Locations of Foreign Direct Investment: The Role of Immigrants, Bilateral Investment Treaties and Patents

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Contents

Preface

Foreign direct investment (FDI) undertaken by multinational firms is of fundamental importance for economies across the world. In the host economies of FDI, multinationals enhance productivity in the firms they invest in (Arnold and Javorcik, 2009), have positive spillover effects on firms in the same sector and in upstream sectors (Javorcik, 2004a; Haskel et al., 2007), and pay higher wages than domestic firms (Feenstra and Hanson, 1997; Lipsey and Sjöholm, 2004). The effects are amplified for FDI that is related to research and development (R&D), with additional spillovers through technology transfers (Bottazzi and Peri, 2003; Blalock and Gertler, 2008), labour turnover (Fosfuri et al., 2001) and patent citations (Jaffe et al., 1993; Thompson and Fox-Kean, 2005; Thompson, 2006). The effects of FDI are not restricted to the host economies of FDI. Home countries of FDI are also affected through within-firm and across-border knowledge spillovers (Blomström and Kokko, 1998; De La Potterie and Lichtenberg, 2001), increased domestic investment (Desai et al., 2009) and home employment effects (Brainard and Riker, 1997; Lipsey, 2004).

As an open economy, Germany is strongly intertwined in the web of FDI flows, with the size of inward and outward FDI having grown significantly in the past years. From 1999 to 2014, the stock of German outward investments has grown from €411bn to €958bn, with German multinationals employing 6.9mn people abroad in 2014. Over the same time period, the stock of German inward FDI has risen from €234bn to €462bn, with foreign multinationals accounting for 2.9mn jobs in Germany as of 2014.[1]

[1] Source: German Central Bank. The numbers include firms with both direct and indirect ownership links.

Given the economic significance of foreign direct investment flows, the question of where to locate a new investment is of great relevance. This is true both for the investing firm, for whom the location decision is a crucial ingredient for the ultimate success or failure of an investment, as well as for potential host countries, for whom FDI brings in numerous benefits. Despite a large literature on this topic (e.g. Cheng and Kwan, 2000; Head and Mayer, 2004; Bénassy-Quéré et al., 2007), many aspects of location decisions are still left for further research. For example, the precise mechanisms through which informal networks help to attract FDI, as well as the differential impact of location variables between general and research-related FDI have received only little attention in the literature so far. In addition, while there is some evidence for the positive effect of bilateral investment treaties on the location choice of FDI (e.g. Neumayer and Spess, 2005; Busse et al., 2010), the underlying tradeoff between investment attraction and the scope for regulation on the government's side deserves further attention.

This thesis sheds light on these significant questions, by contributing to our understanding of the factors that determine the location of FDI and its impact on host states. In particular, we emphasize the role of immigrants in attracting FDI, analyse the potential gains and losses in attracting FDI through bilateral investment treaties and delve into the special role of patents in determining the characteristics and location determinants of FDI.

Chapter 1 analyses the question whether the presence of immigrants helps to attract FDI from the immigrants' country of origin. While the traditional literature on the connection between immigrants and economic activity has focused on their role in generating trade (Gould, 1994; Rauch and Trindade, 2002), the literature on immigrants and FDI has gained some traction only recently (Javorcik et al., 2011; Burchardi et al., 2016). We contribute to this literature by being the first to look at the exact channels of the FDI-migration link, and by offering stronger estimation precision through a natural experiment and more fine-grained units of analysis. Our model proposes that immigrants attract FDI due to the information that they provide to investors, thereby lowering entry costs. Using a rich dataset on 402 German districts, 84 source countries and 13 years, we show that immigrants are successful in attracting FDI from their country of origin into their districts of residence. In order to get behind the mechanism of FDI attraction, we use further disaggregation to show that the results are stronger for smaller firms, service sector firms, firms with one shareholder only and a parent firm's first entry into Germany. We also employ a quasi-natural experiment, namely the large-scale immigration of ethnic Germans to Germany in the 1990s ('Spätaussiedler') and the ensuing exogenous allocation of these immigrants to validate our qualitative results.

Chapter 1 contributes to the existing literature on FDI and migration on several margins. We are the first to provide comprehensive evidence for the exact channel through which the FDI-migration link works: Using our disaggregated results, we demonstrate that the central mechanism is the role of immigrants in facilitating information provision to firms. The use of a quasi-natural experiment for identification is an additional novelty in the FDI-migration literature. Coupled with improved data quality through a more granular analysis at the district level and the inclusion of weighted variables and additional controls to mitigate endogeneity problems of earlier papers, the chapter makes for a more convincing case concerning the FDI-migration link than the existing literature.

Chapter 2 develops a theoretical model on bilateral investment treaties (BITs) and their welfare effects on firms who invest and the state who regulates. It also contains an empirical analysis to estimate the compensation costs of a BIT, and necessary redistributive fees to recover these costs. The existing theoretical literature on BITs is either framed in a purely domestic setting (Aisbett et al., 2010b), or considers BITs in the context of classical expropriations (Tomz and Wright, 2010). However, we argue that a newly emerging type of regulatory expropriation, which has a very different motivation than classical expropriation, is the more interesting case to look at. In addition, there is a large empirical literature on BITs, answering the question whether BITs attract FDI (e.g. Neumayer and Spess, 2005; Busse et al., 2010), but it has neglected the costs involved in terms of compensation payments for the state so far.

The model in Chapter 2 fills these theoretical and empirical gaps in the literature. In this model, the government is accountable to its electorate and can react to exogenous policy-relevant shocks. It can choose to regulate industries that were hit by a shock, thereby satisfying the electorate and raising its own utility. Firms in this model can choose to invest in the country, but face the risk of so-called regulatory expropriation through the government's regulation efforts, which would imply losing revenue. The government hence imposes a negative externality on firms when choosing to regulate. In the no-BIT world, there is over-regulation and under-investment compared to the first best scenario.

The introduction of a BIT forces the government to pay out compensation for the revenue that is lost under regulation, to internalize the externality. It causes firms to gain unilaterally at the state's expense. We show that a BIT improves aggregate welfare for very productive industries, but fails to achieve that for less productive industries, which suggests considering BITs on a by-industry basis. It implies that newly incoming FDI may lower overall welfare, whereas the protection of already existing FDI is a source of unambiguous gain. If a BIT improves aggregate welfare, we propose to redesign BITs by introducing a profit fee that redistributes gains such that a pareto-improvement results. In further extensions, we add tax revenues through FDI and the distinction between domestic and foreign firms, as well as the choice between exporting and FDI. These extensions generate further insights, such as the possibility of multiple equilibria and the reversal of comparative statics results through the introduction of a BIT.

In the empirical part of the chapter, we test the model by employing data on existing BITs and lawsuits to estimate the probability of arbitration cases if Germany were to sign a BIT with the US. We then add information from the legal literature (Hodgson, 2014) on average cost structures of lawsuits to estimate the expected compensation costs and the necessary redistributive profit fee.

Chapter 2 contributes to the theoretical literature on BITs by being the first to explicitly model the tradeoff between investment protection and regulation, while accounting for the newly emerging type of regulatory expropriations in an international context. The findings concerning aggregate efficiency gains, different effects by industry productivity and the role of domestic and foreign firms, as well as exports and FDI are all new to the literature and provide a novel framework for the analysis of the effects of BITs. The suggestion to consider industry-specific BITs and a redistributive profit fee are useful policy implications, motivated by the aim to maximize aggregate welfare while at the same time thinking about political feasibility. The chapter also contributes to the empirical literature by being the first to estimate compensation costs resulting from the ratification of a BIT.

Chapter 3 analyses the qualitative and quantitative differences between general FDI and R&D- or patent-related FDI ('patenting FDI') both in terms of descriptive statistics and their location determinants.[2] By doing so, the chapter draws upon several strands of the established literature: On the one hand, there is a large literature on the location determinants of FDI in general (see Blonigen, 2005, for a survey), looking at factors such as market access, infrastructure, institutions and tax policy. On the other hand, a separate strand of the literature analyses the location determinants of R&D activity (Kumar, 2001; Cantwell and Piscitello, 2005; Demirbag and Glaister, 2010), emphasizing the role of science-related human capital, local R&D spending and intellectual property protection rights. The chapter also relates to the 'exporter superstar' literature (Bernard et al., 1995, 2007), but with our focus being on the 'patenting superstar' firms within the group of multinationals instead.

Chapter 3 brings all strands together by being the first to undertake a direct comparison: We analyse how foreign affiliates belonging to either one of the two types of FDI differ in terms of size, age, productivity, regional and sectoral distribution, as well as how they

[2] We define patenting FDI as investments by parent firms who have applied for patents. More detailed definitions are presented in Chapter 3.

differ in their response to a set of location determinants. Using a firm-level panel dataset on the universe of German outward FDI and patenting activity abroad, we show that patenting FDI is much larger, older, has higher labour productivity and is more concentrated than general FDI. These characteristics provide a direct incentive to put special emphasis on the attraction of this specific set of investments. We further distinguish our results within the group of patenting multinationals, by looking at subsets such as patent applications, patent inventions and patent ownership. We also document the dynamic relationship between patents and FDI, by showing that affiliates where patents preceded investments are larger and hold higher-quality patents than those where the timing order is reversed. Our regression results reveal that patent-related FDI is much more likely to be attracted by large markets, higher local R&D spending, stronger intellectual property protection and better informal networks through immigrants than general FDI. It is less negatively affected by geographic distance and corporate tax rates. These effects are even stronger for patents of higher quality, and also differ by patenting motivation.

