Incomplete Contracts, Financial Frictions and Trade -

Firms and Consumers in a Global Economy

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Chapter 1

Introduction and Summary

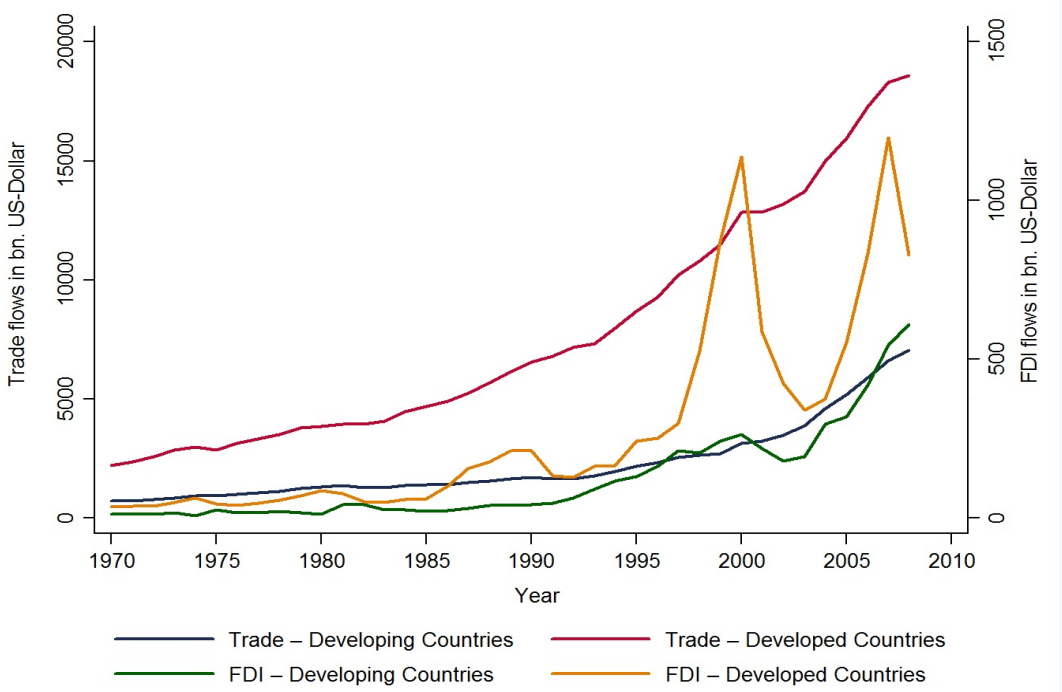
The economic integration of world economies over recent decades has led to a spectacular transformation of the global economy. Several historical events have contributed to this dynamic integration process. First, fast-growing emerging markets, with China and other East Asian economies at the forefront have implemented economic reforms, opened up their markets and integrated into the world economy. Second, the creation of institutions such as the single market program, and the introduction of the Euro has further deepened the economic integration in the European Union. Third, after the fall of the Iron Curtain and the transition from planned to market economies, many Eastern European countries have reoriented towards the European Union, resulting in the Eastern European Enlargement in 2004. Finally, the removal of protectionist measures and the development of new technologies have led to a strong reduction in transport and communication costs (Krugman (1995), Feenstra (1998)).

As a consequence of these events trade and Foreign Direct Investment (FDI) flows have increased dramatically over recent decades as shown in Figure 1.1. In the period from 1970 to 2008, total world trade flows increased from 2,922 billion USD to 25,619 billion USD with an annual average growth rate of 6%.[1] By comparison, world GDP at the same time grew with an annual rate of 3% only and increased from 12,163 billion USD to 40,575 billion USD (World Bank

[1] World trade flows are measured as the sum of imports and exports of all worldwide trading countries. Source: World Bank (2010).

(2010)).

Figure 1.1: Worldwide Trade and FDI flows from 1970-2008



Notes: The graph summarizes worldwide trade and FDI flows in developing and developed countries for the period from 1970 to 2008 and are in 2005 constant USD. Trade is measured as the sum of exports and imports between all countries. FDI is the sum of total inward FDI in the reporting economy. Developed countries are all high-income countries and developing countries are all middle- and low-income countries according to the definition of the World Bank (2010). Trade data stem from the World Development Indicators (2010). FDI flows are from the UNCTAD Handbook of Statistics (2010).

Consequently, the share of world trade to world GDP increased from 24% in 1970 to 64% in 2008. Although the trade flows of developed and developing economies have increased strongly, the share of total world trade of developing economies has increased from 23% to 27%, emphasizing the growing importance of these countries in the "new" global economy.[2] Even more striking is the development of FDI flows over recent decades.[3] In 1970, total FDI flows amounted to 48 billion USD only, with 35 billion USD in developed and 13 billion USD in

[2]Developed countries are all high-income countries and developing countries are all middle- and low-income countries according to the definition of the World Bank (2010).

[3]FDI flows are measured as the sum of total inward FDI flows in the reporting economy. Source: UNCTAD Handbook of Statistics 2010.

developing countries. Since then, FDI flows in both country groups have exploded with an average annual growth rate exceeding 12%, reaching its highest level in 2007 with more than 1,700 billion USD. Again, FDI flows have increased strongly in both country groups and by 2008 FDI in developing economies amounted to 611 billion USD and in developed countries sum up to 827 billion USD respectively.

These numbers highlight the dramatic change in the world economy and the tremendous impact of globalization on firms and consumers around the world. Firms were faced with new production opportunities and thereby they had to reorganize their business models. On the one hand, the integration of low-wage countries allowed firms to relocate their production processes by slicing up the value chain across different locations around the world (Helpman (1984), Helpman and Krugman (1987)). On the other hand, the ongoing integration and availability of new technologies allowed firms to serve consumers in foreign markets not only via exporting, but also by setting up new production plants for final goods production in the destination market (Brainard (1993), Helpman et al. (2004)). At the same time, globalization has increased competition among firms, and developing and designing new innovative products today is a key ingredient to survive in the "new" global market. As a consequence, firms around the world have substantially increased their R&D efforts in order to become a technology leaders in their markets (Grossman and Helpman (1993), Bloom et al. (2011)). The surge in trade flows has also had a strong effect on consumers by reducing product prices, because of competition and the integration of low-wage economies, and by increasing the number of available products and product varieties. Consequently, consumers today can choose from a larger and cheaper set of products compared with the situation a few decades ago (Feenstra (1994), Broda and Weinstein (2006)).

This change in the global economy gives rise to numerous interesting and important questions on the effects of globalization on firms and consumers. In this thesis I provide three empirical essays, which deliver new insights into and provide answers on the questions how institutions and trade affect consumers and firms acting in a global economy, thereby helping to further improve our understanding of the "new" global economy. In chapter 2 I address the question how the availability of newly imported products, in the course of the ongoing glob-

alization and European Integration process over the last decade, has positively affected consumer welfare, and show which countries have benefited most from access to new products. Chapter 3 analyzes how financial conditions affect the decision of multinational firms whether to serve foreign markets via exporting or by setting up an affiliate in the destination market and how this shapes the composition of export and FDI sales in an industry. Finally, chapter 4 studies the effect of contracting institutions on R&D investments and shows how improvements in the contracting environment in a country promote R&D investments and thereby improve the innovative capacity of a country?

Chapter 2 is based on the observation that as a consequence of the ongoing European Economic Integration process, trade flows within the European Union, but also trade with non-European Union member states, have more than doubled over the past decade.[4] Because of the establishments of new trade linkages, this process has raised the number of newly imported products by more than 18%, indicating high gains for consumers.

In this chapter, we empirically test one of the fundamental prediction of the "New Trade Theory" first outlined by Krugman (1979, 1980) and analyze to what extent the increased availability of newly imported products has positively affected consumer welfare in the 27 European Union member states for the period from 1999 to 2008. To test this channel we build on the influential work of Feenstra (1994) and Broda and Weinstein (2006). In this framework, increasing the share of newly available products increases consumer welfare, while reducing available products generates consumer losses. We use a rich dataset of highly disaggregated trade data at the eight-digit level of the Combined Nomenclature product classification, which allows us to identify more than 8,000 different product categories to structurally estimate the gains from imported variety.

Our results show that nearly all countries within the European Union have gained significantly from the increase in newly imported products. However, our results differ across countries and we find that the gains from variety are relatively low for large and advanced economies, modest for small, developed economies and high for the "new" member states of the European Union. For example, our

[4]This chapter was co-written by Lukas Mohler from the University of Basel.

results suggest that gains from newly imported products in Latvia exceed more than 3.0% of GDP for our considered period. When we decompose our results according to the region of origin, we find that on average 70% of the gains stem from intra-EU trade, highlighting the importance of the European Integration process regarding trade flows and imported product variety and their positive effect on consumer welfare.

In chapter 3, I study the impact of financial conditions on multinational firm activity. This study is motivated by recent developments in exports and FDI flows during the financial crises and prior findings in the literature that financial conditions have sizeable effects on multinational firm activity. The question I address in this analysis is to what extent financial conditions affect the composition of export and FDI sales of multinational firms.

To answer this question, I develop a theoretical multi-country, multi-sector model of international trade, where I integrate financial constraints into a model of multinational firms developed by Brainard (1993) and Helpman et al. (2004). In this model, firms can choose to serve foreign markets via exporting or FDI, but need to raise external capital to finance their multinational activities. These additional financing costs are higher for FDI than they are for exporting, given the higher amount of credit required and the higher risks associated with FDI. In addition, the ability of firms to raise external capital varies across industries, and firms operating in financially vulnerable industries find it more difficult to obtain external financing. As a result, the model predicts that firms operating in financially vulnerable sectors more often choose to serve foreign markets via exports instead of FDI given their limited ability to raise external capital for more finance-intensive FDI strategies.

Based on the theoretical model, I develop an empirical strategy to test the main predictions of the model. I construct a dataset for German firms that covers 26 manufacturing industries and 38 countries for the period 2002 to 2007 using detailed information from the Midi (Microdatabase Direct Investment) database and firm-level data from the AMADEUS database. I find evidence in the data that financial frictions have a sizeable economic effect on the composition of export and FDI sales. My estimates suggest that industries that are 10% less dependent on external finance on average have a 3% to 5% lower ratio of exports to

FDI sales. This result suggests that aside from traditional explanations from the proximity-concentration literature, financial frictions are of similar importance for the composition of multinational firm activity.

Finally, chapter 4 empirically analyzes how differences in institutions across countries affect the compositions and levels of R&D investments. This chapter is motivated by two empirical observations. First, we know from prior literature that good institutions have an overall positive effect on economic development. Second, we know that most of the differences in economic development stem from differences in productivity and technical progress and that R&D investments play a key role in the development of new technologies and innovations. Aside from these observations, there is little empirical evidence about the underlying specific channels generating these economic outcomes. In this chapter I fill this gap by empirically analyzing the link between the quality of contracting institutions and R&D investments at the country-industry level and provide new evidence about how good institutions promote R&D investments.

To test this hypothesis, I develop an econometric framework that is based on the insights of the incomplete contracts literature. In this type of models a final goods producer and an input supplier agree to invest in R&D to develop and design a new product or new technology. However, because of the relationship-specificity of the R&D investments and existence of incomplete contracts, there is a classical hold-up problem resulting in under-investments. This effect of under-investment will be even more pronounced in industries that produce complex goods and therefore have a higher need of individually customized input goods and rely more on good contracting institutions compared with other industries producing more simple products. Since good contracting institutions in a country can mitigate the potential negative effects resulting from the hold-up problem, countries with good contracting institutions will have higher R&D investments and this effect is higher, especially in those industries that rely more heavily on a good contracting environment.

I develop a generalized difference-in-difference model to test this prediction for a set of 29 OECD countries in 22 manufacturing industries for the period from 1996 to 2006. I find strong support in the data that contracting institutions have a positive, highly significant and sizeable economic effect on the compositions and

levels of R&D investments. For example, if Korea were to improve its contracting institutions to the level of Sweden, my estimates suggest that R&D investments in the highly contract-intensive industry "Motor vehicles, trailers and semi-trailers" would increase from 1.95 billion USD to 2.67 billion USD. These results show that the institutional environment in a country is a major determinant of R&D investments and thereby supports the technological progress of a country.

Each of the three chapters analyzes different aspects that have and will continue to shape the ongoing globalization process. The results of this thesis deliver fresh insights into the "new" global economy and help economists and policymakers further improve their understanding of the effects of their decisions on firms and consumers acting in the "new" global economy.

Chapter 2

The Gains from Variety in the European Union

2.1 Introduction

The European Union (EU) with its 27 member states today constitutes the largest single market in the world. Over the past decade, several historical events have deepened the economic integration of economies within Europe but also of EU member states into the world economy. First, the euro was introduced as book money in 1999 and today is the official currency of 17 EU member states. Second, the transition of the Eastern European economies from planned economies to market economies after the fall of the Iron Curtain was accompanied by a surge and redirection of trade flows towards the "old" member states as well as a strong increase of trade between Eastern European countries themselves. This transition led to the eastern enlargement in 2004, when ten new member states joined the EU, followed by Romania and Bulgaria in 2007. Finally, the EU and its member states were confronted with the integration of fast-growing emerging markets into the world trading system over the last decade, with China and other East Asian economies at the forefront.

These dynamic processes of economic integration were paralleled by a strong increase in trade flows for most member states. From 1999 to 2008 the total value of imports for all EU countries combined has more than doubled. This surge in trade flows was accompanied by an increase in the number of imported product varieties available to consumers. The establishment of new trade linkages (new goods and new trading partners) raised this number of imported varieties by 18%, a value that suggests large gains for consumers as a result of newly available products.

In this contribution, we adopt the methodology of Feenstra (1994) and Broda and Weinstein (2006) to structurally estimate the gains from imported variety for all 27 EU member states for the period from 1999 to 2008. We explore a rich dataset of highly disaggregated trade data at the 8-digit level of the Combined Nomenclature product classification (CN). The effects on consumer welfare of newly available products are particularly interesting with regard to EU economies, since the EU consists of several small and medium-sized economies with a high degree of political and economic integration within the EU as well as within the world economy. In addition, studying a variety of countries allows us to analyze

and interpret results across different economies, adding another dimension to this approach.

Our results can be summarized as follows. For most countries the gains from variety are positive. However, the results largely differ across member states. We identify three different groups of economies. First, for the largest four members of the EU (in terms of GDP), the impact of imported variety is only slightly above zero or even negative for the considered period. This can be explained by small import shares and the fact that these economies were already well integrated within the EU and the world economy in 1999. Secondly, for the smaller "old" member states, we find modestly positive gains, all below 1% of GDP. Finally, for the "new" member states of the EU, with the exception of Malta, the gains from variety are strongly positive, mostly larger than 1% of GDP. For example, variety gains in Latvia amount to 3.0% of GDP, which is of the same magnitude as Broda and Weinstein (2006) find for the United States when examining the longer period from 1972 to 2001. Our results imply that especially for fast-growing, less-developed and smaller countries, the establishment of new trade linkages are an important source of trade-based welfare gains. When we split up the gains regarding regions of origin, we find that for a typical country about 70% of the gains stem from intra-EU trade, indicating the importance of the European integration process regarding trade flows and imported variety.

Our paper mainly contributes to two strands of the empirical trade literature. First, we add to the literature on the "love for variety" motive, a key element of the "New Trade Theory" laid out in the theoretical models of Krugman (1979, 1980, 1981). Contributions on this subject include, for example, Feenstra (1992) who shows in a numerical example how trade barriers can affect the number of available products and reduce consumer welfare. Following this idea, Romer (1994) calibrates a model with fixed export costs and finds that a substantial reduction in trade barriers will lead to more exported varieties, resulting in an increase of GDP of up to 20%. The first extensive empirical analysis of the variety gains from trade was done by Broda and Weinstein (2006). These authors extend the methodology developed by Feenstra (1994) to construct an artificial price index that measures the impact of traded varieties on consumer welfare. Using highly disaggregated trade data and the assumption that goods are differentiated across countries, they

show that the growth in product variety has been an important source of welfare gains. Covering U.S. import data from 1972 to 2001, their results suggest an upward bias in the conventional price index of the magnitude of 1.2% per year, which translates into an overall effect of 2.6% of GDP for the overall period. Put differently, consumers are willing to pay roughly 0.1% of their annual income to gains access to a larger set of goods and varieties. Similarly, and based on previous work by Klenow and Rodríguez-Clare (1997), Arkolakis et al. (2008) analyze how trade liberalization in Costa Rica has affected product variety and consumer welfare. They find, however, that the welfare increase after trade liberalization via an extended product variety set is very limited, since new products are imported in small quantities.[1,2] In summary, some empirical evidence on the variety gains from trade exists; it is, however, restricted to very few country analyses. With our contribution, we add results for 27 countries to this literature.

Second, while the European integration process has attracted substantial interest in the literature, the analysis of EU trade flows, and in particular of their positive effects on consumer welfare, has been scarce. In the European trade literature three prominent lines can be identified. First, several studies have tried to quantify the positive effect of the introduction of the euro on trade: see Baldwin (2006) for a survey. Second, researchers have studied the effect of European integration and the role of national borders on intra-EU trade flows, including Nitsch (2000) and Chen (2004). Finally, Buch and Piazolo (2001) and Manchin and Pinna (2009) study the implications of the Eastern European enlargement in 2004 on growth and the redirection of trade flows towards the EU. All these studies rely on aggregated trade data. A notable exception is Funke and Ruhwedel (2005) who provide an empirical analysis of disaggregated trade data on export variety and economic growth in Eastern European countries and find a high correlation between increased imported variety and economic growth.[3] However, none of the papers in this literature covers the potential effect of variety changes on consumer

[1] For a more microeconomic perspective on the effects of new varieties on consumer, gains see Hausman (1981), Hausman (1994), and Trajtenberg (1989).

[2] For a theoretical explanation of the increase in traded varieties, also see Yi (2003), Melitz (2003), and Bernard et al. (2003).

[3] Other contributions investigate this relationship in an non-EU context, as for example Feenstra and Markusen (1994), Broda et al. (2006), and Feenstra and Kee (2008).

welfare. This is at the heart of our contribution.

The rest of the paper is organized as follows. In Section 2, we describe the dataset and provide detailed descriptive statistics on the number of imported varieties for all the member states. Section 3 briefly reviews the methodology developed by Feenstra (1994) and Broda and Weinstein (2006) to account for variety changes in import price indices, and Section 4 presents the results for the 27 members of the EU. Also, several robustness checks are carried out. Section 5 concludes.

2.2 Data and Descriptive Statistics

For our analysis, we use highly disaggregated trade data from Eurostat (2010) . Approximately 10,000 product categories at the CN-8 level for the period from 1999 to 2008 are defined in this dataset.[4] We use quarterly data from the first quarter of 1999 to the first quarter of 2008 to rule out potential seasonality effects. For each member state, we collect information on the value and quantity of all imported products from all worldwide trading partners. The complete dataset consists of more than 5 million observations.

2.2.1 Aggregate European Union Import Flows and Variety

We first present statistics on import flows at the aggregate EU level and for different country subgroups: Given the diverse structure of the EU economies and their differences in terms of size (GDP), growth rate, import value and share, as well as accession date, EU members were affected differently by the integration process. We identify three different types of countries in the EU. First, the "large old" economies including Germany, Italy, France and the United Kingdom with the largest GDP in the EU, in sum accounting for over 60% of total EU GDP in 2008; second, the eleven "small old" high-income member states that had joined the EU by 1995; and third, the twelve fast-growing, less-developed "new" mem-

[4]Table 2.7 in Appendix B provides some detailed information on the the product categories defined in the Eurostat data.

ber states, mostly from Eastern Europe, which joined the EU in 2004 and 2007, respectively. These definitions are applied throughout our analysis.

From the first row in columns (1) and (2) of Table 2.1, we can infer that aggregate nominal import values of the EU member states from worldwide trading partners have more than doubled from 487 billion euros in the first quarter of 1999 to 979 billion euros in the first quarter of 2008. Since one focus of our study is to analyze trade flows *within* the EU, we split up total imports into imports from other EU countries (internal imports) and imports from the rest of the world (ROW, external imports) in rows two and three. We observe that trade within the EU accounts for more than 60% of all imports. Both internal and external trade flows have grown at rapid rates and roughly doubled in this period. This strong increase in imports was accompanied by another effect, a strong increase in the number of imported varieties. In our analysis, a good is defined as a CN-8 product category. Following Armington (1969), a variety is then assumed to be a particular good imported from a particular country. Based on this definition, we find a strong increase from 1.678 million to 1.970 million imported varieties during the last decade (columns (1) and (2) of row four). About two-thirds of imported varieties stem from EU internal imports (rows five and six). Given the relatively small number of potential trading partners for a single product within the EU, this is a large share and highlights the importance of intra-EU trade as a source of new product varieties for consumers.[5]

In columns (3) to (8), we decompose the import flows according to our defined country blocks. The "large four" economies account for nearly half of all imports. Despite the strong growth in import value, the total number of imported varieties increased modestly by 8% from roughly 457,000 to 497,000, indicating that imports have grown at the intensive margin.[6] While 65% of total imports stem from the EU-27 member states, they account for 58% of imported varieties in 1999. Both shares slightly decrease over time, emphasizing the growing im-

[5]Our dataset includes 189 countries. Hence, each member state is faced with 26 potential internal trading partners in each product category and with 162 external ones.

[6]Growth at the intensive margins of trade is defined as an increase in value of existing varieties. This is in line with the findings of Besedes and Prusa (2007) for high-income countries. Growth at the extensive margin is defined as an increase in the number of varieties.

Table 2.1: Aggregate Imports for each EU Subgroup, 1999-2008

	"All-27"		"Large four"		"Small old"		"New"	
	99	08	99	08	99	08	99	08
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Value of imports in mil. EUR								
World	487	979	277	485	179	372	31	122
EU-27	328	624	181	300	124	236	23	89
ROW	159	354	96	185	55	136	8	33
Number of imported varieties in th.								
World	1,678	1,970	457	497	663	796	559	678
EU-27	1,078	1,274	265	281	446	505	367	488
ROW	600	697	192	216	217	291	192	189

Notes: Values in millions of euros. Number of varieties in thousands. A variety is defined as a particular good, defined according to the CN-8 classification, imported from a particular country. All variables are calculated by aggregating each individual variable for each of our defined subgroups for the first quarter in 1999 and the first quarter in 2008.

portance of trade with non-EU member states over the last decade. We obtain a similar picture for the "small old" member states, although internal EU-27 imports are even more important on average for these economies. In contrast to the "large four", imports have also substantially grown along the extensive margin. This increase in variety is, to a large extent, due to trade with non-EU members. In this category, the number of imported varieties has grown substantially from about 217,000 to 291,000. Finally, for the "new" member states, we obtain a somewhat different picture. First, trade with other European member states is of central importance for this group of countries and amounts to 70% of total imports. Second, although the nominal import value from both EU and non-EU members in 2008 was roughly four times larger than in 1999, the fact that the number of varieties imported from other EU members has grown by nearly 50% (from approximately 367,000 to 488,000), while the number of varieties from the rest of the world has

been slightly decreasing (from about 192,000 to 189,000), is striking.[7]

2.2.2 Imported Variety of the European Union Member States

We now focus on country data to provide a more detailed picture of the evolution of the imported variety set for each single member state. Given our assumption that products are differentiated across countries, there are two potential sources for new varieties. First, an entirely new good's category can be imported, and second, the number of supplying countries within an already imported category can increase. Table 2.2 tabulates the number of imported goods (columns (1) and (2)) and the average number of trading partners (columns (3) and (4)) that supply these goods for all 27 EU members. Larger and high-income countries tend to import a larger set of goods from a more diverse set of countries.[8]

From columns (1) and (2), we infer that for all but one of the "old" member states, the number of imported product categories decreases slightly, while modest to substantial increases have been realized by some of the "new" member states. For example, in Latvia the number of product categories that have been imported increased from 6,274 in 1999 to 7,228 in 2008. At the same time, columns (3) and (4) reveal that the average number of supplying countries within available goods has increased for all countries, except for Hungary and Malta. The relative increase in the average number of supplying countries are modest in the four largest members, but larger than 30% in many "small old" and "new" member states. For example, in Romania the average number of supplying countries per product category has grown from 6.50 to 9.30. Combining columns (1) to (4), this translates into an overall increase in imported varieties for all countries except Cyprus, Hungary, and Malta, as can be inferred from columns (5) and (6).

[7] A further decomposition of the number of imported varieties at the country level has shown that the main suppliers in terms of varieties of EU economies in 2008 were (in decreasing order) Germany, Italy, the Netherlands, Great Britain, Belgium and the United States. The driving suppliers of new varieties between 1999 and 2008 are China, Poland, the Czech Republic, Turkey, Belgium, Austria, the Netherlands, Spain and Hungary. Hence, besides established suppliers, some emerging EU and non-EU economies have been the main contributors to the substantial variety growth observed above.

[8] This is in line with the New Trade Theory first outlined by Krugman (1979) and with what empirical studies by Hummels and Klenow (2005) and Broda and Weinstein (2004) have found.

Table 2.2: Variety of EU-27 Imports from Worldwide Trading Partners, 1999-2008

	Total no. of goods		Mean no. of countries		Total no. of varieties		Varieties disapp.	Varieties new.
	1999	2008	1999	2008	1999	2008	1999	2008
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
France	9,969	9,368	11.34	13.11	113,043	122,795	55,123	64,875
Germany	9,722	8,912	13.91	15.87	135,216	141,464	66,824	73,072
Great Brit.	9,562	9,090	11.38	13.32	108,857	121,124	55,849	68,1162
Italy	9,675	9,072	10.30	12.26	99,628	111,214	50,228	61,814
Austria	9,292	8,791	7.61	9.94	70,742	87,409	34,912	51,579
Belgium	9,685	9,073	8.35	11.09	80,894	100,596	38,008	57,710
Denmark	8,330	8,384	6.52	8.86	54,325	74,268	26,766	46,709
Finland	8,287	7,895	6.62	8.15	54,894	64,352	28,475	37,933
Greece	8,255	8,022	5.69	7.10	46,948	56,991	25,089	35,132
Ireland	8,375	7,947	4.30	5.57	36,046	44,271	20,267	28,492
Luxembourg	7,862	7,834	3.63	4.16	28,578	32,575	13,220	17,217
Netherlands	9,238	8,867	9.91	11.78	91,578	104,446	48,726	61,594
Portugal	8,529	8,429	6.07	6.93	51,779	58,399	26,714	33,334
Spain	9,345	8,931	7.72	9.92	72,127	88,585	35,272	51,730
Sweden	8,855	8,458	8.48	9.95	75,065	84,175	38,823	47,933
Bulgaria	6,649	7,509	5.15	7.16	34,229	53,758	19,986	39,515
Cyprus	5,951	5,932	5.12	5.13	30,477	30,407	20,120	20,050
Czech Rep.	8,848	8,598	8.54	9.55	75,568	82,106	41,095	47,633
Estonia	6,779	7,054	4.90	6.44	33,220	45,404	19,939	32,123
Hungary	7,049	6,805	9.46	9.37	66,689	63,757	40,403	37,471
Latvia	6,274	7,228	4.63	6.76	29,041	48,870	15,874	35,703
Lithuania	6,654	7,378	5.46	7.47	36,343	55,099	20,812	39,568
Malta	5,517	5,258	3.88	3.58	21,418	18,829	15,180	12,591
Poland	8,766	8,653	9.67	10.41	84,736	90,107	46,651	52,022
Romania	7,446	8,243	6.50	9.30	48,421	76,646	25,231	53,456
Slovakia	7,650	7,952	6.03	7.03	46,131	55,894	26,095	35,858
Slovenia	7,785	8,059	6.74	7.04	52,464	56,771	30,415	34,722

Notes: A good is defined after the CN-8 classification and a variety is defined as a good from a particular country. The mean is calculated as the average country supplying a specific good category. The number of new (disappearing) varieties is calculated as the number of all imported varieties that were not imported in the first quarter in 1999 (2008) but were imported in the first quarter of 2008 (1999). Countries are arranged according to our definition of the three subgroups of EU member states.

Our data show that the overall growth rate of new varieties has been relatively

low for the "large old" economies, with an average increase of about 6%; more substantial for the "small old" member states with growth rates of between 12% and 36%; and even higher with growth rates of up to 68% in the case of Latvia, and an average increase of roughly 35% for the "new" member states. The size of the relative change in the number of imported varieties is depicted in the top panel of Figure 2.1. Columns (7) and (8) of Table 2.2 display the turnover of varieties in the member states during the considered decade. In many countries the turnover rate is around 50% of the total number of varieties; that is, about 50% of the varieties that existed in 1999 are no longer present in 2008 (column (7)), and roughly 50% of the new varieties present in 2008 had not been available ten years earlier (column (8)). This result qualitatively holds for all 27 members, although in some "new" member states, the turnover rate is even higher. Thus, not only has the absolute number of imported varieties increased, but also the origin and composition of imported varieties has changed substantially over the last decade.

