value added per employee ratio (with a multiplier of 2.9) as well as a 1.2 times higher TFP. It seems that those firms outperform low-level exporters. That is, firms with a higher export ratio have a higher productivity level.

This monotonic relationship is also confirmed by the following Figure 4.7. *Export ratio* is grouped into three equal percentiles, namely *low*, *medium*, and *high*. The figures show the average productivity values from 1994 to 2003 over all firms for each country separately. It illustrates that the differences are stronger for Germany than for Austria: in Germany TFP varies on average by 18 percent between all three groups of exporting firms whereas in Austria the average difference between each group (low, medium, and high export ratio) is only round about 3 percent. Both figures suggest that a rise in the



Notes: Productivity is the average of the real value added-to-employees ratio over all parent firms. *Export ratio* is the export-to-sales ratio defined as low (high) when the ratio is equal to or below (above) the median.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

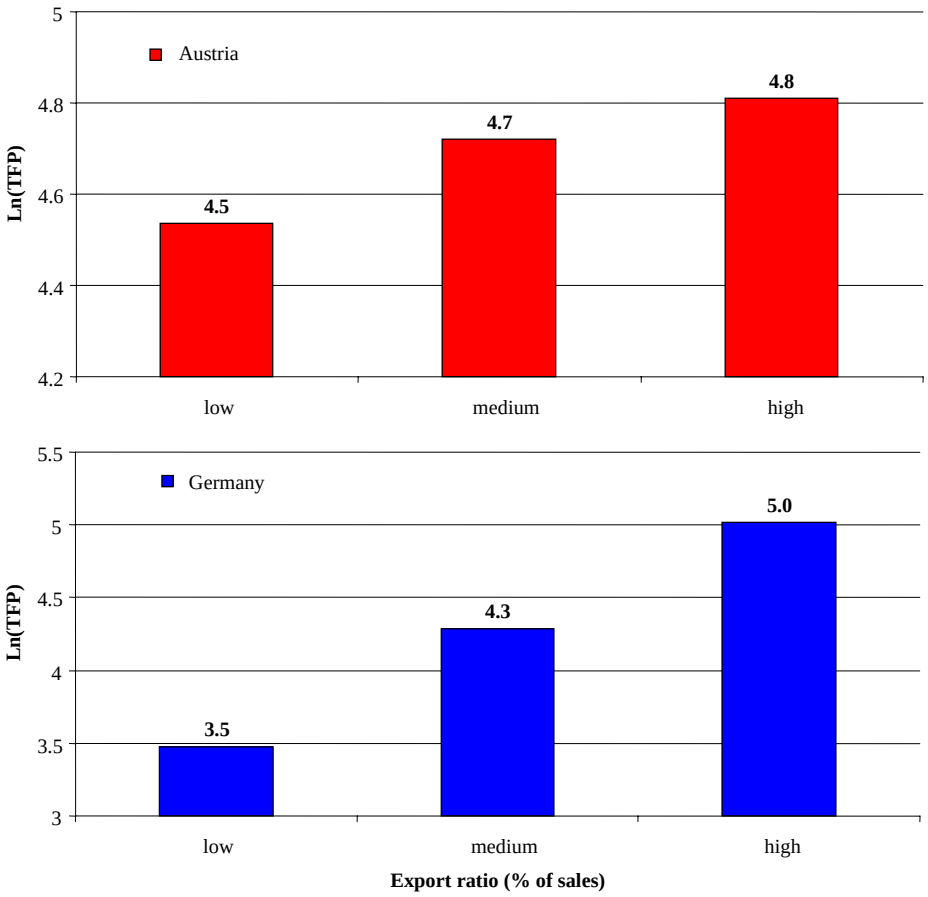
Figure 4.5: Export behavior and labor productivity



Notes: Ln(TFP) is the natural log of the firm's total factor productivity obtained by the Levinsohn and Petrin (2003) technique for each parent firm's sector separately. The dependent variable is the firm's real value added. *Export ratio* is the corporate's export-to-sales ratio defined as low (high) when the ratio is equal to or below (above) the median.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 4.6: Export behavior and TFP

export ratio is associated with an increase in the firm-level TFP.



Notes: Ln(TFP) is the natural log of the Austrian and German firm's total factor productivity obtained by the Levinsohn and Petrin (2003) technique for each parent firm's sector separately. The dependent variable is the Austrian and German firm's real value added, respectively. *Export ratio* is the corporate's export-to-sales ratio defined as low, medium, and high representing three equal-sized percentiles of the export ratio distribution.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 4.7: Export intensity and TFP

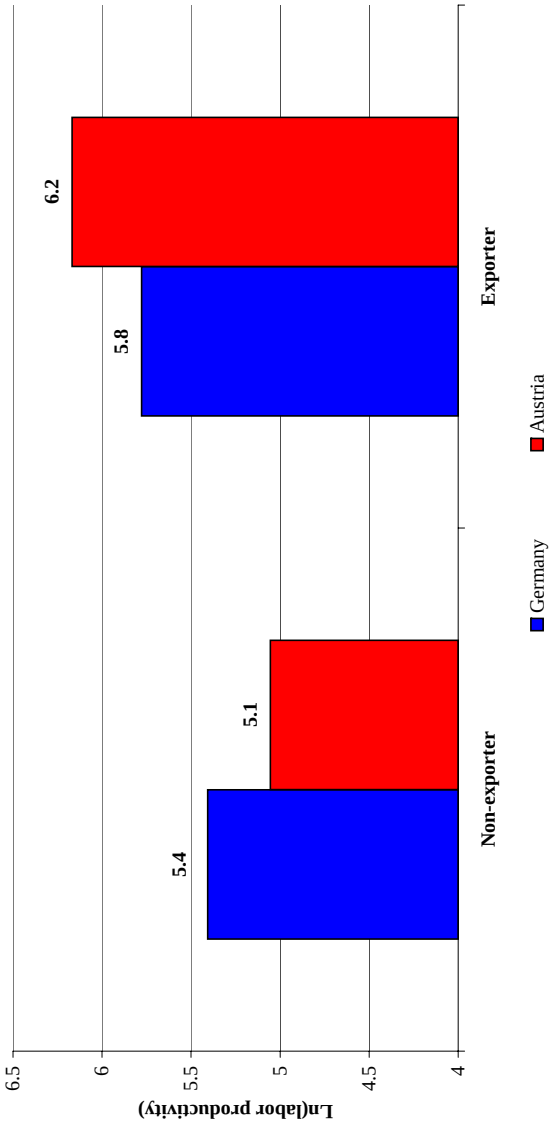
In addition, beside the results on the export ratio, a comparison of exporters versus non-exporters (Figure 4.8) presents exporters as having a higher productivity in both countries, Germany and Austria. Within this consideration, the difference between exporting and non-exporting is larger in Austria than in Germany. It indicates what 4.1 summarizes. The de-

scriptive overview of exporters and non-exporters in both countries within the sample shows that exporting firms are older, have an added value almost twice as high, and are larger in terms of a 6 times greater intangible and 1.5 times greater tangible endowment. Furthermore, exporters show a higher number of employees, a greater capital-to-labor ratio, and revenues that are twice as large. That is, exporters show different characteristics compared with their non-exporting counterparts (Arnold and Hussinger 2005, p.226ff, De Loecker 2007b, p.73). It demonstrates that the results are similar to other (German) studies in the literature suggesting an association between exporting firms and their productivity.

Table 4.1: Summary of firm characteristics

	Non-exporter	Exporter
Age (years)	39	47
Added value (Eur th)	238,182	418,918
Intangibles (Eur th)	810	4,982
Tangibles (Eur th)	152,700	236,655
Employees (number)	2,007	4,824
Capital-to-labor (Eur th)	590	665
Revenue (Eur th)	479,740	939,046

Notes: Mean characteristics of German and Austrian firms in the period from 1994 to 2003. Due to outliers, the upper 2 percent of each considered variable is dropped.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.



Notes: Ln(labor productivity) is the natural log of the firm's revenue-to-employee ratio. The variable exporter is equal to one when a positive export status is observed; otherwise, a firm is a non-exporter when the export status is equal to zero.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure 4.8: Exporting vs. non-exporting and labor productivity

4.5 Empirical results

The descriptive results suggest that exporting firms outperform non-exporting firms. In line with the existing literature, German and Austrian exporters show a higher performance over a wide range of firm characteristics. However, the causality between the interaction of the two variables has to be verified by a clear econometric approach. This leads to the possibility of quantifying the additional impact of exporting on firm-level productivity.