Chapter 3 contributes to the literature by being the first to directly juxtapose the two types of general and patenting FDI. It shows how certain subtypes of FDI differ strongly in their characteristics and location determinants from what we know about general FDI. Similar to the 'exporter superstar' literature, we uncover the existence of 'patenting superstar' firms within the group of multinationals. By doing so, the chapter combines several strands of the literature that have so far existed separately of each other. The chapter also provides fresh insights by expanding the analysis to new types of research-related FDI, such as FDI related to patent applications and patent ownership. These new types may have very different motivations and characteristics compared to what we used to know about R&D activity. We are also the first to document the dynamic relationship between FDI and patents, by showing how the timing order between the two affects affiliate characteristics. In addition, the chapter proposes a novel approach to identify R&D activity, by combining the presence of patents with FDI flows and thereby enabling more precise estimation through an enlarged dataset.

This thesis also relates to current issues widely debated in the general public. Since the beginning of this thesis in 2013, a number of current events have shaped the world, bringing the topics of the thesis to the forefront of global interest. First, the European refugee crisis, in which Germany occupied a key role, has put immigration at the centre of the political debate in many countries. Immigration was also a major topic in the US presidential election of 2016 and the UK's referendum on the decision whether to leave the European Union. Hence, providing a thorough analysis on the various aspects of immigration is of great interest to the general public. Chapter 1 achieves this by looking at the role of immigrants in influencing FDI flows. Second, negotiations over the Transatlantic Trade and Investment Partnership (TTIP) between the EU and the US have received substantial media coverage over the past years. The trade agreement proved to be controversial, in particular because of the inclusion of so-called bilateral investment treaties (BIT). Especially in Germany, movements skeptical of trade agreements have emerged as a result, on a scale not seen for decades. In such an environment, providing an analysis of the impact of BITs on both investors and the state can be a helpful contribution to the debate. Chapter 2 does exactly that, with a special emphasis on how to redesign BITs such that their benefits become more widespread. Third, the German federal government has launched the 'Industry 4.0' strategy, which demonstrates the future potential of integrated processes and decentralized production. It is an ongoing revolution of the manufacturing sector, making use of current communication technologies, with the concept of 'Industrie 4.0' becoming widely known across the world. As a result, we expect accelerated expansion of foreign direct investment through decentralized networks, coupled with significant growth in patents as means to protect intellectual property in connection with 'Industry 4.0'. Chapter 3 provides the analytical groundwork for these developments, by exploring the interaction between FDI and patents, and how patent-related FDI differs from what we know about general FDI.

To summarize, this thesis broadens our knowledge about the location characteristics of foreign direct investment, as well as the tradeoff between investment protection and regulation that is inherent in the politics of international trade. It provides novel insights on the role of immigrants in locating FDI, the gains and losses in signing bilateral investment treaties and ensuing possibilities for redistribution, as well as the stark contrast between patent-related and general FDI. By doing so, the thesis closes numerous gaps in the academic literature, and at the same time relates to current events in recent years. It is hence a valuable piece of research in our ongoing efforts for a better understanding of foreign direct investment.

Chapter 1

Do Immigrants Attract Foreign Direct Investment? District-Level Evidence from Germany

1.1 Introduction

When multinational firms scout possible investment locations abroad, they have a multitude of factors to take into account. These include criteria such as infrastructure, supplier access or local regulations. Suffering from the 'liability of foreignness' (Zaheer, 1995), these multinational firms may face difficulties obtaining such information without local support. As the Economist puts it, 'Although anyone can place a long-distance call, not everyone knows whom to call, or whom to trust.'[1] Hence, multinational firms may also consider the ease at which information about potential locations can be accessed as an important factor. At this point, immigrants from the firm's country of origin can step in to bridge the informational gap between their host country and their home country. Common nationality links immigrants abroad with firms in their home country through

[1]The Economist, April 24th 2010.

formal and informal contacts based on common language, culture, history and shared institutions.[2]

In this chapter, we analyse whether immigrants are indeed a location factor, i.e. whether the presence of immigrants in a particular location helps to attract inward FDI from the immigrants' country of origin. In answering this question, we use a dataset on 402 German districts, 84 source countries and 13 years (1999-2011).[3] The panel structure of the dataset allows us to exploit the variation between districts, countries, and over time. In addition, a quasi-natural experiment of large-scale ethnic German migration from the former Soviet Union ('Spätaussiedler') in the 1990s with random allocation of immigrants is used to confirm the results.

In the baseline specification, a one standard deviation increase in the share of j-country immigrants in district i raises ij-FDI entry by 8.6% each year. Using further disaggregation, we provide evidence that this effect is driven by the role of immigrants in facilitating information flows to parent firms: The effect is stronger if we are looking at a parent firm's first entry, but weaker if the parent firm already has experience in Germany. We also observe that smaller affiliates are more dependent on immigrants, since they do not have the means to hire external help to obtain information, and are hence more likely to rely on informal contacts. The effects are also stronger for affiliates in the service sector, which happen to be smaller than those in manufacturing. In addition, affiliates with only a single foreign multinational as shareholder rely more on immigrants than joint-ventures, as the latter group is more likely to involve a local German partner, who does not face informational obstacles. Lastly, a split by country groups reveals that the FDI-migration link is stronger for parent firms from developing countries and East Asia, compared to parent firms from Europe. The former group is also expected to face stronger informational barriers.

[2] In a survey, Schüller and Schüler-Zhou (2013) provide anecdotal evidence for the relevance of these channels for Chinese investments in Germany. Murat et al. (2009) provide anecdotal evidence for the linkages between the Italian diaspora and Italian outward investments during the 20th century.

[3] Districts have an average population of around 200,000 inhabitants, and an average area of around 900km^2.

Our research question merges several strands of the academic literature. On the one hand, there is a literature about the importance of information flows in determining FDI location (Daude and Fratzscher, 2008; Cristea, 2015). For example, Daude and Fratzscher (2008) have shown that FDI is much more sensitive to information frictions than other forms of capital flows. Similarly, a literature on cultural proximity deals with the question of preference for culturally similar people in trade (Guiso et al., 2009). On the other hand, there is a large literature on the effects of immigrants on local communities. This includes effects on labour markets (Borjas, 2003; Card, 2005), housing costs (Saiz, 2007) and crime (Bianchi et al., 2012). This chapter contributes to the debate in both strands by examining the sensitivity of FDI to information flows, thereby adding increased inward FDI as a possible benefit of the presence of immigrant communities.

While the literature on the relationship between FDI and migration has long been less extensive than the literature on trade and migration (Gould, 1994; Rauch and Trindade, 2002), it has gained some ground in recent years: Kugler and Rapoport (2007) and Javorcik et al. (2011) both use data on US outward FDI and inward migration at the country level to find a positive relationship between the two. However, their focus differs from ours, as our focus is on inward FDI, implying different channels of the FDI-migration link and policy implications. Later papers improved upon identification by using data at the sub-national level, which has the advantage that variables that only vary at the national level such as differences in domestic institutions, historical ties, currencies or national tax laws can be held constant. This approach removes endogeneity problems stemming from country-level heterogeneity.

Buch et al. (2006) look at the contemporaneous relationship between FDI and immigrants in Germany using state-level data. Their model of factor complementarity postulates that foreign parent firms receive a higher return on their capital when they invest in a state with a higher share of immigrants from their own country. The underlying assumption is that immigrant workers have to be employed by the affiliate from their home country.

Following this model, their empirical results show that FDI and immigrants are positively linked in both directions, with the effects being stronger for OECD countries.

Foad (2012) undertakes his analysis using US data from 1990 to 2004. The basic model explains the distribution of FDI stocks across states and source countries, where he finds that states with twice as strong immigration networks will receive on average 20 more FDI entries per year. Hernandez (2014) employs a sample of 288 US FDI entries between 1998 and 2003 from the Directory of Corporate Affiliations. Using a fixed effects probit model, he finds that a 1% increase in immigration concentration has an average marginal effect of a 1.35% increase in the probability of FDI entry for a particular state. The effects are particularly strong for knowledge-intensive industries and parent firms without prior experience. More recently, Burchardi et al. (2016) use US county-level census data on immigrants dating back to 1880. They exploit time variation in order to construct an instrumental variable based on push- and pull factors, as well as social networks factors, to estimate the impact of ancestry on FDI today. Their results show that doubling the number of immigrants from a particular country raises the probability of local firms engaging in FDI with that country by 4.2%. Effects are more pronounced for second-generation immigrants and more diverse origin and destination populations. However, the analysis in papers employing US data is only cross-sectional in nature due to the data limitations of decennial immigrant data from the US census and the lack of comprehensive US FDI data over time.