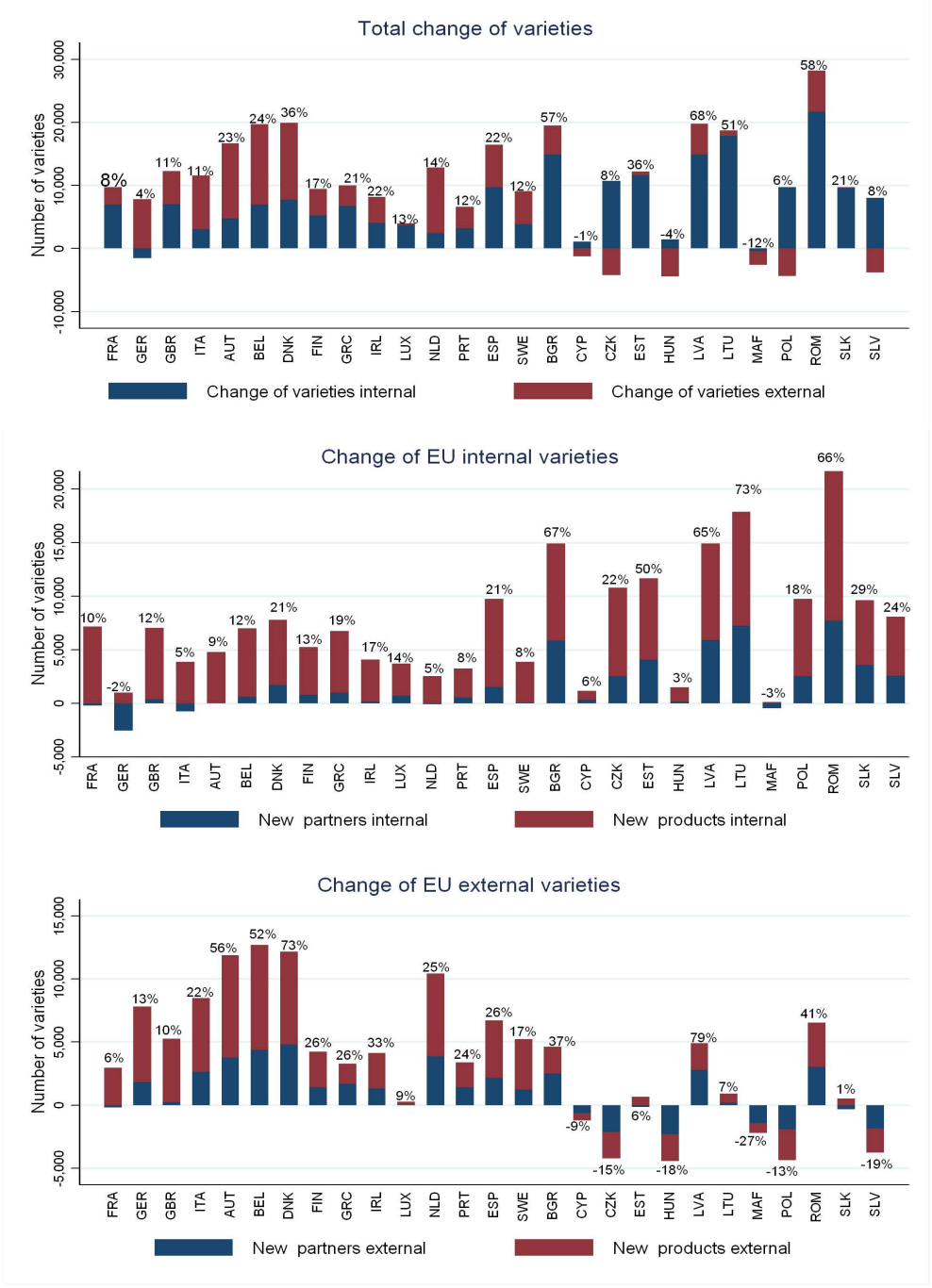
2.2.3 Variety Adjustments of Internal and External Imports

Figure 2.1 provides summary statistics on the contribution of internal and external EU trade flows on the imported variety in each country. The top panel displays the absolute number of new imported varieties, split up by the contribution of internal and external trade flows.[9] For example, in Denmark (DNK) the number of new imported varieties amounts to 19,943, implying a relative increase of imported varieties of 36%. Of this total, 7,774 varieties can be attributed to the import of new varieties from non-EU member states and 12,169 to the import of new varieties from EU member states. We observe that for most of the "old" EU members the establishment of new trade linkages outside the EU accounts for approximately 60% of new imported varieties. On the other hand, in many of the new member states, more than 90% of new imported varieties stem from internal EU trade partners. For some of the new member states such as Poland and the Czech Republic, the number of imported varieties from non-EU member states is even decreasing, an observation that is in line with the numbers from Table 2.1[10]

[9] Netted out; i.e., disappearing varieties are subtracted from new varieties.

[10] This observation may hint at a trade diversion effect following the Eastern Enlargement in 2004. However, our interest lies in the analyzes of the variety gains given the realized trade flows.

Figure 2.1: Adjustments in the Variety Set of EU Internal and External Imports



Notes: A good is defined after the CN-8 classification and a variety is defined as a good from a particular country. For convenience we ordered the table according to our definition of our three subgroups of EU member states from left to right. The top graph depicts the total change of EU internal and external imported varieties. The lower two graphs further decompose the change in variety into the number of variety imported from new trading partners or entirely new imported product categories.

In the middle and bottom panel of Figure 2.1, we further decompose the contribution of internal (middle panel) and external (bottom panel) trade flows; the percentage change again depicts the relative change of imported varieties. We split up the contribution along two dimensions. First, we calculate the number of new imported varieties from product categories that have already been imported in 1999 (New partners). Second, we compute the number of new imported varieties due to imports of entirely new product categories, including all countries supplying these products (New products). The middle panel analyzes the change of internally traded varieties. For nearly all "old" members, over 90% of new internal varieties can be attributed to the emergence of entirely new products rather than the increase in trading partners within already imported goods. For the "new" member states, the EU has been an important source of both, new products and new partners. For example, in Romania (ROM), the number of internally imported varieties increased by 21,685 (a 66% relative increase). Of this total, 7,669 varieties are due to imports from extending the set of trading partners within existing product categories, and 14,016 varieties are due to imports of entirely new product categories.

Finally, the bottom panel reveals that for the "old" EU-15 members, the number of imported varieties from non-EU countries has been increasing, mainly due to imports of entirely new product categories.[11] For example, in Italy (ITA) the number of externally imported varieties has grown by 8,498 (a 22% relative increase), whereof 5,870 new varieties can be attributed to imports of entirely new product categories. On the other hand, for many of the Eastern European countries, the number of trading partners as well as the number of new products from non-EU members has been unchanged or slightly decreased. In a nutshell, Figure 2.1 depicts a diverse pattern of extensive margin adjustments of the 27 EU economies' imports. Before turning to the empirical analysis, we lay out the methodology used to analyse these variety changes.

[11] This seems to contradict the observation that the number of product categories mostly decreased in these countries (Table 2.1). However, new product categories were imported from more countries than disappearing categories, which leads to this result.

2.3 Empirical Strategy

In this section, we briefly review the methodology used to determine the gains from variety. It was mainly developed by Feenstra (1994) and extended by Broda and Weinstein (2006). We follow Feenstra (1994) to derive an exact price index for a CES utility function for each imported good with a constant number of varieties. This index is then extended by allowing for new and disappearing varieties. We then aggregate the good's indices to an aggregate import price index based on the contribution of Broda and Weinstein (2006). We start with a simple CES utility function with the following functional form for a single imported good. To define a variety of a good, we assume that imports of one good g are treated as differentiated across countries of supply, c. Consumers' utility M_{gt} is defined as

$$M_{gt} = \left(\sum_{c \in C} d_{gct} M_{gct}^{1-\sigma_g} \right)^{\frac{1}{(1-\sigma_g)}} ; \sigma_g > 1, \tag{2.1}$$

where C denotes the set of available countries, and hence of all potentially available varieties. M_{gct} is the subutility derived from the imported variety c of good g in period t, and $d_{gct} > 0$ is the corresponding taste or quality parameter. The elasticity of substitution among varieties is given by σ_g and is assumed to be larger than one. Using standard cost minimization gives us the minimum unit-cost function

$$\phi_{gt}(I_{gt}, \vec{d}_{gt}) = \left(\sum_{c \in I_{gt}} d_{gct} (p_{gct})^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}, \tag{2.2}$$

where p_{gct} is the price of variety c of good g in period t, and $\vec{d}_{gt}$ is the vector of taste or quality parameters. $I_{gt} \subset C$ is the subset of varieties of good g imported at time t. Suppose the set of available product varieties I_{gt} in period t and $t-1$ is identical, the taste parameters $\vec{d}_{gt}$ are also constant over time, and $\vec{x}_t$ and $\vec{x}_{t-1}$ are the cost-minimizing consumption bundle vectors for the varieties of one good for the given price vectors. In this case, Diewert (1976) defines an exact price index

as the ratio of the minimum cost functions

$$P_g(\vec{p}_{gt}, \vec{p}_{gt-1}, \vec{x}_{gt}, \vec{x}_{gt-1}, I_g) = \frac{\phi_{gt}(I_g, \vec{d}_g)}{\phi_{gt-1}(I_g, \vec{d}_g)}, \tag{2.3}$$

where the price index does not depend on the unknown taste parameters $\vec{d}_{gt}$. Sato (1976) and Vartia (1976) have derived the exact price index for our CES unit-cost function. It can be written as the geometric mean of the individual price changes

$$P_g(\vec{p}_{gt}, \vec{p}_{gt-1}, \vec{x}_{gt}, \vec{x}_{gt-1}, I_g) = \prod_{c \in I_g} \left(\frac{p_{gct}}{p_{gct-1}} \right)^{w_{gct}}, \tag{2.4}$$

where the weights are calculated using the following expenditure shares:

$$w_{gct} = \frac{\left(\frac{s_{gct} - s_{gct-1}}{\ln s_{gct} - \ln s_{gct-1}} \right)}{\sum_{c \varepsilon I_g} \left(\frac{s_{gct} - s_{gct-1}}{\ln s_{gct} - \ln s_{gct-1}} \right)}, \tag{2.5}$$

$$s_{gct} = \frac{p_{gct} x_{gct}}{\sum_{c \varepsilon I_g} p_{gct} x_{gct}}. \tag{2.6}$$

So far, we have assumed that all varieties of one good are available in both periods. The price index developed by Feenstra (1994) allows us to incorporate new and disappearing product varieties. The effects of a change in the variety set are given by the following proposition.

Proposition: For every good g, if $d_{gct} = d_{gct-1}$ for $c \in I_g = ((I_{gt} \cap I_{gt-1});\ I_g \neq \emptyset$, then the exact price index for good g with change in varieties is given by

$$\Pi_g(\vec{p}_{gt}, \vec{p}_{gt-1}, \vec{x}_{gt}, \vec{x}_{gt-1}, I_g) = \frac{\phi_{gt}(I_{gt}, \vec{d}_g)}{\phi_{gt}(I_{gt-1}, \vec{d}_g)} \tag{2.7}$$

$$= P_g(\vec{p}_{gt}, \vec{p}_{gt-1}, \vec{x}_{gt}, \vec{x}_{gt-1}, I_g) \left(\frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{\frac{1}{\sigma_g - 1}} \tag{2.8}$$

where

$$\lambda_{gr} = \frac{\sum_{c \varepsilon I_g} p_{gcr} x_{gcr}}{\sum_{c \varepsilon I_{gr}} p_{gcr} x_{gcr}}\ ;\ r = t, t-1. \tag{2.9}$$

The idea of the Feenstra (1994) index is to correct the conventional price index P_g by multiplying it with an additional term which measures the influence of new and disappearing varieties and is called the lambda ratio. The numerator λ_{gt} measures the impact of new varieties: Varieties available at t, but not at $t-1$ (i.e., new varieties), are comprised in the set I_{gt} but not in the set I_g, and therefore expenditures on such varieties lower λ_{gt}. Analogously, expenditures on varieties available at, $t-1$ but not at t (i.e., disappearing varieties) lower the term λ_{gt-1}. Hence, the price index is corrected downward if expenditure on new varieties is relatively large and expenditure on disappearing varieties is relatively small. Furthermore, a high elasticity of substitution causes the term $(\frac{\lambda_t}{\lambda_t-1})^{\frac{1}{\sigma-1}}$ to approach unity and, consequently, dampens the effect of the lambda ratio on the price index. This is intuitive, since new and disappearing products will only have a minor influence on the welfare of consumers if close substitutes exist. We use the methodology proposed by Feenstra (1994) in our empirical analysis to obtain consistent estimates for the elasticity of substitution, see Appendix A. Having derived the exact price index for one good, we can now aggregate the imported goods to an aggregate import price index as in Broda and Weinstein (2006). This is done by building a geometric mean of the price indices. The aggregate import price index is then given by

$$\Pi(\vec{p}_t,\vec{p}_{t-1},\vec{x}_t,\vec{x}_{t-1},I) = \left[\prod_{g\in G} P_g(.)\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{(1/\sigma_g-1)}\right]^{w_{gt}}, \quad (2.10)$$

$$= CIPI(I)\prod_{g\in G}\left(\frac{\lambda_{gt}}{\lambda_{gt-1}}\right)^{w_{gt}/(\sigma_g-1)}, \quad (2.11)$$

where the weights w_{gt} are analogously defined as in (2.5) and (2.6). Equation (2.11) shows that the aggregate exact import price index is the product of the conventional import price index, $CIPI(I)$, and the aggregated lambda ratios. The factor correcting the conventional import price index can thus be expressed by the ratio of the corrected import price index and the conventional import price

index—called the endpoint ratio (EPR).

$$EPR = \frac{\Pi^M}{CIPI(I)} = \prod_g \left(\frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{w_{gt}/(\sigma_g - 1)}. \tag{2.12}$$

Using a simple Krugman (1980) structure of the economy, the inverse of the EPR can be weighted by the share of imports on the GDP to obtain the gains from variety (GFV):

$$GFV = \left[\frac{1}{EPR} \right]^{w_t^M} - 1, \tag{2.13}$$

where w_t^M is the import share.

2.4 Results

In this section, we present and discuss the variety gains estimates for the EU member states. We also show where these gains originate geographically and provide some robustness measures.

2.4.1 The Gains from Variety in the the European Union

In the first step of our calculation, we use equation (2.9) to calculate the lambda ratios for each imported product category of each country. The lambda ratios are a more precise measure of variety growth than the count data used in Table 2.2, since they take the consumer budget decision into account by using expenditure shares as weights. Summary statistics for these ratios are presented in Table 2.3:[12] For example, the median lambda ratio for Ireland is $0.96 < 1$, implying that the typical imported product category in Ireland experienced a positive variety growth

[12]There are fewer lambda ratios calculated than product groups: Some lambda ratios cannot be defined at the CN-8 level, since there is no common variety at the beginning and the end of the chosen time period. In this case, we follow Broda and Weinstein (2006) and define the lambda ratio at the SITC-5 or even the SITC-3 level. The sigma for these categories is obtained by calculating the weighted average of all corresponding CN-8 sigmas. Hence, we use all sigmas estimated at the CN-8 level.

of about 4%.[13]

Table 2.3: Summary Statistics: Lambda Ratios, EU-27

	Nobs	Mean	Median	5%	95%
France	1,795	1.27	0.99	0.43	1.83
Germany	1,573	1.25	0.99	0.38	1.88
Great Britain	1,304	1.16	0.98	0.31	1.75
Italy	1,627	1.16	0.98	0.33	1.90
Austria	1,435	1.27	0.99	0.36	2.11
Belgium	1,613	1.31	0.98	0.29	1.90
Denmark	1,097	1.46	0.97	0.27	2.07
Finland	1,206	1.64	0.97	0.18	2.79
Greece	1,172	1.25	0.95	0.19	2.27
Ireland	1,319	1.33	0.96	0.23	3.11
Luxembourg	1,264	1.36	1.00	0.28	1.91
Netherlands	1,450	1.28	0.98	0.23	2.13
Portugal	1,240	1.34	0.99	0.27	2.42
Spain	1,412	1.17	0.96	0.21	2.00
Sweden	1,225	1.20	0.97	0.28	2.02
Bulgaria	681	1.08	0.81	0.11	2.27
Cyprus	506	1.77	0.97	0.17	3.75
Czech Republic	1,245	1.42	0.98	0.22	2.79
Estonia	717	1.51	0.90	0.12	2.99
Hungary	764	1.68	1.00	0.21	3.19
Latvia	654	1.20	0.79	0.09	3.01
Lithuania	813	1.15	0.83	0.08	2.28
Malta	540	1.90	1.00	0.17	6.19
Poland	1,221	1.56	0.99	0.21	2.94
Romania	871	1.54	0.86	0.13	2.93
Slovakia	850	1.36	0.96	0.17	2.56
Slovenia	992	1.53	0.97	0.24	2.92

Notes: 5% and 95% denote the respective percentiles. Goods are defined at the CN-8 level and the number of observations denotes the number of calculated lambda ratios according to equation (2.9). Outliers larger than 100 are dropped. This concerns 81 lamba ratios out of the total of 30,000 ratios calculated. Countries are arranged according to our definition of the three subgroups of EU member states.

In the largest four EU economies, the average growth in imported variety has

[13]Calculated as 1/0.96=4.2%.

been moderate, with median lambda ratios of 0.98 or 0.99, indicating a weighted variety growth of 1% or 2%. In the "small old" member states, the median lambda ratios range from 0.95 in the case of Greece to 1.00 for Luxembourg. The "new" member states have experienced a higher increase in imported varieties. The median lambda ratio can be as low as 0.79 in Latvia or 0.81 in Bulgaria, indicating a variety growth of up to 25%. Exceptions are Malta, Hungary, and Poland with median lambda ratios of 0.99 or 1.00. From the quantiles displayed in the last two columns of Table 2.3, it can be inferred that there is substantial variation across product categories with respect to variety growth.

As pointed out by our theoretical framework, this observed variety growth does not directly imply an increase in consumer welfare, since the degree of substitutability within the different product categories is essential in our model. For example, the availability of a new variety of car fuel is expected to have a low impact on consumer welfare, since fuel is a homogeneous good. Within a CES framework, this homogeneity is expressed by a high value of the elasticity of substitution. On the other hand, consumers do care about different varieties within differentiated product groups, such as footwear, furniture or automobiles. Consequently, these product categories exhibit low elasticities of substitution, and therefore new varieties in these product categories lower the price index substantially.[14] We estimate the elasticities of substitution for every imported product category of each country following Feenstra (1994). Table 2.4 reports descriptive statistics of the estimated elasticities.[15] Our estimation of the elasticities of substitution reveals that the median elasticity of countries ranges from 3.41 to 4.89. These values are of similar magnitude as those obtained in other studies, as for example in Broda and Weinstein (2006), Broda et al. (2006) or Berry et al. (1995). Based on the assumption of a Krugman-type economy, this translates into median markups

[14] We test whether these presumptions about the elasticities of homogeneous and differentiated goods are true. See below.

[15] A total of 2,093 estimated elasticities in Malta may seem too few, considering that this country imported 5,517 goods in 1999 alone. However, some product categories in very small countries are imported from very few trading partners and for only a very short time span. For these goods, it is not possible to estimate the elasticities of substitution. See Feenstra (1994) for more information about this estimation technique. In the calculation of the variety gains below, we replace the missing elasticities at the CN-8 level by estimates at the CN-4 product level.

of between 25% and 42%.

Table 2.4: Summary Statistics: Elasticities of Substitution, EU-27

	Nobs	Mean	StE	Median	5%	95%
France	10,491	11.29	0.83	4.22	1.87	22.15
Germany	10,191	10.78	0.89	4.67	2.16	22.82
Great Britain	9,929	9.25	0.85	3.84	1.77	18.83
Italy	9,797	14.28	1.42	4.60	1.94	26.84
Austria	8,316	8.27	0.48	3.70	1.61	18.90
Belgium	9,338	8.53	0.40	4.10	1.75	21.51
Denmark	7,631	7.94	0.55	3.42	1.51	19.21
Finland	6,764	12.44	0.90	4.04	1.66	25.06
Greece	6,728	9.04	0.72	3.41	1.47	20.99
Ireland	6,210	10.80	1.29	3.47	1.49	19.53
Luxembourg	5,173	13.70	1.40	3.51	1.36	30.92
Netherlands	8,696	12.06	1.01	4.38	1.72	26.99
Portugal	7,182	12.03	1.47	3.65	1.58	21.38
Spain	9,179	9.05	0.53	3.89	1.68	20.97
Sweden	7,722	9.83	0.53	4.32	1.79	22.54
Bulgaria	5,314	12.63	1.30	4.57	1.70	30.36
Cyprus	2,814	20.13	4.19	4.56	1.60	37.37
Czech Republic	7,525	12.14	1.19	4.33	1.73	25.86
Estonia	4,695	14.39	1.70	4.18	1.60	27.72
Hungary	6,914	13.61	0.94	4.52	1.76	30.57
Latvia	4,542	13.16	1.49	4.33	1.66	30.65
Lithuania	5,137	11.26	0.74	4.50	1.70	31.19
Malta	2,093	8.89	0.69	3.59	1.40	22.70
Poland	8,129	13.02	1.19	4.31	1.80	28.09
Romania	6,436	13.49	0.78	4.89	1.76	36.49
Slovakia	6,189	10.60	0.77	3.98	1.53	26.70
Slovenia	6,328	10.01	0.68	4.07	1.60	24.64

Notes: 5% and 95% denote the respective percentiles. Elasticities are estimated at the goods level, which is defined at the CN-8 level. Outlier elasticities larger than 10,000 are dropped. This concerns 15 elasticities out of the total of 190,000 elasticities estimated. Countries are arranged according to our definition of the three subgroups of EU member states.

The last two columns of Table 2.4 show the 5% and 95% percentiles, indicating large differences across products regarding the substitutability of varieties. In the case of Sweden, for example, 5% of all elasticities are higher than 22.54. Such

high values imply almost perfectly homogeneous varieties from the viewpoint of a CES consumer.

We test whether our estimated elasticities are sensible from a practical point of view. First, we categorize them according to the classification of Rauch (1999).[16] We find that our estimates fit the expectations well: Homogeneous product categories exhibit a median elasticity of 4.8, reference priced products of 4.3, and differentiated products of 4.0. This also holds for the individual countries in our dataset. Second, we estimate the elasticities at different product aggregation levels; i.e., CN-6 and CN-4. We find that the elasticities tend to decrease in broader defined product categories. These results strengthen our confidence in our elasticity estimates.

Our results do not suggest any apparent systematic differences between median elasticities across different countries; e.g., between small and large or between "old" and "new" member states. This is noteworthy, given the different structure of the EU economies in terms of size, growth rate and development. Hence, our results do not lend direct support to recent theoretical models, as for example Melitz and Ottaviano (2008).

Using our estimated elasticities of substitution and the lambda ratios, we calculate the corrected price indices following equation (2.8) for each of the product categories in all member states. Following equation (2.11), these indices are then aggregated into the corrected import price index. The ratio of the conventional import price index and the corrected import price index then results in the EPR as displayed by equation (2.12). We obtain the bias in the conventional import price index (in the following simply referred to as the "bias") by calculating $1/EPR-1$. The EPR and the bias are depicted in Table 2.5. For example, a bias of 3.66% in Estonia implies that the conventional import price index overstates the actual price evolution by 3.66%, by not taking the change in the variety set into account. Finally, by weighting the bias by the import share as in equation (2.13), we obtain the GFV expressed as a percentage of GDP.

[16] Rauch (1999) classifies goods as homogeneous if they are traded on organized exchanges, as reference priced if the goods can be identified by referring to list prices, meaning that prices can be quoted without mentioning the name of the manufacturer, and as differentiated if products differ over a multitude of dimensions including, for example, a brand name or the place of selling.

Table 2.5: Import Price Index and the Gains from Variety, EU-27

	EPR	Bias	Import Share	GFV
France	1.001	-0.06%	0.24	-0.01%
Germany	1.001	-0.12%	0.26	-0.03%
Great Britain	0.997	0.34%	0.21	0.07%
Italy	0.993	0.73%	0.21	0.15%
Austria	0.992	0.79%	0.41	0.32%
Belgium	0.994	0.61%	0.84	0.51%
Denmark	0.976	2.47%	0.30	0.72%
Finland	1.002	-0.20%	0.29	-0.06%
Greece	0.995	0.46%	0.25	0.11%
Ireland	0.991	0.89%	0.38	0.33%
Luxembourg	0.999	0.12%	0.56	0.07%
Netherlands	0.990	1.00%	0.51	0.51%
Portugal	0.990	1.03%	0.34	0.35%
Spain	0.983	1.73%	0.26	0.46%
Sweden	0.993	0.71%	0.30	0.21%
Bulgaria	0.972	2.85%	0.53	1.50%
Cyprus	0.979	2.15%	0.38	0.80%
Czech Republic	0.986	1.42%	0.65	0.93%
Estonia	0.965	3.66%	0.76	2.76%
Hungary	0.979	2.09%	0.62	1.30%
Latvia	0.945	5.84%	0.52	3.02%
Lithuania	0.982	1.87%	0.60	1.12%
Malta	1.037	-3.60%	0.69	-2.49%
Poland	0.990	0.97%	0.35	0.34%
Romania	0.971	2.98%	0.43	1.28%
Slovakia	0.977	2.34%	0.79	1.84%
Slovenia	0.981	1.90%	0.60	1.13%

Notes: Estimates are based on the definition of a good at the CN-8 level. A variety is defined as a particular good from a particular country. The endpoint endpoint ratio (EPR) is calculated according to equation 2.12 and the gains from variety (gfv) is based on equation 2.13, where the import share is the ratio of imports to GDP. Countries are arranged according to our definition of the three subgroups of EU member states.

The biases in the "large four" countries are small in magnitude. In the case of France and Germany, they are even slightly negative, implying an increase in the import price index and hence a consumer loss through variety. Given the relatively

small import shares of these large economies, this translates into small gains or losses from imported varieties, not substantially different from zero.

In the "small old" economies of the EU, we observe that the conventional import price index is biased upwards in all countries except in the case of Finland, where the bias is negative, but close to zero. The magnitude of the biases is larger on average than in the "large four" economies, with Austria, Denmark, Ireland, the Netherlands, Portugal, Spain and Sweden experiencing a bias of more than 0.7% over the considered time span. Weighting the biases with the generally higher import shares results in GFV that mostly lie between 0.2% and 0.75% of GDP. GFV for consumers remain limited in these countries.

In all "new" member states—with the exception of Malta—the change in the variety set translates into lower import prices as shown by the positive biases. The magnitude of the correction in the price index is much larger than in the "old" member states, with Estonia and Latvia experiencing lower import prices of over 3%, while in Bulgaria, Lithuania, Romania, and Slovakia, the bias is larger than 2%. For Poland, we observe the lowest positive bias with 0.96%. Consumers in these countries have thus profitted from lower import prices to a greater extent than consumers of the "old" member states. Expressed relative to total production, the gains amount to as much as 3.02% of GDP in the case of Latvia. High GFV above 1.5% of GDP are also found in Bulgaria, Estonia and Slovakia. Cyprus, the Czech Republic, Hungary, Lithuania, Romania, and Slovenia exhibit modest gains that still lie above 0.8% of GDP. In Poland, the GFV are small with only 0.34% of GDP—a result also driven by the relatively low import share. Such variety gains can be interpreted in the following way. Consumers in Latvia are willing to spend 3.02% of their GDP in the year 2008 to gain access to the larger set of imported varieties available in 2008 compared to the set of varieties available in 1999.

2.4.2 Geographical Origin of the Gains from Variety

In a next step, we analyze whether the GFV stem from internal EU trade or from trade with countries outside the EU. The methodology presented in Section 2.3 allows us to compute the EPR for each trading partner, or, more appropriately here, the EPR stemming from trade with a group of countries. For each country

group i, in our case the EU and ROW, the EPR is computed as follows:

$$EPR_i = \prod_g \left[\left(\frac{\lambda_{gt}}{\lambda_{gt-1}} \right)^{(w_{gt}/(\sigma_{g-1}))W_{igt}} \right], \tag{2.14}$$

where W_{igt} is the ideal log-change weight of country group i on good g. By multiplying both EPR_i, the total EPR as reported in Table 2.5 is obtained. In our case,

$$EPR = EPR_{EU} EPR_{ROW}. \tag{2.15}$$

The bias in the price index can then be calculated as described above and the results for all 27 EU members are given in Table 2.6. Columns (1) and (2) depict the EPR resulting from the imports from other EU member states and from the ROW, respectively, while columns (3) and (4) display the bias in the import price index resulting from these imports.[17] For example, Greek consumers gain from the change in the variety set imported from its EU trading partners, expressed by a bias of 1.16%, depicted in column (3). At the same time, Greece loses from the change in imported variety of its ROW trading partners—with a negative bias in the import price index of -0.69%, as displayed in column (4). In Latvia, the country with the highest gains from variety, the upward bias of the import price index is 5.18% considering just imports from other EU members, but only 0.63% regarding ROW imports. Hence, the GFV predominantly stem from intra-EU trade.

Most countries experience lower import prices due to both variety imports from other EU members and from ROW countries. However, in all these countries, the upward bias stemming from internal imports is much higher than from external imports.[18]

[17] To calculate this bias, we make the implicit assumption that when the variety set supplied by EU countries changes, the composition of ROW imports remains the same—and vice versa.

[18] Again, this seems to contrast with some results from the descriptive analysis, especially for the "old" members where we have seen that the greater part of the variety count increase stems from ROW countries. However, these statistics neglect the weighting of varieties. Varieties from EU countries are often imported at greater value than ROW varieties. The results highlight the necessity of relying on more sophisticated variety measures instead of using simple count data.

Table 2.6: Geographical Origin of the Gains from Variety, EU-27

	EPR		Bias	
	EU	ROW	EU	ROW
France	1.001	1.000	-0.06%	0.01%
Germany	1.000	1.001	0.03%	-0.15%
Great Britain	0.997	1.000	0.34%	0.00%
Italy	0.995	0.998	0.50%	0.24%
Austria	0.993	0.999	0.72%	0.08%
Belgium	0.994	1.000	0.59%	0.02%
Denmark	0.980	0.995	2.00%	0.47%
Finland	0.997	1.005	0.26%	-0.46%
Greece	0.989	1.007	1.16%	-0.69%
Ireland	0.992	0.999	0.84%	0.05%
Luxembourg	0.998	1.001	0.22%	-0.11%
Netherlands	0.994	0.996	0.58%	0.42%
Portugal	0.992	0.998	0.80%	0.23%
Spain	0.992	0.991	0.84%	0.89%
Sweden	0.994	0.998	0.56%	0.15%
Bulgaria	0.979	0.993	2.17%	0.66%
Cyprus	0.989	0.990	1.14%	0.99%
Czech Republic	0.986	1.000	1.46%	-0.04%
Estonia	0.971	0.993	2.95%	0.70%
Hungary	0.987	0.992	1.33%	0.76%
Latvia	0.951	0.994	5.18%	0.63%
Lithuania	0.984	0.998	1.64%	0.22%
Malta	1.027	1.010	-2.61%	-1.02%
Poland	0.992	0.999	0.83%	0.13%
Romania	0.976	0.995	2.44%	0.53%
Slovakia	0.979	0.998	2.11%	0.23%
Slovenia	0.983	0.998	1.69%	0.21%

Notes: Estimates are based on the definition of a good at the CN-8 level. A variety is defined as a particular good from a particular country. The endpoint endpoint ratio (EPR) is calculated according to equation 2.12 and the bias as defined in the text. Both variables are calculated for EU-27 member states and for the rest od the world respectively. Countries are arranged according to our definition of the three subgroups of EU member states.