Table 4.2: Export status and productivity

	Explanatory variables				
	Export status	Ln(size) & Ln(K/L)	Fixed effects	R2	Observations
Firm characteristics Ln(X)					
Y/L	0.8042*** *[0.116]*	*yes*	*yes*	0.6	2150
VA/L	0.5483*** *[0.074]*	*yes*	*yes*	0.5	1850
TFP (OLS)	0.4927*** *[0.074]*	*yes*	*yes*	0.2	1805
TFP (Levpet)	0.4889*** *[0.078]*	*yes*	*yes*	0.2	1589

Notes: A constant term as well as year, industry, and firm fixed effects are included throughout all the specifications. Clustered standard errors are in brackets. Each dependent variable is at the plant level i in industry j and year t. Y/L is the parent firm's turnover per employee. VA/L is the firm's value added per employee. TFP is obtained by OLS and Levinsohn and Petrin (2003), respectively, both with real value added as dependent variable. *Export status* is a dummy equal to one if the corporate global foreign sales are greater than zero. Also included throughout all specifications is the parent firm's natural log of turnover, namely $Ln(size)$, the log of the parent firm's capital-to-labor ratio, namely $Ln(K/L)$, and a country dummy distinguishing between Germany and Austria. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 4.2 starts with a fixed effects estimation using the explanatory variable *export status* to predict values of different firm productivity measures. All the specifications include the firm's size and the firm's capital-to-labor ratio as controls. The variables are given for period t. The first two firm

characteristics, Y/L and VA/L,, represent labor productivity. The last two variables show the impact on the firm's total factor productivity obtained by OLS and Levinsohn and Petrin (2003). The results show that all the coefficients are highly statistically significant with a positive sign. In detail, exporters' labor productivity is larger by roughly 0.55 to 0.80 whereas TFP is larger by 0.5 compared with non-exporters. Therefore, the average percentage difference of the productivity level ranges roughly between 60 and 70 percent.[19] This confirms the existence of an export premium, suggesting that exporting firms perform better than their non-exporting counterparts. However, as mentioned in the existing literature, this specification following Equation 4.5 can not be interpreted as a causality running from exports to productivity.[20]

Table 4.3 presents the same set-up for the impact of the corporate's export ratio as a percentage of sales as the explanatory variable on firm characteristics. The outcome is similar to the results in Table 4.2. For all 4 productivity measures, the β-coefficient on *export ratio* is highly significant and positive. It also shows the descending order from labor productivity to TFP. An increase in the *export ratio* by 1 percentage point raises both labor productivity measures Y/L and VA/L by roughly 1.23 percent. The same increase in the export ratio variable boosts TFP obtained by OLS by 1.09 percent and TFP obtained by Levinsohn and Petrin (2003) by 1 percent. Again, those who export more show a better firm performance. Owing to the fact of self-selection, at this point a causal interpretation is not plausible.

To gain further insight into whether exporting improves firm performance, the following regressions focus on a chronological relationship between the two variables. In more detail, Table 4.4 presents the results for a one- and two-period lagged export status as the independent variable on firm perfor-

[19] The differences in the productivity level are calculated by 100(expβ-1). See, amongst others, Wagner (2007), p.62ff.

[20] See, amongst others, Bernard and Jensen (1999), Hahn (2004), and Wagner (2007).

Table 4.3: Export ratio and productivity

	Explanatory variables				
	Export ratio	Ln(size) & Ln(K/L)	Fixed effects	R2	Observations
Firm characteristics Ln(X)					
Y/L	1.2266*** *[0.142]*	*yes*	*yes*	0.6	2115
VA/L	1.2033*** *[0.159]*	*yes*	*yes*	0.5	1840
TFP (OLS)	1.0880*** *[0.152]*	*yes*	*yes*	0.2	1795
TFP (Levpet)	0.9920*** *[0.155]*	*yes*	*yes*	0.2	1583

Notes: A constant term as well as year, industry, and firm fixed effects are included throughout all the specifications. Clustered standard errors are in brackets. Each dependent variable is at the plant level i in industry j and year t. Y/L is the parent firm's turnover per employee. VA/L is the firm's value added per employee. TFP is obtained by OLS and Levinsohn and Petrin (2003), respectively, both with real value added as dependent variable. *Export ratio* is the value of corporate exports as a percentage of sales. Also included throughout all specifications is the parent firm's natural log of turnover, namely $Ln(size)$, the log of the parent firm's capital-to-labor ratio, namely $Ln(K/L)$, and a country dummy distinguishing between Germany and Austria. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

mance. Moreover, it focuses on the most reliable productivity measures, namely VA/L for labor productivity and TFP by Levinsohn and Petrin (2003) as the dependent variables.

This comes from the fact that the present work aims to investigate the learning-by-exporting hypothesis whereas knowledge flow or technology spillovers will primarily show up in TFP (Hahn 2004, p.17). In addition, focusing on VA/L allows the comparison of the results with other studies that analyze only labor productivity due to missing data. Table 4.4 also reports results with the firm's labor endowment as the dependent variable. As Hahn (2004, p.17) argues, employment captures improved resource allocation that can be ascribed to exporting. In a chronological sense, Table 4.4 suggests that exporting improves firm performance. All the β-coefficients on the past export variables are statistically significant. In specifications (1) and (2), the lagged

export variables yield on average a 60 percent higher labor endowment in exporting firms in subsequent periods. Labor productivity as well as total factor productivity are also larger for preceding exporting activities than non-exporting. For instance, the coefficients in specifications (5) and (6) suggest that preceding exports lead to on average a 22 percent higher TFP in period t compared with non-exporting. Contrary to other mentioned studies about exports and firm level productivity, the results suggest that German and Austrian firms gain from exporting: exporters are more productive. Moreover, the productivity gap widens in the following years.[21] That is, after 2 years of exporting, the productivity is around 24 percent higher compared to non-exporting firms.

Taking these results as a basis, Arnold and Hussinger (2005, p.233) test the causal relationship using the Granger causation method. That is, in terms of exports and performance, lagged values of exporting predict TFP significantly better than lagged values of TFP.[22] Using the same underlying method, Table T4.3 in the Appendix reports that TFP in period t is better explained by the lagged export variables with a significance level of 5 percent. On the contrary, lagged values of TFP do not have a statistically significant impact on the export status. This indicates the existence of an impact of exports on productivity.

Bernard and Jensen (1999, p.14) argue that the "cleanest" test for the causality question is given by Equation 4.6. It estimates the impact of the initial exports on the average annual growth rate of productivity. Table 4.5 reports the effects of the current as well as initial exporting behavior on the annual average growth rate of labor productivity and TFP. For labor pro-

[21] See De Loecker (2007b), p.80ff.

[22] See Arnold and Hussinger (2005), p.233. They use a linear model to test the impact of two lags of TFP and exports on TFP and another linear probability model to test the impact of lagged TFP and exports on the current export status. Their results show that firm performance determines export behavior. The reverse Granger causality can be excluded.

Table 4.4: Lagged export status

	Firm characteristics Ln(X)					
	L		VA/L		TFP (Levpet)	
	(1)	(2)	(3)	(4)	(5)	(6)
Export status$_{t-1}$	0.4440***		0.6496***		0.1360*	
	[0.123]		*[0.024]*		*[0.078]*	
Export status$_{t-2}$		0.6447**		0.5759***		0.2428***
		[0.291]		*[0.022]*		*[0.059]*
Ln(size) & Ln(K/L)	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
R2	0.9	0.9	0.7	0.7	0.2	0.2
Observations	2000	1302	1251	1097	1052	932

Notes: A constant term as well as year, industry, and firm fixed effects are included throughout all the specifications. Clustered standard errors are in brackets. Each dependent variable is at the plant level i in industry j and year t. L is the parent's firm number of employees. VA/L is the firm's value added per employee. TFP is obtained by Levinsohn and Petrin (2003) with real value added as dependent variable. *Export status* is a dummy equal to one if the corporate global foreign sales are greater than zero. Also included throughout all specifications is the parent firm's natural log of turnover, namely $Ln(size)$, the log of the parent firm's capital-to-labor ratio, namely $Ln(K/L)$, and a country dummy distinguishing between Germany and Austria. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

ductivity, the β-coefficients on export status are highly significant at the 1 percent level. The annual impact for exporting compared with non-exporting ranges from 0.2 to 0.6 percent. Similarly, in the case of TFP, all the coefficients are statistically significant at least at the 5 percent level. The annual impact of the export status ranges between 0.2 and 1 percent. Owing to the fact that initial exports are statistically significant, it provides further evidence that exports cause performance growth. Exporting leads to higher productivity levels and growth rates. Therefore, German and Austrian exporters gain additional benefits by growing faster than their counterparts.[23] Moreover, these results confirm the findings of a larger productivity gap in the Table before. The annual average growth rate is increasing in the years of exporting.[24] It suggests that continuous export behavior may lead to higher productivity growth compared with non-exporting or an subsequent export start.