In the light of the literature, this chapter contributes to the literature on several margins:

First, we present comprehensive evidence in favour of a particular channel explaining the FDI-migration link, namely the role of immigrants in facilitating information flows. Previous papers have either offered differing explanations, or have hypothesized the role of information, but have not presented direct evidence in favour of it.[4] This is the first piece of research, to our knowledge, to delve deeper into the precise channel of the FDI-

[4] A single exception is Hernandez (2014), where there is one regression that looks at the difference between first-time and experienced investors.

migration link and to empirically assess the validity of competing explaining mechanisms. We make use of our rich dataset by breaking down the results by order of entry, affiliate size, shareholders, sector, and origin country of the parent firm. These disaggregated analyses are new to the literature, and we argue that their results can only be explained by the information hypothesis.

Second, we are the first to use a quasi-natural experiment for identification. The setting is the large-scale migration in the 1990s of ethnic Germans ('Spätaussiedler') from the former Soviet Union to Germany, who were exogenously allocated across districts. Due to the small sample size of immigrants and related affiliates, the setting is only used as a validation exercise to complement the main analysis. Nevertheless, we are the first to exploit truly exogenous variation in the form of a quasi-natural experiment to shed new light on the question of causality between immigration and FDI.

Third, data quality has been improved markedly along several dimensions: This chapter is among the first to undertake a fine-grained analysis at the district level, leading to more precise estimates.[5] This stands in contrast to papers using country-level or state-level data, where unrelated geographical areas may get conflated, leading to aggregation bias. Instead, districts are more likely to constitute the appropriate unit of analysis, as geographical mobility and knowledge about local characteristics are often confined to the district level, if one thinks of daily commuting distances.[6] Hernandez (2014) also cites the advantage of a district-level analysis for the same reasons. In addition, the dataset spans 13 years (1999-2011) and contains annual variation in both FDI and immigrants. This is an improvement compared to papers employing US data, where immigrant data are only updated every ten years. In addition, the number of source countries has increased to 84, which includes all countries that have invested in Germany over the sample period. This allows us to exploit much more detailed variation between districts, within districts over

[5] More recently, Burchardi et al. (2016) have similarly conducted their analysis at the US county level. However, their data are cross-sectional in nature since they only observe one wave of FDI stocks.

[6] According to Winkelmann (2010), 80% of commuters in Germany have a daily commuting distance of below 25km.

time, and between source countries, to generate more precise estimates. Furthermore, the data used in this chapter originate from administrative sources and are comprehensive due to compulsory reporting, which stands in contrast to surveys and census samples used in previous papers.

Fourth, we include economic geography in our analysis. Previous papers have treated all regions symmetrically, without any geographical interdependency between regions. This omits the fact that parent firms may take location determinants in neighbouring regions into account when making decisions. It also gives rise to some arbitrariness in variables such as district GDP, since its size is determined by how the political boundaries are drawn.[7] We are the first in the FDI-migration literature to include distance-weighted explanatory variables, by applying the same methodology as in Amiti and Javorcik (2008). By doing so, we account for the fact that parent firms may also factor in immigrants in neighbouring districts when determining their location decision and we ameliorate the arbitrariness in political boundaries.

Lastly, we deal with the endogeneity problems of the previous literature in a more comprehensive way. By looking at FDI entry rather than FDI stocks, and varying the lag length of explanatory variables, the problem of reverse causality can be mitigated. Lagged stocks of FDI are included as covariates to control for potentially spurious effects from country-specific firm agglomerations in a particular district. The inclusion of district fixed effects removes the possible endogeneity channel of district agglomeration effects. Country fixed effects control for the fact that source countries differ in their likelihood to invest, which could bias the results if there was systematic correlation with migration patterns. While a few of the above remedies have been used in previous papers, none has approached all aforementioned endogeneity issues at once.

The issue of immigration has recently gained much political attention, especially in the wake of the European refugee crisis in 2015. For policymakers who are interested in

[7] In Germany, this means that many small districts in the Ruhr area have rather small GDP, despite the fact they are actually part of a much larger metropolitan region, which implies large market potential.

the benefits and costs of immigration, especially at the local district level, the question whether immigrants attract FDI is hence particularly relevant. This chapter assesses the amount of FDI that the presence of immigrants can help to attract, hints at which immigrants are most effective at doing so, and what kind of FDI may be involved. Germany is an interesting case to study this question: It is the largest country in Europe in terms of absolute immigrant population and the second largest country in Europe in terms of inward FDI.[8]

The remainder of this chapter is organized as follows: Section 1.2 develops the theoretical framework to explain the FDI-migration link. Section 1.3 describes the dataset, with section 1.4 displaying some descriptive statistics. Sections 1.5.1 to 1.5.3 discuss the model specifications, with section 1.5.4 to 1.5.8 presenting the baseline results and further disaggregated analyses. Section 1.6 then concludes.

1.2 Theoretical Framework

Possible channels for the FDI-migration link include the provision of information and cultural proximity. For multinational firms who may have insufficient knowledge about a particular country abroad, knowing own-country immigrants in location i helps to put this place on the map, letting firms know about the existence of this location in the first place. In addition, immigrants can provide firms with information about possible local investment projects, greenfield sites and market characteristics. They can also help to liaise with authorities as immigrants may have a better grasp of the local language. Some of the information may be unique to the location in question, while some information (e.g. about national laws) can be generalized to the whole country. Hence, immigrants help in providing location-specific as well as nation-specific information. Moreover, cultural proximity may cause firms to favour dealing with brokers who are more similar to themselves, introducing a preference for own-country immigrants abroad (McPherson et al.,

[8] Source: CIA World Factbook 2013. 1st in terms of FDI is the United Kingdom.

2001; Guiso et al., 2009). All these factors help to lower entry costs for multinational firms in locations where a large immigrant community from their own country can be found.[9] We formalize the above ideas in a simple model, and show how the strength of the FDI-migration link depends on the characteristics of the parent firm and the investment.

A multinational parent firm h from country j maximizes profits by choosing a district i to invest in. Profits consist of two components: The first component is $r_{hi} > 0$, which denotes the revenue that firm h can generate in district i. It is assumed that r_{hi} is unrelated to the firm's country of origin. The revenue r_{hi} enters the profit function positively, and is treated as a 'black box' containing all firm- and district-specific determinants of revenue, such as market potential or the firm's productivity.

The second component is the cost $c_{hij} > 0$, which denotes the firm- and district-specific cost that is needed to obtain necessary information about the location before investing there. It includes costs of inquiring market characteristics, potential sites for investment and liaising with local authorities. This cost enters the profit function negatively. More formally, the parent firm's maximization problem is as follows:

$$\max_i \pi_{hij} = r_{hi} - c_{hij} \tag{1.1}$$

We assume $\exists h, i, j : r_{hi} > c_{hij}$. The information cost c_{hij} in turn consists of two components: The district-specific cost c^D represents the cost of obtaining information about a particular district. The nation-specific cost component c^N represents the cost of learning nation-specific characteristics (e.g. national tax laws).

$$c_{hij} = c^D_{hij}(.) + c^N_{hij}(.) \tag{1.2}$$

[9]Alternative explanations for a positive FDI-migration link include immigrants creating demand for special consumer goods, or immigrant labour being complementary to foreign capital. However, as we will show later, these alternative explanations are less consistent with the disaggregated results in the empirical section.

The cost of acquiring information occurs only once. As soon as a parent firm has obtained district- or nation-specific information, it can be used repeatedly for additional investments in the same entity at zero marginal cost. This implies that once a parent firm entered a district (nation), it will never have to incur the cost of acquiring information about the same district (nation) again. This weakens the FDI-migration link for subsequent entries. With ϕ^K_{hij} denoting the information cost for any first entry, we have:

$$c^K_{hij}(.) = \begin{cases} \phi^K_{hij}(.) > 0 & \text{if first entry by } h \text{ in K} \\ 0 & \text{if subsequent entry by } h \text{ in K} \end{cases} \qquad K = D, N \tag{1.3}$$

Since we are dealing with only one nation (Germany), c^N_{hij} can only occur once, whereas c^D_{hij} can occur multiple times, if each investment is in a different district.

For a parent firm, the presence of own-country immigrants helps to lower the cost of obtaining both types of information through the link of common nationality. More formally, with mig_{ij} denoting a measure of immigrants from country j in district i, we have:

$$\frac{\partial \phi^K_{hij}(.)}{\partial mig_{ij}} < 0 \qquad K = D, N \tag{1.4}$$

Each firm h has an idiosyncratic cost function $\phi(.)$, reflecting the difficulty it faces in obtaining information about a location. Parent firms from countries further away or with larger differences in institutions compared to the host country have higher information costs. Without loss of generality, the label h orders parent firms in ascending order by the costs they face:[10]

$$\phi^K_{(h+1)ij}(.) - \phi^K_{hij}(.) > 0 \qquad K = D, N \tag{1.5}$$

[10]For simplicity, we assume that this order is the same for both the nation- and district-specific information cost.