Other countries, such as the Czech Republic, Luxembourg and Finland gain from the higher variety from intra-EU trade, but lose part of these gains due to the lower variety imported from ROW countries. In Finland, this loss dominates the

gains.[19]

2.4.3 Interpretation of the Results

Our results can be summarized as follows: The average bias of the import price index (the total GFV) for the "large four" amounts to 0.18% (0.04%).[20] Internal EU trade flows contributed about 60% to this low value. For the "smaller old" member states, we estimate positive gains with an average bias in the price import index (total GFV) of 1.11% (0.39%). Although these countries profited from both, internal and external imports, our results show that more than 70% of the gains can be attributed to imports from other EU members. Finally, in the "new" member states the upward bias of the import price index (the total GFV) amounts to 1.74% (0.92%) on average. These countries have benefited substantially from internal EU trade over the last decade. Internal trade accounts for about 85% of the total gains from imported varieties.

One explanation for this pattern of the gains from variety makes use of the ongoing process of European integration as well as globalization in general: The "large four" countries already played a key role in the global economy at the beginning of the observation period and had well-established trade links within the EU as well as within the global trading system. Consequently, access to new varieties via important new trade linkages was limited, given their already diverse structure of imports in 1999. Hence, we observe that most trade was growing at the intensive margin, resulting in relatively low variety gains. Besides these reasons, the smaller import shares also play a role in these countries when calculating the gains from variety.

For the high-income, "small old" member states, we observe in Section 2 that import diversity is somewhat more limited compared with the largest economies. The increase over the last decade, however, has been more substantial and their large import shares make imports, and the imported variety of products in par-

[19] One exception is Malta. This country experiences variety losses from both blocks, the losses from EU trading partners being larger in magnitude.

[20] We calculate the weighted average bias of the import price index using the size of each country in terms of its GDP. This is done to obtain a clearer picture of the differences between the three country blocks.

ticular, an important source of welfare gains. At the same time, trade of these countries with other EU members was already well diversified by the year 1999, with the EU being a particularly important source of imports for decades. These countries were part of the EU for a longer period and had already adopted important institutions like the single market program before 1999. This also explains the slower growth rate of new trade linkages within the EU trade network compared to the higher growth rate of trade linkages with non-EU trading partners as described in Section 2. However, our analysis shows that when using the more sophisticated structural estimation technique, most of the gains from variety actually stem from new imported varieties from EU trading partners. This can be explained by the fact that most of the new imported varieties from non-EU partners were imported at relatively low values.

The "new" member countries, on the other hand, were less well integrated within the world trading system and the EU in 1999 and consequently took advantage of the dynamic globalization process over the last decade to diversify and extend their imported variety set. Our results imply that most of the gains stem from internal EU imports—the descriptives statistics in Section 2 have already shown that new trade linkages were established predominantly with other EU members. With the reorientation of the transition economies towards "old" Europe in combination with the reduction in trade barriers and the adoption of important institutions of the EU during the accession period, the trade linkages of these countries with all the other EU-27 members have grown at a rapid rate, resulting in substantial consumer welfare gains via the existence of a more diverse set of products and varieties.

2.4.4 Robustness of the Results

The empirical approach used in our study rests on a few strong assumptions. One potential issue is the dependence of the results on the estimated elasticities of substitution. Secondly, the trade dataset used for our analysis dictates that a particular definition of an imported variety is adopted, which, in turn, drives the results. Third, since the methodology used above only focuses on imported varieties and neglects changes in the domestic variety, we provide a short discussion on how

this simplification may influence our results.

Estimating elasticities of substitution from trade data is a difficult task. Due to the data restrictions, several strong assumptions have to be made to identify this parameter. It is beyond the scope of this paper to discuss this in detail.[21] To assess the impact of the estimated elasticities on our results, we keep the elasticities for each country and each product group constant at different levels and calculate the variety gains using a fixed elasticity of $\sigma = 3$, $\sigma = 4$, $\sigma = 6$ or $\sigma = 8$. Under all specifications, the qualitative implications of our results presented above continue to hold. The "large four" exhibit the lowest gains, close to zero for all four countries. Gains in the "small old" members are positive—with the exception of Finland—but lower than the gains in the "new" member states. For example, using $\sigma = 6$, Estonian consumers enjoy variety gains amounting to 2.32% (down from 2.76% using the estimated elasticities) of GDP, while in the Netherlands and in Great Britain the gains amount to 0.59% (0.59%) and 0.10% (0.07%). Hence, the observed differences between countries predominantly stem from fundamental differences in the import variety set as observed in the trade data.[22]

In our contribution, a variety is defined as a particular good imported from a particular country. Blonigen and Soderbery (2010) argue that the variety definition imposed by conventional trade data hides some variety growth. Using a detailed market data set on the U.S. automobile market, the authors show that the gains from variety double if more disaggregated variety definitions (i.e., different car brands and models) are used. Bernard et al. (2009) comment in the same vein and argue that new (and still scarce) firm-level data imply higher variety gains from trade, since every firm produces several different varieties. From this point of view, our results provide a conservative measure for the GFV.

Given the data restrictions, we cannot assess how a more detailed variety def-

[21] Interested readers are referred to Feenstra (1991), which is the more detailed working paper version of Feenstra (1994), as well as to an appendix available on Robert C. Feenstra's website. Furthermore, Soderbery (2010) discusses several of the properties of the employed estimator.

[22] This is not to say that country- and product-specific elasticities are not important for finding the true gains. In fact, the distribution of product-specific elasticities is highly skewed and thus it is hard to justify an "average" elasticity that is applied on all products. For example, Broda and Weinstein (2006) show that by using the median elasticity instead of the full distribution, the variety gains are overestimated by 100%.

inition might affect our results. However, we can re-estimate the variety gains using different aggregation levels of the trade data; e.g., CN-6, to analyze how less detailed data influence our results. For this purpose, we also re-estimate the elasticities of substitution to match them with the now broader product categories. The variety gains turn out to be robust to a change in the product definition from CN-8 to CN-6. For example, in Estonia the GFV decrease from 2.76% to 2.62% of GDP; in Italy, they remain at 0.15%; and in Belgium welfare gains slightly increase from 0.51% to 0.67%. Hence, even though varieties are now more broadly defined and some variety growth captured at the CN-8 level is excluded, our results remain robust. One explanation for this result is the fact that the elasticities of substitution generally decrease if products are defined in a broader manner. Hence, by using less disaggregated data, we potentially miss some variety growth. However, the broader defined varieties are estimated as being more differentiated, and this has an opposite effect on our estimated gains.

More importantly, we observe that although we use different variety definitions, the qualitative assessments discussed above—for example that "new" members gain more from imported variety—remain the same.[23]

Using the model described in Section 2, we implicitly assume that domestically produced and imported goods cannot be substituted. A change in the variety of imported goods does not affect the domestic economy, or more specifically, the variety of domestically produced goods. The same stark assumption is used by Broda and Weinstein (2006). Several contributions address this issue theoretically. For example in Melitz (2003), more productive foreign firms crowd out less productive domestic firms, leading to a decrease in domestically produced varieties. As Arkolakis et al. (2008) or Baldwin and Forslid (2010) show, the total number of varieties *consumed* in a country can even decrease after trade liberalization in such a model.[24]

[23] We also perform the exercise using product categories defined at CN-4. The qualitative results remain the same. However, GFV generally decrease using this definition which only defines about 1,000 products. Thus, the missed variety growth lowers the gains, while the lower elasticities do not fully compensate this decrease.

[24] Of course, one still has to weight these varieties by the expenditure shares. Thus, these results themselves do not imply that the gains from variety would be negative. In fact, Feenstra (2010) shows that using the Melitz (2003) model, gains from imported variety and losses from

In a recent contribution, Ardelean and Lugovskyy (2010) address this issue empirically by setting up a simple model, in which domestically produced and imported varieties can be substituted. Depending on the magnitude of the elasticities and relative productivity of the domestic sectors, domestic varieties are assumed to be replaced by imported varieties upon trade liberalization. The authors quantify a potential bias resulting from ignoring this possible substitution and find that the bias of the price index is not more than 8% in U.S. manufacturing.[25] It is difficult to say how this result relates to the gains found for the countries of the EU. Member states differ in various aspects that determine the potential crowding-out of domestically produced varieties. Further research is needed beyond the scope of this paper to address these important questions.

2.5 Conclusion

Over the last decade, the member states of the EU have been part of a dynamic economic integration process within Europe as well at a global level, resulting in a strong increase in imported products and varieties. In this paper, we adopt the methodology outlined by Feenstra (1994) and Broda and Weinstein (2006) to estimate the effects of variety growth on consumer welfare for all EU member states for the period from 1999 to 2008.

Our results show that for most countries the import price index is biased upwards due to the omission of newly imported varieties. This gives rise to positive welfare gains to consumers stemming from an increased product variety. However, our analysis also reveals substantial differences across countries. Based on the assumption of a Krugman-type economy, we were unable to identify any sizable gains from newly imported varieties for the largest four countries of the EU over the last decade. The gains are more substantial for the smaller and especially the younger member states of the EU. Our results suggest positive welfare gains of 3% of GDP in the case of Latvia. Especially for smaller and fast-growing

domestically produced varieties have to cancel each other out.

[25] Concentrating on the automobile sector, Blonigen and Soderbery (2010) show that by taking domestically produced automobiles from foreign affiliates in the United States into account, variety gains even increase by an additional 70%.

economies, the creation and extension of trade linkages thus present an important source of welfare, a fact often neglected in the discussion about the positive effects of globalization and economic integration.

To shed further light on the source of these gains, we identify to what extent intra-EU and non-EU imports contribute to the gains from variety. Our analysis shows that the majority of the welfare gains can be attributed to increased variety imports from other EU members. Imports from non-EU countries did not contribute much to the gains; on the contrary, according to our results these imports often even contributed negatively, thus mitigating the positive effects of variety growth in the total imports. These results prove to be reasonably robust under several different specifications.

A Appendices to Chapter 2

A.1 Estimation of the Elasticity of Substitution

We briefly review the estimator developed by Feenstra (1994). Based on our utility function (2.1), we can derive the import demand equation for a single variety using expenditure shares s as defined above.[26] Taking logs and first differences results in:

$$\Delta \ln s_{g,c,t} = \varphi_{g,t} - (\sigma_g - 1)\Delta \ln p_{g,c,t} + \varepsilon_{g,c,t}, \tag{2.16}$$

where σ_g is equal across countries, $\varphi_{g,t} = (\sigma_g - 1)\ln[\phi g, t^M(d_t)/\phi^M_{g,t-1}(d_{t-1})]$ is a random effect, since d_t is unobserved and $\varepsilon_{g,c,t} = \Delta \ln\ d_{g,c,t}$. The export supply equation in logs and first differences is specified by

$$\Delta \ln p_{g,c,t} = \psi_{g,t} + \frac{\omega_g}{1+\omega_g}\Delta \ln s_{g,c,t} + \delta_{g,c,t}. \tag{2.17}$$

where $\omega_g \geq 0$ is the good specific inverse supply elasticity[27] (assumed to be constant across countries) and $\delta_{g,c,t}$ is an error term. We assume that the the error terms between the demand and supply curve $(\varepsilon_{g,c,t}, \delta_{g,c,t})$ are uncorrelated after controlling for good- and time-specific effects. To take advantage of this assumption, we first eliminate the random terms $\varphi_{g,t}$ and $\psi_{g,t}$ from equations (2.16) and (2.17) by taking differences relative to a reference country k:

$$\Delta^k e_{g,c,t} = -(\sigma_g - 1)\Delta^k ln\ p_{g,c,t} + \varepsilon^k_{g,c,t} \tag{2.18}$$

$$\Delta^k \ln p_{g,c,t} = \frac{\omega_g}{1+\omega_g}\Delta^k \ln s_{g,c,t} + \delta^k_{g,c,t}, \tag{2.19}$$

where $\Delta^k K_{g,c,t} = \Delta K_{g,c,t} - \Delta K_{g,k,t}\ \ for\ K = (\ln p, \ln s)$, $\varepsilon^r_{g,c,t} = \varepsilon_{g,c,t} - \varepsilon_{g,r,t}$ and $\delta^r_{g,c,t} = \delta_{g,c,t} - \delta_{g,r,t}$. We can now use the assumption of the independent error

[26] Using shares helps to avoid the problems of measurement error of unit-value indices as pointed out by Kemp (1962)

[27] If $\omega_g = 0$ we get the special case of a horizontal supply curve

terms to multiply (2.18) and (2.19) and dividing by $(1-\rho_g)(\sigma_g-1)$ to obtain

$$\left(\Delta^k \ln p_{g,c,t}\right)^2 = \theta_{1,g}\left(\Delta^k \ln s_{g,c,t}\right)^2 + \theta_{2,g}\left(\Delta^k \ln p_{g,c,t}\Delta^k \ln s_{g,c,t}\right) + u_{g,c,t} \text{ or}$$

$$Y_{g,c,t} = \theta_{1,g}X_{1,g,c,t} + \theta_{2,g}X_{2,g,c,t} + u_{g,c,t}, \tag{2.20}$$

with obvious definitions of $\theta_{1,g}$ and $\theta_{2,g}$. Since the error term $u_{g,c,t}$ is correlated with the prices and expenditure shares in $X_{1,g,c,t}$ and $X_{2,g,c,t}$, we do not get a consistent estimator for $\theta_{1,g}$ and $\theta_{2,g}$. Feenstra (1994) shows how to exploit the panel structure of the data to get a consistent estimator by averaging (2.20) over all t. Hence, we can use the GMM estimator developed by Hanson (2005) to run a regression on the transformed equation of (2.20) to estimate $\theta_{1,g}$ and $\theta_{2,g}$ consistently.

$$\overline{Y}_{g,c,t} = \theta_{1,g}\overline{X}_{1,g,c,t} + \theta_{2,g}\overline{X}_{2,g,c,t} + \overline{u}_{g,c,t}. \tag{2.21}$$

where upper bars on variables denote sample means over t. This will produce consistent and efficient estimates of $\theta_{1,g}$ and $\theta_{2,g}$ as long as for some countries $i \neq k$ and $j \neq k$

$$\left(\frac{\sigma^2_{\varepsilon,c}+\sigma^2_{\varepsilon,r}}{\sigma^2_{\varepsilon,j}+\sigma^2_{\varepsilon,r}}\right) \neq \left(\frac{\sigma^2_{\delta,c}+\sigma^2_{\delta,r}}{\sigma^2_{\delta,j}+\sigma^2_{\delta,r}}\right) \tag{2.22}$$

Once, we have consistent estimators of $\theta_{1,g}$ and $\theta_{2,g}$ we can calculate the elasticity of substitution σ_g:
As long as $\theta_{1,g} > 0$, σ_g can be estimated as

$$\text{a) if} \quad \widehat{\theta}_{2,g} > 0 \quad \text{then} \quad \widehat{\rho}_g = \tfrac{1}{2} + \left(\tfrac{1}{4} - \frac{1}{4(\widehat{\theta}^2_{2,g}/\widehat{\theta}_{1,g})}\right)^{1/2},$$
$$\text{b) if} \quad \widehat{\theta}_{2,g} < 0 \quad \text{then} \quad \widehat{\rho}_g = \tfrac{1}{2} - \left(\tfrac{1}{4} - \frac{1}{4(\widehat{\theta}^2_{2,g}/\widehat{\theta}_{1,g})}\right)^{1/2},$$

and in either case,

$$\widehat{\sigma}_g = 1 + \left(\frac{2\widehat{\rho}_g - 1}{1-\widehat{p}_g}\right)\frac{1}{\widehat{\theta}_{g2}}. \tag{2.23}$$

A.2 Data Description

Table 2.7: Summary Statistics: Product Codes of the Combined Nomenclature

Year	Total number of product codes (1)	New product codes (2)	Deleted product codes (3)	Total change (4)	Net change (5)
1999	10,428	144	303	447	-159
2000	10,314	109	223	332	-114
2001	10,274	50	90	140	-40
2002	10,400	780	654	1,434	126
2003	10,404	19	15	34	4
2004	10,174	273	503	776	-230
2005	10,096	97	175	272	-78
2006	9,842	486	740	1,226	-254
2007	9,720	917	1,039	1,956	-122
2008	9,699	75	96	171	-21

Notes: The large turnovers in the years 2002, 2006 and 2007 are due to reclassifications that appear regularly. The empirical approach presented above is robust towards such reclassifications of products, as for example noted in Broda and Weinstein (2006).

Chapter 3

Export versus FDI and the Role of Financial Frictions

3.1 Introduction

The global financial crisis was accompanied by a strong decrease in world trade flows and foreign direct investment (FDI). According to the WTO (2010) world trade flows collapsed by more than 12% in the year 2009 and at the same time FDI flows dropped by more than 37% (UNCTAD (2010)). As a consequence of the financial crisis credit markets tightened and firms faced difficulties in obtaining external finance. Additionally, recent estimates show that around 90% of total world trade is associated with some form of trade finance (e.g. Auboin (2009)), and that firms use a substantial amount of external capital to finance FDI (e.g. Marin and Schnitzer (2006)). Therefore, a growing literature on finance and multinational corporations has emphasized that multinational firm activity, in the form of exporting or FDI, is closely linked to the availability of external finance to a firm.

The main focus of this literature has been on the effect of financial frictions in explaining the export status and export volume of firms, sectors and countries (e.g. Greenaway and Kneller (2007), Manova (2009)). A few, more recent studies also emphasize the growing importance of the interaction between financial conditions and FDI, but remains silent on how financial frictions affect the decision of a firm to engage in FDI (e.g. Chor et al. (2007), Manova et al. (2011), Antràs et al. (2009)). This literature on finance and multinational corporations so far analyzes the two forms of multinational activity separately, but does not focus on how financial frictions affect the internationalization strategy of a firm jointly.

Another strand in the literature examines the determinants of the trade-off of a firm whether to serve foreign markets via exporting or horizontal FDI. The focus of this line of research has been the proximity-concentration trade-off in driving the decisions of firms whether to engage in exporting or in horizontal FDI, but has not taken into account other determinants, such as the financing environment of firms.

In this contribution I close this gap by unifying the explanation for the decision of a firm whether to serve foreign markets via exporting or doing FDI with the theory on finance. The specific question I address in this study is to what extent do financial frictions affect the internationalization strategy of a firm? Do firms

acting in less financial vulnerable industries have a higher probability to engage in FDI or exporting? And how does this affect the overall composition of export and FDI sales at the industry and country level?

To answer these questions, I integrate a simplified version of the financial constraints theory of exporting from Manova (2009) into the Helpman et al. (2004) framework. This analysis provides new insights into the trade-off whether a firms serves foreign markets via export or FDI and explains how financial frictions affect and shape the overall composition of export and FDI sales within a sector, but also at the country level. The model generates new empirical predictions about the activity of multinational firms which find support in the data.

To motivate the empirical analysis, I develop a multi-country, multi-sector heterogenous firm model of international trade. In the theoretical framework firms can decide to serve foreign markets via exporting or by setting up an affiliate in the destination market. The decision of the market entry mode of a firm in this setup depends on the relative costs associated with both strategies. Both activities require investments in sunk costs. While exporting requires lower fixed costs compared to FDI, firms face higher variable costs, in the form of transport costs, when they choose to export. In contrast to Helpman et al. (2004) firms have not sufficient funds to finance their multinational activity via internal funds and have to raise external capital. In combination with the existence of imperfect capital markets, firms have to pay an interest rate premium to the investor. These additional financing costs vary for both activities. In comparison with export, they are higher for FDI, given the higher amount of credit required and the higher risks associated with FDI. Furthermore, credit constraints affect firms in different sectors unevenly. For technological reasons, firms in certain industries require more external finance and/or have to pay higher interest rates, resulting in higher financing costs.

The model predicts that in financially vulnerable sectors more firms choose to serve foreign markets via exporting rather than engaging in FDI, given the higher costs to acquire external capital. Consequently, these sectors exhibit higher ratios of relative export sales to FDI sales, which constitutes the new prediction of the model. In addition, the choice of the market entry mode of a firm depends on traditional variables as pointed out in the proximity-concentration literature, such

as market size, transport costs, fixed costs and dispersion of firm productivity.

I develop an empirical strategy to test the predictions of the model, using a panel dataset for Germany that covers 26 manufacturing industries and 38 countries for the period 2002 to 2007. I combine data on FDI activity from the Midi (Microdatabase Direct Investment) database provided by the Deutsche Bundesbank (2010) with detailed balance sheet information for about 25,000 firms from the AMADEUS databank published by Bureau van Dijck Electronic Publishing (2005) to construct measures for the financial vulnerability of an industry. I stay closely to the model and proxy financial constraints using the liquidity ratio as a measure of the ability of a firm to finance investments internally. Since I do not observe the interest rate firms have to pay to the investor, I follow the previous literature and use asset tangibility with the share of tangible assets relative to total assets as a measure to provide collateral for the investor and thereby having easier access to external capital. As alternative measures for financial frictions, I use the debt ratio and absolute value of cash-flows available to a firm. However, as in line with previous research in this case my results tend to be more tentative. The results show that my measures of financial frictions help to predict the composition of trade and investment in the manner of the model suggested. Industries which are less financially dependent and/or have more collateral to offer, are characterized by a larger volume of FDI sales relative to exports. These findings are robust to alternative specifications of the empirical model. I implement an instrumental variable strategy to circumvent problems arising from potentially reverse causality effects.

I find that the effects of financial frictions are of similar magnitude compared to the traditional variables of the proximity-concentration trade-off, such as trade costs and country size. My estimates suggest, that industries which are 10% less dependent on external finance or have a 10% higher ratio of tangible assets on average have a 3% to 7% lower ratio of export and FDI sales. In addition I confirm the results first established by Helpman et al. (2004) and show that the dispersion of firm level productivity within an industry is also an important force in determining the ratio of export to FDI sales for Germany. Finally, I find strong support in the data for the proximity-concentration trade-off.

This paper contributes to a growing literature on finance on trade. While pre-

vious studies have emphasized the important role of financial institutions in determining trade flows and have shown that financial development can be a source of comparative advantage, these papers mostly focused on the aggregate levels of trade flows. (e.g. Kletzner and Bardhan (1987), Beck (2002), Beck (2003), Matsuyama (2005), Hur et al. (2006), Do and Levchenko (2007)).[1] Based on the emerging models of heterogenous firms, more recent papers have taken a microeconomic perspective and have analyzed to what extent financial frictions affect firm level participation in export markets and how these effects shape the intensive and extensive margins of trade. One important contribution in this strand of literature is a paper by Manova (2009). In her theoretical and empirical analysis she shows how the dependence on external finance and ability of a firm to provide collateral affects the exporting behavior of firms and how these effects determine the overall export composition at the sectoral and country level.[2] While Manova (2009) uses highly disaggregated trade data for her analysis, subsequent empirical studies have used firm level data to examine the effect of financial frictions on the exporting behavior of firms, including Muûls (2008), Berman and Héricourt (2008) and Andreev (2010). All these studies find a negative effect of financial frictions on the export market participation and export sales at the firm level. Greenway et al. (2007) use a set of balancesheet data for English firms and show in their empirical analysis how financial conditions affect the exporting behavior of a firm and at the same time how exporting improves the financial health of an enterprise. While their results on the impact of the financial health on exporting are inconclusive, they find that exporting improves the overall financial situation of a company. All these papers have solely focused on the export market participation of firms but do not take into account alternative market entry forms, in particular not foreign direct investment.

So far only a few paper have considered the interaction of financial frictions and foreign direct investment. Most of these papers examine the ability of subsidiaries of multinational corporations to use internal capital markets to circum-

[1] In a more general view this paper can also be linked to the literature on trade and institutions, see for example Nunn (2007) and Levchenko (2007).

[2] See Chaney (2005) for an alternative way of modeling financial constraint in a heterogenous firm model.

vent financial constraints in the destination country. For instance, Manova et al. (2011) and Hericourt and Poncet (2009) find that subsidiaries of multinational firms in China are less financially constraint compared to domestic firms. In a related study Desai et al. (2008) examine how affiliates can take advantage of internal capital markets to increase production and outperform domestic producers. Antràs (2003) show that in equilibrium the production location and integration decision of a firm are affected by credit constraints if the investments of the input supplier are relationship specific.[3] Chor et al. (2007) analyze how financial development of the host country affects the location decision of subsidiaries. They find that a higher level of financial development of the host country induces lower sales of the affiliate since a higher share of production remains in the host country. More closely related to my approach is a study by Buch et al. (2009), which analyzes the negative effects of financial constraints of German multinational firms at the parent level on the intensive and extensive margin of affiliate sales. Although these studies examine how financial frictions affect the production decision of multinational firms, they mostly focus on the effect of internal capital markets on foreign direct investment, but do not analyze the effect of financial constraints on exports or other alternative market entry modes.[4]

Finally, the paper provides new insights into and evidence on the proximity-concentration trade-off as first pointed out by Brainard (1993, 1997) and extended to incorporate heterogenous firms by Helpman et al. (2004). In these types of models, the decision of exporting or to serve foreign markets via an affiliate, depends on the relative costs associated with both activities and the productivity of a firm. A pecking order of firm productivity determines the market entry choice of a firm, where it is only profitable for the most productive firm to engage in FDI, while less productive firms choose to export or merely produce domestically. See Greenaway and Kneller (2007) for an overview of this literature. So far none of this literature has considered alternative explanations such as financial frictions,

[3]Also related to this strand of literature is a paper by Marin and Schnitzer (2006) which analyzes the mode of financing FDI. See also Smarzynska Javorcik and Spatareanu (2008) for evidence that less credit-constrained Czech firms self-select into becoming suppliers of multinational firms.

[4]In another paper by Buch et al. (2005) they analyze the composition and determinants of German foreign direct investment using the same dataset I use in this paper.

which affect the decision between exporting and FDI.

The remainder of this paper is organized in the following sections. In section 3.2 I set up the theoretical model. The model generates predictions about the composition of the sales of multinational firms. In section 3.3 I describe the data I use and provide detailed descriptive statistics for all key variables. Based on the theoretical I develop an empirical framework to test the predictions of the model and provide results of different estimations strategies in section 3.4. Section 3.5 forms the conclusion.

3.2 Theoretical Framework

In the following section I extend the multi-sector heterogenous firms model of international trade from Helpman et al. (2004) by incorporating a simplified version of the financial constraints theory as proposed by Manova (2009).

3.2.1 Demand

Consider a world with N countries and S sectors in each country. A continuum of heterogenous firms produces differentiated goods in each country and sector. Consider a two-level utility function where consumers exhibit a love of variety and consume all available products in each sector. The utility function for each country n is given by a Cobb-Douglas aggregate over sector specific CES consumption indices C_{ns}:

$$U_n = \prod_s C_{ns}^{\Theta_s}, \quad C_{ns} = \left[\int_{\omega \in \Omega_{ns}} q_{ns}(\omega)^{\alpha} d\omega \right]^{\frac{1}{\alpha}} \tag{3.1}$$

where $q_{ns}(\omega)$ represents the consumption of variety ω in sector s from country n, and Ω_{ns} is the set of varieties available to consumers in country n in sector s. The elasticity of substitution between two varieties is given by $\varepsilon = 1/(1-\alpha) > 1$ and $0 < \alpha < 1$. The parameter Θ_s indicates the share of each sector in total expenditure and satisfies $\sum_s \Theta_s = 1,\ 0 < \Theta_s < 1$. As was originally shown by Dixit and Stiglitz (1977), consumer behavior can be modeled by considering the set of varieties consumed as an aggregate good $Y_n \equiv U_n$ associated with an ideal price index for

sector s of country n

$$P_{ns} = \left[\int_{\omega \in \Omega_{ns}} p_{ns}(\omega)^{1-\varepsilon} d\omega \right]^{\frac{1}{1-\varepsilon}} \tag{3.2}$$

where p_{ns} denotes the price of a variety in sector s for country n. Using these aggregates consumers' demand for variety ω in country n in sector s can be expressed as

$$q_{ns}(\omega) = \frac{p_{ns}(\omega)^{-\varepsilon} \Theta_s Y_n}{P_{ns}^{1-\varepsilon}} \tag{3.3}$$

This specification implies a constant elasticity of demand for each variety ε, and the price is higher if ε is lower.

3.2.2 Production

In this model, firms first decide if they want to produce for the domestic market, before they choose whether to serve the foreign market via exporting or horizontal FDI.

There is a continuum of firms in every sector and each firm produces a distinct variety ω. Before producing for the domestic market, firms have to pay fixed market entry costs, f_e measured in labor units. Once firms have paid their market entry costs they draw their firm specific productivity $1/a$ from a cumulative distribution function $G(a)$ with support $[a_L, a_H]$ where $a_H > a_L > 0$.[5] When firms sell in the domestic market they only bear production costs a.[6]

Next, firms decide if they want to serve the foreign market n. If a firm from country n wants to export its product to a different country i it faces two additional costs: a fixed export cost of serving the market in country i which equals f_x^{ni}, and a variable transport cost τ_{ni}. For the latter, I adopt the widely used 'melting iceberg' specification and assume that $\tau_{ni} > 1$ units of a good have to be shipped from country n to country i in order for one unit of this good to arrive. The former

[5] Since I am only interested in the trade-off between exporting and FDI, I consider a partial equilibrium model. The main prediction of the model also hold in a general equilibrium model. See Melitz (2003) and Helpman et al. (2003) for a general equilibrium approach.