Another approach to finding growth differences in productivity is to compare continuous exporters and non-exporting firms (Bernard and Jensen 1999, p.19ff, Wagner 2007, p.62ff). In detail, this method estimates the chronological impact of preceding exports on post-entry productivity growth.[25] Therefore, following Bernard and Jensen (1999), the estimation strategy is given by

$$\begin{aligned} \%\Delta(Prod)_{it} = \beta_0 + \beta_1 Start_{it} + \beta_2 Stop_{it} + \beta_3 Cont_{it} \\ + \beta_4 Ln(size)_{it} + \beta_5 Ln(K/L)_{it} + \beta_6 \Phi_{it} + \epsilon_{it}. \end{aligned} \tag{4.7}$$

$Start_{it}$ is a dummy variable equal to 1 if the firm exports in t but not

[23] The same set of specifications is estimated for the firm's export ratio. The results remain qualitatively unchanged, suggesting annual growth rates between 0.3 and 1 percent. The coefficient of the export ratio in $t-2$ becomes insignificant but close to the 10-percent threshold.

[24] See De Loecker (2007b), p.80ff.

[25] See Wagner (2007), p.63.

Table 4.5: Impact of exports on the average annual growth rate $\%\Delta X$

	VA/L			TFP (Levpet)		
	(1)	(2)	(3)	(4)	(5)	(6)
Export status$_t$	0.4152*** *[0.114]*			0.2697** *[0.136]*		
Export status$_{t-1}$		0.2072*** *[0.049]*			0.1562** *[0.077]*	
Export status$_{t-2}$			0.6068*** *[0.076]*			0.9896*** *[0.118]*
Ln(size) & Ln(K/L)	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
R2	0.4	0.3	0.5	0.3	0.5	0.4
Observations	1227	1173	801	1062	1022	706

Notes: A constant term as well as year, industry, and firm fixed effects is included throughout all the specifications. Clustered standard errors are in brackets. Each dependent variable is the average annual growth rate calculated at firm level i in industry j. In specifications (3) and (6), the annual average growth rate is calculated with a period length of 2 years. VA/L is the firm's value added per employee ratio. TFP is obtained by Levinsohn and Petrin (2003). It is calculated with real value added as dependent variable. *Export status* is equal to one if the firm exports in period t. Also included throughout all specifications is the parent firm's natural log of turnover, namely $Ln(size)$, the log of the parent firm's capital-to-labor ratio, namely $Ln(K/L)$, and a country dummy distinguishing between Germany and Austria. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

in the initial period $t-1$ and $t-2$, respectively. Its coefficient compares export starters with firms that do not export at all. $Stop_{it}$ is a dummy variable equal to 1 if the firm is exporting in $t-1$ $(t-2)$ but not in period t. That is, the β-coefficient subsequent productivity growth of export stoppers with non-exporters. Finally, $Cont_{it}$ is a dummy variable equal to 1 if the firm exports in $t-1$ and t. Contrary to Bernard and Jensen (1999), if the initial period is $t-2$, the $Cont_{it}$-variable equal to 1 means that the firm exports throughout all periods without a break. Therefore, it compares the productivity growth of continuous exporting with non-exporting during the considered period. Again, owing to the fact of a chronological changeover in the firm's export behavior, β_3-coefficient in Equation 4.7 reveals an impact of exporting on firm labor productivity and TFP growth.

Table 4.6 reports the results on annual average growth rates. As expected, the coefficient on the *start* variable is positive and highly significant throughout all the specifications. This suggests that export starters experience an annual increase in their productivity growth rate of roughly 0.7 percent. As expected, negative but mainly insignificant is the β_2-coefficient on the stop measurement. The sign of the coefficient on $Cont$ is positive and, specification (3) excepted, highly significant. It indicates that annual labor productivity grows between 1 and 1.5 percent. The result of the effect on the TFP growth rate in specification (4) is not very satisfying. It reports an increase of 1 percent whereas specification (3) reports a negative and insignificant coefficient. Moreover, these findings confirm an increasing productivity gap between exporters and non-exporters. The earlier a firm started to export and, additionally, if the firm shows continuous export activities, the larger the firms productivity growth rates. However, considering productivity growth the estimates for Germany and Austria show lower coefficients compared with transition economics.[26] This may suggest that

[26] Compare De Loecker (2007b).

productivity in these countries is less driven by international knowledge flow than solely influenced by the possibility to exploit additional economies of scale.[27] To summarize, beside the ambiguous results for continuous exporters on TFP growth rate, there is empirical evidence of increasing labor productivity. Beside that, starting to export is associated with an improving firm performance.

Table 4.6: Starter, stopper, and continuous export activities

	VA/L		TFP (Levpet)	
length of interval (years)	1 years	2 years	1 years	2 years
	(1)	(2)	(3)	(4)
$Start_{it}$	0.7288***	0.7221***	0.6253**	0.7147***
	[0.207]	*[0.086]*	*[0.278]*	*[0.070]*
$Stop_{it}$	-0.574	-0.214	-0.5069*	-0.0984
	[0.496]	*[0.156]*	*[0.287]*	*[0.103]*
$Cont_{it}$	1.5435***	1.0010***	-0.4034	0.5571***
	[0.127]	*[0.049]*	*[0.273]*	*[0.040]*
Ln(size) & Ln(K/L)	*yes*	*yes*	*yes*	*yes*
Fixed effects	*yes*	*yes*	*yes*	*yes*
R2	0.4	0.6	0.3	0.5
Observations	1138	842	995	740

Notes: A constant term as well as year, industry, and firm fixed effects are included throughout all specifications. Clustered standard errors are in brackets. Each dependent variable is the average annual growth rate calculated at firm level i in industry j with a length of T years. VA/L is the firm's value added-per-employee ratio. TFP is obtained by Levinsohn and Petrin (2003). It is calculated with the real value added as dependent variable. *Start* is a dummy equal to one if the firm exports in t but not in $t-1$. *Stop* is a dummy variable equal to one if the firm exports in $t-1$ but not in t. *Continuous* is equal to one if the firm shows exports greater than zero in t and the initial period $t-1$ and $t-2$, respectively. Also included throughout all specifications is the parent firm's natural log of turnover, namely $Ln(size)$, and the log of the parent firm's capital-to-labor ratio $Ln(K/L)$, and a country dummy distinguishing between Germany and Austria. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

[27] See Section 4.1.

4.6 Robustness: 2SLS Estimates

Owing to the simultaneous causality problem between exports and productivity, OLS provides inconsistent results. Beside the lagged value regressions to verify further the chronological and causal impact of exporting on productivity, this section applies an instrumental variable approach. This requires a valid instrument that is correlated to the export variable while at the same time it is uncorrelated with the error term. It has to identify variation in the observation's export activity that is exogenous to the firm's productivity. Therefore, it has to be checked whether the instrumental variable *peer group's export ratio* fulfills the relevance as well as the exogeneity condition.

The employed instrument is defined as the average export-to-sales ratio of the firm's related foreign peer group.[28] Owing to the instrument's relevance, there is a negative correlation between the foreign peer group's export ratio and the firm's export activity. The first-stage results show that the lower the export ratio of the peer group, the higher is the firm's exporting activity. In detail, the first-stage regressions show highly significant coefficients suggesting the instrument's relevance. As a result, the instrument is related to the firm's exports and the first condition is fulfilled. To be reasonably exogenous, the instrument must affect the firm's productivity level only indirectly. In more detail, the firm's individual total factor productivity can be understood not to influence the other countries originated peer group decision to export. That is, foreign export behavior is not directly motivated by German or Austrian labor productivity or TFP. Moreover, owing to the argument of potential spillover effects, a direct impact of the peer group's export behavior on domestic firm-level productivity can be excluded because this effect can be primarily ascribed to domestic exporting peer group members and is in the first instance caused by domestic industries. It circumvents

[28] See Section 4.3 for a detailed description of the peer group variable.

the endogeneity problem of reverse causation running from productivity to exporting.

Table 4.7 presents the results for the 2SLS estimates, instrumenting exports by the peer group variable. The table illustrates the results for labor productivity, TFP obtained by OLS, and TFP calculated with Levinsohn and Petrin (2003). It suggests that the export status as well as the export ratio have a positive and significant impact on productivity. The β-coefficients on *export status* slightly increase from 0.27 to 0.3 and 0.28 using TFP calculations by OLS and Levinsohn and Petrin (2003), respectively.