For parent firms who face higher costs in obtaining information, immigrants are assumed to provide an absolutely larger reduction in these costs:

$$\frac{\partial \phi^K_{(h+1)ij}(.)}{\partial mig_{ij}} - \frac{\partial \phi^K_{hij}(.)}{\partial mig_{ij}} < 0 \qquad K = D, N \tag{1.6}$$

Following directly from our assumptions, the above model gives rise to three hypotheses, which will be analysed in the empirical section:

Hypothesis 1: Districts with a larger measure of immigrants from country j receive more FDI entries from country j.

Hypothesis 2: Once a parent firm has already invested in a country, the importance of immigrants decreases for the subsequent entry in the same country.

Hypothesis 3: Immigrants are more important for parent firms who face larger information barriers.

1.3 Data

1.3.1 Foreign Direct Investment

Data on inward FDI in Germany are obtained from the 'Mikrodatenbank Direktinvestitionen' (MiDi) database, provided by the Research Data and Service Centre (RDSC) of the Deutsche Bundesbank (the German Central Bank). The MiDi database collects annual statistics on German inward and outward FDI in accordance with the German Foreign Trade and Payments Regulation. For inward FDI, all affiliates in Germany with a balance sheet in excess of €3mn and a direct foreign share of more than 10% are legally required to report to the German Central Bank. Indirect participating interests need to be reported if they exceed 50%. Hence, due to the compulsory nature of reporting, the MiDi database contains the complete universe of inward FDI in Germany above the thresholds. Both greenfield investments and M&A investments are reported. More information can be found at Schild and Walter (2015).[11]

An important topic is the issue of multi-location affiliates in the MiDi database. We only know the German headquarter location of the affiliate. This means that for multi-location affiliates, we would not be able to distinguish additional branches belonging to the same legal entity as the headquarter.[12] This could potentially introduce a margin of error if we want to measure economic activity of multi-location affiliates in a particular district. As in Spies (2010), we will use the number of affiliates as our dependent variable, as the extensive margin is much less affected by this error than the intensive margin (assets, employees, revenue) could potentially be. In addition, the extensive margin is also more likely to be influenced by immigrants as information providers than the intensive margin.

1.3.2 Immigrants

Data on immigrants in Germany are provided by the German Federal Statistical Office in its Genesis database, who obtain their information from the Central Foreigner's registry. In this context, immigrants are classified as foreign passport holders.[13] Data are available at the district-country-year level. This means that for each year t, we have information on how many immigrants from country j were residing in district i. This general dataset on immigrants in Germany is used for our baseline analysis and the disaggregated results in section 1.5.4 to 1.5.7.

[11]The MiDi database has the digital object identifier 10.12757Bbk.MiDi.9913.01.01.

[12]On the other hand, legally independent affiliates of the same parent firm would indeed show up as separate entries in the MiDi database.

[13]A potential shortcoming of the dataset is that it does not include naturalized citizens. Naturalized citizens would be captured by the term 'migrational background'. This information is contained in the annual micro census in Germany. However, the census' sample size is too small to draw inferences at the district level for smaller immigrant groups. Nevertheless, the micro census sample was examined for some large immigrant groups to infer whether the ratio of 'migrational background' vs. 'foreign passport holders' varies regionally. It turns out that the ratio is much lower in East Germany, which is why East Germany is excluded from the sample in a robustness check, presented in Appendix A.2.

In addition to the baseline analysis, we have a validation exercise in section 1.5.8, where we use an additional dataset on the large-scale immigration by ethnic Germans from the former Soviet Union in the 1990s ('Spätaussiedler'). The setting is used as a quasi-natural experiment. After the break-up of the Soviet Union, travel restrictions were lifted and millions of ethnic Germans living in the former Soviet Union were now able to move to Germany, where they were granted German citizenship upon arrival. Immigration of ethnic Germans in the mid-1990s largely took place from Russia and the Central Asian Republics. The immigrants were allocated to the federal states, who then applied state-specific allocation keys based on the population size of each district.[14] This implies that variations in the relative shares of ethnic German immigration that each district ended up receiving were orthogonal to other location factors. From 1996 on, an amendment to the Place of Residence Allocation Act required immigrants to stay at their assigned place, otherwise they would risk losing all social benefits. This policy was in place until 2001. Piopiunik and Ruhose (2015) provide evidence that compliance was high.

This historical setting can thus be viewed as a quasi-natural experiment, where immigrants were randomly allocated across districts, and where the allocation decision is independent of any FDI determinants. The same dataset has been used in papers analysing the effects of exogenous immigration shocks on labour market outcomes (Glitz, 2012) and crime (Piopiunik and Ruhose, 2015).[15] It includes inflows of ethnic Germans into each district from 1996 to 1998. Exceptions are Bavaria and all 5 East German states, where records were either not kept at the district level, or where records were too patchy.

1.3.3 Other Data

Further data on district variables (e.g. district coordinates, GDP, settlement share, tertiary education) were also sourced from the Federal Statistical Office, using its regional

[14] Allocation to the federal states is undertaken using the Königssteiner Schlüssel, which allocates shares to states according to their population and tax base.

[15] These papers also provide a more detailed description of the historical background and the allocation policy.

database. Country coordinates for computing distances were obtained from the GeoDist database of CEPII (see Mayer and Zignago, 2011). More information about data processing (e.g. weighting variables by distance, changes in district borders over time) is included in Appendix A.1.2.

The dataset has a panel structure with 3 dimensions: Districts, countries and years. There are 402 districts in Germany, but since the state of Saarland collects data on immigrants only at the state level, the number of districts is essentially reduced to 397, with Saarland's 6 districts merged into one unit. The sample originally contained 197 countries for which FDI and immigrant inflows could potentially be observed. To facilitate computation, all countries that have never invested in Germany in the sample period were dropped, which leaves us with 84 countries only.[16] In terms of years, the sample ranges from 1999 - 2011. In total, the panel dataset contains 459,329 observations, where the cross-sectional unit is 'district-country'.[17]

1.4 Descriptive Statistics

In this section, we present some descriptive statistics concerning the distribution of FDI and immigrants in Germany. Starting with our outcome variable of interest, inward FDI, Table 1.1 shows the top 15 districts in terms of the number of foreign affiliates in Germany. We can see that FDI has a very skewed picture, with large city districts dominating as attractive investment hubs. In 2011, the top 10 districts contained 37.7% of total inward FDI in Germany in terms of the number of affiliates. Despite the concentration of FDI at the top, there is also a rather long tail of districts that receive some intermediate amount of FDI. In total, there were 14,590 foreign affiliates in Germany in 2011.

[16] One could argue that this approach leaves out valuable information, and reduces the explanatory power of the analysis. But from a policy perspective, we are dealing with the subset of more relevant countries, since the analysis would not be too interesting for countries that never invest in Germany in the first place.

[17] Regressions will show less observations since we lose time periods through lags and as the PPML estimator drops observations to ensure the existence of estimates.

Table 1.1: Top FDI stock districts in 2011

	District	# Affiliates
1.	Frankfurt	1010
2.	Hamburg	797
3.	Berlin	784
4.	Munich (City)	749
5.	Düsseldorf	732
6.	Munich (District)	483
7.	Cologne	367
8.	Mettmann	209
9.	Main-Taunus	194
10.	Essen	173
11.	Hannover	169
12.	Stuttgart	142
13.	Offenbach (District)	140
14.	Rhein-Kreis Neuss	129
15.	Bremen	127

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, own calculations.