[6] For simplicity I assume that there are no fixed costs to serve the domestic market. Consequently, all firms that enter an industry also produce for the domestic market.

one can be interpreted as the costs of forming a distribution and servicing network in a foreign country. On the other hand, if a firm serves the foreign market via foreign direct investment (FDI) it bears additional fixed costs f_{di}^{ni}. These fixed FDI costs include the costs of a distribution and service network as well as the additional costs of establishing a new plant or subsidiary in the foreign country. The difference between f_{di}^{ni} and f_x^{ni} can then be interpreted as plant-level returns to scale for one sector.[7] For the entire analysis I assume

$$f_{di}^{ni} > \tau_{ni} f_x^{ni}. \tag{3.4}$$

While FDI saves transport costs, it requires higher fixed costs compared with the export strategy.[8]

Given the CES utility function there is monopolistic competition in final goods in each sector. In combination with consumer demand (3.3) the effective consumer price for a domestically produced good – by a domestic firm or a foreign affiliate – is given by $p_{ns}(\omega) = \frac{a}{\alpha}$, and for imported goods, $\tau_{ni} p_{ns}$, where $\frac{1}{\alpha}$ is the standard markup, being smaller if the elasticity of demand is higher. Using these conditions the additional profits of a firm from exporting to country i can be expressed as

$$\pi_x^{nis} = (\tau_{ni} a)^{1-\varepsilon} D^{is} - f_x^{ni} \tag{3.5}$$

and the additional profits from FDI in country i are given by

$$\pi_{di}^{nis} = a^{1-\varepsilon} D^{is} - f_{di}^{ni} \tag{3.6}$$

where $D_{is} = (1-\alpha)\left(\frac{1}{\alpha P_{is}}\right)^{1-\varepsilon} \Theta_s Y_i$ (see the Appendix B.2).[9] Both profit functions are increasing in productivity and more productive firms perform better in

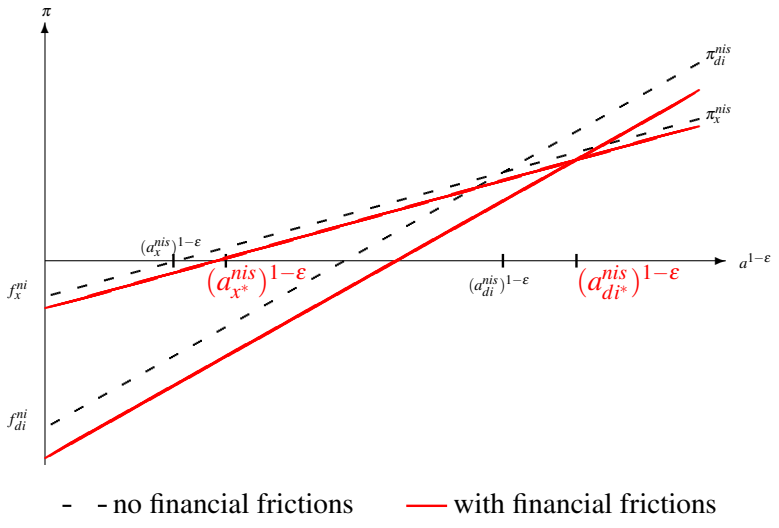
[7] For example, if in an industry the difference between both fixed costs is high, then taking advantage of scale effects in production in the plant located in the home market is more attractive than paying the additional relative high FDI fixed costs, indicating high plant-level returns to scale for this industry.

[8] Here I exclude the possibility of export platform FDI, and vertical FDI. For an extension to include vertical FDI see Helpman et al. (2003).

[9] All firms that export or do FDI also produce for the domestic market. Since I am interested in the trade off between FDI and Export, I skip the profit functions for domestic sales here.

both activities and are plotted in Figure 3.1. Profits are represented on the vertical axis and $a^{1-\varepsilon}$ on the horizontal axis. Since $\varepsilon > 1$, $a^{1-\varepsilon}$ is a monotonic transformation of labor productivity $1/a$ and can be used as a productivity index. Both profit functions are increasing linearly in $a^{1-\varepsilon}$. Given lower fixed costs and additional transport costs in the case of exporting from country n to country i, the slope of the profit function is smaller and the intercept is higher compared with the profit function for FDI. Equations (3.5) and (3.6) can be used to solve for the critical

Figure 3.1: Profits and Productivity Cut-offs for Exporting and FDI with and without Credit Constraints.



cut-off levels $(a_x^{nis})^{1-\varepsilon}$ and $(a_{di}^{nis})^{1-\varepsilon}$ depicted in Figure 3.1 by the following two conditions.

$$(a_x^{nis})^{1-\varepsilon} = \tau_{ni}^{\varepsilon-1}(D_{is})^{-1} f_x^{ni}, \tag{3.7}$$

$$(a_{di}^{nis})^{1-\varepsilon} = \frac{1}{(1-\tau_{ni}^{1-\varepsilon})}(D_{is})^{-1}(f_{di}^{ni} - f_x^{ni}). \tag{3.8}$$

Firms with a productivity lower than $(a_x^{nis})^{1-\varepsilon}$ can not profitably serve the foreign market and will only produce for the home market. Firms with productivity levels between $(a_x^{nis})^{1-\varepsilon}$ and $(a_{di}^{nis})^{1-\varepsilon}$ will export to market i, since the profits from exporting are higher than the profits from serving market i via an affiliate. Finally, the most productive firms, with productivity levels above $(a_{di}^{nis})^{1-\varepsilon}$, will choose to

serve the foreign market i via FDI.[10]

3.2.3 Credit Constraints

I adopt a reduced version of Manova (2009) to incorporate financial constraints into the model to analyze the effects of financial constraints on multinational firm activity.[11]

Consider the following setup. If firms aim to internationalize their business, they need to raise external finance. At the beginning of each period they make a take-it-or-leave-it offer to a potential investor, a financial contract is signed and the investment for exporting or FDI is made. The contract specifies the amount of credit and repayment to the creditor at the end of the period.

Since, I am interested in the effect of credit constraints on the trade-off between export and FDI I assume for simplicity that firms only need external capital to cover fixed export costs f_x^{ni} and fixed FDI costs f_{di}^{ni}, while transport costs τ_{ni} and market entry costs f_e^n can be financed via internal cash-flows.[12] For example firms' previous profits may not be sufficient to cover all fixed export and FDI costs.[13] This is also in line with the observation in the data that firms use substantial external finance to cover their investment costs, which is especially true for German firms (see also Bayraktar et al. (2005)).[14]

Hence, firms need to raise outside capital for a fraction d_s, $0 < d_s < 1$, of the fixed export or fixed FDI costs if they want to serve market i and lower values of d_s indicate less reliance on external finance. In this model the dependence on external finance is sector-specific as a result of an industry specific technological component as pointed out by Rajan and Zingales (1998), Classens and Laeven

[10] In this model I abstract from the case that firms serve foreign markets via exporting and FDI simultaneously.

[11] See also Braun (2003) and Buch et al. (2009) for a similar approach.

[12] Allowing for external finance for transport costs and fixed production costs in the home market would not change the results qualitatively.

[13] Firms may not be able to transfer profits from one period to another due to the presence of a principal–agent problem, where stockholders demand the redistribution of all earnings at the end of each period to avoid dispensable investments by the management.

[14] This way of modeling financial constraint is also in line with the idea that a firm is uncertain about its future earnings and faces up-front costs to expand their business.

(2003) and Manova (2009) among others. Firms will have to raise $d_s f_x^{ni}$ if they want to export to country i and $d_s f_{di}^{ni}$ if they want to set up an affiliate in country i. Since the fixed costs of setting up an affiliate, f_{di}^{ni}, are higher than the fixed costs of exporting, f_x^{ni}, by assumption (3.4), firms need to raise more external finance in the case of FDI.

Due to the existence of financial frictions, for example information asymmetries, creditors will charge an interest rate $r_{x,di}^s > 1$, which is assumed to be strictly higher for FDI than for exporting ($r_{di}^s > r_x^s$).[15] [16] More specifically, I assume that the interest rate for FDI is a positive multiple of the interest rate for exporting ($r_{di}^s = \eta r_x^s$) with $\eta > 1$. The assumption of a higher interest rate for FDI compared to exporting is motivated by the idea of higher risks for the investor. In the case of FDI, the assets for production of the new plant are located in a foreign country generating higher uncertainties for the creditor about future revenues of the project, due to country specific factors (local labor productivity, management skills, language barriers etc.). Furthermore, in the case of a default of the firm, it may also be more difficult for the creditor to enforce his claim, as part of the production facilities are located in a different country. FDI also requires higher investments and a higher share of external finance exposing the firm to higher future financial risks. Finally, distance and country specific effects also generate higher monitoring costs for the creditor.

In addition, I assume that the interest rate firms have to pay to the creditor varies across industries. Although this is a strong assumption, it is again based on the idea, that, for technological reasons, some sectors find it is easier to obtain external capital. For example, as pointed out by Beck (2003) and Manova (2009), some industries have a higher share of tangible assets which can serve as collateral, lowering the risk for the creditor and consequently firms' costs to acquire external capital. Given this setup two new profit functions for exporting and FDI can be derived.[17] In the case of exporting from country n to country i, firms

[15] Here, the model deviates from others (e.g. Manova (2009)) where credit constraints only affect the ability to receive a credit but do not have a direct negative effect on the profit function of a firm.

[16] For simplicity, I assume that the world market interest rate which is the outside option for the creditor is normalized to 1.

[17] I choose this way of modeling financial constraints to stick closely to the observable data that

maximize

$$\pi_x^{nis} = (\tau_{ni}a)^{1-\varepsilon}D^{is} - (1-d_s)f_x^{ni} - d_s r_x^s f_x^{ni} \tag{3.9}$$

and in the case of FDI in country i firms maximize profits by

$$\pi_{di}^{nis} = a^{1-\varepsilon}D^{is} - (1-d_s)f_{di}^{ni} - d_s r_{di}^s f_{di}^{ni} \tag{3.10}$$

Given the results from above, we already know that without financial constraints highly productive firms will serve the foreign market via an affiliate in the foreign country, while firms with lower productivity serve the foreign market via exports. From the system of equations (3.9) and (3.10) we can see that financial constraints affect both the decision to export and the decision for FDI.[18] This has two effects. First, some firms which potentially would export without financial constraints are now not profitable enough to cover the additional financing costs and choose to produce for the domestic market only. Second, firms that potentially would serve the foreign market via FDI, now can not raise enough external finance to cover the high fixed costs of FDI and choose to serve the foreign market via the less finance intensive alternative, exporting. Equations (3.9) and (3.10) can be used to solve for the new productivity cut-off levels for exporting and FDI:

$$a_{ex}{*}^{1-\varepsilon} = \frac{(1-d_s)f_{ex}^{ni} + d_s r_x^s f_{ex}}{(D_{is}\tau_{ni}^{1-\varepsilon})} \tag{3.11}$$

$$a_{di}{*}^{1-\varepsilon} = \frac{(1-d_s)(f_{di}^{ni} - f_{ex}^{ni}) + d_s(r_{di}^s f_{di}^{ni} - r_x^s f_{ex}^{ni})}{D_{is}(1-\tau_{ni}^{1-\varepsilon})} \tag{3.12}$$

Both new productivity cut-offs are strictly higher, than in the situation without credit constraints and are depicted in Figure 3.1. Now, only firms from country n with the new, higher productivity cut-offs $(a_{x^*}^{nis})^{1-\varepsilon}$ and $(a_{di^*}^{nis})^{1-\varepsilon}$ can profitably export or make FDI in country i. These new cut-offs are lower for lower val-

I will use in the empirical section, but one can easily think of different models generating similar results.

[18] The effect that more productive firms are less financial constraint has been explored by Beck et al. (2005) and Forbes (2007).

ues of d_s and $r^s_{x,di}$, indicating that lower financial constraints, due to less external financial needs and/or lower interest rates, reduce the negative effect on the productivity cut-off. In the absence of financial frictions ($d_s = 0$ and/or $r^s_{ex,di} = 1$), we get the familiar results as in (3.7) and (3.8).

3.2.4 Export versus FDI with Credit Constraints

In the next step I examine to what extend financial constraints affect the magnitude of relative export versus FDI sales. Let s^{nis}_x denote the export sales from country n in country i in sector s and s^{nis}_{di} be the sales of affiliates from country n in sector s in country i. Then, relative export to FDI sales in country i in sector s can be expressed as

$$\frac{s^{nis}_x}{s^{nis}_{di}} = \tau^{1-\varepsilon}\left[\frac{V(a_x)}{V(a_{di})} - 1\right] \tag{3.13}$$

where

$$V(a) = \int_0^a \gamma^{1-\varepsilon} dG(\gamma) \tag{3.14}$$

Recall from (3.6) that firm sales are determined by firm level productivity given by $a^{1-\varepsilon}$. Given this specification, function V(.) summarizes firm level heterogeneity within one sector and directly determines the distribution of sales, profits, exports, and FDI sales in a foreign country within one sector. Since $V(.)$ is a direct mapping of firm level productivity to firm sales, the distribution of export versus FDI sales within one sector in a foreign country i depends on the distribution of labor coefficients exogenously given by $G(a)$ and the elasticity of substitution ε. To model firm level heterogeneity $G(a)$ I use the Pareto distribution. This is convenient for three reasons. First, it is obvious from (3.14) that if firm productivity $1/a$ is Pareto distributed with shape parameter k, firm sales are also Pareto distributed with shape parameter $k-(\varepsilon-1)$.[19] Second, this shape parameter provides a good measure for firm sales dispersion and can be easily implemented in the empirical

[19]The cumulative distribution function of Pareto random variable x with shape parameter k and scale parameter b is given by

$$F(x) = 1 - \left(\frac{b}{x}\right)^k, \text{ for } x \geq b > 0,$$

section, where lower values of k and higher values of ε indicate a higher dispersion of firm level sales.[20] Third, and even more important, any truncation of the Pareto distribution from above, again results in a Pareto distribution with the same shape parameter $k-(\varepsilon-1)$. Using the properties of the Pareto distribution $V(a_1)/V(a_2)$, can be reformulated as $(a_1/a_2)^{k-(\varepsilon-1)}$ for each $a \in [a_L, a_H]$ and equation (3.13) can be reformulated as

$$\frac{s_{ex}^{nis}}{s_{di}^{nis}} = \tau_{ni}^{1-\varepsilon}\left[\left(\frac{a_{ex^*}^{nis}}{a_{di^*}^{nis}}\right)^{k-(\varepsilon-1)} - 1\right] \tag{3.15}$$

Plugging (3.11) and (3.12) into (3.15), relative export to FDI sales can then be written as

$$\frac{s_{ex}^{nis}}{s_{di}^{nis}} = \tau_{ni}^{1-\varepsilon}\left[\left(\frac{(1-d_s)(f_{di}^{ni}-f_{ex}^{ni})+d_s(r_{di}^s f_{di}^{ni}-r_{ex}^s f_{ex}^{ni})}{(1-d_s)(f_{ex}^{ni})+d_s r_{ex}^s f_{ex}} * \frac{1}{\tau_{ni}^{\varepsilon-1}-1}\right)^{\phi} - 1\right] \tag{3.16}$$

with $\phi = \frac{k-(\varepsilon-1)}{\varepsilon-1} > 1$. Equation (3.16) relates the relative share of export and FDI sales to the fixed costs of exporting and FDI, transport costs, firm level dispersion, the dependence on external finance and the industry specific interest rate.[21] The following proposition characterizes the comparative static results for the relative size of export and FDI sales within and across industries.

Proposition: Relative export to FDI sales to country i in sector s are higher for lower fixed export costs, higher fixed FDI costs, higher returns to scale at the plant-level, lower trade costs, and lower firm level dispersion. Furthermore, this ratio is higher in sectors which have a lower share of internal funds and higher external financing costs.

Since x has a finite variance if and only if $k > 2$, I assume that $k > \varepsilon + 1$, which ensures that both the distribution of productivity draws and the distribution of firm sales is finite. See also Helpman et al. (2004) for a detailed explanation.

[20] Axtell (2001) points out that a Pareto distribution best fits U.S firm sales. In the empirical section I show that this is true for German firms data, too.

[21] Note that $f_{di}^{ni} > \tau_{ni} f_x^{ni}$ in combination with $d_s f_x^{ni} > t_s f_e^n$ ensure that the term in the inner brackets is always larger than 1.

$$\frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial f_{ex}^{ni}} < 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial f_{di}^{ni}} > 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial \tau_{ni}} < 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial(f_{di}^{ni} - f_{ex}^{ni})} > 0$$
$$\frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial(k-(\varepsilon-1))} > 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial d_s} > 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial r_{x,di}^{s}} > 0 \quad (3.17)$$

Proof. See the Appendix B.2.

Intuitively, within industry s an increase in the FDI fixed costs f_{di}^{ni}, a decrease in the fixed export costs f_x^{ni} or transport costs τ_{ni} results in higher relative export sales to country i, as the profitability of exporting increases. Since f_{di}^{ni} incorporates both country level fixed costs, represented by f_x^{ni}, as well as the costs of forming a subsidiary, an equal absolute increase in both f_{di}^{ni} and f_x^{ni}, indicating overall higher country fixed costs, reduces relative export to FDI sales. On the other hand, when plant-level returns to scale are high, given by a high difference between f_{di}^{ni} and f_x^{ni}, relative export to FDI sales increase due to the realization of scale effects in production in the plant located in the home market. Comparative statics also show that in industries with higher level of productivity dispersion – induced by a higher elasticity of substitution or a higher dispersion of firm productivity – relative export sales are expected to be lower, since FDI sales increase disproportional more than export sales for a given cut-off productivity level of $(a_{x^*}^{nis})^{1-\varepsilon}$ and $(a_{di^*}^{nis})^{1-\varepsilon}$.

So far, these results have already been established in the literature (e.g., Helpman et al. (2004)). The novelty of this paper is to incorporate financial constraints into a model with heterogenous firms to analyze to what extend financial frictions affect the composition of export and FDI sales. As pointed out above, credit constraints affect firm profitability, inducing higher cut-off productivity levels $(a_{x^*}^{nis})^{1-\varepsilon}$ and $(a_{di^*}^{nis})^{1-\varepsilon}$. The model predicts higher relative FDI sales in sectors which require less outside finance (d_s lower) or have lower costs of acquiring external capital, since these sectors will find it easier to expand their business to foreign markets. These predictions constitute the novel contribution of the model and will be tested in the empirical section.

3.3 Data and Descriptive Statistics

In the following section I describe the dataset used in the empirical analysis and provide descriptive statistics for all key variables. The data required fall into three categories: data on the composition of international commerce, measures of financial constraints and data for the proximity–concentration trade-off including indices capturing firm level dispersion within an industry. To empirically analyze the effects of financial frictions on the composition of export and FDI sales in a multi-country multi-sector model, I require detailed data for all variables of the model varying along both dimensions.

I construct a panel dataset of German affiliate sales and German exports for 22 manufacturing sectors for the period 2002–2007. I follow Helpman et al. (2004) and restrict my analysis to a sample with 39 countries (see Table 3.9 for the list of countries). The advantage of this approach is that potential problems of censoring, due to the many zeros of trade and FDI sales across countries and sectors, are reduced and that the results are directly comparable with those of Helpman et al. (2004). At the same time this comes at the cost of reducing the representativeness of the sample. However, the sample covers 95% of all German FDI activity and 64% of all German exports.

3.3.1 Data on International Commerce

The Microdatabase Direct Investment (MIDI) provided by the Deutsche Bundesbank (2011) is one of the few datasets in the world which collects detailed data on FDI activity and comprises all foreign direct investments above 3 million Euro and/or if the voting share of the investment is $> 10\%$.[22] Besides information about the country and sector in which the affiliate firm is active, the database contains balancesheet information about the turnover of each affiliate, which I will use as a proxy for FDI sales. In addition the database provides information about other variables such as assets and employees of foreign affiliates. Export data are from Eurostat (2010) with detailed information about trading volume and trading part-

[22] In my analysis I will focus only on direct dependent investments and skip indirect investments via an affiliate in a foreign country. For a more detailed explanation and description of the MIDI database see Lipponer (2008).

ners across all sectors at a highly disaggregated level. I aggregate both variables according to the two-digit NACE industry classification and calculate the ratio for each country-industry pair.

Table 3.1 shows summary statistics for the ratio of export sales vs. FDI sales across countries, where the standard deviation is calculated across time.

Table 3.1: Export versus FDI Sales by Country

Country	Ex/FDI	std.	Country	Ex/FDI	std.
ARG	0.508	0.384	ISR	1.619	0.385
AUS	2.368	0.174	ITA	4.268	1.162
AUT	2.968	0.293	JPN	1.230	0.486
BEL	3.951	1.291	KOR	1.295	0.267
BRA	0.564	0.086	MEX	1.424	0.225
CAN	0.938	0.224	MYS	1.281	0.099
CHE	5.697	0.832	NLD	7.429	2.082
CHL	0.464	0.135	NOR	2.904	0.685
CHN	2.050	0.418	NZL	0.846	0.212
CZE	2.548	0.232	POL	3.014	0.976
DNK	5.050	1.292	PRT	1.530	0.339
ESP	3.585	1.441	ROM	2.316	1.228
FIN	3.785	0.504	SGP	1.624	0.405
FRA	3.461	0.598	SWE	4.062	1.509
GBR	4.697	1.071	THA	0.909	0.799
GRC	2.036	0.361	TUR	1.873	0.235
HKG	5.201	1.108	TWN	3.418	1.601
HUN	1.678	0.188	UKR	1.767	1.490
IDN	0.885	0.474	USA	1.404	0.192
IND	1.536	0.554	ZAF	1.615	0.435
IRL	1.775	0.881			
Average in the cross section (panel):				2.477	(2.606)
Standard deviation in the cross section (panel):				1.596	(2.048)

Notes: EX/FDI represents the ratio of export sales over FDI sales for a particular country. The standard deviation is calculated across years for the period 2002 to 2007.

More remote, large countries, such as Brazil (0.564), on average have lower ratios of export to FDI sales, while closer trading partners, especially within the

European Union, such as the Netherlands (7.429) have relatively more exports sales than FDI sales, supporting the theory of the proximity-concentration trade-off. The overall average in the cross-section (panel) is 2.477 (2.606), indicating that on average export sales in a destination market is more than twice the size of foreign affiliate sales. From Table 3.1 one can also see that there is substantial variation, as well across countries as across time.

Table 3.2 summarizes the ratio of export to FDI sales across industries.

Table 3.2: Export versus FDI Sales by Industry

NACE	Industry description	Ex/FDI	std.
15	Food products and beverages	3.793	5.099
17	Textiles	3.359	2.810
18	Wearing apparel; dressing	3.102	4.021
19	Leather; manufacture of luggage, handbags, and footwear	1.448	0.949
20	Wood and of products of wood and cork	2.197	1.772
21	Pulp, paper and paper products	3.668	3.069
22	Publishing, printing and reproduction of recorded media	1.347	1.963
23	Coke, refined petroleum products and nuclear fuel	0.413	0.383
24	Chemicals and chemical products	1.734	1.871
25	Rubber and plastic products	1.924	1.612
26	Other non-metallic mineral products	0.729	0.598
27	Basic metals	5.621	7.071
28	Fabricated metal products, except machinery and equipment	1.890	1.759
29	Machinery and equipment n.e.c.	5.091	9.167
30	Office machinery and computers	2.590	0.513
31	Electrical machinery and apparatus n.e.c.	1.813	2.603
32	Radio, television and communication equipment	4.310	6.220
33	Medical, precision and optical instruments, watches	3.641	4.699
34	Motor vehicles, trailers and semi-trailers	3.515	6.146
35	Other transport equipment	3.128	3.839
36	Furniture; manufacturing n.e.c.	5.227	5.926
Average in the cross section (panel):		2.754	(2.848)
Standard deviation in the cross section (panel):		1.549	(1.670)

Notes: EX/FDI represents the ratio of export sales over FDI sales within an industry. The standard deviation is calculated across years for the period 2002 to 2007.

Again, one can observe substantial variation, across industries and time. While some sectors like "29: Machinery and Equipment" (5.09) have higher export to FDI ratios, we observe lower ratios in other sectors e.g. "19: Leather; manufacture of luggage, handbags, and footwear" (1.44), reflecting differences in industry characteristics such as fixed costs of FDI and/or exporting or scale effects in production. For example, setting up a plant in the "19: Leather; manufacture of luggage, handbags, and footwear" industry can be associated with lower fixed costs and/or generate higher scale effects compared to the "29: Machinery and Equipment" sector. On average exports of an industry exceed FDI sales by a factor of 2.754.

3.3.2 Measures of Financial Constraints

The contribution of this paper is to analyze to what extent financial factors determine the relative size of exports and FDI sales within an industry. Therefore, I need adequate measures for financial constraints for the empirical analysis. In this section I provide a detailed description and discussion of all variables used in the succeeding analysis.

I use a set of balancesheet and profit and loss data at the firm level from the AMADEUS database published by Bureau van Dijck Electronic Publishing (2005) and calculate several different financial ratios to measure financial constraints at the firm level. I have an unbalanced dataset on turnover, assets, liabilities, cash-flow, and their main line business by industry for approximately 25,000 German firms in the entire sample (See Table 3.10 in the Appendix B.1 for a detailed description of the dataset).[23] As is common in the literature, I then calculate the median across firms for each measure of financial constraint within an industry as a proxy for the financial vulnerability of an industry.[24] Although, this comes at

[23] I will use turnover as a proxy for sales although this can be problematically since turnover can also include revenues which are not directly related to production e.g. sales of an affiliate. I do this for two reasons. First, many companies in the sample only report turnover but not sales. Second, this is consistent with the FDI data, since I also only observe turnover and not sales for foreign affiliates. Calculations also showed a very high correlation of 0.98 between firm sales and turnover if both variables are observed.

[24] The main reason of using medians instead of mean values is to rule out potential outlier problems.

the disadvantage of losing a lot of information at the firm level, this is in line with the setup of the theoretical model and is based on the assumption that financial vulnerability captures a large technological component which is innate to a sector and therefore will also be partly reflected in the structure of the balancesheets as pointed out by Rajan and Zingales (1998), Classens and Laeven (2003), and Kroszner et al. (2007), among others. This approach also helps to mitigate potential problems arising from endogeneity issues that firm's financial vulnerability responds to changes in the export and/or FDI status, since this is less likely for an entire industry.[25] In addition, this way of modeling financial constraints also allows of implementing an instrumental variable approach in the empirical analysis to circumvent potential endogeneity problems.

First, I follow Greenway et al. (2007) and calculate the liquidity ratio of a firm defined as the firm's current assets less current liabilities over total assets. This measure proxies for the availability of internal funds for a firm, which corresponds to my parameter d_s in the theoretical model. Higher liquidity ratios indicate a better financial condition of the firm, due to the increased availability of short term internal funds, implying less reliance on external finance. Hence, a higher liquidity ratio is expected to be associated with a lower ratio of export and FDI sales.[26]. The median liquidity ratio for all sectors is 0.397 as can be seen from column one in Table 3.3, ranging from 0.276 in the "15: Food products and beverages" industry to 0.539 in the "19: Leather, luggage, handbags, and footwear industry", indicating that some sectors have on average more liquid funds available than other sectors and may be less dependent on external finance.

Second, I follow Manova (2009) and calculate the asset tangibility of a firm as the ratio of tangible assets to total assets. According to this line of literature firms with more tangible assets find it easier to pledge collateral, mitigating the risk for the investor and consequently reducing the costs for external capital, captured in the model by the interest rate $i^s_{di,x}$.[27] Therefore, firms and sectors with a higher ra-

[25] For example, exporting and FDI may result in higher profits improving financial condition of a firm resulting in a reverse causality effect.

[26] Table3.11 in the Appendix B.1 shows how firms differ in their availability of internal funds

[27] See also Braun (2003) for a similar approach and a detailed discussion.

Table 3.3: Summary Statistics - Financial constraints

NACE	Industry description	Liquidity Ratio		Asset Tangibility		Debt Ratio		Cash flow (th. Euro)	
		Median	std.	Median	std.	Median	std.	Median	std.
15	Food products and beverages	0.276	0.074	0.338	0,008	0.600	0.014	994	219
16	Tobacco products	0.369	0.128	0.121	0,053	0.461	0.105	367	81
17	Textiles	0.428	0.039	0.227	0,012	0.571	0.030	577	124
18	Wearing apparel; dressing	0.428	0.046	0.077	0,018	0.587	0.026	525	177
19	Leather manufacture (e.g. luggage, handbags)	0.539	0.135	0.144	0,023	0.465	0.076	733	612
20	Wood and of products of wood and cork	0.348	0.039	0.240	0,029	0.704	0.010	264	23
21	Pulp, paper and paper products	0.310	0.035	0.368	0,019	0.559	0.021	1.555	555
22	Publishing, printing of recorded media	0.371	0.041	0.219	0,025	0.588	0.023	419	50
23	Coke, refined petroleum products, nuclear fuel	0.263	0.066	0.281	0,040	0.552	0.066	3.150	765
24	Chemicals and chemical products	0.369	0.020	0.232	0,017	0.433	0.020	2.176	523
25	Rubber and plastic products	0.357	0.057	0.296	0,016	0.584	0.020	721	188
26	Other non-metallic mineral products	0.363	0.035	0.291	0,018	0.534	0.019	567	132
27	Basic metals	0.379	0.030	0.301	0,022	0.571	0.018	1.045	243
28	Fabricated metal products	0.385	0.025	0.240	0,025	0.642	0.015	255	48
29	Machinery and equipment n.e.c.	0.451	0.045	0.158	0,017	0.541	0.011	553	97
30	Office machinery and computers	0.477	0.051	0.092	0,019	0.464	0.020	359	132
31	Electrical machinery and apparatus n.e.c.	0.435	0.032	0.166	0,023	0.518	0.014	712	170
32	Radio, television, communication equipment	0.429	0.047	0.153	0,012	0.538	0.018	750	128
33	Medical precision, optical instruments, watches	0.522	0.043	0.117	0,008	0.470	0.014	379	93
34	Motor vehicles, trailers and semi-trailers	0.340	0.026	0.227	0,011	0.586	0.018	1.352	239
35	Other transport equipment	0.430	0.054	0.153	0,015	0.641	0.018	767	468
36	Furniture; manufacturing n.e.c.	0.437	0.015	0.186	0,008	0.559	0.023	303	103
	Industry average	0.210		0.396		0.553		842	
	Industry standard deviation	0.079		0.069		0.065		679	
	Correlation								
	Liquidity ratio	1.000							
	Asset tangibility	–0.767		1.000					
	Debt ratio	0.363		–0.405		1.000			
	Cash flow	–0.211		–0.135		–0.328		1.000	

Notes: This table summarizes the measures for asset tangibility, liquidity ratio, leverage ratio and cash-flow, for all 22 NACE sectors used in the empirical analysis. The lower two rows of the table report the cross-sector mean and standard deviation of these measures. The bottom rows report the correlations between all four measures.

tio of tangible assets are expected to have a lower ratio of export over FDI sales.[28] Table 3.3 shows the median and standard deviation over time for asset tangibility at the industry level. While some sectors use a relative high share of tangible assets in production, such as the "21: Pulp, paper and paper products" industry with a median value of 0.368, in other sectors e.g., the "18: Wearing apperal and dressing" with 0.077, the ratio of tangible assets over total assets is relative low, indicating less reliance on fixed assets in production as depicted column one. The overall industry average is 0.210 with a standard deviation of 0.079. Low values for the standard deviation for all sectors indicate that the median ratio of tangible assets over total assets appears to be stable over time, supporting the assumption of industry-specific characteristics.[29]

In the robustness tests, I use two alternative measures for financial frictions, the debt ratio and the absolute value of cash-flows. Although both measures may be less reliable for measuring financial frictions than the previous one, both have been used widely in the corporate finance literature (e.g., Whited (1992),Fazzari and Petersen (1993), Cleary et al. (2007)) but also more recently in the international trade and finance literature (e.g. Buch et al. (2009)).