This confirms the findings presented previously in the tables: exporting firms are roughly 30 percent more productive than their non-exporting counterparts. In addition, an increase in the *export ratio* by 1 percentage point raises labor productivity by 1.7 percent, TFP (OLS) by 1.6 percent, and TFP using Levinsohn and Petrin (2003) by 1.5 percent. Also, the coefficients on the control variables *size* and K/L show the expected positive and statistically significant signs. Therefore, they indicate a causal relationship of exports on firm productivity. To summarize, if the exogeneity of the instrument is accepted, the results confirm the findings of additional productivity gains by German and Austrian exporting activities compared with their non-exporting counterparts.

Beside the peer group instrumental approach, I have also used the annual change of global export tariffs as an instrument, expecting an increase in tariff rates to have a negative impact on exporting. In addition, the dependent variable is changed from the level into the growth rate variable. The results are quite similar to the annual growth rate estimations, confirming a causality running from exports to performance. In the case of labor productivity, the annual growth rate is roughly 0.4 percent and in the case of TFP the average annual growth rate is approximately 1.4 percent. However, in spite of the good results, one has to accept the instrument's exogeneity. This is debatable

Table 4.7: IV results by the peer groups' export ratio

Dependent variable	Ln(Productivity)					
	Exports, instrumented by the peer groups' export ratio					
	IV VA/L	IV VA/L	IV TFP OLS	IV TFP OLS	IV TFP LP	IV TFP LP
	(1)	(2)	(3)	(4)	(5)	(6)
Export status	0.2695***		0.3038**		0.2844*	
	[0.053]		*[0.145]*		*[0.162]*	
Export ratio		1.6951**		1.6063**		1.5371*
		[0.717]		*[0.766]*		*[0.891]*
Ln(size)	0.6333***	0.5807***	0.5580***	0.5856***	0.6743***	0.6931***
	[0.080]	*[0.072]*	*[0.105]*	*[0.104]*	*[0.095]*	*[0.132]*
Ln(K/L)	0.9035***	0.8870***	0.4906***	0.4797***	0.6157***	0.5975***
	[0.043]	*[0.046]*	*[0.070]*	*[0.073]*	*[0.071]*	*[0.084]*
Fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Test of predictive power of instrument	*p-value=0.000*		*p-value=0.000*		*p-value=0.000*	
R2	0.9	0.9	0.9	0.9	0.9	0.9
Observations	975	954	932	922	765	759

Notes: 2SLS estimations with a constant term as well as year, industry, and firm fixed effects are included throughout all specifications. Clustered standard errors are in brackets. The dependent variable is firm's productivity calculated as value added per labor and total factor productivity at firm level i in industry j in year t, respectively. *Export status* is a dummy equal to one if the parent firm exports in period t. *Export ratio* is the total amount of exports as a percentage of parent sales. $Ln(size)$ is the natural log of the firm's turnover. $Ln(K/L)$ is the firms capital-to-labor ratio. Throughout all the specifications, a country dummy is included distinguishing between Germany and Austria. Alternative specifications also include the subsidiaries' total asset endowment and the parent firms' cost of employees without any substantial change for the coefficients on exports. The first stage results are significant at the 1 percent level. *, **, *** indicate significance at the 10, 5, and 1 percent level, respectively.

because of an (indirect) impact of tariffs on productivity.[29]

4.7 Conclusion

This chapter is a contribution to the huge amount of empirical studies on the relationship between exports and firm performance. Following the approach by Bernard and Jensen (1999), it studies the relationship between German and Austrian export activities and the related firm-level productivity. Therefore, the underlying analysis tries to say that an interdependency of the considered variables exists in both directions: more productive firms self-select themselves into the export market as well as exports raising firm performance. In more detail, the chapter shows, on the one hand, that exporters are more productive and, on the other hand, the extent to which exporting behavior leads to a rise in productivity levels and growth rates. The empirical results of a unique data matching suggest that exporters compared with non-exporters are more productive by roughly 40 percent. Moreover, exporting yields an additional annual average productivity growth rate by roughly 1 percent compared with non-exporting. These results are robust to different productivity measurements, estimation specifications, and regression techniques like an instrumental variable approach. Contrary to German findings by e.g. Arnold and Hussinger (2005) and Wagner (2002), firms benefit from exporting. Moreover, contrary to the annual productivity gains of exporting firms in transition economies like Slovenia (De Loecker 2007), my results for Germany and Austria indicate significant but lower productivity growth rates. It implies that the learning-by-exporting hypothesis in terms of new knowledge might be even more true when exporting of firms in less developed countries is analyzed. In the case of Germany and Austria the results indicate that exporters rather experience a productivity boost owing

[29] For instance, see Amiti and Konings (2007) and Chapter 2 of this thesis.

to economies of scale and further investment incentives than through gaining additional technical knowledge.

Appendix to Chapter 4

Tables and Figures

Table T4.1: Production function estimates: German industries

Dependent variable: *real added value* $_{it}$				
	OLS		Levpet	
industry	capital	employees	capital	employees
14: Other mining and quarrying	0.242	0.766	0.591	0.201
15: Manufacturing - food products and beverages	0.281	0.709	0.275	0.608
17: Manufacturing - textiles	0.158	0.709	0.49	0.588
20: Manufacturing - wood and products of wood	0.095	0.931	0.056	0.591
21: Manufacturing - pulp, paper and paper products	0.232	0.72	0.469	0.41
22: Publishing, printing, reproduction of rec. media	0.182	0.734	0.179	0.701
24: Manufacturing - chemicals and chemical products	0.114	0.886	0.028	0.607
25: Manufacturing - rubber and plastic products	0.321	0.554	0.069	0.542
26: Manufacturing - non-metallic mineral products	0.248	0.625	0.281	0.596
27: Manufacturing - basic metals	0.27	0.685	0.342	0.527
28: Manufacturing - fabricated metal products	0.212	0.71	0.1	0.534
29: Manufacturing - machinery and equipment n.e.c.	0.161	0.776	0.382	0.695
31: Manufacturing - electrical machinery	0.151	0.815	0.402	0.685
32: Manufacturing - radio, television, communication	0.4	0.6	0.257	0.706
33: Manufacturing - medical, precision, optical instruments	0.204	0.758	0.065	0.733
34: Manufacturing - motor vehicles, trailers, semi-trailers	0.286	0.668	0.381	0.648
35: Manufacturing - transport equipment	0.188	0.745	0.404	0.593
36: Manufacturing - furniture, n.e.c.	0.182	0.753	0.242	0.751
40: Electricity, gas and water supply	0.308	0.571	0.395	0.367
45: Construction	0.223	0.733	0.186	0.738
50: Sale, repair of motor vehicles and motorcycles	0.256	0.633	0.28	0.43
51: Wholesale trade and commission trade	0.155	0.672	0.165	0.669
52: Retail trade	0.201	0.731	0.068	0.705
60: Land transport, transport via pipelines	0.423	0.395	0.311	0.585
62: Air transport	0.09	0.973	0.444	0.011
64: Post and telecommunications	0.186	0.818	0.387	0.921
67: Activities auxiliary to financial intermediation	0.267	0.369	0.587	0.192
72: Computer and related activities	0.23	0.744	0.196	0.784
74: Other business activities	0.23	0.424	0.135	0.608
90: Sewage and refuse disposal	0.175	0.54	0.004	0.6

Notes: The dependent variable is the firm's real added value at plant level i in industry j and year t. All the variables are given in natural logs. A constant term as well as year dummies are included throughout all the specifications. The coefficients for each industry are obtained from simple OLS estimations and Levinsohn and Petrin (2003) estimations, respectively. The calculations run at a two-digit ISIC industry level.
Source: Amadeus (Bureau van Dijk 2005). Author's calculations.