Table 1.2: Top FDI stock districts by country in 2011

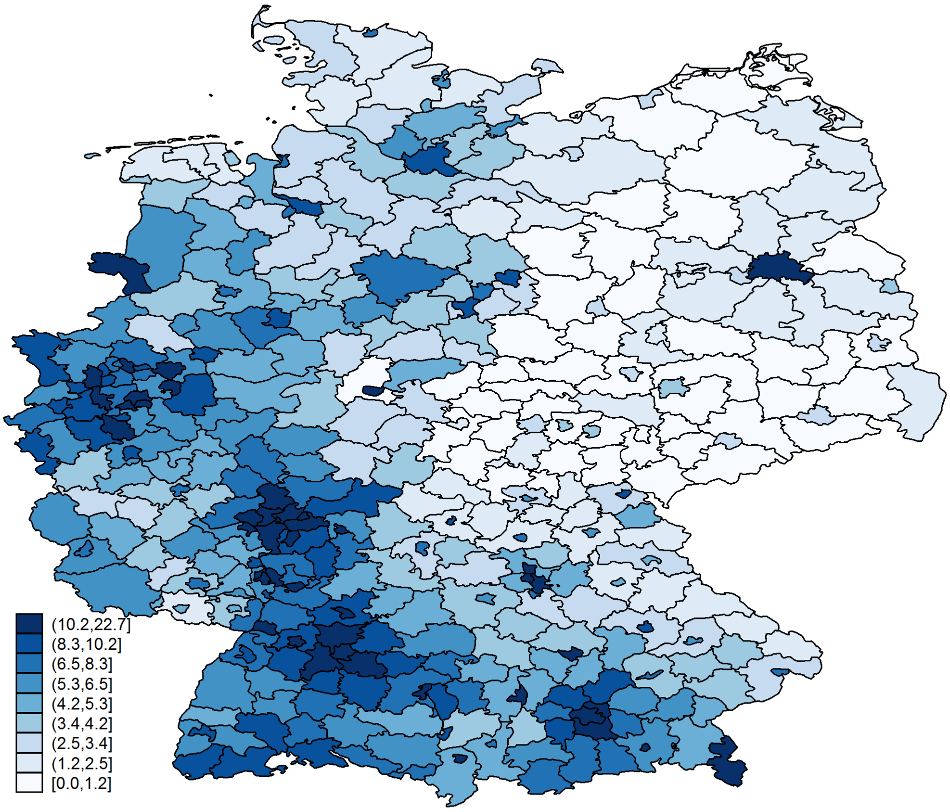
	France	# Aff.	Italy	# Aff.	Netherlands	# Aff.
1.	Frankfurt	69	Munich	99	Hamburg	175
2.	Berlin	62	Hamburg	27	Düsseldorf	159
3.	Düsseldorf	54	Cologne	19	Frankfurt	151
4.	Hamburg	50	Munich (Dist.)	19	Berlin	127
5.	Cologne	48	Frankfurt	16	Cologne	110

	Switzerland	# Aff.	Denmark	# Aff.	Japan	# Aff.
1.	Munich	112	Berlin	61	Düsseldorf	81
2.	Lörrach	66	Hamburg	49	Hamburg	22
3.	Frankfurt	63	Flensburg	16	Frankfurt	17
4.	Berlin	55	Pinneberg	10	Rhein-Neuss	17
5.	Hamburg	52	Schlesw.-Flensb.	10	Main-Taunus	14

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, own calculations.

Table 1.2 plots a more nuanced picture, disaggregating by source country, to show the top 5 destinations in terms of the number of affiliates for 6 chosen countries. We can see that the top destinations vary with the source country. For example, Italian multinationals predominantly invest in Munich, whereas Japanese multinationals choose Düsseldorf

Figure 1.1: Immigrant population (all nationalities) as % of total district population, 2011



Source: German Federal Statistical Office, own calculations.

as their prime location. Another picture that emerges is that FDI tends to follow a gravitational pull, as has often been found in the literature (Irarrazabal et al., 2013): Multinationals investing in Germany prefer to do so close to their own country's borders. This can be observed in the case of Switzerland and Denmark, where the districts of Lörrach (bordering Switzerland) and the districts of Flensburg and Pinneberg (both close to Denmark) show up in their top 5 destinations, while they do not feature in the other countries' top 5.[18]

The next part presents descriptive statistics about the explanatory variable of immigrants. Figure 1.1 shows a map with the distribution of the immigrant population share in Germany, aggregated across all nationalities. We can see that larger immigrant con-

[18]Due to the confidential nature of the MiDi data, only large investor countries could be presented. It is required that the number of affiliates and parent firms both exceed 3, in order to avoid identification of particular entities. This requirement is more easily fulfilled for large investor countries.

Table 1.3: Top immigrant share districts by country in 2011, % of total district population

	France	Share	Netherlands	Share	Switzerland	Share
1.	Ortenaukreis	1.03 %	County Bentheim	7.34 %	Waldshut	0.91 %
2.	Baden-Baden	0.92 %	Kleve	5.07 %	Lörrach	0.79 %
3.	Trier	0.66 %	Heinsberg	2.64 %	Konstanz	0.39 %

	USA	Share	Italy	Share	Turkey	Share
1.	Heidelberg	0.75 %	Wolfsburg	4.10 %	Gelsenkirchen	8.10 %
2.	Kaisersl. (Dist.)	0.70 %	Ludwigshafen	3.54 %	Duisburg	7.91 %
3.	Hochtaunuskreis	0.55 %	Solingen	3.25 %	Heilbronn	6.84 %

	Russia	Share	Japan	Share	China	Share
1.	Baden-Baden	1.21 %	Düsseldorf	0.94 %	Darmstadt	0.59 %
2.	Bayreuth	0.71 %	Frankfurt	0.40 %	Erlangen	0.58 %
3.	Düsseldorf	0.70 %	Rhein-Neuss	0.21 %	Goslar (Dist.)	0.49 %

Source: German Federal Statistical Office, own calculations.

centrations are found in highly urbanized areas of western and southern Germany and the city states. However, this does not mean that the aggregate picture is representative of particular nationalities. Instead, each nationality has their own distinctive distribution pattern across Germany: Table 1.3 shows us the top 3 districts with the highest shares of immigrants from a specific country. For Germany's neighbouring countries, districts with the highest concentration of immigrants are often found close to the border. This is true for France, the Netherlands and Switzerland. For US citizens, the largest concentration is found in the vicinity of existing or former military bases. Turkish and Italian immigrants cluster in traditional industrial areas, reflecting the large scale immigration from these countries in the context of the so called 'guest worker' programme in the 1950s and 1960s. Russian immigrants prefer the surroundings of classical spa and festival towns, such as Baden-Baden and Bayreuth.[19] Japanese immigrants are mainly found in the vicinity of large international cities with good airport links. Lastly, Chinese immigrants are concen-

[19]In fact, Dostojewski traveled to Baden-Baden on his second trip to Western Europe in 1863 and lost nearly all his money in the local casino. This story has been picked up by Russian writer Leonid Zypkin later on in his novel 'Summer in Baden-Baden', possibly prompting Russians to follow the traces of their great novelist.

trated around university towns, with all top 3 districts containing large institutions of tertiary education.

These descriptive statistics demonstrate that there is considerable variation in both our dependent and explanatory variable. FDI and immigrants do not all congregate in the same metropolitan area. Instead, each source country shows a very distinctive pattern of FDI and immigration. This variation enables us to identify the relationship between FDI and immigrants efficiently.

1.5 Regression Analysis

1.5.1 Endogeneity

When thinking about the relationship between FDI and immigrants, there are several endogeneity problems that could bias the results. First, there is the question of reverse causality. Are immigrants attracting investments? Or is it the other way round, in that parent firms first decide to invest, bring their own expatriate workers, who then in turn take their families with them? This reverse causality would be difficult to disentangle if one were to use stocks of both immigrants and FDI. However, for newly incoming FDI, the existing stock of immigrants is more likely to be exogenous. A parent firm that contemplates investing into a particular district in year t is unlikely to have influenced the existing immigrant stock in year $t-1$. Hence, the parent firm may view the existing immigrant stock as exogenous from its own perspective, and factor it in when forming its location decision. For this reason, we will use new FDI entries rather than stocks as explanatory variable. In total, there were 8,476 firm entries over our time period.

It could still be the case that the actual FDI decision precedes the migration decision. A parent firm could make a decision at time $t-2$ to set up a plant at time t in district i. This decision, known at $t-2$, prompts immigrants from the same country to locate in district i at $t-1$.[20] If that was true, the causality would run from FDI to immigrants, but our regression would wrongly suggest immigrants attracting FDI. To mitigate this endogeneity problem, we vary the lag of the explanatory variable of immigrants, up to $t-7$. With longer lags, the above reverse causality seems less plausible. In addition, we collapse the dataset by merging several years into one time period, thereby also implicitly lengthening the lag of the explanatory variable. The results for this robustness exercise are presented in Appendix A.2.

Another endogeneity problem stems from the existing stock of affiliates. It could be that a large business community from country j in district i has already been formed, indicated by a large number of affiliates from country j. This established business community could then attract new FDI entries from country j due to agglomeration effects. At the same time, j-country immigrants could be attracted as expatriates move in or because immigrants spot more general business opportunities. If that were the story, new FDI entries and the existing immigrant stock would be spuriously correlated, with the actual effect stemming from the role of the business community in attracting both FDI and immigrants. In order to control for that, we include the number of existing affiliates (the FDI stock) from country j in district i as a control variable.

Even then, it may still be the case that district fixed factors affect our estimations: For example, district i could happen to be a very attractive location for both FDI and immigrants, e.g. due to the existence of an international airport. In that case, attractive district location characteristics would pull in both immigrants and FDI, most likely of all countries. Any positive relationship between FDI and immigrants of a particular country that we observe would then be spurious, as part of the coefficient would contain the effects stemming from district-specific location advantages. Hence, we include district fixed effects in the regression in order to control for these time-invariant location characteristics. Furthermore, an additional regression is run, which includes the share of all other

[20] A worker team might be sent to district i to set up the plant, or other immigrants might voluntarily move there, sensing business opportunities by selling special products to expatriates.

immigrants (excluding immigrants from the country of the parent firm), to show that our results are indeed driven by country-specific immigrants, and not just by immigrants in general. Results for this additional regression are presented in Appendix A.2.