The debt ratio is defined as the ratio of total debt over total assets. Similar to asset tangibility, one can interpret the debt ratio as a measure of a firm to provide collateral, or more generally, the firms ability to obtain a credit. Firms which are highly leveraged ex ante have fewer assets available that can serve as collateral and at the same time are exposed to a higher financial risk and therefore will find it more difficult and/or more costly to obtain a credit. Consequently a higher debt ratio is expected to result in a higher ratio of export to FDI sales. Nevertheless, using the debt ratio as a proxy for financial frictions can be problematical. For example, a higher debt ratio can also result precisely from a firm or an entire sector having easier access to external finance and consequently using a higher level of external finance with lower values, signaling better financial health. For the debt ratio, the average median value of all sectors is 0.533 as can be seen from

[28] Table3.11 in the Appendix B.1 summarizes how firms differ in their endowment with tangible assets

[29] These results are also in line what other papers have found e.g. Braun (2003) or Manova (2009).

column five in Table 3.3, indicating that all manufacturing sectors use a substantial share of external capital for financing their business. This ratio can be as high as 0.704 in the case of the "20: Wood and of products of wood and cork" industry, indicating a high level of leverage in this industry, while other sectors such as the "29: Machinery and equipment n.e.c." industry operate at lower debt ratio levels of 0.464.

Finally, I use the absolute value of cash-flows as a measure for the internal funds available for financing a particular project, reducing the necessity for external capital, and predicting that higher cash-flows result in a higher share of FDI sales. However, cash-flows can be an imprecise measure for financial frictions, since they partly reflect business cycle effects and show a relative high variation across firms and over time. Therefore, cash flows may capture less of an industry specific component compared with the previous measures.[30] One can see that cash flows vary substantially across sectors. While the median firm in some sectors generate high cash-flows, as for the example the "24: Chemicals and chemical products" industry with a median cash flow of around 3 million Euro per year, the average across industry is only 0.842 million Euro. Cash flows also tend to vary substantial over time. For example the median firm in the "35: Other transport equipment" industry generates a cash flow of 0.767 million Euro per year, while the standard deviation over time is 0.468 million Euro. Finally, from the bottom of Table 3.3 one can see that some of the variables are highly correlated with each other. This is not surprising since some of this variables are constructed in a similar way.

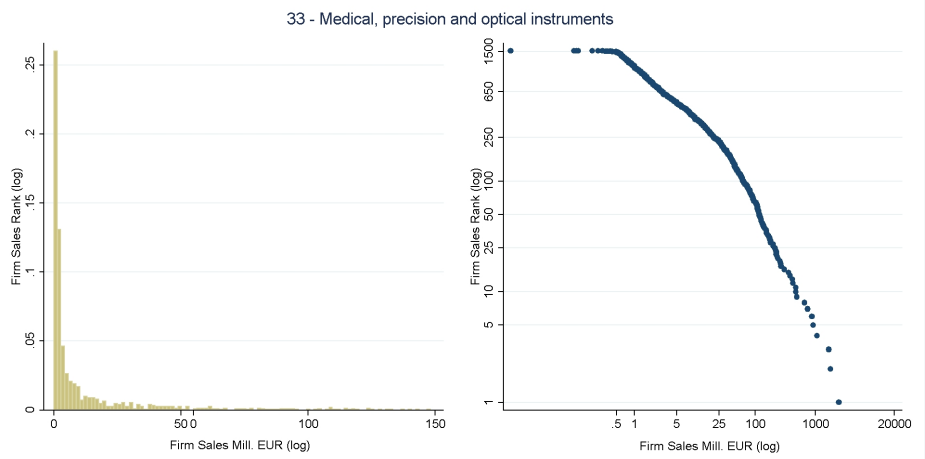
3.3.3 Measure of Firm Dispersion and Proximity Concentration Variables

Another prediction of the model is that within an industry, the ratio of export to FDI sales will be lower if firm level dispersion is higher. This fact was first shown theoretically and empirically by Helpman et al. (2004) for the United States. I

[30]Following Kaplan and Zingales (1997) criticism, there has been a debate on the usefulness of investment-cash flow sensitivities as a measure for financial constraints, dealing with problems arising from endogeneity issues as well as taking into account access to external finance. See also Brown et al. (2009) for a more recent overview of the discussion.

contribute to this literature by replicating the results for Germany. In the model, differences in firm size are reflected by differences in productivity, since more productive firms have a larger market share and higher sales. I assume that firm level productivity is determined by a stochastic process which follows a Pareto distribution, where the shape parameter k of the distribution varies across industries and reflects firm dispersion within a sector.[31] [32] Using this setup one can compute the firm level dispersion of an industry by regressing the logarithm of an individual firm's rank within the distribution on the logarithm the firm's size.[33] Figure 3.2 depicts the distribution of firm operating revenues (left) and plots (log) firm level sales and (log) firm rank sales (right) for the "33: Medical, precision and optical instruments" industry for the year 2005.

Figure 3.2: Distribution of Firm Sales



Notes: Both graphs show the distribution of firm sales within the " 33 Medical, precision and optical instruments industry for the year 2005 ". The left graph is a simple histogram of firm level sales and is truncated to firm sales lower than 150 million Euros for a better illustration of the distribution. The right graph plots the logarithm of an individual firms's rank within the distribution and the logarithm of firm's sales. In the right graph of figure 3.2 the dispersion measure is represented by the slope of the linear regression line, while its goodness of fit is represented by deviations from this line, where a flatter line indicates higher firm dispersion.

[31] Note, that in the model the dispersion of firms also depends on the sector specific elasticity of substitution among products ε.

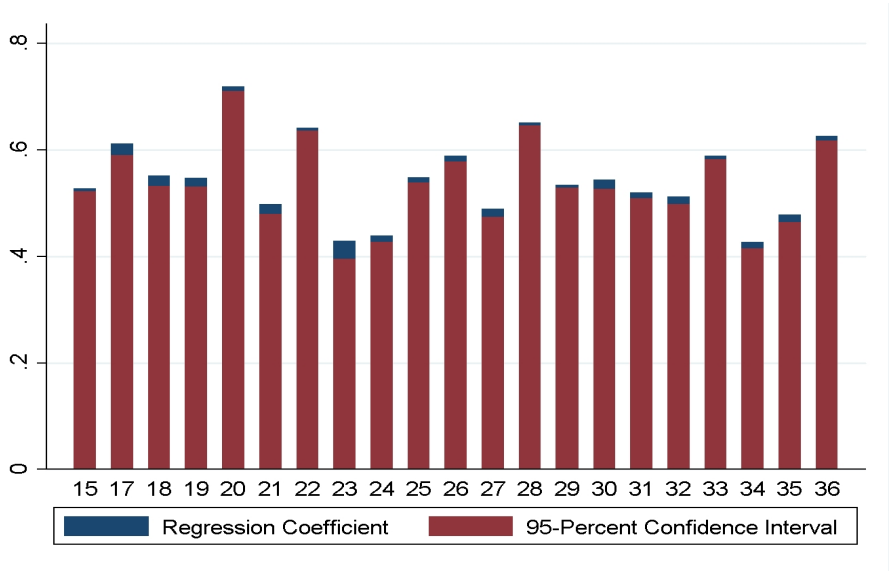
[32] Using the Pareto distribution is in line what other papers have found. See for example Eaton and Kortum (2002), Luttmer (2007) and Growiec et al. (2007).

[33] Under the assumption of a Pareto distribution the estimated parameter of the slope of this regression line is identical to the proposed shape parameter of my model $k-(\varepsilon-1)$. See Axtell (2001) and Helpman et al. (2004) for a detailed discussion.

From the graph one can see that only very few firms have very high levels of turnover and that the distribution of German firm sales fits very well to the assumption of a Pareto distribution.[34] Figure 3.3 summarizes the estimated coefficients and standard errors for the shape parameter for all industries for the year 2005, with lower values indicating a higher firm level dispersion.[35]

While the "24: Chemicals and chemical products" industry shows high level of firm sales dispersion this is less so in other industries, such as "22: Publishing, printing and recorded media". Small estimated standard errors for all industries once more support the idea of using the Pareto distribution as a measure for firm level sales dispersion.[36]

Figure 3.3: Regression Fit to the Pareto Distribution



Notes: The graph summarizes the estimated coefficients for the slope of the Pareto distribution and its standard deviation.

In the theoretical model, the ratio of export to FDI sales is a function of the

[34] The picture looks very similar for all other industries and years.

[35] Alternatively, one can also calculate the standard deviation of log firm sales within one sector, which is computationally equivalent to the previous measure under the assumption of a Pareto distribution, although they sometimes differ slightly in practice. See Helpman et al. (2004) for a detailed discussion. Nevertheless, calculations show a very high correlation of both parameters of 0.97.

[36] Again, the picture looks very similar for all other years.

relative costs of both activities: the fixed costs of FDI, the fixed costs of exporting, and transport costs. Many of these costs are difficult to quantify and data availability is very limited. Since the main focus of this paper is to analyze how financing these costs affects the composition of international commerce, I use a set of sector and country dummies in the empirical analysis to account for these effects in most of the specifications. Nevertheless, the dataset also allows of constructing some proxies for these variables which are described in more detail the following section.

Transport costs can be either for shipping or moving a good from one country to another or due to other barriers created by destination-country specific effects. I take the unweighted average tariffs obtained from the WITS TRAINS database (World Bank (2009)) to proxy for these costs: this has been widely used in the empirical trade literature. One advantage of tariffs is that they vary across industries and countries and hence allow for differences in transport costs across both dimensions. But at the same time other studies have shown that tariffs can also be a poor proxy for trade costs as they may only capture a relatively small part of the overall transport costs. In addition, in my sample, tariffs contain many zeros or low values and also do not exhibit a high variation across time, since many of the largest German trading partners are within the European Union or have free trade agreements with Germany.[37]

As pointed out above, it is very difficult to find adequate measures for fixed costs of exporting and fixed costs of FDI. Both costs are unobserveable and vary across countries and industries. Based on my assumption in the theoretical model that all fixed costs of exporting are also common to the fixed costs of FDI, I control for these common market entry costs in the empirical analysis by using a set of industry and country dummies. While Helpman et al. (2004) only have a cross section dataset, which does not allow them to control for country-sector specific costs simultaneously, I can do this by exploiting the time dimension of my panel dataset.

Since I assume that the fixed costs of exporting are part of the fixed costs of

[37]Another proxy for transport costs is the distance between two countries. However, since I have a panel dataset and distance does not vary across time and industry, this effect is absorbed by the country fixed effect.

FDI, all additional fixed costs of FDI stem solely from the costs of maintaining additional capacity in a foreign country. Therefore, I compute the value of tangible assets per employee at the sectoral level, to proxy for additional plant level fixed costs, which is a novelty in the literature. Although the costs for property, plant and equipment per employee a firm has to acquire in order to set up a new production facility is a plausible proxy for additional plant costs, one potential disadvantage of this measure is that it partly correlates with my measure of financial constraints – asset tangibility – resulting in less precise estimates. Furthermore, this measure may also not be independent of firm size or firm productivity which potentially can bias my estimated coefficient. Again, including industry–country pair dummies can also be used as an effective control variable for these additional fixed plant costs.

3.4 Empirical Evidence: Financial Constraints and the Composition of International Commerce

In the following sections, I first derive an empirical model, that is based on the predictions of the theoretical model described in the previous section. I then estimate in the empirical analysis several variants of this model and test if the predictions of the model are also present in the data.

3.4.1 Empirical Model

Based on the previous analysis, I can directly derive the empirical model, given by the following specification.

$$\begin{aligned} log(Ex/FDI)_{ijs} &= \beta_0 + \beta_1 FinCon_{st} + \beta_2 Disper_{st} + \beta_3 FixPlant_{st} + \\ &\quad \beta_4 Tariffs_{sjt} + \beta_5 X_{ct} + \phi_s + \gamma_j + \delta_t + \varepsilon_{sjt} \end{aligned} \tag{3.18}$$

$(Ex/FDI)_{jst}$ is the ratio of export to FDI sales in partner country j in sector s in year t. $FinConstr_{st}$ represents one of my four measures for financial constraints of an industry as described in the previous section and $Disper_{st}$ measures firm level dispersion within an industry. $FixPlant_{st}$ is the proxy for fixed plant costs

in a given sector, $Tariffs_{sjt}$ reflect country-industry specific trade costs and X_{ct} is a set of time-varying partner country control variables. Industry fixed effects ϕ_s control for systematic differences across sectors that determine the composition of international commerce within an industry. For example if Germany has a comparative advantage in a given industry such as electrical machinery, this may affect the ratio of export to FDI sales, regardless of whether firms in this sector are more or less financially constrained.[38] The industry dummies thus explicitly account for factor endowments and Ricardian determinants of comparative advantage. Country fixed effects γ_j control for partner specific effects including the fixed costs of exporting and other country characteristics such as financial development or the institutional quality of a country. Finally, δ_t represents year fixed effects and captures all effects that countries and industries face in common. The error term ε_{sjt} reflects any omitted factor that affects patterns of the ratio of export to FDI sales.

As pointed out previously, one novelty of this paper is its use of a panel dataset to analyze the composition of international commerce. This has the advantage that it allows of controlling for industry specific effects, eliminating concerns about an omitted variable bias problem, which has been a shortcoming of previous studies. Nevertheless, the dataset also has some limitations which directly affect the empirical strategy employed in the analysis. As pointed out above, Germany is one of the few countries which report detailed FDI sales. Consequently, I am not able to explore cross country variations in financial development to analyze the impact of financial constraints on the composition of exports and FDI sales as other papers have done in the empirical trade and finance literature (e.g., Beck (2003) and Manchin and Pinna (2009)). Based on the setup of the model, I aggregate export and FDI sales to the two digit NACE industry level, rather than using firm level data (e.g., Buch et al. (2009)). Although this way of modeling allows of circumventing potential endogeneity problems, it also limits the number of observations per year, potentially reducing the preciseness of some of the estimates. Due to this limitations, the goal of my empirical analysis is to test whether the central tendencies in the data are consistent with the comparative statics of (3.16)

[38] The same argument also applies for the measure of firm level dispersion.

and evaluating the economic significance of the magnitudes associated with the estimated coefficients.

3.4.2 Empirical Results

I start my analysis with a simple OLS regression of the logarithm of Export sales over FDI sales on my two key measures for financial constraints, liquidity ratio and asset tangibility, and my two alternative measures, cash-flow and debt ratio, and use these estimates as a benchmark for the following analysis. In a further step, I perform a detailed analysis of my two key variables of interest, liquidity ratio and asset tangibility and test the robustness of my results to different specifications and inclusions of other potential explanatory variables. I test if the results are sensitive to the use of cash-flows and the debt ratio as alternative proxies for financial constraints. Finally, I employ an instrumental variable strategy to address problems arising from potential endogeneity bias.

Table 3.4 presents the results for the benchmark model, where the logarithm of export to FDI sales is regressed on each of my four measures of financial constraints and a set of industry and partner-country fixed effects.[39] The estimated coefficients on the various measures for financial frictions all have the expected sign and are statistically significant at the 1% level with the exception of the debt ratio, which has the wrong sign and is insignificant. First results also indicate that the magnitude of the effects also have a sizeable economic effect. Given the specification of the model, a 10% increase in the liquidity ratio (asset tangibility), indicating better financial health of a sector, results in a 7.4% (9.4%) percent decrease of the ratio of export to FDI sales. These results can be seen as initial evidence of the impact of financial constraints on the ratio of export to FDI sales and serve as a starting point for the following analysis.

Since in the first regression I do not attempt to control for any other variables that might affect the trade-off between exporting and FDI this precludes any structural interpretation of the coefficients, as they may reflect other effects that

[39]One may also want to include all four different measures of financial constraints into a single regression model. But since some of them are constructed in a similar way, this may cause problems due to collinearity issues as can also be seen from the bottom of Table 3.3.

determine the ratio of exports and FDI sales.

Table 3.4: Export versus FDI Sales and Financial Constraints - Baseline Specification

Dependent variable: $log(Ex/FDI)_{ijs}$				
	(1)	(2)	(3)	(4)
Liquidity ratio	–0.741			
	(–4.27)***			
Asset tangibility		–0.940		
		(–4.20)***		
Cash flow			–0.250	
			(–2.96)***	
Debt ratio				–0.098
				(–0.17)
Industry, country FE	Yes	Yes	Yes	Yes
Observations	2,163	2,163	2,163	2,163
R^2	0.509	0.509	0.507	0.505

Notes: The dependent variable is defined as the (log) ratio of Export sales over FDI sales from country *j* to country*i* in a two-digit NACE sector *s* in year *t*, 2002 - 2007. Liquidity ratio, Asset tangibility, Cash flow and Debt ratio are defined in the text. All regressions include a constant term, sector fixed effects and importer fixed effects. Errors are clustered at the industry level. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

Table 3.5 reports more detailed results for the liquidity ratio, which is my primary measure for the availability of internal funds to a firm. In column (1) I include the measure for firm level dispersion, fixed plant costs and tariffs. I also include a set of partner-country fixed effects to control for market size and fixed market entry costs in the destination country. Standard errors are clustered at the industry level to allow for correlated idiosyncratic shocks at the industry level.[40][41]

First, consider the results for the traditional proximity-concentration vari-

[40]Moulton (1990) shows in his influential work, how ignoring the correlation of the disturbances in grouped panel data may lead to seriously downward biased estimates of the standard error. If this is the case results can be misleading.

[41]Similar results are obtained under clustering at the country level instead.

ables. The estimated coefficients for the proxy of fixed plant costs and tariffs have the correct sign and are statistically significant. High transportation costs and low fixed plant costs tend to attract more FDI as predicted by the model. Overall, these results support the idea of the proximity-concentration trade-off first studied by Brainard (1997). Next, consider the effects for firm dispersion. The estimated coefficient is negative and significant in all four specifications, although their magnitudes are somewhat smaller compared with the estimates obtained by Helpman et al. (2004). German industries in which firm size is highly dispersed show lower ratios of export sales relative to FDI sales, since a larger number of firms within these industries find it more profitable to serve foreign markets via FDI. This result was first established by Helpman et al. (2004) for the U.S. and my results confirm that this is also true for German industries.

To control for industry specific effects, I include a set of industry fixed effects in column (2). While the coefficient for tariffs remains nearly unchanged, the proxy for fixed plant costs is now reduced and no longer significant. Similarly, the coefficient for firm dispersion also decreases and now is significant at the 5% level. This is not surprising since the industry fixed effects capture part of the variation in the data. More importantly, the point estimate and significance level for the liquidity ratio are increasing in this specification, emphasizing the importance of controlling for industry fixed effects.

I include a set of other potentially explanatory variables at the country level, that may affect the decision of a firm whether to export or set up an affiliate in the destination market, which are not captured by the partner-country fixed effects. Results are reported in column (3). I include a measure for the development of the financial system in a country to control for the effect that firms may take advantage of a good financial system and raise external capital in the destination market to finance their multinational activity. I also include a variable for the rule of law to control for the overall quality of the institutional environment and political risk in a country, since previous studies have shown that this affects the strategy of multinational firms (e.g. Kesternich and Schnitzer (2010)). Finally, I add GDP per capita to control for the overall development of the partner economy. While my estimates for tariffs and fixed plant costs are nearly unchanged compared with the results from the previous estimation, the coefficient for firm level dispersion

Table 3.5: Export versus FDI Sales - Liquidity Ratio

Dependent variable: $log(Ex/FDI)_{ijs}$					
	(1)	(2)	(3)	(4)	(5)
Liquidity ratio	–0.301	–0.714	–0.523	–0.847	–0.267
	(–1.87)***	(–2.34)***	(–1.95)*	(–2.27)***	(–1.89)*
Firm dispersion	–1.562	–.938	–2.848	–1.272	–2.497
	(–4.84)***	(–1.80)**	(–2.22)**	(–0.83)	(–2.27)**
Fixed plant	0.377	0.137	0.035	0.119	0.013
	(4.87)***	(0.90)	(0.20)	(0.60)	(0.09)
Tariffs rate	–0.017	–0.015	–0.016	–0.070	0.003
	(–3.98)***	(–3.71)***	(–2.75)***	(–4.18)***	(1.72)*
Rule of law			–0.0402		
			(–0.48)		
Financial dev.			0.952		
			(3.81)***		
GDP per capita			1.123		
			(2.13)**		
Industry FE	No	Yes	Yes	Yes	No
country FE	Yes	Yes	Yes	Yes	No
Industry-country FE	No	No	No	No	Yes
Time FE	No	No	No	No	Yes
Observations	2,142	2,142	1,742	1,336	2,142
R^2	0.323	0.519	0.472	0.565	0.929

Notes: The dependent variable is defined as the (log) ratio of Export sales over FDI sales from country j to country$i$ in a two-digit NACE sector s in year t, 2002 - 2007. Liquidity ratio and Firm dispersion are as defined in the text. All other variables are defined in Table 3.12. Errors are clustered at the industry level. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

is increased and significant at the 5% level. For the development of the country and the quality of the financial system, I obtain positive and highly significant estimates, while the coefficient for the institutional environment is negative, but not significant. These results are counterintuitive, since one would expect that a better economic development and easier access to external capital in the destination country will have a stronger effect on FDI than on exporting. However, it can be easily the case that these variables also capture other, more general factors, not controlled for in this specification. Finally, consider the estimated coefficient for the liquidity ratio. In this specification the effect is slightly reduced and significant at the 10% level only.

As another robustness check, I test whether my results depend on the country selection in my sample. In the previous analysis I used the full set of countries. This full sample also includes some less developed and transition economies, especially from Eastern Europe. In these economies at least part of the FDI is of a vertical nature where firms explore factor endowment differences across countries to optimize their production process.[42] These effects are not embraced by my model, which solely focuses on horizontal FDI and consequently can affect the consistency of the empirical model.[43] In addition, if part of the produced goods of an affiliate are exported to various countries along the supply chain this may cause correlations of the residuals across countries, even after controlling for country fixed effects. Therefore, I follow Brainard (1997) and Helpman et al. (2004) and rerun the regression for a smaller sample only including the largest countries to mitigate these effects.[44] As can be seen from column (4) the estimated coefficient for tariffs has increased, while the the proxy for fixed plant costs is still insignificant. Additionally, the point estimate for firm dispersion is higher compared with my estimates of the full sample in column (2) but now is not significant. This is not surprising, given the reduced number of observations.[45] These results support the idea that especially for horizontal FDI the proximity-concentration trade-off

[42] See, for example, Helpman (1984) and Yeaple (2003).

[43] See Buch et al. (2005) for a survey of the composition of German FDI.

[44] See Appendix 3.9 for a list of the two country samples.

[45] Note, that the measures for firm level dispersion and financial frictions only vary along the industry and time dimension but not at the partner country level as the measures for the proximity-concentration variables do.

and firm level dispersion are important determinants, but that this is less the case for vertical FDI. The estimated coefficient for the liquidity ratio does not change much, indicating that there is no differential effect of financial frictions between vertical and horizontal FDI. This is not surprising, since one can easily think of a similar effect of financial frictions for financing vertical FDI.

So far I have used partner-country and industry fixed effects, but have not exploited the full structure of the panel dataset. Therefore, I include a combination of country-industry fixed effects and time fixed effects in the following specification. For example, this enables the generalization of the assumption of common fixed costs at the country level to the more flexible assumption of an industry-country pair specific structure of the fixed costs of exporting. If both types of dummy variables are included in the estimation, the system is solely identified by the time variation of the data. While this on the one hand furthermore reduces concerns about potential omitted variable bias problems, it also strongly reduces the variation in the data to identify the effect of financial constraints on export and FDI sales.[46] Results are shown in column (5). Similar to previous results, the estimated coefficient for the fixed plant costs is not significant. The estimated coefficient for tariffs is now lower and significant at the 10% level. This can be attributed to the effect of including both, country-industry and time dummies, as they capture most of the variation of tariffs, which varies along these two dimensions but exhibits a relatively low variation over time. At the same time, the point estimate and significance of the firm level dispersion measure increases and is significant at the 5% level, further underlining the importance of firm heterogeneity for explaining the ratio of exports to FDI sales. For the liquidity ratio the following result is obtained. Both, the point estimate and significance level for the liquidity ratio decrease and is now significant at the 10% level only. These results indicate that my previous estimates were not misspecified and the availability of internal funds is an important factor in explaining the ratio of export to FDI sales.

In the following analysis, I re-estimate the model but now using asset tangibility as my key measure for financial constraints. Results are presented in Table 3.6.

[46]This effect can also been seen in the strong increase of the R^2 from 0.5 to 0.9, which can be mainly attributed to the increased information explained by the fixed effects.

I follow the previous analysis and in the first step include a set of partner-country fixed effects and my other explanatory variables, tariffs, fixed plant costs and firm dispersion. As can be seen from column (1), I obtain similar estimates in terms of magnitude and significance for all additional explanatory variables compared with my previous estimates in column (1) in Table 3.5. The estimated coefficient for asset tangibility has the correct sign as predicted by the theoretical model and is significant at the 5% level. I add industry fixed effects to the model in column (2). In this specification, as well the point estimate as the significance level for asset tangibility increases, once more highlighting the importance of including industry fixed effects. The estimates for all other variables are nearly identical to the one obtained in the previous analysis in Table 3.5. Next, I include a set of additional explanatory variables at the country level in column (3). Most interestingly, the estimated coefficient for asset tangibility is slightly reduced but still negative and highly significant, while the results for all other parameters are in line with the similar specification in Table 3.5 in column (3). Finally, I use the smaller set of countries in column (4) and include a combination of country-industry and time fixed effects in column (5). Again, my estimates for all other explanatory variables are similar if compared with the corresponding results in Table 3.5. In column (4) the point estimate for asset tangibility[47] is higher and still significant at the 1% level. However, in column (5) I obtain a negative, but borderline insignificant effect for asset tangibility, which can be explained by the inclusion of a combination of country-industry and year fixed effects. These results further support the hypothesis that the availability of tangible assets is an important source for acquiring external finance and thereby has an effect on the composition of export and FDI sales.

Besides the qualitative results of the estimates, another question focuses on whether financial constraints have an economic sizeable effect on the composition of export to FDI sales. For example, according to my estimates for the full specified model (column (3) in Table 3.5 and 3.6), a 10% increase of the liquidity ratio (asset tangibility) implies a reduction of the ratio of export to FDI sales by 5.23% (6.36%). For example, the model predicts that improving the liquidity

[47]The coefficient significant at the 13% level.

Table 3.6: Export versus FDI Sales - Asset Tangibility

Dependent variable: $log(Ex/FDI)_{ijs}$					
	(1)	(2)	(3)	(4)	(5)
Asset tangibility	–0.260	–0.888	–0.636	–0.849	–0.297
	(–3.50)**	(–2.52)***	(–2.39)***	(–2.60)***	(–1.56)
Firm dispersion	–1.283	-0.766	–2.596	-0.933	–2.749
	(–3.58)***	(-1.88)*	(–2.05)**	(–0.82)	(–2.63)***
Fixed plant	0.276	–0.005	0.059	–0.005	–0.025
	(2.55)**	(–0.03)	(0.33)	(–0.00)	(–0.19)
Tariff rate	–0.017	–0.016	–0.016	–0.069	0.002
	(–3.86)***	(–3.82)***	(–2.75)***	(–4.13)***	(1.38)
Rule of law			–0.045		
			(–0.54)		
Financial dev.			0.987		
			(4.00)***		
GDP per capita			1.200		
			(2.16)**		
Industry FE	No	Yes	Yes	Yes	No
country FE	Yes	Yes	Yes	Yes	No
Industry-country FE	No	No	No	No	Yes
Time FE	No	No	No	No	Yes
Observations	2,142	2,142	1,742	1,336	2,142
R^2	0.318	0.519	0.565	0.472	0.928

Notes: The dependent variable is defined as the (log) ratio of Export sales over FDI sales from country j to country i in a two-digit NACE sector s in year t, 2002 - 2007. Asset tangibility and Firm dispersion are as defined in the text. All other variables are described in Table 3.12. Errors are clustered at the industry level. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

ratio (asset tangibility) in the "33: Radio, television, communication equipment" from 0.153 (0.429) to 0.180 (0.514) results in a decrease of the export to FDI ratio from 4.310 to 3.879 (3.766). Furthermore it is interesting to compare the results obtained for the financial friction variables with the estimates for the traditional explanatory variables. Therefore I compute the standardized beta coefficients as shown in Table 3.13 in the Appendix B.1.[48] The calculations show that the effect of financial frictions is of similar magnitude as for other variables, e.g., tariffs or firm level dispersion. Hence, the results suggest that beside the traditional determinants on the trade-off between exports and FDI, financial frictions also have a sizeable economic effect.