Table T4.2: Production function estimates: Austrian industries

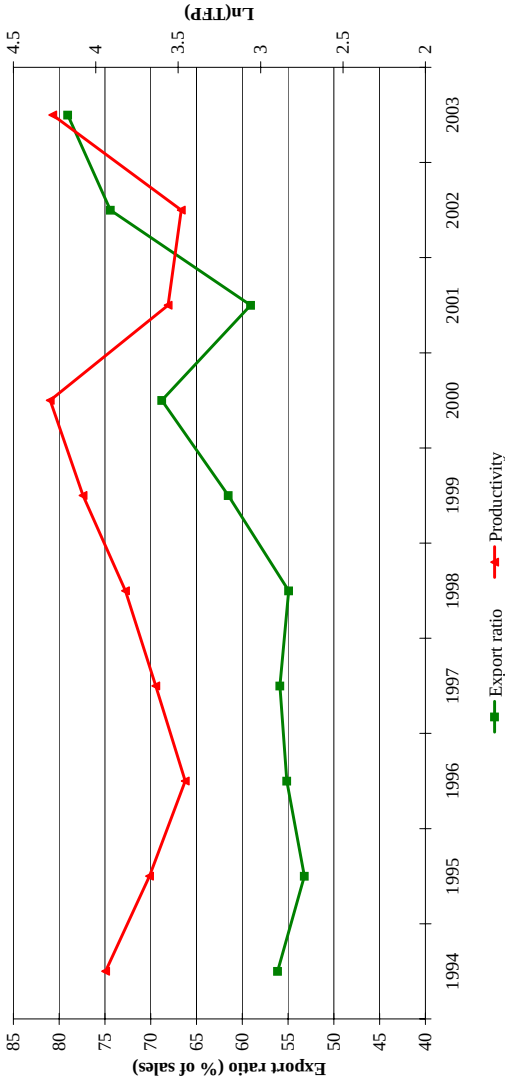
Dependent variable: *real added value* $_{it}$				
	OLS		Levpet	
industry	capital	employees	capital	employees
15: Manufacturing - food products and beverages	0.438	0.638	0.215	0.702
17: Manufacturing - textiles	0.093	0.924	0.619	0.691
20: Manufacturing - wood and products of wood	0.01	0.393	0.456	0.609
26: Manufacturing - non-metallic mineral products	0.152	0.864	0.559	0.654
27: Manufacturing - basic metals	0.333	0.647	0.711	0.631
28: Manufacturing - fabricated metal products	0.116	0.903	0.51	0.724
29: Manufacturing - machinery and equipment n.e.c.	0.049	0.893	0.376	0.813
32: Manufacturing - radio, television, communication	0.236	0.665	0.585	0.809
36: Manufacturing - furniture, n.e.c.	0.19	0.864	0.657	0.322
40: Electricity, gas and water supply	0.688	0.268	0.49	0.597
45: Construction	0.26	0.699	0.206	0.502
50: Sale, repair of motor vehicles and motorcycles	0.26	0.614	0.419	0.36
51: Wholesale trade and commission trade	0.179	0.671	0.423	0.113
52: Retail trade	0.15	0.806	0.309	0.886
60: Land transport, transport via pipelines	0.181	0.921	0.398	0.663
63: Supporting and auxiliary transport activities	0.146	0.797	0.607	0.028
67: Activities auxiliary to financial intermediation	0.442	0.27	0.502	0.123
74: Other business activities	0.165	0.476	0.504	0.425

Notes: The dependent variable is the firm's real added value at plant level i in industry j and year t. All the variables are given in natural logs. A constant term as well as year dummies are included throughout all the specifications. The coefficients for each industry are obtained from simple OLS estimations and Levinsohn and Petrin (2003) estimations, respectively. The calculations run at a two-digit ISIC industry level.
Source: Amadeus (Bureau van Dijk 2005). Author's calculations.

Table T4.3: Granger causality

Dependent variable	F-statistic	
TFP_t (Levpet)	Export status$_{t-1}$ = 0, Export status$_{t-2}$ = 0	F(2,547)=2.96 Prob>F=0.05
Export status$_t$	TFP_{t-1} = 0, TFP_{t-2} = 0	F(2,596)=1.2 Prob>F=0.3

Notes: A constant term as well as year, industry, and firm fixed effects are included throughout all the specifications. Robust errors are in brackets. Each dependent variable is at the plant level i in industry j and current year t. TFP is obtained by Levinsohn and Petrin (2003) with real value added as dependent variable. *Export status* is a dummy equal to one if corporate global foreign sales are greater than zero. Beside that, also included throughout all specifications is the parent firm's natural log of turnover $Ln(size)$ as well as the log of the parent firm's capital-to-labor ratio $Ln(K/L)$, and a country dummy distinguishing between Germany and Austria. The F-statistic tests the joint significance of the lagged values of exports and productivity, respectively.



Notes: TFP is obtained by Levinsohn and Petrin (2003) with real value added as dependent variable.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure F4.1: Austrian export ratio and TFP (1994 - 2003)

Notes: TFP is obtained by Levinsohn and Petrin (2003) with real value added as dependent variable.
Sources: Hoppenstedt (Hoppenstedt 2009), Thomson ONE Banker (Thomson Reuters 2009), Amadeus (Bureau van Dijk 2005), and Chair for International Economics, University of Munich. Author's calculations.

Figure F4.2: German export ratio and TFP (1994 - 2003)

Chapter 5

Concluding Remarks

This thesis focused on the relationship between innovation, trade liberalization and firm performance. The analysis concentrated especially on German and Austrian firms investing in Eastern Europe. I found that trade liberalization with Eastern Europe and the ongoing process in eastern enlargement has a decisive influence on the firm's decision about the international organization and the corporation's performance.

Chapter 2 studied the impact of innovation on the organizational structure. Following Acemoglu et al. (2004) the theoretical framework predicts that a larger parental pool of knowledge raises the probability of offshoring. I identified that this holds true in a national as well as an international context. However, when the producer loses territorial protection, the changeover from non-integration to integration is delayed along with an increasing pool of innovations. That is, the decision to outsource holds *longer*. Employing data for 2005 on German firms investing in Eastern Europe, the empirical study gives evidence for the theoretical predictions. Besides my findings about the impact of the firm productivity and the outside option of the firm on the organizational structure, which are in line with other prominent literature, the results indicate the existence of a gap between outsourcing and

offshoring comparing home and abroad in favor of a *longer* decision for an arm's-length relationship. Therefore, the results indicate that an increasing pool of innovations encourages international outsourcing.

Chapter 3 dealed with the impact of trade liberalization on German and Austrian firm productivity. In more detail, I considered different types of tariff cuts analyzing the preceding periods of the eastern enlargement. Unique matching of data from 1994 to 2003 suggests that tariff reductions raise parent firm productivity significantly. A ten percentage point decrease in tariff rates can lead to total factor productivity gains of up to 2 percent. The data allow distinction between three types of tariffs: output, intra-firm and input tariff rates. The size of the results strongly depends on the type of tariff and country analyzed. That is, the empirical study suggests that for different productivity measures input tariff rates show the largest effects, followed by intra-firm and output tariff rates. The impact of a ten percentage point tariff cut ranges between 0.3 and 2 percent. The effect for Austria is larger than for Germany. The results also suggest that trade liberalization makes offshoring cheaper and this in turn increases productivity. The chapter contributes in this way that it is the only study using data from Germany, Austria and the firm's corresponding Eastern European affiliates. Moreover, it is the only one which explores tariffs on intra-firm imports and distinguishes between intra-firm tariffs and tariffs on intermediate inputs.

Chapter 4 shifted the perspective from imports to exports. It considered the relationship between export activities and firm-level productivity. Unique matching of German and Austrian micro data from 1994 to 2003 suggests that exporters are more productive by around 40 percent compared with non-exporters. Moreover, besides other analysis techniques, instrumental variable estimations suggest that exporting causes a rise in firm-level productivity. The estimation methodology started with following the approach by Bernard and Jensen (1999). I found that exporting yields an additional annual average

productivity growth rate by roughly 1 percent compared with non-exporting firms. It allows the conclusion that, against other findings of existing studies, both directions hold: more productive firms self-select themselves into export markets and being active in foreign markets boosts firm-level productivity. Summarizing, the chapter showed, on the one hand, that exporters are more productive and, on the other hand, the extent to which exporting behavior leads to a rise in productivity levels and growth rates. Moreover, my findings presented that the impact of exporting on productivity growth is smaller for German and Austrian firms compared to transition economics. It suggests that exporters rather experience a productivity boost owing to economies of scale and investment incentives than through additional knowledge.

Bibliography

Abraham, K.G., and Taylor, S.K. (1996). "Firm's Use of Outside Contractors: Theory and Evidence", *Journal of Labor Economics*, 14(3), pp. 394-424.

Acemoglu, D., Aghion, P. and Zilibotti, F. (2002). "Vertical Integration and Distance to Frontier", *National Bureau of Economic Research, NBER Working Paper,* No. 9191.

Acemoglu, D., Aghion, P., Griffith, R. and Zilibotti, F. (2004). "Vertical Integration and Technology: Theory and Evidence", *National Bureau of Economic Research, NBER Working Paper,* No. 10997.

Acemoglu, D. and Zilibotti, F. (2001). "Productivity Differences", *Quarterly Journal of Economics,* 116(2), pp. 563-606.

Ackerberg, D., Caves, K. and Frazer, G. (2005). "Structural Identification of Production Functions", *Working paper,* Dec. 2006 submitted to *Econometrica.*

Aghion, P. and Griffith, R. (2005). "Competition and Growth: Reconciling Theory and Evidence", MIT Press, Cambridge MA.

Aghion, P. and Tirole, J. (1997). "Formal and Real Authority in Organizations", *Journal of Political Economy,* 105(1), pp. 1-29.