In addition, we have seen that for Germany's neighbouring countries, both FDI and immigrants tend to cluster at the border. This means that distance could play a crucial role in the FDI-migration link: It may be the case that by merely being located close to country j, a particular district i will receive more FDI and immigrants from country j. Then, any positive relationship between FDI and immigrants may be spurious, reflecting the positive influence distance has on both. This channel concerns only a few neighbouring countries and can be controlled for by including a distance variable. This variable contains the geodesic distance between district i and the largest city of country j.

1.5.2 Immigrant Measures

We will use three different measures to capture immigrants. The first measure is the logarithm of the absolute number of immigrants in district i from country j at time t. This gives us an indication of the number of potential contacts a foreign business could relate to. However, this measure does not account for the size of a particular district, so large districts will automatically have large immigrant numbers, even though relative shares might be small. To account for that, we also use the immigrant share, measured as percentage share of the immigrant population from country j in district i at time t. This is defined as:

$$Immigrants\ share_{ijt} = \frac{immigrants_{ijt}}{population_{it}} \cdot 100\% \tag{1.7}$$

The advantage of this measure is that the immigrant share indicates the strength of the immigrant network in the local community, and normalizes by the size of the district. A larger concentration of immigrants can send a more precise signal to parent firms in their original home country about local circumstances (Foad, 2012).

However, the average share of immigrants varies strongly by country of origin. While a share of 1% in a particular district would be rather high for Japanese immigrants, the same number would be considered low for Turkish immigrants in Germany. Hence, a third immigrant measure normalizes the immigrant share in district i by the nationwide share of immigrants from country j. This measure will be called immigrant intensity:[21]

$$Immigrants\, intensity_{ijt} = \frac{immigrants_{ijt}/population_{it}}{immigrants_{jt}/population_{t}} \tag{1.8}$$

The advantage of this measure is that it tells us about the strength of an immigrant network in a particular district relative to the nationwide average share. A higher immigrant intensity in district i would then imply that parent firms can tap relatively abundant information sources in this district compared to relatively scarcer information somewhere else in Germany.

In accordance with most of the literature on FDI and migration, we will use the immigrant share as the main measure in all specifications. Results using the other two measures will be shown for robustness purposes.

[21] The idea draws upon Foad (2012), but the interpretation of the measure offered in this chapter is different.

1.5.3 Specification

Incorporating all the considerations above, the baseline specification looks as follows:

$$\begin{aligned} fdi\_entry_{ijt} = \beta_0 + \beta_1 immigrants_{ijt-1} + \beta_2 fdi\_st_{ijt-1} + \beta_3 market_{it} + \\ \beta_4 dist_{ij} + \beta_5 settle_{it} + \beta_6 tertiary_{it} + \delta_i + \eta_j + \mu_t + \epsilon_{ijt} \end{aligned} \tag{1.9}$$

Subscript i stands for the district, j stands for the country, and t denotes the year.

Here, fdi_entry_{ijt} denotes the number of foreign affiliates from country j entering into district i in year t. As discussed in previous sections, using the number of affiliates entering a district as dependent variable is the recommended choice to mitigate endogeneity problems and measurement errors. Depending on the specification, $immigrants_{ijt-1}$ stands for the logarithm of the absolute number of immigrants, the immigrant share (in %), or immigrant intensity. The immigrant variables were all weighted by distance: The own district has weight 1, and other districts enter with lower weights that depend negatively on distance. Weights are computed using a negative exponential function, with details about the weighting process in Appendix A.1.2. The coefficient β_1 on the immigrant variable is of our main interest, and we expect a positive sign.

Variables fdi_st_{ijt-1} and $dist_{ij}$ were included to mitigate endogeneity problems as discussed in section 1.5.1. fdi_st_{ijt-1} gives us the number of the existing stock of affiliates from country j in district i in year $t-1$.[22] The variable $dist_{ij}$ stands for the the logarithm of distance of district i to the largest city of country j in kilometres.

[22]Readers may worry about the classical dynamic panel problem of a lagged dependent variable in the covariates in combination with fixed effects, also known as the Nickell bias (Nickell, 1981). The answer to this issue is threefold: First, the setup here differs from the classical lagged dependent variable case in that our dependent variable is not the stock of FDI, but FDI entry instead. Second, the specification includes district- and country fixed effects only, rather than district-country fixed effects. This implies that any possible correlation between the error term and the covariates is small, as the mean computed in de-meaning is taken across JT and IT observations, rather than just T observation as in the classical case. Third, as the Nickell bias in a fixed effects framework is downward, any findings of positive results actually strengthen the case for a positive relationship.

Other variables that may influence the attractiveness of a location are included. The variable $market_{it}$ contains the GDP of district i in year t, including weighted GDP of neighbouring districts.[23] It stands for market potential, and indicates the attractiveness of a particular location in terms of its market size. The variable $settle_{it}$ stands for the share of built-up area in district i in %. The variable offers a way to distinguish urban and rural districts, with a higher value of $settle_{it}$ denoting a more urban district. The variable $tertiary_{it}$ gives us the share of inhabitants holding a tertiary degree in district i. We include district-, country- and year fixed effects. This controls for any time-invariant characteristics in districts or countries and time-varying macroeconomic effects that may influence the FDI decision.[24]

The dependent variable is a count variable with non-negative integer values, and a large proportion of zero observations, due to the sparse nature of FDI entry at the district-country level. This setup suggests the use of the Poisson or negative binomial estimator. However, as discussed above, our specification demands a large number of fixed effects to mitigate endogeneity problems. The large number of fixed effects causes the nonexistence of estimates in the classical Poisson and negative binomial estimator. As has become common in the trade gravity literature in cases like these, the Poisson pseudo-maximum-likelhood estimator (PPML) as discussed in Silva and Tenreyro (2006) is used. The PPML estimator identifies and drops regressors that may cause problems in classical Poisson estimation. For robustness purposes, results from a censored regression model using the Tobit estimator are also shown. Standard errors are clustered at the country-district level.

Summary statistics are presented in Table 1.4. Depending on whether the variables vary at the district-country-year level or are more aggregate in nature, the number of unique

[23]Similar to the immigrant variable, the detailed methodology for the weighting process can be found in Appendix A.1.2.

[24]A short note on the incidental parameter problem: The data consist of all possible district-country pairs, with only district- and country fixed effects included. This means that adding a new country would add 397x13 additional observations but only one new parameter. Adding a new district would add 84x13 additional observations but only one new parameter. Hence, the incidental parameter problem is much mitigated, with Egger et al. (2011) providing further details of this discussion.

Table 1.4: Summary statistics

	N	Mean	Median	90^{th} pctile	St Dev
District-country-year level					
Log abs. # immigrants (weighted)	459,329	3.685	4.049	7.018	2.930
Immigrants share (weighted, in %)	459,329	0.071	0.009	0.137	0.276
Immigrants intensity (weighted)	459,329	0.927	0.731	1.783	1.096
FDI entry (# affiliates)	5,161	2.8	1	5	9.7
FDI stock (# affiliates)	5,161	29.2	11	55	78.9
District-country level					
Log distance (km)	35,333	8.03	8.35	9.22	1.11
District-year level					
Log market potential (€mn)	5,161	9.09	9.66	10.85	2.70
Settlement share (in %)	5,161	20.12	13.27	45.00	15.26
Tertiary education share (in %)	5,161	7.49	6.72	12.39	3.68
District level					
Aussiedler share '96-'98 (in %)	229	0.51	0.49	0.82	0.26

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, CEPII, Glitz (2012), German Federal Statistical Office, own calculations.

observations varies for each variable. FDI entry and FDI stock are exceptions, as only aggregated district-year (instead of district-country-year) level summary statistics could be provided due to confidentiality reasons.

1.5.4 Results - Baseline

Results are presented in Table 1.5. Column (1) contains the results from the baseline regression using the immigrant share as dependent variable. The coefficient on the immigrant share is positive and highly significant. The results provide support for hypothesis 1 from section 1.2 that immigrants help to attract FDI. Interpreting the coefficient as semi-elasticity, we can see that raising the weighted percentage-point immigrant share from country j in district i by one standard deviation (sd: 0.276) increases j-country FDI entry in district i by 8.6% for each year.[25]

The FDI stock variable is positive and highly significant. This gives us an indication of country agglomerations at the district level. Multinationals like to invest where other

[25] This is computed as $e^{0.276 \cdot 0.2998} - 1 = 0.086$.