To test whether my results are robust to different measures for financial frictions, I use cash-flows and the debt ratio as alternative proxies for financial frictions. Similar to asset tangibility and liquidity ratio, the debt ratio proxies for the ability of a firm to obtain external credit and cash-flows measures the availability of internal funds to a firm. Results are presented in Table 3.7. The first two columns show results using the debt ratio and column (3) and (4) report estimates for cash-flows. While I obtain a positive and at the 5% level significant estimate for the debt ratio in the first specification (column(1)), the coefficient is still positive but not significant once industry fixed effects and additional control variables at the partner-country level are included (column(2)). As a final robustness check, I use cash-flows as an alternative measure for the availability of internal funds to a firm. In the reduced specification without industry fixed effects and additional partner-country control variables, the estimated effect is positive and highly significant as predicted in the manner of the model as can be seen in column (3). However, once the full set of controls is included, both the magnitude and the significance of the coefficient is reduced (column (4)). Again, in all four specifications, the estimates for my measure of firm level dispersion and the proxies for the proximity-concentration trade-off are similar in magnitude and significance if compared with the previous results in Table 3.5 and Table 3.6. Overall, these findings further support the prediction that financial constraints affect the composition

[48] A beta coefficient is defined as the product of the estimated coefficient and the standard deviation, divided by the standard deviation of the dependent variable. See, Wooldridge (2009) for a detailed discussion.

of export to FDI sales, although the results are more tentative if the debt ratio is used as a proxy for financial constraints. Furthermore, both variables capture less of an industry specific component as discussed in section 3.3 and hence results in this case have to be interpreted with more caution.

Table 3.7: Export versus FDI Sales and Financial Constraints - Robustness

Dependent variable: $log(Ex/FDI)_{ijs}$				
	(1)	(2)	(3)	(4)
Debt ratio	0.163**	0.184		
	(2.16)	(1.30)		
Cash flow			–0.308	–0.159
			(–4.53)***	(–1.67)*
Firm dispersion	–1.751	–2.683	–3.193	–2.311
	(–4.97)***	(–2.11)**	(–6.45)***	(–1.78)*
Fixed plant	0.463	0.042	0.270	0.063
	(7.69)***	(0.24)	(3.54)***	(0.37)
Tariff rate	–0.018	–0.017	–0.018	–0.016
	(–4.11)***	(–2.75)***	(–4.25)***	(–2.79)***
GDP per capita		1.289		1.100
		(2.59)***		(2.14)**
Rule of law		–0.047		–0.031
		(–0.57)		(–0.38)
Financial dev.		1.015		1.020
		(4.19)***		(4.21)***
Industry FE	No	Yes	No	Yes
country FE	Yes	Yes	Yes	Yes
Observations	2,163	1,742	2,163	1,742
R^2	0.310	0.471	0.317	0.472

Notes: The dependent variable is defined as the (log) ratio of Export sales over FDI sales from country j to country$i$ in a two-digit NACE sector s in year t, 2002 - 2007. Cash flow and Debt ratio and Firm dispersion are as defined in the text. All other variables are defined in Table 3.12. Errors are clustered at the industry level. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

3.4.3 IV-Estimation

The final robustness check addresses the concern about a potential endogeneity bias for the measures of financial frictions. While the model predicts a causal effect of financial constraints on the composition of international commerce, one might also argue that the status of exporting or engaging in FDI also affects the financial condition of a firm or a sector respectively. For example a firm or sector with a high share of FDI may generate higher revenues than a firm or sector with high export shares, implying better financial conditions for the former one: this generates concerns about a reverse causality effect in the empirical model.[49] In this case, OLS estimates are inconsistent. To address this problem, I implement an instrumental variable strategy which allows for taking into account such effects. Using an instrumental variable approach also has the advantage that it allows for controlling for measurement errors simultaneously.

An appropriate instrument has to identify the variation in the observed ratio of export to FDI sales at the sectoral level that is exogenous to the proposed measures of financial frictions. Therefore it has to satisfy two conditions. First, it must be correlated with the measure of financial constraint. Second, it must fulfill the exclusion restriction, that is, it must not be correlated with the error term of the equation of interest.

In the following estimations, I will use data on financial constraints of French firms as an instrument for the measure of financial constraints, where the variables for French firms are constructed in exactly the same way as for German firms. Using data of French firms is motivated by two facts: First, France is a country of similar size and economic development and therefore the industry structure and composition of firms within an industry is comparable. Second, data for French firms are also available from the AMADEUS database provided by the Bureau von Dijk (2005), ensuring comparability of the definitions of the variables of interests.[50] However, due to the substantial differences in data availability of cash

[49] See, Manova (2009) and Greenway et al. (2007) for a discussion in the case of exporting and Buch et al. (2009) in the case of FDI.

[50] Helpman et al. (2004) have used the same strategy to identify the effect of firm heterogeneity on the ratio of export to FDI sales.

flows for German and French firms across years and sectors and the ambiguous results for the debt ratio in the previous analysis, I apply the instrumental variable strategy only to the variables liquidity ratio and asset tangibility.

While the first assumption on the relevance of the instruments can be tested, we have to assume that the second assumption on the exclusion restriction holds in the empirical model. Since France is the largest trading partner of Germany and both economies are highly integrated. Consequently one may argue that if German firms are less financially constraint they may have higher exports and/or FDI sales in the French market, implying tougher competition in this market, resulting in lower profits for French firms, thus affecting their financial structure.[51] This may violate the exclusion restriction. Nevertheless, given the setup of the model and the assumption that financial constraints carry a large technological component across countries, which is also in line what the prior literature has found, I assume that this condition holds in all specifications.[52]

The results of the instrumented variable specifications are shown in Table 3.8. Columns (1) to (4) show results for the first and second stage estimation for the full sample, including all countries, and columns (5) to (8) show results for the first and second stage estimation if the narrow sample is used. From columns (1) and (3) one can see that in both estimations the coefficient for the instrumental variable is highly significant and has the expected sign in the full sample case. In addition I also use an F-test to check the relevance of the instruments in the first stage regression. In both cases the value of the F-test exceeds 10, confirming the relevance of the instrumental variables in the first stage estimation and reducing concerns of a potentially weak instrument. The high positive correlation between the measures of financial frictions across countries also supports the idea of a common technological component at the industry level. From columns (2) and (4) one can see that in the second stage estimation for the full sample both variables remain significant and have the predicted sign. In both estimates the significance level of the measure for financial frictions is reduced, as is usual when an instrumental variable strategy is applied. For the liquidity ratio the estimated

[51] This argument can also be made in the other direction.

[52] See Rajan and Zingales (1998), Classens and Laeven (2003) and Manova (2009) among others.

Table 3.8: Export versus FDI Sales and Financial Constraints - Instrumental Variable Specification

	Wide sample				Narrow sample			
Dependent variable:	(log) Liqu. ratio (GER)	(log) $(Ex/FDI)_{ijs}$	(log) Asset tang.(GER)	(log) $(Ex/FDI)_{ijs}$	(log) Liqu. ratio (GER)	(log) $(Ex/FDI)_{ijs}$	(log) Asset tang.(GER)	(log) $(Ex/FDI)_{ijs}$
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity ratio (FRA)	0.182	–0.624			0.235	–0.599		
	(2.59)***	(–1.72)*			(2.42)***	(–1.59)		
Asset tangibility (FRA)			0.553	–0.216			0.499	–0.181
			(18.77)***	(–1.93)***			(12.81)***	(-1.65)*
Firm dispersion	–1.087	–1.615	0.700	–3.775	–0.969	–1.793	0.743	–1.449
	(–7.10)***	(–1.77)*	(8.36)***	(–1.66)*	(–5.38)	(–1.90)*	(7.03)***	(–0.93)
Fixed plant	–0.045	.005	0.081	0.321	-0.013	0.037	0.089	0.348
	(–0.27)	(0.03)	(5.26)***	(1.67)*	(-0.70)	(0.17)	(4.79)***	(1.35)
Tariff rate	0.002	–0.001	0.002	–0.015	0.002	-0.007	0.002	–0.006
	(2.81)***	(–2.01)***	(0.76)	(–3.60)***	(2.81)***	(–3.97)***	(0.19)	(–4.13)***
Industry, country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,142	2,142	2,142	2,142	1336	1336	1,336	1,336
Adj. R^2	0.784	0.336	0.965	0.509	0.789	0.416	0.978	0.558
F-value	18.49		52.74		16.03		41.74	

Notes: The dependent variable is defined as the (log) ratio of Export sales over FDI sales from country j to country$i$ in a two-digit NACE sector s in year t, 2002 - 2007. Asset tangibility, Liquidity ratio and Firm dispersion are as defined in the text. Liquidity ratio (FRA) and Asset tangibility (FRA) are used as instruments for Asset tangibility (GER) and Asset tangibility (GER) respectively. All other variables are described in Table 3.12. Errors are clustered at the industry level. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

effect only slightly decreases from –0.714 to –0.624, while for asset tangibility the estimated coefficient decreases more strongly from -0.888 to -0.216 compared with the corresponding estimates in Table 3.5 and Table 3.6.[53] For most of the other variables the obtained results are in line with previous findings, although some of them differ slightly in magnitude and also are sometimes less significant (e.g. firm dispersion). I obtain similar results in terms of magnitudes when using the smaller sample of countries. However, given the reduced number of observations, the significance for some variables is lower. For the liquidity ratio I obtain nearly the same coefficient, but it is now marginally insignificant, while asset tangibility also has nearly the same estimated effect, but now is also only significant at the 10% level. Since my approach is limited to testing whether the central tendencies of the predictions of the model hold, these results further support the previous findings.

3.5 Conclusion

This paper analyzed theoretically and empirically how financial frictions affect the composition of multinational firm sales. I developed a model of heterogenous firms where firms can either choose to serve foreign markets via exporting or via horizontal foreign direct investment (FDI). In order to finance their multinational activity, firms need to raise external capital to finance the fixed costs of exporting and FDI. Due to the existence of information asymmetry and uncertainty about future revenues, firms have to pay an interest rate to the investor, which is higher in the case of FDI, given the higher credit required and associated risk of setting up an affiliate in a foreign country. Due to distortions in the financial market, the model predicts that the fraction of firms which choose to serve foreign markets via FDI rather than exporting is higher in financially vulnerable sectors.

I constructed a panel dataset for the period from 2002 to 2007 using German firm-level data for 26 manufacturing sectors and 38 partner countries. The empir-

[53] Determining the exact sign of the bias in this setup is not straightforward, since in equilibrium, French firms exporting to Germany at the same time may affect financial health of Germany firms and industries.

ical analysis showed that sectors which are less financially constrained, measured as a higher liquidity ratio and/or a higher share of tangible assets, have a lower ratio of export to FDI sales, as predicted by the model. This finding is robust to several extensions of the empirical analysis. My estimates suggest that financial barriers have an explanatory power similar to the traditional explanations of multinational firm sales. However, when using the debt ratio and absolute value of cash-flow as alternative measures to capture the effect of credit constraints, the results tend to be more tentative.

One broader implication of my analysis is that financial frictions determines the overall activity of multinational firms in a country and is an important determinant of the composition of export and FDI sales at the sectoral but also at the country level. Therefore, improving access to external finance for firms through the development and design of adequate financial institutions has a broader impact on the overall structure of a country acting in a integrated world economy.

This paper is one of the first studies analyzing the effect of financial frictions on multinational firm activity, in form of exporting and FDI, jointly, and leaves open several questions for future research. While the effect of financial frictions on exporting has received substantial interest in the literature over the last years, we still know relatively little about the effect of financial frictions on FDI, especially at the microeconomic level. Using datasets with detailed firm level information will further help to improve our understanding how firms choose their multinational strategy when facing financial constraints.

B Appendices to Chapter 3

B.1 Data and Descriptives

Table 3.9: List of Countries

AUT	Austria*	KOR	Korea, Rep.*
ARG	Argentina*	MYS	Malaysia
AUS	Australia*	MEX	Mexico*
BEL	Belgium*	NLD	Netherlands*
BRA	Brazil*	NZL	New Zealand*
CAN	Canada*	NOR	Norway*
CHL	Chile*	POL	Poland
CHN	China	PRT	Portugal
CZE	Czech Republic	ROM	Romania
DNK	Denmark*	SGP	Singapore*
FIN	Finland	ZAF	South Africa*
FRA	France*	ESP	Spain*
GRC	Greece	SWE	Sweden*
HKG	Hong Kong, China*	CHE	Switzerland*
HUN	Hungary	TWN	Taiwan, China*
IDN	Indonesia	THA	Thailand*
IRL	Ireland*	UKR	Ukraine
ISR	Israel	GBR	United Kingdom*
ITA	Italy*	USA	United States*
JPN	Japan*		

Notes: *Indicates Narrow sample

Table 3.10: Summary Statistics - Balance Sheet Data

Variable	Obs.	Mean	Median	Std. Dev.	Min	Max
Assets						
Intangible fixed assets (in th. EUR)	9,463	3,138	16	83,579	0	7,001,000
Tangible fixed assets (in th. EUR)	9,479	15,938	1,211	198,733	0	12,258,000
Other fixed assets (in th. EUR)	9,368	29,799	2	652,005	-44	41,145,000
Current assets (in th. EUR)	9,292	46,770	4,440	605,059	0	35,604,000
Cash and cash equivalent (in th. EUR)	9,275	6,563	170	149,856	-25	10,705,000
Total Assets (in th. EUR)	9,498	95,206	7,025	130,1856	0	63,604,000
Liabilities						
Shareholder funds (in th. EUR)	9,498	32,830	1,421	426,773	-291	20,513,000
Long Term debt (in th. EUR)	9,495	15,374	889	212,961	-213	15,235,000
Other non current liabilities (in th. EUR)	9,497	22,467	673	388,326	-5	21,648,000
Current liabilities (in th. EUR)	9,292	25,085	638	433,611	0	26,543,000
Total shareholder funds and liabilities (in th. EUR)	9,498	95,206	7,025	1,301,856	0	63,605.000
Employees	16,815	203	25	2,098	1	152,408
Cash-flow	8,427	6,473	3,490	83,506	-161	4,253,000
Operating revenue	24,173	54,724	471	856,899	0	65,379.000

Notes: Data stem from the AMADEUS databank published by Bureau van Dijck Electronic Publishing (2005) and represent German firms for the year 2005.

Table 3.11: Summary Statistics - Average Balance Sheet Data

Variable	All Firms	Asset tangibility		Liquidity ratio	
		high	low	high	low
Assets					
Intangible fixed assets	1.84%	1.46%	2.23%	1.42%	2.31%
Tangible fixed assets	25.48%	42.32%	8.08%	18.02%	33.80%
Other fixed assets	5.16%	3.15%	7.24%	3.32%	7.24%
Current assets	67.21%	53.25%	82.50%	77.29%	56.78%
Cash and cash equivalent	9.13%	6.42%	11.94%	12.40%	5.44%
Liabilities					
Shareholder funds	24.26%	24.03%	24.50%	30.86%	16.34%
Long Term debt	32.43%	36.80%	27.91%	40.61%	23.43%
Other non current liabilities	15.37%	12.92%	17.90%	18.39%	11.86%
Current liabilities	28.54%	73.14%	30.30%	10.54%	48.40%

Notes: This table presents average balance sheets using data from the AMADEUS databank published by Bureau van Dijck Electronic Publishing (2005) and represents German firms for the year 2005. The different lines are calculated as the percentage of the book value of total assets and total liabilities. The first column shows results for all firms in the data, while column two (four) and three (five) depict the ratios for low and high values of tangible assets (liquidity ratio). I calculate the average of all firms below and above the median firm of all firms in the sample to differentiate between firms with low or high asset tangibility (liquidity ratio).

Table 3.12: Data Description

Variable	Definition and Source
	Industry-level data
Liquidity ratio	(Current assets - Current liabilities)/Total assets (Source: AMADEUS database provided by Bureau van Dijck Electronic Publishing (2005))
Asset tangibility	Tangible assets / Total assets (Source: AMADEUS databse, Bureau van Dijck (2005))
Cash flow	Cash flow from operations (Source: AMADEUS databse, Bureau van Dijck (2005)))
Debt ratio	Total debt / Total assets (Source: AMADEUS databse, Bureau van Dijck (2005))
Operating revenue	Turnover + adjustments (Source: AMADEUS databse, Bureau van Dijck (2005))
Fixed plant costs	Tangible assets / employee (Source: AMADEUS databse, Bureau van Dijck (2005))
Tariffs	Effectively applied import tariff rate in % (weighted industry average) (Source: WITS TRAINS database, World Bank (2009))
Exports	Aggregated exports of all German firms in sector s in host country c (Source: COMTRADE database, Eurostat (2010)))
FDI sales	Aggregated turnover of all German affiliates in sector s in host country c (Source: MIDI databse, Deutsche Bundesbank (2011))
	Country-level data
GDP per capita	Source: Host country for GDP per capita ("cgdp") in constant USD from Penn World Tables 7.0. Source: Penn World Tables 7.0.
Financial development	Financial development is measured as the natural log of private credit by banks and other financial institutions to the private sector as a share of GDP. Source: Beck et al. (2000)
Institutions	Is an index that measures the extent to which agents have confidence in the quality of contract enforcement, property rights and courts. The index ranges from 0 to 10. Source: Kaufmann et al. (2007)

*Notes:*This is table reports the definition and source for all variables used in the empirical analysis.

Table 3.13: Export versus FDI Sales Financial Constraints - Economic Significance

Variable	Mean	Std. Dev.	Coeff.	"Beta"
Ex FDI	0.37	1.18		
Liquidity ratio	–0.94	0.22	–0.71	–0.13
Asset tangibility	–1.62	0.26	–0.88	–0.19
Cash flow	6.48	0.63	–0.30	–0.16
Debt ratio	–0.59	0.12	0.16	0.02
Tariff rate	3.39	6.25	0.02	0.11
Fixed plant	3.20	0.53	0.37	0.17
Firm dispersion	0.57	0.08	–2.84	–0.19

Notes: "Beta" coefficient are calculated as the product of the estimated coefficient for the independent variable and its standard deviation, divided by the standard deviation of the dependent variable. Calculations are based on estimates in column (2) of Table 3.5 and 3.6 and column (1) and (3) of Table 3.7. In the case of fixed plant costs calculations are based on column (1) in Table 3.5.

B.2 Mathematical Appendix

Derivation of profits

In the case of exporting the firms maximization problem is given by:

$$max\ \pi_x^{nis}(a) \quad = \quad p_{is}(a)q_{is}(a) - q_{is}(a)\tau_{ni}a - f_x^{ni} \tag{3.19}$$

$$s.t.\ q_{ns}(a) \quad = \quad \frac{p_{ns}(a)^{-\varepsilon}\Theta_s Y_n}{P_{ns}^{1-\varepsilon}} \tag{3.20}$$

Firms set prices to maximize profits. The first order conditions that follow from 3.19 and 3.20 are given by:

$$\frac{\delta \pi_x^{nis}(a)}{\delta p_{is}(a)} = (1-\varepsilon)\frac{p_{is}(a)^{-\varepsilon}\Theta_s Y_n}{P_{ns}^{1-\varepsilon}} - (-\varepsilon)\frac{p_{is}(a)^{-\varepsilon-1}\Theta_s Y_n}{P_{ns}^{1-\varepsilon}}\tau_{ni}a = 0 \tag{3.21}$$

Rearranging yields the optimal price:

$$p_{ns}(a) = \frac{\tau_{ni}a}{\alpha} \tag{3.22}$$

Plugging 3.22 into 3.19 results in the optimal quantity sold:

$$q_{ns}(a) = \left(\frac{\tau_{ni}a}{\alpha}\right)\frac{\Theta_s Y_n}{P_{ns}^{1-\varepsilon}} \tag{3.23}$$

Finally, inserting 3.22 and 3.23 into 3.19 and rearranging gives us the maximal profits in case of exporting:

$$\pi_x^{nis} \quad = \quad (\tau_{ni}a)^{1-\varepsilon}D^{is} - f_x^{ni} \tag{3.24}$$

In the case of FDI optimal profits in country i can be expressed as:

$$\pi_{di}^{nis} \quad = \quad a^{1-\varepsilon}D^{is} - f_{di}^{ni} \tag{3.25}$$

where, $D_{is} = (1-\alpha)\left(\frac{1}{\alpha P_{is}}\right)^{1-\varepsilon}\Theta_s Y_i$.

Proof of Proposition 1:
From 3.16 it is straightforward to see that:

$$\frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial f_{ex}^{ni}} < 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial f_{di}^{ni}} > 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial \tau} < 0$$

$$\frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial(f_{di}^{ni}-f_{ex}^{ni})} > 0 \quad \frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial(k-(\varepsilon-1))} > 0$$

Next, consider the case of a change in the dependence on external finance d_s:

$$\begin{aligned}
\frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial d_s} &= \frac{f_{ex}^{ni}-f_{di}^{ni}+r_{di}^{s}f_{di}^{ni}-r_{x}^{s}f_{ex}^{ni}}{(\tau_{ni}^{\varepsilon-1}-1)((1-d_s)f_{ex}^{ni}+d_s f_{ex}^{ni}r_x^s)} - \\
&- \frac{(f_{ex}^{ni}r_x^s-f_{ex}^{ni})((1-d_s)(f_{di}^{ni}-f_{ex}^{ni})+d_s(f_{di}^{ni}r_{di}^{s}-f_{ex}^{ni}r_x^s))}{(\tau_{ni}^{\varepsilon-1}-1)((1-d_s)f_{ex}^{ni}+d_s f_{ex}^{ni}r_x^s)^2} \\
&= \frac{f_{di}^{ni}(r_{di}^{s}-r_x^s)}{f_{ex}^{ni}(\tau_{ni}^{\varepsilon-1}-1)(1+d_s(r_x^s-1))^2} > 0
\end{aligned}$$

Finally, consider the derivative for a change in the sector specific interest rate $r_{di,x}^{s}$ with $r_{di}^{s} = \eta r_x^s$ and $\eta > 1$:

$$\begin{aligned}
\frac{\partial(s_{ex}^{nis}/s_{di}^{nis})}{\partial r_{di,x}^{s}} &= \frac{d_s(f_{di}^{ni}\eta-f_{ex}^{ni})}{((1-d_s)f_{ex}^{ni}+d_s f_{ex}^{ni}r_x^s)(\tau_{ni}^{\varepsilon-1}-1)} - \\
&- \frac{d_s f_{ex}^{ni}((1-d_s)(f_{di}^{ni}-f_{ex}^{ni})+d_s(f_{di}^{ni}i_x^s\eta-f_{ex}^{ni}r_x^s))}{((1-d_s)f_{ex}^{ni}+d_s f_{ex}^{ni}r_x^s)^2(\tau_{ni}^{\varepsilon-1}-1)} \\
&= -\frac{(d_s-1)d_s f_{di}^{ni}(\eta-1)}{f_{ex}^{ni}(1+d_s(\eta-1))^2(\tau_{ni}^{\varepsilon-1}-1)} > 0
\end{aligned}$$

Q.E.D. ■

Chapter 4

Incomplete Contracts, Relationship Specificity and R&D Investments

4.1 Introduction

One of the most fundamental challenges in economics is to explain the large differences in economic development across countries. This study is motivated by two well-established empirical observations. First, we know that institutions matter a lot for the overall economic performance. Since the seminal paper by Kormendi and Meguire (1985) and because of the availability of new datasets on institutional quality, a vast literature provides empirically and theoretically analysis as to how institutions affect the economic development of countries (e.g. Barro (1991), Hall and Jones (1999), La Porta et. al (1997, 1998), Acemoglu et al. (2004)). According to these studies, a consensus has been reached that good institutions have a positive effect on the level of income and growth rates of countries. Although, there have been numerous studies trying to empirically analyze the link between good institutions and economic performance at the macroeconomic level, we are far away from thoroughly understanding the underlying channels how good institutions enhance economic development.

Second, there is widespread agreement that most of the differences in income across countries can be explained by differences in productivity and technical innovations, which provide the foundation for the bulk of economic growth (Acemoglu (2009), Griliches (1998)). In addition, it is prominently argued that R&D investments play a key role in the development of new technologies and innovations and, therefore, largely contribute to the observed differences in productivity growth across countries and industries. Again, despite the importance of R&D investments as an explanation for differences across countries in technological progress, there is little empirical evidence about the specific determinants of R&D investments, and especially about its interaction with contracting institutions at the country-industry level.

This empirical study fills this gap by examining the link between the quality of contracting institutions and R&D investments at the country and industry level. The specific question I address in this study is how firms' R&D investments respond to country-wide contracting institutions when firms act in industries that rely heavily on a good contracting environment. More precisely, this study analyzes if contract intensive industries have higher R&D investments when countries

have better contracting institutions.

To test this specific channel, I develop an empirical model that is based on the well-established incomplete contracts literature (Grossman and Hart (1986), Hart and Moore (1990), Acemoglu et al. (2007)). The model is based on the idea that an input supplier and a final goods producer agree to develop and design a new product in close cooperation and, therefore, both parties have to invest in R&D. Owing to the relationship-specificity of the investments and the existence of incomplete contracts, there is a classical hold-up problem resulting in under-investment. This hold-up problem is in particularly severe in industries producing complex goods which require many different individually designed intermediate input goods and thereby rely on a good contracting environment (contract-intensive industries). In countries with good contracting institutions, the hold-up problem is mitigated and, consequently, these countries have higher R&D investments. More precisely, if the quality of the judicial system is a key determinant of the level of R&D spending, then companies operating in contract-intensive industries in countries with good contracting environments will have higher R&D investments compared with their counterparts in countries with weak institutional settings. Providing causal estimates of this specific channel is at the heart of this study.

To empirically model this channel I use a a generalized difference-in-difference (DiD) estimation strategy. This approach is based on the work by Nunn (2007) who uses a similar strategy to analyze the effect of good contracting institutions on the specialization pattern of an economy. In this type of empirical models several indicators for the overall development of the judicial system of a country are interacted with a measure of the dependence on a good contracting environment at the industry level to explore the effect of good contracting institutions on the specialization patterns of production and exports in an economy. One key advantage of this difference-in-difference (DiD) strategy is that it allows for the establishment of causality under fairly weak assumptions. I apply this approach to analyze the effect of contracting institutions on R&D investments at the country-industry level.

I find strong support for the effect of contracting institutions on R&D investments in a panel of 29 OECD countries and 22 manufacturing industries for the period from 1996 to 2006. At the country level, I find that good contracting

institutions are positively correlated with an overall higher level of R&D investments. My results at the country-industry level show that countries with better judicial systems have higher R&D expenditures, especially in those sectors where relationship-specific investments are more important. These results are robust to the inclusion of a wide range of control variables. For example I include other potential determinants of R&D investments such as factor endowments, financial development, country size (GDP) and country development (GDP per capita). I also include a measure for the production in a country in a sector, in order to isolate the impact of contractual frictions on R&D investments separate from its effect on domestic output. As the primary measure for the quality of the contracting environment, I use the "rule of law" index from Kaufmann et al. (2007) and obtain consistent results for alternative measures of the overall quality of the judicial system, such as the time or costs to collect an overdue debt. To measure the contractual dependence of an industry I combine information from the United States 2002 Input-Output (I-O) table with information about the product classification of Rauch (1999) to construct an index that measures the share of inputs requiring relationship-specific investments. In robustness checks, I show that my results are not sensitive to alternative definitions and data sources for this measure.

My results suggest that differences in the contracting environment are a major determinant of R&D investments. According to my estimates, differences in the judicial system of a country have a higher explanatory power for R&D investments than do differences in factor endowments. For example, improving the quality of the judicial system by one standard deviation has twice the effect on R&D investments compared with a one standard deviation increase in human capital endowment. Put differently, if Korea were to improve the quality of its judicial system to the level of that of Sweden, then according to my estimates R&D investments in the highly contract-intensive industry "34: Motor vehicles, trailers and semi-trailers" would increase from 1.95 billion USD to 2.67 billion USD.

This study contributes to several strands of the literature. The first strand empirically analyzes the determinants of R&D investments. So far no empirical study has systematically related the effects of contracting institutions to R&D investments. Hence, this study is most closely related to the literature on financing R&D expenditures. This line of research shows that good financial conditions

affect the levels and compositions of R&D investments at the firm and industry level (Aghion et al. (2008), Aghion et al. (2010), Bond et al. (2010), Brown et al. (2009)). All these studies mainly focus on a single industry, different stages of investment decisions or firm development, but have not exploited differences across countries or industries. Here, this paper is most closely related to two empirical studies by Carlin and Mayer (2003) and Maskus et al. (2011). Both papers examine how differences in the development of the financial system across countries affect R&D investments in different industries. Both studies find that countries with better financial systems have higher R&D intensities, especially in financially dependent industries.

The second strand of the literature empirically tests the predictions of the incomplete contracts literature. Despite the strong impact of the theoretical literature over recent decades, a small but growing literature has empirically analyzed the predictions of the incomplete contracts literature on the organizational forms of firms and their investment decisions. Most of these studies focus on a single industry such as trucking (Baker and Hubbard (2003, 2004)), defense (Crocker and Reynolds (1993)), footwear (Woodruff (2002)) or housing market (Field (2005, 2007) and Gebhardt (2011)). A related literature studies the effect of property rights on investment decisions in developing countries, such as Besley (1995) and Jacoby and Mansuri (2008). They find that improving property rights in developing countries can help to increase investments. Again, both papers focus on a single country and on the market for land and property. More closely related to R&D investments and incomplete contracts are two recent studies by Lerner and Malmendier (2010) and Acemoglu et al. (2010). The former analyzes how incomplete contracts affect the design of contracts for research agreements in the biotechnology sector, whereas the latter studies the decision of whether to vertically integrate the production process between a supplier and a producer depending on the technology used in the production process. I deviate from this literature in two ways. First, I directly measure the effect of contracting institutions on R&D investments, rather than analyze the decision of whether to vertically integrate or not. Second, instead of focusing only on a single industry in a country, I exploit differences in the contracting environment across countries and industries to measure the effect of institutions on R&D investments.