Altomonte, C. and Bekes, G. (2008). "Trading Activities, Firms and Productivity", *Bocconi University and Hungarian Academy of Science,* mimeo, October.

Alvarez, R. and Crespi, G. (2007). "Multinational Firms and Productivity Catching-Up: The Case of Chilean Manufacturing", *Central Bank of Chile, Working Paper,* No. 429.

Amemiya, T. (1981). "Qualitative Response Models: A Survey", *Journal of Economic Literature,* 19(4), pp. 1483-1536.

Bibliography

Amiti, M. and Konings, J. (2007). "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia", *American Economic Review,* 97(5), pp. 1611-1638.

Antras, P. (2003). "Firms, Contracts, and Trade Structure", *Quarterly Journal of Economics,* 118(4), pp. 1375-1418.

Antras, P. and Helpman, E. (2004). "Global Sourcing", *Journal of Political Economy,* 112(3), pp. 552-580.

Arnold, J.M. and Hussinger, K. (2005). "Export Behavior and Firm Productivity in German Manufacturing: A Firm-Level Analysis", *Review of World Economics, Weltwirtschaftliches Archiv,* 141(2), pp. 219-243.

Arora, A. and Fosfuri, A. (1998). "Licensing in the Chemical Industry", Conference paper, Intellectual Property and Industry Competitive Standards, Stanford University.

Atallah, G. (2002). "Production Technology, Information Technology, and Vertical Integration under Asymmetric Information", *CIRANO, Working Paper,* No. 2002s-32.

Austrian National Bank (OeNB) (2008). "Erzeugerpreis (Producer prices)", http://www.oenb.at [April, 21st, 2009].

Aw, B.Y, Chung, S., and Roberts, M.J. (1998). "Productivity and the Decision to Export: Micro Evidence from Taiwan and South Korea", *National Bureau of Economic Research, NBER Working Paper,* No. 6558.

Baddeley, M.C. and Barrowclough, D.V. (2009). "Running Regressions - A Practical Guide to Quantitative Research in Economics, Finance and Development Studies", *Cambridge University Press,* New York.

Balakrishnan, S. and Wernerfelt, B. (1986). "Technical Change, Competition and Vertical Integration", *Strategic Management Journal,* 7(4), pp. 347-359.

Bibliography

Baldwin, J.R. and Gu, W. (2003). "Export-Market Participation and Productivity Performance in Canadian Manufacturing", *The Canadian Journal of Economics,* 36(3), pp. 634-657.

Bartel, A., Lach, S. and Sicherman, N. (2005). "Outsourcing and Technological Change", *National Bureau of Economic Research, NBER Working Paper,* No. 11158.

Baye, M.R. (2006). "Managerial Economics and Business Strategy", The McGraw Hill Companies (5th edition), New York.

Becker, W. and Dietz, J. (2002). "Innovation Effects of R&D Cooperation in the German Manufacturing Industry", *University of Augsburg, Institute for Economics, Discussion Paper Series,* No. 222.

Belenzon, S. and Berkovitz, T. (2007). "Innovation in Business Groups", *University of Oxford, Economic Series Working Papers,* No. 368.

Bernard, A.B. and Jensen, J.B. (1999). "Exceptional Exporter Performance: Cause, Effect, or Both?", *Journal of International Economics,* 47(1), pp. 1-25.

Bernard, A.B. and Jensen, J.B. (2004). "Entry, Expansion and Intensity in the U.S. Export Boom, 1987-1992", *Review of International Economics,* 12(4), pp. 662-675.

Bernard, A.B., Jensen, J.B., and Schott, P.K. (2006). "Trade Costs, Firms and Productivity", *Journal of Monetary Economics,* 53(5), pp. 917-937.

Bernard, A.B. and Wagner, J. (1997). "Exports and Success in German Manufacturing", *Review of World Economics, Weltwirtschaftliches Archiv,* 133(1), pp. 134-157.

Bernard, A.B. and Wagner, J. (2001). "Export Entry and Exit by German Firms", *Review of World Economics, Weltwirtschaftliches Archiv,* 137(1), pp. 105-123.

Blau, J.R. and McKinley, W. (1979). "Ideas, Complexity and Innovation", *Administrative Science Quarterly,* 24(2), pp. 200-219.

Bibliography

Blind, K., Edler, J., Fritsch, R. and Schmoch, U. (2003). "Erfindung kontra Patente", *Schwerpunktstudie zur technologischen Leistungsfähigkeit Deutschlands* Frauenhofer-Institut für Systemtechnik und Innovationsforschung, Kalsruhe.

Blomström M. and F. Sjöholm (1999). "Technology, Transfer and Spillovers: Does Local Participation With Multinationals Matter?", *European Economic Review,* 43(4-6), pp. 915-923.

Branstetter, L., Fisman, R. and Foley, C.F. (2005). "Do Stronger Intellectual Propery Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm Level Data", *National Bureau of Economic Research, NBER Working Paper,* No. 11516.

Brusoni, S., Prencipe, A. and Pavitt, K. (2001). "Knowledge Specialization, Organizational Coupling, and the Boundaries of the Firm: Why Do Firms Know More than They Make?", *Administrative Science Quarterly,* 46(4), pp. 597-621.

Bureau van Dijk, Electronic Publishing (2005). "Amadeus database", http://www.bvdep.com/de/Amadeus.html [April, 21st, 2009]. Frankfurt am Main.

Camron, C.A. and Trivedi, P.K. (2005). "Microeconometrics - Methods and Applications", *Cambridge University Press,* New York.

Castellani, D., Serti, F. and Tomais, C. (2008). "Firms in International Trade: Importers and Exporters Heterogeneity in the Italian Manufacturing Industry", *The World Economy,* forthcoming.

Clerides, S., Lach, S., and Tybout, J. (1998). "Is Learning by Exporting Important? Micro-dynamic evidence from Columbia, Mexico and Morocco", *Quarterly Journal of Economics,* 113(3), pp. 903-948.

Commission of the European Communities (1991). "Four Motors for Europe: An Analysis of Cross-regional Cooperation,", *FOP241,* DG XII, Vol 17.

Bibliography

Crepon, B., Duguet, E. and Mairesse, J. (1998). "Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level", *National Bureau of Economic Research, NBER Working Paper,* No. 6696.

Damanpour, F. (1991). "Organizational Innovation: A Meta-Analysis of Effects of Determinants and Moderators", *Academy of Management Journal,* 34(3), pp. 555-590.

De Loecker, J. (2007a). "Product Differentiation, Multi-Product Firms and Estimating the Impact of Trade Liberalization on Productivity", *National Bureau of Economic Research, NBER Working Paper,* No. 13155.

De Loecker, J. (2007b). "Do Exports Generate Higher Productivity? Evidence from Slovenia", *Journal of International Economics,* 73(1), pp. 48-68.

Dixit, A.K. and Stiglitz, J.E. (1977). "Monopolistic Competition and Optimum Product Diversity", *American Economic Review,* 67(3), pp. 297-308.

Drazin, R. and Schoonhoven, C.B. (1996). "Community, Population, and Organization Effects on Innovation: A Multilevel Perspective", *Academy of Mangament Journal,* 39(5), pp. 1065-1083.

Economist, The (2008). "Beyond Doha", *The Economist,* print edition, October 11th, 2008.

Empey, W.F. (1988). "Contracting Out of Services by Manufacturing Industries", *Institute for Research and Public Policy, IRPP,* Montreal, Quebec.

European Patent Office (EPO) (2007a). "The Economic Importance of Patents" http://www.epo.org/topics/innovation-and-economy/economic-impact.html [May, 13th, 2009].

European Patent Office (EPO) (2007b). "Patents are the future", http://www.epo.org/focus/news/2007/070419.html [May, 13th, 2009].

Fattore, V. (1997). "Importance and Significance of Patents", *Catalysis Today,* 34, Chapter 8, pp. 379-392.

Bibliography

Federal Ministry of Economics and Technology (2007). "Shaping Europe's Economic Future", Bundesministerium für Wirtschaft und Tewchnologie (BMWi).

Federal Ministry of Education and Research (2006). "Igniting Ideas! The High-Tech Strategy for Germany", Bundesministerium für Bildung und Forschung (BMBF).

Feenstra, R.C., Markusen, J.R., and Zeile, W. (1992). "Accounting for Growth with New Inputs: Theory and Evidence", *American Economic Review,* 82(2), pp. 415-421.

Fernandes, A.M. (2007). "Trade Policy, Trade Volumes and Plant-Level Productivity in Colombian Manufacturing Industries", *Journal of International Economics,* 71(1), pp. 52-71.