Table 1.5: Results - Baseline

Dependent variable: FDI entry	(1) PPML Full Sample	(2) PPML Full Sample	(3) PPML Full Sample	(4) Tobit Full Sample
Immigrants Share(t-1)	0.2998***			0.6316***
	(0.1000)			(0.1419)
Immigrants Intensity(t-1)		0.2127***		
		(0.0477)		
Immigrants Absolute(t-1)			0.2598***	
			(0.0467)	
FDI Stock(t-1)	0.0049***	0.0053***	0.0052***	0.1007***
	(0.0009)	(0.0009)	(0.0009)	(0.0055)
Distance	-0.5960***	-0.3919***	-0.3334***	-0.9433***
	(0.0707)	(0.0971)	(0.0989)	(0.1353)
Settlement Share	0.1220***	0.1266***	0.1294***	0.1936***
	(0.0401)	(0.0403)	(0.0402)	(0.0622)
Market Potential	0.7040	0.5260	0.4820	1.1438
	(0.9556)	(0.9603)	(0.9592)	(1.2804)
Distr. Tert. Share	0.0128	0.0194	0.0152	-0.0469
	(0.0269)	(0.0270)	(0.0264)	(0.0390)
Constant	-11.2333	-11.0927	-12.1701	-19.4755
	(8.9383)	(8.9288)	(8.8409)	(12.1819)
Observations	386,780	386,780	386,780	390,764
R^2	0.4857	0.4831	0.4852	
District FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SE Clusters	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

firms from the same country can already be found. This can create virtuous cycles and is an interesting finding in itself for local policymakers. Distance enters negatively, as could be expected. Greater distance from country j reduces the attractiveness of a district for j-country affiliates.[26] The settlement share enters positively, indicating that more urbanized districts receive more FDI than more rural districts. Lastly, market potential and the share of tertiary educated inhabitants do not have significant coefficients. At the district level, their importance for location decisions seems to be rather subdued.

Columns (2) - (3) present results using the alternative definitions of immigrants, namely immigrant intensity and the absolute number of immigrants. In both cases, the immigrant variable is still positive, highly significant, and the coefficients on the other covariates are stable in sign and magnitude. Column (4) contains the results using the Tobit estimator, to show that results do not depend on the particular properties of the PPML estimator. Again, the coefficient on immigrant share is positive and highly significant, with coefficients on other variables retaining sign and significance as well.

1.5.5 Results by Order of Entry

Having established a positive link between immigrants and FDI, the following sections will look at possible channels to explain the link. We hypothesize that immigrants attract FDI because they facilitate information provision for firms from their home country. In the next sections, we will disaggregate our results by order of entry, sector, size, shareholders and country groups, to present evidence in favour of the information hypothesis. In contrast, alternative explanations for a positive FDI-migration link, such as immigrants creating demand for special consumer goods, or immigrant labour being complementary to foreign capital, cannot explain the disaggregated results.

[26] This is in contrast to the theoretical considerations in the classical proximity-concentration tradeoff (Brainard, 1993), but it is consistent with findings in the empirical literature (Irarrazabal et al., 2013), where it has been shown that FDI shows a gravity-like behaviour similar to trade flows.

We first differentiate our results by the order of entry. This means that we split the sample of FDI entries according to whether a particular FDI entry was a parent firm's first affiliate in Germany, or whether it was a subsequent entry of a parent firm who already has experience in Germany. The sample of subsequent entries was then further disaggregated into whether the subsequent entry was undertaken in the same district (state) as the first entry, or whether it has been in a different district (state).[27] Hence, the specification is the same as in regression (1.9), only with the dependent variable being replaced.[28]

Results are presented in Table 1.6. Column (1) shows the results with parent firms' first FDI entries. We can see that the coefficient on the immigrant share is positive and highly significant, and larger in magnitude than in the baseline specification. Column (2) shows results for using parent firms' subsequent FDI entries as dependent variable. In this specification, the coefficient on the immigrant share is much smaller, and only marginally significant. It looks like once a parent firm has established an affiliate in Germany, the presence of immigrants is considered much less important when deciding for a second time where to invest.

The results are consistent with the role of immigrants in providing information and the existence of nation- and district-specific information costs, thereby supporting hypothesis 2 from section 1.2. Since the nation-specific part of this information cost has become redundant when entering for a second time, the importance of immigrants as information providers is reduced for subsequent entries.

The picture is confirmed when we disaggregate subsequent entries further. Column (3) contains only those subsequent entries as the dependent variable, where the entry was undertaken in the same district as the first entry. For this subsample, the coefficient

[27]Out of a total of 8,476 affiliate entries from 1999 - 2011, 7,020 were a parent firm's first entry. This leaves 1,456 affiliates for subsequent entries. Looking at subsequent entries in the same district leaves us with 275 affiliates. It is left to the reader how much significance to attach to the regressions with only small sample sizes, as in the latter case. The results are presented nevertheless for completeness.

[28]In particular, the FDI stock variable remained the same, containing the whole FDI stock rather than just certain entries.

Table 1.6: Results by order of entry

Dependent variable: FDI entry	(1) PPML First Entry	(2) PPML Subseq. Entry	(3) PPML Subseq. Same D.	(4) PPML Subseq. Diff. D.	(5) PPML Subseq. Same St.	(6) PPML Subseq. Diff. St.
Immigrants Share(t-1)	0.4685***	0.2848*	0.0717	0.3680**	-0.0276	0.4016**
	(0.1019)	(0.1635)	(0.4593)	(0.1643)	(0.4789)	(0.1717)
FDI Stock(t-1)	0.0050***	0.0091***	0.0131***	0.0059***	0.0117***	0.0059***
	(0.0012)	(0.0026)	(0.0037)	(0.0019)	(0.0036)	(0.0019)
Distance	-0.7824***	-0.8650***	-1.3171***	-0.8268***	-1.2248***	-0.8209***
	(0.0780)	(0.1257)	(0.3145)	(0.1318)	(0.3092)	(0.1355)
Settlement Share	0.1569***	0.2589***	0.5807***	0.1726*	0.4717***	0.1801*
	(0.0475)	(0.0931)	(0.1726)	(0.1029)	(0.1665)	(0.1052)
Market Potential	-0.7326	3.9707*	15.5702**	2.6375	15.6298***	2.6202
	(1.1033)	(2.1347)	(6.2850)	(2.4551)	(5.6525)	(2.3435)
Distr. Tert. Share	-0.0281	0.0867	0.2054	0.0341	0.1685	0.0337
	(0.0307)	(0.0618)	(0.2864)	(0.0533)	(0.2630)	(0.0535)
Constant	2.7748	-40.3933**	-146.8897**	-27.7355	-146.5516***	-27.6685
	(10.4226)	(19.4034)	(59.5194)	(22.1047)	(53.4557)	(21.0289)
Observations	351,040	115,752	17,175	95,304	20,436	93,324
R^2	0.3562	0.2139	0.5282	0.1424	0.5136	0.1401
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
SE Clusters	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: RDSC of the German Central Bank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

on the immigrant share is not significantly different form zero. In contrast, column (4) shows that immigrants retain their importance when the subsequent entry is undertaken in a district that is different from the first. However, the coefficient is still smaller in magnitude compared to first entries in column (1). This is also consistent with the story that while nation-specific information will have become redundant, district-specific information will need to be required afresh for the type of entries in column (4).

Column (5) has subsequent entries in the same state as the first entry as dependent variable. As in column (3), the coefficient of the immigrant share variable is insignificant. On the other hand, column (6) presents results with subsequent entries in a different state than the first entry. Here, immigrants seem to matter again. Interestingly, the coefficient in column (6) is larger than in column (4), implying that immigrants matter more when moving to another state rather than only another district. A possible explanation is that the further away a parent firm moves from its original first investment location, the more the parent firm will depend on new information provided by immigrants. The usefulness of the old information provided by immigrants is decreasing in distance.

It may also be worth noting that market potential becomes significant and the importance increases strongly in magnitude when a parent firm invests for a second time, especially if the entry happens in the same district / state as before. This indicates learning on the parent firm's side: While a parent firm may still face some uncertainty about the first location, thereby depending on immigrant support to overcome informational barriers, the second entry can be fully devoted to local characteristics, such as market potential considerations.

1.5.6 Results by Sector, Size and Shareholders

Table 1.7 presents results by sector, size of the affiliate and its shareholders. Column (1) and (2) split the sample of FDI entries into manufacturing and services affiliates.[29] Similar to the sample split in the previous subsection, only the dependent variable has changed. It is evident that services affiliates are more influenced by immigrants in their location decision compared to manufacturing affiliates. Given that services affiliates are much smaller in the sample, these results shed new light on the type of FDI that immigrants attract. Instead of pulling in high value-added manufacturers, immigrants are more likely to attract smaller services FDI. Columns (3) and (4) present results splitting the sample into affiliates with a balance sheet above and below €20mn. We can see that the FDI-migration link is driven by smaller affiliates, since only their immigration coefficient is larger than in the baseline and strongly significant. This is consistent with the hypothesis that information frictions are crucial: Larger affiliates may be able to fall back on in-house divisions of their parent firms to assist them in obtaining information, or can hire external consultants to help them doing so. In contrast, the same might not be worthwhile for smaller affiliates, where reduced investments imply that parent firms may have to rely on informal connections through immigrants. Interestingly, parent firms of larger affiliates put a larger emphasis on market potential of their prospective locations.