Finally, as pointed out previously, this study contributes to the literature on contractual frictions and their effect on macroeconomic outcomes. A number of studies analyze the effect of imperfect contracts on differences in economic performance across countries, including Castro et al. (2004), Acemoglu et al. (2001), Acemoglu et al. (2004, 2010) and Glaeser et al. (2004). All these papers find, that a better contracting environment is associated with a higher level of economic activity and that institutions play an important role in the overall development of a country. Related literature has focused on the effect of institutions on specialization patterns in production across countries. Studies by Levchenko (2007), Costinot (2009), Nunn (2007) and Azim and Fujiwara (2010) show, that a better judicial system can lead to a comparative advantage in industries that are contract-intensive, resulting in higher output and exports in these industries. Here, the empirical study by Nunn (2007) is most closely related to my approach, since he shows in his empirical contribution that countries with better contracting institutions have higher exports, especially in sectors that are contract-intensive. However, while Nunn (2007) focuses on exports he does not consider the effect of contracting institutions on R&D investments.

This study fills an important gap in the literature as it is the first empirical analysis that systematically examines how good contracting institutions promote R&D investments and thereby can help to explain observed differences in economic development across countries and industries.

The rest of the paper is structured as follows: in section 4.2, I briefly describe the underlying theory of my empirical model and provide descriptive statistics that further motivate my approach. Section 4.3 explains the empirical model and identification strategy employed in the subsequent analysis, whilst section 4.4 describes the dataset as well as the definition and construction of my key variables of interests. In section 4.5, I present the results of my baseline specification as well as the robustness checks of my empirical analysis. Section 4.6 forms the conclusion.

4.2 Theoretical Background

In the following section, I describe the underlying theory of the empirical model and provide some initial first descriptive evidence on the effect of contractual frictions on R&D investments. The channel I test in the empirical section builds on the insight that if investments are relationship-specific, incomplete contracts will lead to under-investments (Grossman and Hart (1986), Hart and Moore (1990), Acemoglu et al. (2007)).[1]

To see exactly how contract enforcement can affect R&D investments consider the following setup. A final goods producer plans to develop a new product, and part of the new necessary inputs needed to produce the final good have to be developed and produced by an input supplier. For simplicity, assume that the relationship between both parties lasts for two periods only. In the first period, both firms undertake R&D investments to develop a new product and in the second period both parties bargain over the division of the surplus.

There are two important assumptions that affect the incentives and outcomes of this cooperation: First, it is assumed that R&D investments are relationship-specific and, therefore, that the value of R&D investments is higher within the buyer-seller relationship than it is outside the relationship. This argument is particularly relevant for R&D investments, since the idea of cooperation in this framework is to develop a new innovative good that is distinct from other products already in the market.[2] Therefore, the newly developed input good produced by the supplier has less value outside the relationship. Second, it is assumed that only a fraction of the R&D activities undertaken by the input supplier in the development of the new intermediate input is contractible, while the rest is non-contractible ex-ante. For example it is impossible or too costly to write a contract for the full set of possible future states.[3] In my setup, the fraction of contractible activities is determined by the overall quality of the contracting environment in a country. Once

[1] Earlier contributions to this literature include Klein et al. (1978) and Williamson (1979).

[2] Acemoglu et al. (2007) and Lerner and Malmendier (2010) emphasized the role of good contracting institutions in the development and adoption of new technologies.

[3] While Grossman and Hart (1986) and Hart and Moore (1990) assumed that none of the activities are contractible, I follow Acemoglu et al. (2007) and assume that only parts of the investments and production decisions are not contractible.

the outcome and value of the investment is realized in period two, both parties negotiate on the surplus of the cooperation. That is, the division of the surplus of the investment can only be determined ex post. Hence, the willingness of both parties to invest into R&D depends on their expected outcome of the ex-post bargaining game. Since none of the two parties is the full residual claimant of the surplus from their investments ex-post, they tend to under-invest ex-ante. A higher degree of contractual incompleteness thus leads to lower R&D investments by both parties.[4]

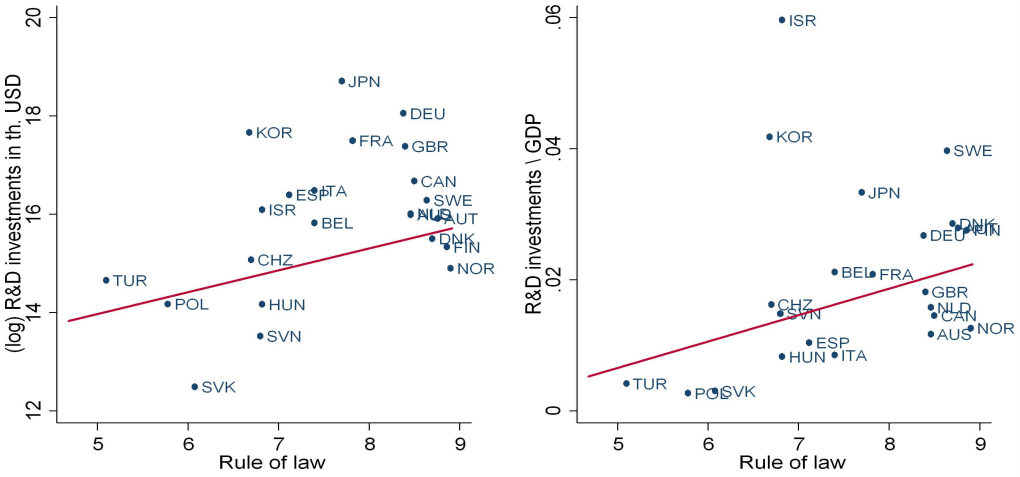
In countries with a better judicial system, the share of non-contractible activities is lower and ex-post bargaining is mitigated. Consequently, countries with good contracting institutions will have less under-investment in R&D, and this effect will be even more pronounced in sectors where relationship-specific R&D investments are more important for developing new final goods. Providing causal estimates of this particular channel is at the heart of this paper.

To further motivate my empirical approach, the following section presents descriptive statistics on the variation in R&D investments and depicts simple correlations between R&D investments and indicators for contractual development at the country level and contractual dependence at the industry level.

For simplicity, I focus on data for the year 2006 only. To highlight the differences across countries Figure 4.1 plots the level of (log) R&D investments against the "rule of law" index of Kaufmann et al. (2007). The left picture shows that countries with weak contract enforcement, such as Poland or Turkey, have substantially lower levels of R&D investments compared with countries with good judicial systems such as Sweden or Denmark. To avoid that these results are simply driven by differences in country size the right panel also plots the share of R&D investments relative to GDP against the quality of the judicial system in a country. Again, countries with overall better judical systems have significantly higher R&D investments.

[4]Another strand of the incomplete contracts literature has analyzed how the decision, whether vertical integration or outsourcing, can help to mitigate the problems arising from the existence of incomplete contracts. However this literature has also shown that this decision can only partly reduce the negative effects on investment decisions due the existence of incomplete contracts.

Figure 4.1: R&D Investments and Judicial Quality



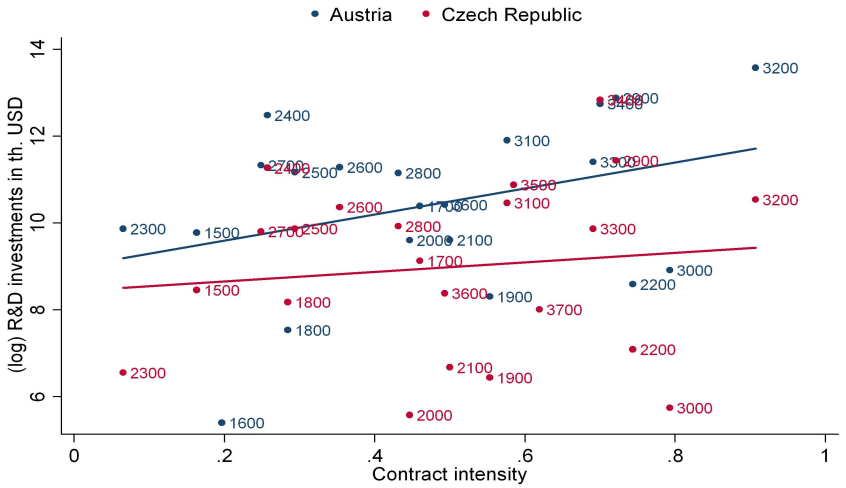
Notes: This graph shows the relationship between (log) R&D investments in thousand USD and the judicial quality in a country. The left graph plots the total of R&D investments in a country across all sectors against the rule of law index (Coeff.=0.59**, R-squared 0.19). The right graph plots the share of R&D investments in a country across all sectors relative to GDP (Coeff.=0.03*, R-squared 0.06). All data are for 2006.

While these figures show the differences of R&D investments across countries, they do not exploit the differences across industries. To emphasize the differences across sectors, I compare R&D investments at the industry level for two similar countries in terms of GDP, namely Austria and Czech Republic, in Figure 4.2. While Austria has a relatively good contracting environment, the judicial system in the Czech Republic is of lower quality.

In the graph, sectors are ordered by their contractual dependence and plotted against the volume of R&D investments in each industry.[5] While Austria has an overall higher level of R&D investments in nearly all industries, the differences across sectors is even higher the more dependent an industry is on a good contracting environment.

[5]Contractual dependence is measured as the share of intermediate inputs requiring relationship-specific investments to produce a final good. For a detailed explanation of the construction of this variable see section 4.4.

Figure 4.2: R&D Investments: Austria versus Czech Republic



Notes: This graph plots (log) R&D investments in thousand USD against contract intensity at the industry level for two countries. Austria ((log) GDP 19.37) has a much more developed judicial system compared with the Czech Republic ((log) GDP 19.19) for 2006.

4.3 Empirical Strategy

From the previous discussion, it follows that countries with better contract enforcement have higher R&D investments, especially in those sectors that use intensive inputs requiring relationship-specific investments. I estimate this prediction using the following generalized DiD specification:[6]

$$(log)R\&D_{ict} = \beta_1 Q_{ct} + \beta_2 z_i Q_{ct} + \beta_3 h_i H_c + \beta_4 k_i K_c + \eta_c + \eta_i + \eta_t + X_{ct} + \varepsilon_{ict} \quad (4.1)$$

where, (log)$R\&D_{ict}$ denotes the natural logarithm of $R\&D$ investments in country c in industry i in period t, Q_{ct} is a measure of the quality of contract enforcement in country c in period t and z_i represents the importance of relationship-specific investments (e.g. contract intensity) in industry i. H_c and K_c denote country c's endowment with human and physical capital and h_i and k_i denote human capi-

[6]This estimation strategy was first proposed by Nunn (2007). It is based on the influential work by Rajan and Zingales (1998), which has been used in numerous studies. More recent papers include Manova (2009) and Pang and Wu (2009). In combination with R&D investment intensity the approach of Rajan and Zingales (1998) has been used by Maskus et al. (2011).

tal and physical capital intensity in industry i, respectively. Country fixed effects η_c control for fixed differences across countries and industry fixed effects capture omitted sector-specific effects such as technology or factor intensity. The year dummies capture all effects that countries and industries face in common, such as communication costs, global business cycles and other general macroeconomic conditions. I also include a set of country-time varying control variables X_{ct} including (log) GDP and (log) GDP per capita to control for different economic developments at the country level over time. The error term ε_{cit} combines any omitted factor that affects the patterns of R&D investments. According to my hypothesis, I expect my coefficient of interest, β_2 to be positive, namely that countries with better contract enforcement institutions have higher R&D investments in industries that are more contract-intensive.[7]

This estimation strategy is conceptually distinct from simple regressions of R&D investments on the measures of contract enforcement at the country level. In this simple type of regression, changes in the institutional environment or policy reforms also affect the broader economic development of a country level and thereby is correlated with other factors, which at the same time influence R&D investments (e.g. Financial development). Therefore, such estimates cannot be seen as conclusive evidence of the effect of contract enforcement on R&D investments. Because of the same argument, my estimates of β_1 cannot be attributed to the distinct effect of institutions on R&D investments and thereby its interpretation remains unclear.

In the Difference-in-difference (DiD) specification, the identification of my coefficient of interest β_2 is not subject to such concerns. In this setup the identification of β_2 is based on the cross-country time variation of my judicial quality measure and variation across industries in contract intensity.[8] A key advantage of introducing the latter variation is that it helps establish causality, since contract intensity of an industry captures a technological component which is innate to

[7]The same argument applies to my two other interaction terms $h_i H_c$ and $k_i K_c$

[8]In this setup, the (continuous) treatment is given by the development of the judicial system in a country. The treatment group includes those sectors located in a country with a good judicial system, while the control group are sectors in a country with a weak contracting environment.

an industry and, therefore, is exogenously determined.[9]. Hence, the variation in contract intensity across sectors identifies the effect of contract enforcement on R&D investments separately from other effects such as the general institutional setting or general economic environment, since these are unlikely to be correlated with contract intensity at the industry level. While this identification strategy assumes that my measure for contract intensity is constant across countries, it does not require identical contract intensity values in each country, although it is important that the ordering of industries remains stable across countries. Also note that *R&D* investments vary over time and across industries and countries, while contract intensity is constant across countries and time. Thus, time-varying R&D expenditures at the country-industry level are not likely to be causal for contract intensity. In addition, the index for contract intensity is based on United States data. To rule out any feedback effect from United States R&D investments to these industry characteristics, I exclude the United States in my empirical analysis, which further shields against potential reverse causality effects.

There are several reasons which may bias my estimates of equation 4.1, which I now address. First, there maybe a potential omitted variable bias problem, namely, if other determinants of R&D investments are not included in equation 4.1 my results will be biased upwards. At first sight, it is difficult to think of other determinants of R&D investments at the country-industry level. However, as can bee seen at the bottom of Table 4.2 contract-intensive industries, also tend to be skill-intensive. At the same time, countries with good contracting institutions also tend to have high endowments of skilled labor, as shown in at the bottom of Table 4.1. Therefore, my coefficient of interest β_2 may capture the effect, that highly developed countries specialize in high-tech, skill-intensive industries with high R&D investments. To account for this potential bias, I include several interaction terms that vary at the country-industry level, such as Human capital endowment and human capital intensity, to control for alternative determinants of R&D investments.

A second concern is that there a potential sources of reverse causality. How-

[9]This means in the DiD context, that the assignment of a sector to the treatment or control group is exogenous and not related to the treatment itself

ever, in the DiD specification this is only the case if R&D investments are causal to my interaction term of interest $z_i Q_{ct}$. So far, there exists no theory that relates R&D investments to the development of judicial quality of a country.[10] However, one may argue that countries with large R&D-intensive industries have a higher need for the development of good contracting institutions and that these industries will lobby for an improvement in the contracting environment. To affect my estimates of β_2 the intensity of lobbying would need to be of the same systematical pattern related to contract intensity in all countries, which I assume to be unlikely. Nevertheless, if this is the case, the magnitude of my estimates could be influenced upward or downward, depending on the specific mechanics underlying the lobbying interaction. Finally, using time-invariant measures of contractibility in the robustness section further helps mitigating the potential effect of reverse causality, since these variables do not respond to changes in R&D investments over time.[11]

4.4 Data and Descriptive Statistics

In the empirical analysis, I evaluate the effect of contracting institutions on R&D investments by regressing the (log) of R&D expenditures on the interaction of country-level measures for the judicial quality with sector-level measures for contract intensity.

Data for R&D Investments

R&D investments are in thousands of USD and stem from the STAN database (OECD (2011)). According to the Frasatti Manual (2002), R&D expenditures are defined in the following way: "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the

[10] Levchenko (2008) used a political economy model to show how trade integration can affect the development of institutions.

[11] In previous literature, people have instrumented for the judicial quality of a country by using legal origin. However, legal origin has been shown to have a broader impact on the overall development of an economy and therefore it is not obvious if the exclusion restriction holds. In unreported results I confirm my estimates using this IV approach. However, I obtain an even higher effect for the judicial quality interaction term in these specifications.

stock of knowledge, ... , and the use of this stock of knowledge to devise new applications". In the STAN database, industrial R&D is defined as R&D expenditures in a particular industry classified according to the two-digit ISIC Revision 3.1 classification, regardless of the origin of funding. Data are available for 1987 to 2007 for 40 countries and 28 industries. Owing to many missing values for non-OECD countries, I focus on OECD countries only, restricting my sample to 29 countries. I further restrict the sample to the period from 1996 to 2006, since data for my primary measure of the judicial quality in a country are only available for this period. In the empirical analysis, I provide sensitivity analysis and show that none of my results are affected by this selection. Furthermore, I focus on manufacturing industries only for several reasons. First, my outlined theory focuses on inputs supplied by another manufacturer. Therefore, the overall setup is less adequate for service industries. Second, data on R&D investments in service industries are only available for a few sectors: in addition, these sectors appear to have very different values for my contract intensity measure. This selection reduces my sample to 22 industries.

Data on Judicial Quality

To analyze the impact of contracting institutions on R&D investments across countries, I use the "rule of law index" developed by Kaufmann et al. (2007) to measure the judicial quality of a country. This index comprises a number of different variables that measure the perceptions of the predictability, competence and effectiveness of the judicial system within a country and that has been widely used in the literature to measure the judicial quality of a country (e.g. Nunn (2007), Levchenko (2007) or Berkowitz et al. (2006)). The index ranges from 0 to 10, with 0 indicating a bad and 10 a good judicial system.[12] Data are available for 1996 to 2006 for all countries in the sample.[13] In the panel of 29 countries, judicial quality varies significantly across countries, but less so over time. This is not

[12]The original index ranges from -2.5 to 2.5. For convenience I transform the index to range from 0 to 10.

[13]Due to missing values for the years 1997, 1999 and 2001 I use a non-parametric linear interpolation to estimate these values. Given the high persistency of institutions this procedure does not affect my results.

surprising since institutions within a country are highly persistent and they tend to change slowly over time.

Column 1 in Table 4.1 lists the countries and depicts the mean and standard deviation over time for the judicial quality index for each country for the period from 1996 to 2006. The cross-section (panel) average score for the judicial quality of a country is 7.71 (7.71) with a standard deviation of 0.96 (0.98). In the median country (France) the judicial quality index ranges from 7.54 to 8.04. In the cross-section the country with the worst judicial system in my sample is Turkey with an average score of 4.91 and the country with the highest score is Finland with an average score of 8.78. In the overall panel, the index varies from 4.68 (Turkey, 1998) to 8.92 (Denmark, 2007).

In the empirical analysis, I also use four alternative measures for the judical quality of a country. I use the variables repudiation of contracts and risk of expropriation obtained from La Porta et al. (1998) to proxy for the quality of the judicial system. Finally, I use two variables from the World Bank's Doing Business Database, which compromises statistics on the efficiency and costs of a judicial system. These two indices are available for a subset of countries only and they do not vary over time. Summary statistics and correlations among all measures in the cross-section are depicted in Table 4.8 in the Appendix C.2.

Measures of Contract Intensity

To identify the effect of legal institutions on R&D investments, I need a variable that measures the importance of relationship-specific investments at the industry level. I follow Nunn (2007) and construct an index at the industry level to measure the dependence of a sector on a good contracting environment for each industry.

In a first step, I use the 2002 United States Input-Output (I-O) Use Table from the Bureau of Economic Analysis (BEA) (2011), which provides information about the values of the intermediate inputs used to produce a final good for 439 industries according to the BEA I-O industry classification.[14] Since data on R&D investments are only available at the two-digit ISIC Rev. 3.1 level of dis-

[14]The BEA I-O industry classification is comparable, although slightly more restrictive, than is the six-digit North American Industrial Classification System (NAICS).

Table 4.1: Country Characteristics

Country	Rule of Law		Human Capital Endowment	Physical Capital Endowment
	avg.	(std.)		
Australia	8.45	(0.04)	88,075	2.98
Austria	8.66	(0.08)	71,627	2.23
Belgium	7.62	(0.13)	76,452	2.77
Canada	8.36	(0.08)	82,442	3.01
Chile	7.51	(0.08)	22,451	2.19
Czech Republic	6.71	(0.14)		
Denmark	8.68	(0.10)	70,514	3.00
Finland	8.78	(0.07)	89,195	2.83
France	7.80	(0.14)	84,928	2.2
Germany	8.23	(0.08)	89,368	2.66
Hungary	6.86	(0.12)	33,856	3.09
Iceland	8.55	(0.36)	66,642	2.53
Ireland	8.15	(0.15)	55,738	2.56
Israel	7.06	(0.39)	51,767	2.82
Italy	7.40	(0.17)	82,317	2.15
Japan	7.63	(0.13)	64,180	2.64
Korea	6.73	(0.13)	24,650	2.52
Netherlands	8.43	(0.05)	79,069	2.66
New Zealand	8.63	(0.12)	78,048	3.37
Norway	8.76	(0.12)	94,830	3.01
Poland	6.36	(0.35)	33,948	2.63
Portugal	7.41	(0.20)	29,436	1.67
Slovak Republic	5.84	(0.21)		
Slovenia	7.12	(0.23)		
Spain	7.49	(0.23)	61,637	2.00
Sweden	8.57	(0.07)	72,777	2.83
Switzerland	8.74	(0.12)	10,786	2.76
Turkey	4.92	(0.25)	16,290	1.55
United Kingdom	8.30	(0.11)	50,408	2.68
Country avg. cross section (panel)	7.71	(7.71)	64,588	2.59
Country std. cross section (panel)	0.98	(0.96)	24,954	0.43
Correlation				
Rule of law (avg.)		1.00		
(log) Physical capital endowment		0.81	1.00	
(log) Human capital endowment		0.56	0.54	1.00

Notes: The table summarizes the variation in rule of law, physical capital and human capital used in the empirical analysis. Column one reports the average rule of law for each country for the period 1993 to 2006 and column two the corresponding standard deviation across time. In the bottom of the table I also report the cross country mean and standard deviation in the cross section as well as the correlation between all measures.

aggregation, I aggregate the final goods of the United States I-O Use Table to the two-digit ISIC Rev. 3.1 level.[15] I use this information to calculate the share of each intermediate input used in the customization of a final good.

Second, I use the classification of Rauch (1999) to identify which intermediate inputs that are used in production need relationship-specific investments. Rauch (1999) classified 1,190 goods according to the four-digit SITC Rev. 2 system into three different categories: sold on an organized exchange, reference priced or neither. If a good is sold on an organized exchange or is referenced priced this can be seen as an indicator of thick markets with many buyers and sellers for more standardized input goods. These markets are much less susceptible to the hold-up problem described in the previous section, since the input supplier or final goods producer can easily sell/buy the intermediate good to/from another participant in the market. Therefore, I define a good to be relationship-specific if it is neither sold on an organized exchange nor reference priced.[16] Next, I construct a concordance table from the four-digit SITC Rev. 2 classification to the BEA I-O classification. This allows me to calculate the share of each intermediate input used in the production that is relationship-specific (neither reference priced nor sold on an organized exchange). Finally, I combine this information with my information from the U.S. I-O Use Table and calculate for each final good the proportion of its intermediate inputs that are relationship-specific. For a more detailed explanation of the construction of this index, see Nunn (2007).

Column (3) in Table 4.2 lists the contract intensity for each industry used in the empirical analysis. According to this index, in the median contract-intensive industry "36: Furniture, manufacturing n.e.c" about 49% of the inputs used in the production of final goods are classified as being relationship-specific while 51% of the inputs are traded on thick markets and are sold on an organized exchange or are reference priced. The index varies significantly across industries with an average contract intensity of 0.47 and a standard deviation of 0.22. The overall picture of the contract intensity of an industry also appears sensible. Industries,

[15] I construct a concordance table from the BEA I-O industry classification to the 2-digt ISIC Rev. 3.1 classification. For a detailed explanation see the Appendix C.1.

[16] Rauch (1999) provided a liberal and a conservative classification of products. Throughout the paper, I use the liberal classification.

such as "23: Coke, refined petroleum products, nuclear fuel" or "15: Food products and beverages", with a high share of primary inputs, that are sold on thick markets, are classified as less contract-intensive. By contrast, industries such as "32: Radio, television and communication equipment" or "30: Office, accounting and computing machinery" are classified as highly contract-intensive, requiring a high proportion of customized intermediate inputs.

In the robustness analysis, I also construct a Herfindahl index, which measures the concentration of intermediate inputs used in production as an alternative proxy for the contract intensity of an industry.[17] Again, I select the share of each input used in production for a final good from the 2002 United States I-O Use Table to compute this index. The reason for using the Herfindahl index is the following: if a final goods producer sources inputs only from a few input suppliers (high-input concentration), and all other intermediate inputs are only used relatively little, then the risk of expropriation for this firm is relatively low. Hence, this firm is less dependent on a good judicial environment, compared with a firm that sources many inputs in equal weights from different sources (low-input concentration).[18]

Data on Factor Endowments and Factor Intensity

Data on factor endowments and factor intensity are from standard sources. I use the (log) stock of physical capital per worker and (log) human capital per worker as constructed by Caselli (2005). Human capital per worker is defined as the average years of schooling in the population over 25 years old and physical capital is the average capital stock per worker in a country. Columns 4 and 5 in Table 4.1 provide summary statistics for both measures for each country. Data on factor intensity stem from Bartelsman and Gray (1996). Capital intensity is measured as the ratio of total real capital stock and value added for industries in the United States and human capital intensity is calculated as nonproduction worker wages divided by the total wages for United States industries. Summary statistics for each industry are depicted in columns 4 and 5 in Table 4.2. The Appendix C.1

[17] To measure the institutional dependence of a sector, this index was also used by Levchenko (2007) and Blanchard and Kremer (1997)

[18] The correlation between both measures of contract intensity is 0.36.

Table 4.2: Industry Characteristics

ISIC code	Industry	R&D in mil. USD	Contract Intensity	Physical Capital Intensity	Human Capital Intensity
15	Food products and beverages	1,208	0.163	0.891	0.374
16	Tobacco products	63	0.196	0.185	0.402
17	Textiles	433	0.460	0.776	0.377
18	Wearing apparel, dressing and dying of fur	93	0.284	0.379	0.369
19	Leather, leather products and footwear	62	0.553	0.738	0.358
20	Wood and products of wood and cork	285	0.446	0.670	0.317
21	Pulp, paper and paper products	652	0.500	1.100	0.346
22	Printing and publishing	299	0.743	0.632	0.355
23	Coke, refined petroleum products	1,460	0.065	1.917	0.346
24	Chemicals and chemical products	31,134	0.257	0.824	0.539
25	Rubber and plastics products	3,491	0.294	0.917	0.314
26	Other non-metallic mineral products	2,093	0.353	0.911	0.304
27	Basic metals	3,790	0.249	1.149	0.305
28	Fabricated metal products, except machinery	2,281	0.431	0.704	0.377
29	Machinery and equipment, n.e.c	14,256	0.721	0.822	0.383
30	Office, accounting and computing machinery	10,240	0.793	0.731	0.736
31	Electrical machinery and apparatus, n.e.c.	10,470	0.576	0.483	0.547
32	Radio, television, communication equipment	28,937	0.907	0.951	0.595
33	Medical, precision and optical instruments	8,310	0.690	0.542	0.655
34	Motor vehicles, trailers and semi-trailers	26,202	0.700	0.834	0.260
35	Other transport equipment	10,064	0.585	0.586	0.503
36	Furniture; manufacturing n.e.c.	1,257	0.493	0.493	0.338
	Industry average	7,140	0.471	0.783	0.413
	Industry standard deviation	9,736	0.226	0.340	0.125
	Correlation				
	Contract intensity		1.000		
	Physical capital intensity		-0.276	1.000	
	Human capital intensity		0.462	-0.226	1.000

Notes: This table reports the measures of contract intensity, physical capital intensity and human capital intensity used in the empirical analysis for all 22 manufacturing sectors used in the empirical analysis. In the bottom of the table I also report the industry average and industry standard deviations across countries as well as the correlations between all measures.

describes all other variables used in the empirical analysis.

4.5 Results

I now turn to the results of my estimations of equation 4.1. The sample consists of 29 countries and 22 manufacturing industries for the period from 1993 to 2006 and, therefore, the maximum number of possible observations is 9,338. However, because data on R&D investments are not available for all country-industry-year pairs the panel is unbalanced and the number observations drops to 6,049. In the section 4.5.1, I first report the estimates of my baseline specification, before turning to the robustness and sensitivity analysis in section 4.5.2.

4.5.1 Main Results

Table 4.3 reports OLS estimates of equation 4.1. In the first column, I only include my measure for judicial quality and my judicial quality interaction term. In this specification, I also add a set of country, industry and year fixed effects as well as GDP and GDP per capita. I cluster errors by industry-year pair, since the error term in equation 4.1 reflects unobserved common shocks to industries in a certain year.[19] The coefficient of judicial quality is positive but not significant. This can be attributed to the fact that my measure for judicial quality, rule of law and institutions in general change slowly over time and, therefore most of the direct effects are captured by the country fixed effect. My main coefficient of interest β_2 is positive and highly significant and supports the hypothesis that contract enforcement is important for explaining R&D investments.

Next, I include two factor endowment interactions for human and physical capital as alternative determinants of R&D investments. Since data on factor endowments are only available for 26 countries,[20] the number of observations drops

[19] Moulton (1990), showed in her influential work that ignoring the correlation of the disturbances, in grouped panel data may lead to seriously downward biased estimates of the standard error. If this is the case results can be misleading.

[20] The countries for which factor endowments are not available are Slovenia, the Czech Republic and the Slovak Republic.