Fryges, H. and Wagner, J. (2008). "Exports and Productivity Growth: First Evidence from a Continuous Treatment Approach", *Review of World Economics, Weltwirtschaftliches Archiv,* 144(4), pp. 695-722.

German Federal Statistical Office (2008a). "Engagement deutscher Unternehmen im Ausland", *Destatis, STATmagazin,* April 2008, available at http://www.destatis.de [April, 21st, 2009].

German Federal Statistical Office (2008b). "Verlagerung wirtschaftlicher Aktivitäten - Erste Ergebnisse", *Destatis,* Berichtsjahr 2006, Wiesbaden.

German Federal Statistical Office (2008c). "Erzeugerpreisindizes (Producer prices)", http://www.destatis.de [April, 21st, 2009].

German Patent and Trade Mark Office (GPTO) (2006). "Annual Reports 2002-2006 (Jahresberichte)", http://presse.dpma.de/presseservice/publikationen/jahresberichte/index.html [April, 21st, 2009].

Bibliography

German Patent and Trade Mark Office (GPTO) (2008a). "Patente - Eine Informationsbroschüre zum Patent", http://presse.dpma.de/docs/pdf/broschueren/1/patente_dt.pdf [April, 21st, 2009].

German Patent and Trade Mark Office (GPTO) (2008b). "Deutsches Patent und Markenamt", http://www.dpma.de/index.htm [April, 21st, 2009].

German Patent and Trade Mark Office (GPTO) (2008c). "DEPATISnet", . http://depatisnet.dpma.de/DepatisNet/ [April, 21st, 2009]

Glass, A.J. and Saggi, K. (2001). "Innovation and Wage Effects of International Outsourcing", *European Economic Review,* 45(1), pp. 67-86.

Görg, H., Hanley, A., and Strobl, E. (2008). "Productivity effects of International Outsourcing: Evidence from Plant Level data", *Canadian Journal of Economics,* 41(2), pp. 670-688.

Goldberg, P.K., Khandelwal, A., Pavcnik, N., and Topalova, P. (2008). "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India", *National Bureau of Economic Research, NBER Working Paper,* No. 14416.

Greenaway, D. and Kneller, R. (2007). "Firm Heterogeneity, Exporting and Foreign Direct Investment", *The Economic Journal,.* 117(February), pp. F134-F160

Greenhalgh, C. and Rogers, M. (2007). "The Value of Intellectual Property Rights to Firms and Society", *Oxford Review of Economic Policy,* 23(4), pp. 541-567.

Greeve, H.R. (2003). "A Behavioral Theory of R&D Expenditures and Innovations: Evidence from Shipbuilding", *Academy of Management Journal,* 46(6), pp. 685-702.

Griliches, Z. (1990). "Patent Statistics as Economic Indicators: A Survey.", *Journal of Economic Literature,* 28(4), pp. 1661-1707.

Griliches, Z. (1992). "The Search for R&D Spillovers", *Scandinavian Journal of Economics,* 94 supplement, pp. S29-S47.

Bibliography

Grossman, S. and Hart, O. (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration", *Journal of Political Economy,* 94(4), pp. 691-719.

Grossman, G. and Helpman, E. (2002). "Integration versus Outsourcing in Industry Equilibrium", *Quarterly Journal of Economics,* 117(1), pp. 85-120.

Grossman, G. and Helpman, E. (1991). "Innovation and Growth in the Global Economy", *MIT Press,* Cambridge, Mass.

Grossman, G. and Helpman, E. (2003). "Outsourcing versus FDI in Industry Equlibrium", *Journal of the European Economic Association,* 1(2-3), pp. 317-327.

Grossman, G. and Helpman, E. (2004). "Managerial Incentives and the International Organization of Production", *Journal of International Economics,* 63(2), pp. 237-262.

Hagemejer, J. and Kolasa, M. (2008). "Internationalization and Economic Performance of Enterprises: Evidence from Firm-Level Data", *Munich Personal RePEc Archive, MPRA Paper,* No. 8720, unpublished.

Hahn, C.H. (2004). "Exporting and Performance of Plants: Evidence from Korean Manufacturing", *National Bureau of Economic Research, NBER Working Paper,* No. 10208.

Hall, B.H. and Ziedonis, R.H. (2001). "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995", *RAND Journal of Economics,* 32(1), pp. 101-128.

Halpern, L., Koren, M., and Szeidl, A. (2005). "Imports and Productivity", *Centre for Economic Policy Research, CEPR Discussion Paper,* No. 5139.

Harrigan, K.R.(1984). "Formulating Vertical Integration Strategies", *Academy of Management Review,* 9(4), pp. 638-652.

Harrigan, K.R.(1985). "Vertical Integration and Corporate Strategy", *Academy of Management Journal,* 28(2), pp. 397-425.

Bibliography

Harrison, A. (1994). "Productivity, Imperfect Competition and Trade Reform: Theory and Evidence", *Journal of International Economics,* 36(1-2), pp. 53-73.

Hart, O. and Moore, J. (1990). "Property Rights and the Nature of the Firm", *Journal of Political Economy,* 98(6), pp. 1119-1158.

Head, K. and Ries, J. (1999). "Rationalization Effects of Tariff Reductions", *Journal of International Economics,* 47(2), pp. 295-320.

Holmes, T.J. and Schmitz, J.A. (2001). "A Gain from Trade: From Unproductive to Productive Entrepreneurship", *Journal of Monetary Economics,* 47(2), pp. 417-446.

Hoppenstedt (2009). "Hoppenstedt firm database", http://www.firmendatenbank.de [August, 28th, 2009]. Darmstadt.

Jaffe, A.B. and Lerner, J. (2004). "Innovation and its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do about It", *Princton University Press,* New Jersey.

Kasahara, H. and Lapham, B. (2008). "Productivity and the Decision to Import and Export: Theory and Evidence", *CESifo, Working Paper Series,* No. 2240. CESifo GmbH.

Kasahara, H. and Rodrigue, J. (2008). "Does the Use of Imported Intermediates Increase Productivity? Plant-Level Evidence", *Journal of Development Economics,* 87(1), pp. 106-118.

Knight, K.E. (1967). "A Descriptive Model of the Intra-Firm Innovation Process", *Journal of Business,* 40(4), pp. 478-496.

Krishna, P. and Mitra, D. (1998). "Trade Liberalization, Market Discipline and Productivity Growth: New Evidence from India", *Journal of Development Economics,* 56(2), pp. 447-462.

Bibliography

Kunst, R.M. and Marin, D. (1989). "On Exports and Productivity: A Causal Analysis", *The Review of Economics and Statistics,* 71(4), pp. 699-703.

Lachenmaier, S. and Wössmann, L. (2006). "Does Innovation Cause Exports? Evidence from Exogenous Innovation Impulses and Obstacles using German Micro Data", *Oxford Economic Papers,* 58(2), pp. 317-350.

Levin, R.C. (1988). "Appropriability, R&D Spending, and Technological Performance", *American Economic Review,* 78(2), pp. 424-428.

Levinsohn, J. and Petrin, A. (2003). "Estimating Production Functions Using Inputs to Control for Unobservables", *Review of Economic Studies,* 70(2), pp. 317-341.

Louri, H., Loufir, R. and Papanastassiou, M. (2002). "Foreign Investment and Ownership Structure: An Empirical Analysis", *Empirica,* 29(1), pp. 31-45

Luong, T.A. (2008). "The Impact of Input and Output Tariffs on Firms' Productivity: Theory and Evidence", Princeton University, Working Paper.

Marchick, D.M. and Slaughter, M.J. (2008). "Global FDI Policy - Correcting a Protectionist Drift", *The Bernard and Irene Schwartz Series on American Competitiveness*, Council on Foreign Relations, CSR No. 34.

Marin, D. (1992). "Is the Export-Led Growth Hypothesis Valid for Industrialized Countries?", *The Review of Economics and Statistics,* 74(4), pp. 678-688.

Marin, D. (2004). "A Nation of Poets and Thinkers: Less so with Eastern Enlargement? Austria and Germany", *Centre for Economic Policy Research, CEPR Discussion Paper,* No. 4358.

Marin, D. (2006). "A New International Division of Labor in Europe: Outsourcing and Offshoring to Eastern Europe", *Journal of the European Economic Association,* April-May 2-3(4), pp. 612-622.

Bibliography

Marin, D. (2008). "The New Corporation in Europe", *Bruegel Policy Brief,* Issue 2008/07, Bruegel.

Marin, D., Lorentowicz, A. and Raubold, A. (2003). "Ownership, Capital or Outsourcing: What Drives German Investment to Eastern Europe?", *in: Hermann, Heinz and Robert Lipsey (eds), "'Foreign Direct Investment in the Real and Financial Sector in Industrial Countries"',* Springer Verlag, Berlin.

Marin, D. and Verdier, T. (2008). "The Corporate Hierarchies and the Size of Nations: Theory and Evidence", *Centre for Economic Policy Research, CEPR Discussion Paper,* No. 6734.

Maskell, P., Pedersen, T., Petersen, B. and Dick-Nielsen, J. (2005). "Learning Paths to Offshore Outsourcing - From Cost Reduction to Knowledge Seeking", *Danish Research Unit for Industrial Dynamics,* Working Paper, No. 05-17.

Mattoo, A. and Subramanian, A. (2008). "Multilateralism beyond Doha", *Peterson Institute for International Economics,* Working Paper Series, WP 08-8.

Mayer, T. and Ottaviano, G. (2007a). "The Happy Few: New Facts on the Internationalisation of European Firms", *Centre for Economic Policy Research,* Policy Insight, No. 15.

Mayer, T. and Ottaviano, G. (2007b). "The Happy Few: The Internationalisation of European Firms. New facts based on firm-level evidence", *Bruegel Blueprint Series,* Volume 3.

McLaren, J. (2000). "Globalization and Vertical Structure", *American Economic Review,* 90(5), pp. 1239-1254.

Melitz, M.J. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", *Econometrica,* 71(6), pp. 1695-1725.

Merges, R.P. (1997). "Patent Law and Policy: Cases and Materials", *The Michie Company (2nd edition),* Charlottesville, Va.

Mol, M.J. (2005). "Does being R&D Intensive still Discourage Outsourcing? Evidence from Dutch Manufacturing", *Research Policy,* 34(4), pp. 571-582. Brussels.

Mol, M.J., Pauwels, P., Matthyssens, P. and Quintens, L. (2004). "A Technological Contingency Perspective on the Depth and Scope of International Outsourcing", *Journal of International Management,* 10(2), pp. 287-305.

Monteverde, K. (1995). "Technical Dialog as an Incentive for Vertical Integration in the Semiconductor Industry", *Management Science,* 41(10), pp. 1624-1638.

Mugele, C. and Schnitzer, M. (2006). "Organization of Multinational Activities and Ownership Structure", *University of Munich, Discussion Paper,* 2006-23.

Muendler, M. (2004). "Trade, Technology, and Productivity: A Study of Brazilian Manufacturers, 1986-1998", *CESifo, Working Paper Series,* No. 1148. CESifo GmbH.

Muuls, M. and Pisu, M. (2007). "Imports and Exports at the Level of the Firm: Evidence from Belgium", *GEP, Research Paper Series,* No. 2007/28.

Nunn, N. and Trefler, D. (2007). "The Boundaries of the Multinational Firm: An Empirical Analysis", *in: E. Helpman, D. Marin, T. Verdier (Eds.), The Organization of Firms in a Global Economy,* Harvard University Press, 2008.

Olley, G.S. and Pakes, A. (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica,* 64(4), pp. 1263-1297.

Organisation for Economic Co-operation and Development (OECD) (2005). "Oslo Manual - Guidlines for Collecting and Interpreting Innovation Data", *The Measurement of Scientific and Technological Activities,* OECD Publishing (3rd edition), Paris.

Pakes, A. (1996). "Dynamic Structural Models, Problems and Prospects: Mixed Continuous Discrete Controls and Market Interaction ", *in: C. Sims (ed.) Advances in Econometrics,* Sixth World Congress, Vol. II (Cambridge University Press) pp. 171-259.

Pavcnik, N. (2002). "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants", *The Review of Economic Studies,* 69(1), pp. 245-276.

Pro Inno Europe (European Commission) (2008). "European Innovation Scoreboard 2007 - Comparativ Analysis of Innovation Performance", *Directorate-General for Enterprise and Industry,* PRO INNO Europe paper, No. 6.

Quinn, J.B. (2000.) "Outsourcing innovation: The New Engine of Growth", *Sloan Management Review,* 41(4), pp. 13-29.

Rasmussen, B. (2004). "Innovation and Industry Structure in the Biomedical Industry: Some Preliminary Results", *Victoria University of Technology, Pharmaceutical Industry Project Working Paper Series,* Working Paper, No. 17. Cambridge.

Roberts, M.J. and Tybout, J.R. (1997). "The Decision to Export in Colombia: An Emoirical Model of Entry with Sunk Costs", *American Economic Review,* 87(4), pp. 545-564.

Schor, A. (2004). "Heterogeneous Productivity Response to Tariff Reduction. Evidence from Brazilian Manufacturing Firms", *Journal of Developments Economics,* 75(2), pp. 373-396.

Sjöholm, F. (1999). "Exports, Imports and Productivity: Results from Indonesian Establishment Data", *World Development,* 27(4), pp. 705-715.

Stifterverband für die Deutsche Wissenschaft (2004). "FuE-Datenreport 03/04", *in: Wissenschaftsstatistik GmbH (Hrsg.), Forschung und Entwicklung in der Wirtschaft, Bericht über die FuE-Erhebung 2001 und 2002,* Essen.

Stigler, G.J. (1951). "The Division of Labor is Limited by the Extent of the Market", *Journal of Political Economy,* 59(3), pp. 185-193.

Teece, D.J. (1986). "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy", *Research Policy,* 15, pp. 285-305.

Temouri, Y., Driffield, N.L., and Higon, D.A. (2008). "Analysis of Productivity Differences among Foreign and Domestic Firms: Evidence from Germany", *Review of World Economics,* 144(1), pp. 32-54.

Thompson, V.A. (1965). "Bureaucracy and Innovation", *Administrative Science Quarterly,* 10(1), pp. 1-20.

Thomson Reuters (2009). "Thomson ONE Banker", http://banker.thomsonib.com [August, 28th, 2009]

Tomiura, E. (2007). "Foreign Outsourcing, Exporting, and FDI: A Productivity Comparison at the Firm Level", *Journal of International Economics,* 72(1), pp. 113-127.

Topalova, P. (2004). "Trade Liberalization and Firm Productivity: The Case of India", *International Monetary Fund, Working Paper,* 04/28.

Trefler, D. (2004). "The Long and Short of the Canada-U.S. Free Trade Agreement", *American Economic Review,* 94(4), pp. 870-895.

Tybout, J.R. and Westbrook M.D. (1995). "Trade Liberalization and the Dimension of Efficiency Change in Mexican Manufacturing Industries", *Journal of International Economics,* 39(1-2), pp. 53-78.

Vogel, A. and Wagner, J. (2008). "Higher Productivity in Importing German Manufacturing Firms: Self-Selection, Learning from Importing, or Both?", *IZA, Discussion Paper Series,* No. 3854.

Wagner, J. (2002). "The Causal Effects of Exports on Firm Size and Labor Productivity: First Evidence from a Matching Approach", *Economic Letters,* 77(2), pp. 287-292.

Wagner, J. (2007). "Exports and Productivity: A Survey of the Evidence from Firm Level Data", *The World Economy,* 30(1), pp. 60-82.

Bibliography

Wagner, J. (2008). "Exports, Imports and Productivity at the Firm Level. An International Perspective: Introduction by Guest Editor", *Review of World Economics, Weltwirtschaftliches Archiv,* 144(4), pp. 591-594.

Williamson, O. (1975). "Markets and Hierarchies: Analysis and Antitrust Implications", , Free Press, New York.

Williamson, O. (1985). "The Economic Institutions of Capitalism", Free Press, New York.

Wooldridge, J.M. (2005). "On Estimating Firm-Level Production Functions Using Proxy Variables to Control for Unobservables", *Department of Economics, Working Paper,* Michigan State University, Mimeo.

World Bank and United Nations Conference on Trade and Development (UNCTAD) (2008). "World Integrated Trade Solution (WITS)", http://wits.worldbank.org/witsweb [April, 21st, 2009].

World Intellectual Property Organization (WIPO) (2006). "WIPO Patentreport 2006 - Statistics on Worldwide Patent Activities", http://www.wipo.int/ipstats/en/statistics/patents [May, 13th, 2008].

World Intellectual Property Organization (WIPO) (2008). "World Patent Report 2008: A Statistical Review" and "Download Data", Report availability and download data at http://www.wipo.int/ipstats/en/statistics/patents/index.html [September, 9th, 2009].

Yasar, M., Raciborski, R., and Poi, B. (2008). "Production Function Estimation in Stata Using the Olley and Pakes Method", *The Stata Journal,* 8(2), pp. 221-231.

Zhang, J., Baden-Fuller, C., Mangematin, V. and Nesta, L. (2005). "How Technological Knowledge Base Influence Collaborative Activities: Evidence from the Biotechnology Industry", *EBK, Evolution of Business Knowledge, Working Paper*, 2005/21.

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