Table 4.3: R&D Investments and Contracting Institutions - Baseline Specification

Dependent variable: (log) R&D investments					
	(1)	(2)	(3)	(4)	(5)
Judicial Quality: Q_{ct}	–0.067	0.018	0.072	0.073	0.234
	(–0.61)	(0.15)	(0.63)	(0.65)	(2.01)**
Judicial Quality interaction: $Q_{ct} * z_i$	0.425	0.382	0.436	0.430	0.302
	(4.32)***	(3.80)***	(4.54)***	(4.56)***	(3.27)***
H/L x H intensity: $H_c * h_i$		1.105			1.602
		(1.58)			(2.60)***
K/L x K intensity: $K_c * k_i$		0.015			–0.014
		(1.97)**			(–1.54)
Log inc. x value added: $Y_{ct} * va_{ict}$			1.638	1.637	1.490
			(10.49)***	(10.47)***	(9.94)***
Log inc. x intra trade: $Y_{ct} * iit_i$			0.575	0.057	0.080
			(2.70)***	(2.67)***	(3.77)***
Log inc. x TFP growth: $Y_{ct} * tfp_i$			1.124	1.205	1.014
			(2.44)**	(2.61)***	(2.26)**
Log inc. x input variety: $Y_{ct} * (1 - h_i)$			0.130	0.130	0.156
			(2.72)***	(2.65)***	(3.12)***
Fin. dev. x K intensity: $Cr_{ct} * k_i$				–0.099	–0.136
				(–1.40)	(–1.76)*
Additional Controls:			Country, Industry, Year FE, GDP, GDP per Capita		
Observations	6,049	5,300	4,752	4,752	4,326
R^2	0.825	0.832	0.845	0.845	0.852

Notes: The dependent variable is log $R\&D_{cst}$. The dependent variable is defined as the (log) of R&D investments in country c in a two-digit ISIC sector s, in year t for 1997-2007. The measure of contract intensity z_i and Judical Quality Q_{ct} are defined as in the text. All other control variables are defined as in Appendix C.1. If not otherwise stated, standard errors in brackets are clustered at the industry level. All regressions include a constant term. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

to 5,300.[21] Both interaction terms are positive. While my measure for physical capital is significant at the 5%-level, human capital turns out to be borderline not significant in this specification.[22] However, my estimates for the judicial quality interaction are slightly reduced, but they remain positive and highly significant.

I control for other potential determinants of R&D investments at the country-industry level in column (3), which if omitted may bias my estimated coefficient for the judicial quality interaction term. I include a set of control variables at the industry level, which I interact with (log) income per capita. The idea is to capture other possible determinants, unrelated to contract enforcement, that high-income countries may specialize in certain industries and which at the same time have high R&D investments. Since, some of these measure are not available for all industries and countries the number of observations further drops to 4,752. I construct an interaction term with the share of value added relative to Output to control for the effect that high-income countries may specialize in high value added industries, that at the same time have high R&D investments. To take into account the effect that high-income economies concentrate on industries that display rapid technological change, I interact log income per capita with average TFP growth. I also include an interaction term of log income per capita with inter-industry trade to capture the effect that high-income countries may specialize in sectors with a high degree of fragmentation of the production process. Finally, I interact income per capita with a Herfindahl index of input concentration.[23]. Including the Herfindahl index accounts for the effect that my results may solely reflect the fact that high-income countries produce more complex goods, but that this effect is not related to contract enforcement. All interaction terms are positive and significant.[24] However, my estimates for the judicial quality interaction term are nearly unaffected.

[21] I also rerun the estimation of column (1) with the smaller sample. However this did not alter my results.

[22] I also experimented with alternative measures and data sources for human and physical capital endowments. None of these estimates delivered different results. I chose these measures, since they have the largest coverage for my dataset.

[23] I multiply the Herfindahl index by -1 to have an index that increases with input concentration

[24] I also performed regressions, where I included the interaction terms separately and also in different combinations. None of these estimates revealed different results.

In a recent study Maskus et al. (2011) show that financial development has a positive effect on R&D investments. Therefore, I add an additional control variable, to interact financial development with capital intensity at the industry level in column (4). Contrary to their results, in my estimation the interaction term is slightly negative and insignificant in most specifications. However, in contrast to Maskus et al. (2011), I focus on absolute values of R&D investments and use a different measure to capture the effect of financial development on R&D investments.[25] At the same time, it is likely that this effect is already captured by one of my other controls because, for example the interaction of log income and value added is highly correlated with my interaction term for financial development. My results for the judicial quality interaction term remain unchanged.

Finally, I include the full set of controls in column (5). In this case, the number of observations is further reduced to 4,326. All controls have the expected sign and are significant, at least at the 5% level, with the exception of my interaction term for capital endowment, which is now slightly negative and no more significant and financial development which is also slightly negative and significant at the 10% level.[26] More importantly, in this specification my estimates for the judicial quality interaction term are slightly reduced but still positive and highly significant.

Aside from the qualitative results, another natural question is whether contract enforcement also has an economically significant impact on R&D investments. For example, if South Korea (25th percentile of the distribution) were to improve its judicial quality to the level of Sweden (75th percentile of the distribution), Korean's R&D investment in the high contract-intensive industry "34: Motor vehicles, trailers and semi-trailers industry" (75th percentile) would increase by 25% more than it would in the low contract-intensive industry "27: Basic Metals" (25th percentile).[27]

The effects of judicial quality on R&D investments are sizeable not only in

[25] While I use capital intensity to proxy for the demand of external finance at the industry level, Maskus et al. (2011) follow Rajan and Zingales (1998) and Manova (2009) to use external finance dependence and asset tangibility.

[26] In a similar estimation strategy and using similar data source, Manova (2009) obtained nearly the same results for the interaction terms of physical capital endowment and capital intensity.

[27] Comparative statics are based on estimates reported in column (5) in Table 4.3.

absolute values, but also in relative terms. While a one standard deviation increase in the judicial quality interaction term increases R&D investments by 21% standard deviations, a similar increase in the human capital interaction term (physical capital interaction term) increases the dependent variable by only 10% (–1%).[28] [29] Although, institutions tend to change very slowly, some countries such as Iceland (Slovak Republic) substantially improved their judicial quality by 0.94 (0.54) during the period from 1995 to 2006, which approximately corresponds to an improvement of one (half) standard deviation. Hence, improving the judicial quality of a country within a relatively short time period is feasible.

Next, I perform some additional regression analysis to build further confidence into my estimated effect of contract institutions on R&D investments. The results are reported in Table 4.4. First, I add an additional control variable, to interact human capital endowment with contract intensity (column (6)). This specification allows me to separate the effect of good contract institutions from the effect that countries with high human capital endowment also tend to have good contracting environments. My estimated coefficient for the interaction of human capital and contract intensity is negative, which is counterintuitive, but is also only borderline significant at the 10% level. However, my estimates for the judicial quality interaction term are not affected by this. Second, I interact my measure of financial development with contract intensity and obtain a positive and significant effect (column (7)). Despite the high correlation between financial development and judicial quality (0.77), my estimated effect on the judicial quality interaction term is still positive, although it now has been reduced to 0.164 and it is significant at the 10% level only. Finally, I include the log number of establishments in a country by year and sector (column (8)). I find that my results are nearly unchanged and that the total effect of judicial quality on R&D investments is independent of their effects on domestic output. In addition, if countries had a comparative advantage in sectors not adequately modeled in my previous specifications, I include the number of establishments to control for such effects.

[28] I report beta coefficients for my main results in Table C.2 in the Appendix B.

[29] My estimates for the interactions for human and physical capital may seem relatively low compared with my interaction for judicial quality. However, they are of similar magnitude to that what other studies have found (e.g. Nunn (2007), Levchenko (2008), or Manova (2009)).

Table 4.4: R&D Investments and Contracting Institutions - Additional Results

Dependent variable: (log) R&D investments					
	(6)	(7)	(8)	(9)	(10)
Judicial Quality: Q_{ct}	0.155	0.232	0.232		0.234
	(1.35)	(1.95)*	(2.01)**		(2.11)**
Judicial Quality interaction: $Q_{ct} * z_i$	0.448	0.164	0.323	0.299	0.302
	(5.11)***	(1.68)*	(3.75)***	(3.29)***	(4.04)***
H/L x H intensity: $H_c * h_i$		1.749	1.566	1.612	1.602
		(2.78)***	(2.56)**	(2.65)***	(2.19)**
K/L x K intensity: $K_c * k_i$	–0.014	–0.017	-0.015	–0.017	–0.014
	(–1.15)	(–1.82)*	(-1.63)*	(–1.81)*	(–1.53)
Fin. dev. x K intensity: $Cr_{ct} * k_i$	–0.139		-0.193	–0.322	–0.136
	(–1.84)*		(–3.12)	(–2.48)**	(–1.79)*
H/L x contract intensity: $H_c z_i$	–0.860				
	(–1.78)*				
Fin. dev. x		0.360			
contract intensity: $Cr_{ct} * z_i$		(3.08)***			
Establishments in sector i: n_{cit}			0.03		
			(2.92) ***		
Additional Controls:	GDP, GDP per Capita, Log inc. x Interaction				
Country, Industry, Year FE	Yes	Yes	Yes	No	Yes
Country-Year, Industry FE	No	No	No	Yes	No
Multi-Way Clustering	No	No	No	No	Yes
Observations	4,326	4,326	4,280	4,326	4,326
R^2	0.851	0.852	0.891	0.858	0.852

Notes: The dependent variable is log $R\&D_{cst}$. The dependent variable is defined as the (log) of R&D investments in country c in a two-digit ISIC sector s, in year t, for the period 1997-2007. The measure of contract intensity z_i and Judical Quality Q_{ct} are defined in the text. All other controls are defined as in Appendix C.1. If not otherwise indicates standard errors in brackets are clustered at the industry level. In the case of Multi-Way clustering, errors are clustered at the country-industry level. All regressions include a constant term. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

In column (9), I include a full set of country-year fixed effects to take into account differences in economic development across countries over time, that may not be captured by my two other country-time varying control variables GDP and GDP per capita. None of my results is affected by this specification.

In a recent paper Miller et al. (2011) document that in the case of panel datasets with different levels of grouping, controlling for correlation among error terms only within one group may not be sufficient and estimated standard errors can still be seriously biased downwards and thereby results can be misleading. In my setup, the error term may not only be correlated across industries, but also across countries. Column (10) reports the results using the methodology developed by Miller et al. (2011), which allows to implement a multi-way clustering estimator. This estimator not only controls for potential correlations among the error terms across industries and countries simultaneously, but also corrects for potential correlation among the error terms at the country-industry level. In contrast to expectations, the standard errors for the judicial quality interaction term is further reduced. This can be the case if there exists a negative correlation of the error term across countries and industries.[30]

4.5.2 Robustness and Sensitivity Analysis

In the following sections, I test the robustness and sensitivity of my baseline specifications. In a first step, I report the results for the different specifications of the judicial quality interaction term, different measures for contract intensity and alternative measures for my dependent variable in Table 4.5. In Table 4.6 I present the results for different measures for the judicial quality of a country. Finally, I analyze the sensitivity of my estimates to potential outliers in Table 4.7.

For all estimates in Table 4.6 I show the results for the reduced form specification where I only include the factor endowment interaction terms and the specification with the full set of controls. In a first step, I lag all explanatory time-varying variables once. This strategy helps to further mitigate potential simultaneity effects. My estimates for the judicial quality interaction term remain unchanged and

[30]In unreported results, I rerun all estimations using the multi-way clustering approach. All results were nearly unchanged and thereby they had no significant influence on my results.

support the hypothesis that in the proposed empirical specification simultaneity is of less concern. Second, instead of using the 2002 U.S. I-O Table I reconstruct my contract intensity measure z_i using the 1997 U.S. I-O Table. If the assumption holds that contract intensity is a sector-specific technological component that is innate to a sector and does not change over time and especially is not affected by R&D investments, then my results should not be affected by this. I find support for this assumption in the data.

Next, I construct two alternative indices to measure the institutional dependence of a sector and check if my estimates are sensitive to such changes. First, I follow Nunn (2007) and reconstruct my measure for contract intensity z_i. This measure is constructed in exactly the same way as outlined in section 4.4. The only difference between both measures is that I now allow for a broader definition of relationship-specific products and also classify reference priced products, according to the classification of Rauch (1999), as being relationship specific. While my estimates do not change if the smaller set of controls is used, I obtain a positive but no longer significant result in the full specification. Here, it is important to note that the ordering of industries slightly changes when the broader measure z_i^r is used, which can easily have a strong effect on my estimates.[31] Second, I follow Levchenko (2007) and proxy product complexity using the Herfindahl index, which measures the concentration of intermediate input use.[32].[33] Again, my estimates for the judicial quality interaction term are positive and highly significant in both specifications.

In a final step, I check to what extent my results are robust, if I use different measures for my dependent variable. Although the focus of this paper is to analyze to what extent contract institutions affect a special form of investments, namely R&D investments, the outlined theory in section 4.2 also applies to a broader definition of investments. Therefore, I use gross investments at the industry level

[31] Further analysis revealed that if one of the following two sectors "19: Leather, leather products and footwear" or "20: Wood and products of wood and cork" is excluded from the sample, the results are similar to my previous estimates.

[32] Again, I multiply the Herfindahl index by -1 in order to have a measure that increases in institutional intensity

[33] The Herfindahl index of intermediate input use, as a proxy for product complexity, has also been used by Blanchard and Kremer (1997).

Table 4.5: R&D Investments and Contracting Institutions - Alternative Specifications

Dependent variable	(log) R&D investments		(log) R&D investments		(log) R&D investments	
Judicial Quality: Q_{ct} (Q_{ct-1})	0.055	0.292	0.095	0.248	–0.240	0.288
	(0.47)	(2.48)**	(0.83)	(2.22)**	(–1.63)	(1.73)*
Judicial Quality interaction (lag): $Q_{ct-1} * z_i$	0.376	0.313				
	(3.60)***	(3.29)***				
Judicial Quality interaction (1997): $Q_{ct} * z_i$			0.236	0.303		
			(2.99)** *	(3.45)***		
Judicial Quality interaction: $Q_{ct} * z_i^r$					0.542	0.118
					(4.57)***	(0.81)
Controls: Country, Industry, Year FE, GDP, GDP per Capita, Endowments x Interactions	Yes	Yes	Yes	Yes	Yes	Yes
Log inc. x Interactions, Fin. dev. x Interaction	No	Yes	No	Yes	No	Yes
Observations	4,895	4,082	5,300	4,326	5,300	4,326
R^2	0.832	0.851	0.831	0.851	0.832	0.851

Dependent variable	(log) R&D investments		(log) Gross investments		R&D intensity	
Judicial Quality: Q_{ct}	.290	.305	–.007	.128	–5.215	–4.297
	(2.69)***	(2.71)***	(–.06)	(1.10)	(–2.58)**	(–1.98)**
Judicial Quality interaction: $Q_{ct} * z_i$			0.220	0.206	9.406	7.848
			(2.45)**	(2.28)**	(3.56)***	(2.76)***
Herfindahl interaction: $Q_{ct} * (1 - h_i)$	1.224	1.321				
	(5.13)***	(6.41)***				
Controls: Country, Industry, Year FE, GDP, GDP per Capita, Endowments x Interactions	Yes	Yes	Yes	Yes	Yes Yes	
Log inc. x Interactions, Fin. dev. x Interaction	No	Yes	No	Yes	No	Yes
Observations	5,300	4,138	3,917	3,277	4,699	4,682
R^2	0.832	0.855	0.833	0.875	0.163	0.172

Notes: If not otherwise indicated, the dependent variable is (log) $R\&D_{cst}$. The dependent variable is defined as the (log) of R&D investments in country c in a two-digit ISIC sector s, in year t for the period 1997-2007. If not stated differently the measure of contract intensity z_i and Judical Quality Q_{ct} are as defined in the text. All other variables are defined as in Appendix C.1. The first four columns of the upper part of the table report estimates for different specifications of $Q_{ct} * z_i$. Column five and six of the upper part and one and two of the lower part of the table, report estimates for different measures of z_i. The last four columns of the lower part of the table report results for different measures of the dependent variable. Standard errors in brackets are clustered at the industry level. All regressions include a constant term. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

as an alternative measure for my dependent variable.[34] In line with my previous results, I find a positive, significant and sizeable economic effect for my judicial quality interaction term. Second, instead of using the absolute values of R&D investments, I follow Maskus et al. (2011) and use R&D intensity at the industry level. Using R&D investment intensity helps to mitigate any potential problems arising from different industry sizes across countries. Again, I find a positive, highly significant and sizeable economic effect of contract institutions on R&D intensity.[35]

So far, I used "rule of law" as my primary measure for the judicial quality in a country. I now consider different measures for Q_{ct} and re-estimate equation 4.1 using four alternative measures for the contracting environment. The results are reported in Table 4.6. In the first two columns, I use different measures obtained form the World Bank's Doing Business Database. The database contains various measures for the efficiency and costs of the judicial system in collecting an overdue debt.[36] In the first column, I report estimates if the number of days, and in column two, if the number of procedures required, to collect an overdue debt is used. In addition, I use two variables from La Porta et al. (1998) that measure the risk of expropriation and the repudiation of contracts. Although the risk of expropriation does not directly measure the quality of the contracting environment between two parties, it highlights the problems associated with an inefficient judicial system in a country. By contrast, the variable repudiation of contracts directly measures the reliability of contracts in a country.

As can be seen from Table 4.8 all four measures are positively correlated with my previous measure "rule of law", but given the relatively low correlation, for example, for the number of procedures these variables may capture different aspects of the judicial quality in a country.[37] My estimates show that, whatever kind of different measure I use for the judicial quality Q_{ct} I obtain positive, highly significant and sizeable economic results for my interaction term of interest, em-

[34] I use gross investments, since data on net investments are only available for a small subsample of countries and industries.

[35] See Table 4.9 for a comparison of the beta coefficients from different specifications.

[36] See Appendix C.1 for a detailed description of both variables.

[37] All variables are rescaled in a way such that positive values indicate a better judicial quality.

phasizing the robustness of my results.[38] In addition, all four variables are time-invariant, which further helps with establish causality, since these variables do not respond to changes in R&D investments over time, which is part of the identification strategy.

Table 4.6: R&D Investments and Contracting Institutions - Robustness

Dependent variable: (log) R&D investments				
Contract Institution Measure:	Time	Number of procedures	Repudiation of contracts	Risk of expropriation
	(1)	(2)	(3)	(4)
Judicial Quality interaction: $Q_c * z_i$	0.001	0.004	0.026	0.021
	(2.38)**	(4.86)***	(3.56)***	(2.91)***
H/L x H intensity: $H_c * h_i$	1.838	1.709	1.995	2.130
	(2.88)***	(2.79)***	(3.67)***	(3.98)***
K/L x K intensity: $K_c * k_i$	–0.012	–0.011	–0.083	–0.008
	(–1.57)	(–1.33)	(–0.62)	(–0.75)
Additional Controls:	GDP, GDP per Capita, Country, Industry, Year FE, Log inc. x Interactions, Fin. dev. x Interaction			
Observations	4,278	4,271	3,810	3,810
R^2	0.851	0.851	0.842	0.841

Notes: The dependent variable is log $R\&D_{cst}$. The dependent variable is defined as the (log) R&D investments in country c in a two-digit ISIC sector s, in year t for the 1997-2007. The measure of contract intensity z_i is defined in the text. The first row of the table indicates the different measure used to proxy the judicial quality Q_c of a country and is described in the text. All other control variables are as described in the Appendix C.1. Standard errors in brackets are clustered at the industry level. All regressions include a constant term. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

In a final step, I verify that my results are not driven by outliers in the data. The results are reported in Table 4.7. As a first robustness check, I consider whether my results are driven by a particular selection of years in the sample. Therefore, I spilt the sample into two periods, before 2000 and from 2000 onwards in columns (1) and (2). In addition, in unreported results I also repeat each regression by

[38]For a comparison of the size of the effects using beta coefficients, see Table 4.9 in the Appendix B.

excluding a random combination of two years from the sample. Aside from an increased standard error because of the reduced number of observations, my results indicate that my previous findings are not driven by a particular year.

Next, I test whether my results are driven by a particular country in the sample. Therefore, I drop each single country and re-estimate equation 4.1. In columns (3) and (4), I report those estimate which had the largest effect on my results. If Poland is excluded from the sample my estimates for the judicial quality interaction term drops to 0.229 but is still significant at the 5% level. On the other hand, if Norway is excluded, I obtain a coefficient of 0.359, which is also highly significant.

Eventually, I confirm that my results are not driven by a certain industry. I repeat the same exercise and exclude each industry in my estimates and rerun my OLS regression for equation 4.1. Again, columns (5) and (6) report those estimates that had the largest effect on my results. If the industry "34: Motor vehicles, trailers and semi-trailers" is excluded from the sample my estimate drops to 0.199 and is significant at the 5% level. By contrast, if I exclude the "30: Office, accounting and computing machinery" industry, I obtain a coefficient of 0.497, which is also highly significant at the 1% level. Overall my findings in Table 4.7 indicate that the results obtained in the previous analysis are not driven by any particular outlier in the sample and that they appear to be very robust in all specifications.

4.6 Conclusion

In this paper I study the effect of contractual frictions on R&D investments for 29 OECD countries in 22 manufacturing industries for the period 1996 to 2006. I develop an empirical framework based on the theoretical insights from the incomplete contracts literature. In these types of models, incomplete contracts in combination with the necessity of relationship-specific investments lead to a hold-up problem, resulting in under-investment in R&D. I test this prediction by exploiting differences in the institutional environments across countries and differences in the contractual dependence across industries. I find that firms in countries with good contracting institutions have higher R&D investments, especially in indus-

Table 4.7: R&D Investments and Contracting Institutions - Sensitivity Analysis

Dependent variable: (log) R&D investments						
Selection criteria	Year		Excluded country		Excluded industry	
	<2000	$\geq$ 2000	Poland	Norway	"34: Motor..."	"30: Office..."
	(1)	(2)	(3)	(4)	(5)	(6)
Rule of Law: Q_{ct}	–0.263	–0.327	0.244	0.247	0.109	0.324
	(–1.55)	(–1.19)	(1.92)*	(2.13)**	(0.95)	(2.98)***
Judicial Quality interaction: $Q_{ct} * z_i$	0.270	0.265	0.229	0.359	0.497	0.199
	(2.64)***	(2.21)**	(2.49)**	(4.04)***	(5.85)***	(2.45)**
H/L x H intensity: $H_c * h_i$	4.358	0.549	1.877	1.839	1.007	1.336
	(5.65)***	(0.72)	(3.32)***	(3.12)***	(1.80)*	(2.19)**
K/L x K intensity: $K_c * k_i$	–.019	0.038	–0.012	–0.013	–0.013	–0.001
	(–0.82)	(0.89)	(–0.91)	(–0.99)	(–1.06)	(–0.76)
Additional Controls:	GDP, GDP per Capita, Country, Industry, Year FE, Log inc. x Interactions Fin. dev. x Interaction					
Observations	2,203	2,123	4,107	4,278	4,101	4,098
R^2	0.855	0.862	0.853	0.851	0.851	0.861

Notes: The dependent variable is log $R\&D_{cst}$. The dependent variable is defined as the (log) of R&D investments in country c in a two-digit ISIC sector s, in year t foe the 1997-2007. The measure of contract intensity z_i and Judical Quality Q_c are defined in the text. The first row indicates the exclusion restriction applied. Robust standard errors in brackets are clustered at the industry level. All regressions include a constant term. T-statistics in parenthesis. ***,** and * indicate significance at the 1%, 5%, and 10% level.

tries that are contractual dependent. According to my estimates, improving the contracting environment in a country has sizeable economic effects on the levels and compositions of R&D investments. I show that my results are robust to several extensions and alternative measures of my main variables and that causality can be established under fairly weak assumptions.

Although this paper presents a detailed analysis of the effects of contracting institutions on R&D investments at the country-industry level, a number of questions remain open for future research. Aside from the work by Lerner and Malmendier (2010), we still know relatively little about the specific channels how contracting institutions affect R&D investments at the more disaggregate microeconomic level and which types of contractual institutions work best to promote the development of new products and ideas at the firm and industry level. In addition, I mostly use aggregate indices such as the "rule of law" index from Kaufmann et al. (2007) to measure the contracting environment in a country. Using more detailed data about specific contracting institutions may also help to further improve our understanding of the interaction of contracting institutions and R&D investments.

Given the prominent role of R&D investments as a key driver of economic growth, policymakers around the world over recent decades have strongly promoted R&D investments, by providing tax incentives, direct and indirect subsidies or infrastructural support. My results show that improving the contracting environment is important for R&D spending, especially in sectors that produce more complex goods and, therefore, are more dependent on good institutions. This study underscores the importance of a good judicial system if R&D investments are a major policy concern. Policymakers may wish to remove impediments resulting from an inefficient and costly judicial system to attract and promote higher R&D investments in order to improve the innovative capacity of an economy.

C Appendices to Chapter 4

C.1 Data Description

Country Data

Physical capital K_c and Human capital H_c endowment : The stock of physical capital per capita is the total capital stock divided by the total number of workers in a country c. Human capital per worker is measured as the average years of schooling in the population over 25 years old in country i. Source: Caselli (2005).

Financial development (Cr_{ct}): Financial development is measured as the natural log of private credit by banks and other financial institutions to the private sector as a share of GDP in country c in period t. Source: Beck et al. (2000).

GDP, GDP (income) per capita: I use the variable "cgdp" for GDP per capita (income per capita) from the Penn World Tables 7.0. I multiply it by the total population of a country ("POP") to calculate total GDP in a country c in year t. Source: Penn World Tables 7.0.

Number of procedures, Time, Risk of expropriation, Repudiation of contracts: The number of procedures is the total number of procedures mandated by law or court regulation that demand interaction between the parties or between them and the judge or court officer in a country. It ranges from 11 to 41, with a higher value indicating more procedures. Time is the total estimated time of the full legal procedure in calendar days. It equals the total time until the completion of the service of process, duration of trial, or duration of enforcement. It ranges from 48 to 1100, with a higher value indicating a longer time to complete the process. The risk of expropriation index measures the risk of "outright confiscation" or "forced nationalization". It ranges from 0 to 10, with higher scores indicating lower risk. The repudiation of contracts measures the "risk of a modification in a contract taking the form of a repudiation, postponement, or scaling down" because of "budget cutbacks, indigenization pressure, a change in government, or a change in government economic and social priorities". It ranges from 0 to 10, with higher scores indicating lower risk. Summary statistics are depicted in Table C.2 Sources: Bank (2004), Djankov et al. (2003), Kaufmann et al. (2007), La

Porta et al..

Industry Data

Physical capital k_i and human capital h_i intensity: Physical capital intensity is the ratio of total real capital stock (in millions of USD) and value added (in millions of USD) in industry i in the United States in 1996 to 2005. Human capital intensity is measured as the share of nonproduction worker wages to total wages in industry i for 1996 to 2005. Source: Bartelsman and Gray (1996) database.

TFP growth (tfp_i): TFP growth is measured as the average growth rate in TFP in the United States in industry i in 1996 to 2005. Source: UNIDO (2005).

Value added (va_{ict}): Value added is measured as the share of value added to total output in industry i in country c for 1996 to 2005. Source: OECD (2011) .

Herfindahl index (h_i): The Herfindahl index is constructed using shares of inputs used in industry i for the United States for 2002. Source: BEA - 2002 United States I-O Use Table.

Intra-industry trade (iit_i): I use trade data for the United States and the Grubel-Lloyd index to measure intra-industry trade in industry i for the United States in year t. Source: Feenstra et al. (2005) database.

Establishments (n_{cit}): Is the number of domestically active firms in industry i in country c in period t. Source: UNIDO (2005).

All other variables are as described in the text.

Concordance Tables

To combine data from different sources with different industry classification systems I construct two concordance tables.

BEA - HS (2002) - SITC Rev. 2 concordance BEA table: In order to match the 2002 United States I-O Use table into the Rauch (1999) product classification I need to construct a concordance table from the SITC Rev. 2 to the BEA 2002 I-O

classification system. First, I match the concordance table from the SITC Rev. 2 to the HS10 classification, provided by Jon Haveman‘s collection of industry concordances. Second, I use the concordance table available from the BEA to map the I-O system of industry classification to the HS10 classification. Finally, I combine both tables and use the absolute number of HS10 links as an indicator to match an I-O industry to an SITC Rev. 2 industry. In a few cases, one industry was equally linked into multiple industries. In this case, the mapping was performed manually. This matching strategy results in one SITC Rev. 2 industry being matched to only one I-O industry. Consequently, some I-O industries were not matched to any SITC Rev. 2 industry.

BEA - NAICS (2002) - ISIC Rev. 3.1 concordance table: Since all industry variables are measured at the two-digit ISIC rev. 3.1 level, I need to construct a concordance table that maps the BEA 2002 I-O classification system into the ISIC rev. 3.1 classification. In a first step I use the concordance table provided by the BEA to aggregate the data from the 2002 Unites States I-O Use table to the six-digit NAICS (2002) classification. Second, I use the correspondence table provided by the United Nations Statistics division to map the NAICS (2002) classification into the two-digit ISIC rev. 3.1 classification.

C.2 Descriptive Statistics

Table 4.8: Summary Statistics for Alternative Measures of Judicial Quality

Judical quality measure	N	Average	Std	Min	Max
Time	25	259.72	220.08	48	1000
Number of procedures	25	21.72	6.34	11	41
Repudiation of contracts	23	8.92	0.98	5.95	9.98
Risk of expropriation	23	9.30	0.79	7.00	9.98
Correlations					
Rule of law	1.000				
Time	0.227	1.000			
Number of procedures	0.285	0.506	1.000		
Repudiation of contracts	0.778	0.267	0.267	1.000	
Risk of expropriation	0.816	0.275	0.359	0.929	1.000

Notes: This table provide summary statistics for different measures used for the judical quality in a country, which vary at the cross-section only. Data for rule of law are for the year 2000. As described in the data appendix in the empirical analysis I re-scale all variables such that high value indicates a better judicial quality.

Table 4.9: R&D Investments and Contracting institutions - Economic Significance

Dependent variable:	R&D investments	R&D investments	Gross investments	R&D intensity
Judicial Quality interaction: $Q_{ct} * z_i$	21%		20%	61%
Herfindahl interaction: $Q_{ct} * (1 - h_i)$		36%		
H/L x H intensity: $H_c * h_i$	10%	2%	4%	15%
K/L x K intensity: $K_c * k_i$	-1%	0%	0%	4%

Contract Institution Measure:	Time	Number of procedures	Repudiation of contracts	Risk of ex-propriation
Judicial Quality interaction: $Q_c * z_i$	8%	14%	19%	16%

Notes: This table evaluates the economic significance of the effect of contracting institutions on R&D investments. All values are in percentage points and show the effect of a one standard deviation increase of the explanatory variable on R&D investments. The upper part of the table depicts results for the baseline specification, for the Herfindahl index as alternative measure for contract intensity and for my two alternative proxies of R&D investments. The lower part of the table reports results for my four different measures of the contracting environment. All results are based on my estimates reported in tables 4.3 to 4.7.

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