Columns (5) and (6) split the sample by whether the reporting foreign parent firm is the full shareholder of the German affiliate, or whether this is not the case. While we do not know the exact composition of the other shareholders, holding no full share means that there is some likelihood of other German parent firms as co-shareholders. With the involvement of other German parent firms, the problem of information frictions in searching for suitable locations is much reduced. As expected, the greater role of

[29] Manufacturing was defined as affiliates with NACE 1.1 codes ranging from 1500 to 4999 and NACE 2 codes ranging from 1000 to 4499. Services was defined as affiliates with NACE 1.1 codes ranging above 5000 and NACE 2 codes above 4500. The FDI Stock variable in these two regressions was also restricted to manufacturing and services FDI, respectively.

Table 1.7: Results by sector, size and shareholders

Dependent variable: FDI entry	(1) PPML Manufacturing	(2) PPML Services	(3) PPML $B/S > 20mn$	(4) PPML $B/S < 20mn$	(5) PPML Full Share	(6) PPML No Full Share
Immigrants Share(t-1)	0.2101***	0.3466***	-0.0058	0.4445***	0.3256***	0.2788***
	(0.0806)	(0.1241)	(0.1167)	(0.1051)	(0.1203)	(0.0949)
FDI Stock(t-1)	0.0393***	0.0050***	0.0037***	0.0055***	0.0046***	0.0054***
	(0.0806)	(0.1241)	(0.1167)	(0.1051)	(0.1203)	(0.0949)
Distance	-0.4933***	-0.6099***	-0.5554***	-0.6136***	-0.5661***	-0.6444***
	(0.0701)	(0.0861)	(0.0774)	(0.0803)	(0.0782)	(0.0904)
Settlement Share	0.1135**	0.1162**	0.1301**	0.1184***	0.1292***	0.1191*
	(0.0572)	(0.0457)	(0.0527)	(0.0432)	(0.0436)	(0.0622)
Market Potential	0.4622	0.9205	2.3678**	-0.3393	0.3008	2.2363
	(1.1171)	(1.1806)	(1.1632)	(1.0584)	(1.0402)	(1.4383)
Distr. Tert. Share	-0.0800**	0.0461	-0.0323	0.0278	-0.0108	0.0630*
	(0.0316)	(0.0332)	(0.0388)	(0.0276)	(0.0306)	(0.0375)
Constant	-9.2600	-14.2929	-27.1624**	-2.8833	-8.1135	-26.9095**
	(10.8449)	(10.8202)	(11.0576)	(9.9571)	(9.8047)	(13.5247)
Observations	259,464	357,760	246,468	362,768	314,432	308,432
R^2	0.1399	0.4850	0.4309	0.4038	0.4403	0.3013
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
SE Clusters	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: RDSC of the German Central Bank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

information frictions for full foreign shareholders results in a greater role of immigrants in their location decision, as shown by the larger immigration coefficient in column (5).

To conclude, the results in this section provide evidence in favour of hypothesis 3 from section 1.2, as we can show that parent firms with larger informational frictions (smaller affiliates, sole foreign shareholders) are more reliant on immigrants.

1.5.7 Results by Country Groups

We can also look at whether the FDI-migration link is stronger for particular groups of countries. This is done by using the full sample, but generating a dummy variable that is equal to one if the observation belongs to a particular country group, and then interacting the dummy with the immigrant share variable. The country groups are developing countries, the EU15 countries and East Asia (China, Japan, South Korea and Taiwan).[30]

Results are presented in Table 1.8. Column (1) shows the results when the dummy captures the group of developing countries: We can see that the immigration effect is much stronger for parent firms from developing countries, as indicated by the positive and significant interaction term. We further look at additional country groups in column (2) and (3), where the dummy captures the EU15 and East Asian countries, respectively. By adding the coefficients on the interaction and the lower order terms, we find that the FDI-migration link is much weaker for the group of EU15 countries, and much stronger for East Asian countries.[31]

It appears that parent firms from highly developed countries with institutional settings similar to those in Germany and geographical proximity (EU15) depend much less on immigrant support. On the other hand, parent firms from countries more dissimilar

[30]For the set of developing countries, the definition of the German Central Bank was applied.

[31]Due to the non-linear nature of the PPML estimator, the interpretation of interaction terms is not as straightforward as in the linear case (Ai and Norton, 2003). Hence, the results in this section are only seen as indicative. However, an interpretation of coefficients as incidence ratio is still possible. See Buis (2010) and Alstadsaeter et al. (2015) for details.

Table 1.8: Results by country groups

Dependent variable: FDI entry	(1) PPML Full Sample Developing countries	(2) PPML Full Sample EU15	(3) PPML Full Sample East Asia
Immigrants Share(t-1)	0.2941***	0.8346***	0.2941***
	(0.0992)	(0.2545)	(0.0988)
Immigrants Share * Dummy	4.7044***	-0.5670**	5.0598***
	(0.9470)	(0.2619)	(1.0174)
Dummy	-4.2802***	2.0731***	0.4666
	(0.5453)	(0.5721)	(0.6245)
FDI Stock(t-1)	0.0051***	0.0047***	0.0050***
	(0.0009)	(0.0009)	(0.0009)
Distance	-0.5920***	-0.5926***	-0.5997***
	(0.0709)	(0.0697)	(0.0703)
Settlement Share	0.1220***	0.1240***	0.1226***
	(0.0400)	(0.0401)	(0.0401)
Market Potential	0.7033	0.6522	0.7014
	(0.9527)	(0.9565)	(0.9536)
Distr. Tert. Share	0.0125	0.0137	0.0130
	(0.0268)	(0.0269)	(0.0268)
Constant	-7.0174	-10.7976	-11.1736
	(8.9009)	(8.9454)	(8.9218)
Observations	386,780	386,780	386,780
R^2	0.4856	0.4855	0.4860
District FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
SE Clusters	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

to Germany (developing countries) or with large distances (East Asia) are much more reliant on immigrant presence. This underlines the relevance of immigrants as information providers, as the results of this section indicate that subgroups with larger informational barriers tend to rely more on immigrants. It corroborates the results found in Girma and Yu (2002) on the effect of institutional similarity on trade and supports hypothesis 3 from section 1.2.

Further robustness checks on our estimates can be found in Appendix A.2, where additional regressions are conducted based on subsamples (e.g. excluding large cities), further controls, varying the time lag and the weighting function, as well as collapsing years into fewer time periods.

1.5.8 A Quasi-Natural Experiment

As a validation exercise, and to supplement the results from the baseline analysis, we use a quasi-natural experiment to confirm the qualitative results. The question examined here is whether districts that received larger inflows of ethnic German immigrants from the former Soviet Union from 1996-98 also see more Russian parent firms investing over the time period 1999-2011.[32] The advantage of this dataset is that the existing stock of immigrants can be seen as truly exogenous from the perspective of the parent firms. The underlying assumption is that, despite their German heritage, the immigrants still kept ties to their home country, providing valuable information to Russian parent firms deciding to invest in Germany. In this regression, we only have one source country of immigration, namely the former Soviet Union. The time dimension was also collapsed into one time period only, since we use ethnic German immigrant data from 1996-98, which dates before the earliest period of the FDI data.

[32] We only look at Russian parent firms because investments from other source countries of ethnic German migration are virtually nonexistent.

The specification is as follows:

$$fdi\_entry_i = \beta_0 + \beta_1 aussiedler_{i96-98} + \beta_2 fdi\_st_i + \beta_3 market_i + \beta_4 dist_i + \beta_5 settle_i + \beta_6 tertiary_i + \mu_{state} + \epsilon_i \quad (1.10)$$

Here, i stands for the district. The lack of a j subscript for countries stems from the fact that we are only dealing with one source country here. The dependent variable is the cumulated entry of firms from Russia over the time period 1999-2011. The variable $aussiedler_{i96-98}$ gives us the share of ethnic German immigration (as % of total population) into district i in the years 1996 - 1998. This also explains the lack of district fixed effects, as the explanatory immigrant variable is time-invariant and would hence be completely captured if district fixed effects were included. However, state-level fixed effects were included. This accounts for the fact that at a national level, immigrants were distributed amongst the states based on population and tax intake, which could potentially be correlated with other time-invariant location characteristics relevant for the FDI decision. The other variables in specification (1.10) are defined as in the baseline specification (1.9).

Results are presented in Table 1.9, with both PPML and Tobit specifications. As we can see, the coefficient on the share of ethnic German immigrants is positive and significant, albeit only marginally so in the Tobit specification. Districts that received a relatively larger inflow of ethnic German immigrants from countries of the former Soviet Union from 1996 - 1998 also had more Russian affiliates entering from 1999-2011. Compared to the baseline specification in section 1.5.4, the size of the coefficient is much larger. In the PPML specification, a one standard deviation increase (sd: 0.264) in the inflow of ethnic Germans in 1996-1998 leads to a 83% rise in the number of affiliates from Russia entering over the 1999-2011 time period.[33] Bearing in mind that the absolute number of Russian affiliates in Germany is rather small, the absolute economic effects are still moderate. Some of the control variables also behave differently compared to the

[33] This is computed as $e^{0.265 \cdot 2.298} - 1 = 0.83$.

Table 1.9: Results on ethnic German immigrants

Dependent variable: FDI entry	(1) PPML	(2) Tobit
Ethnic Germans Share '96-'98	2.2980**	1.8582*
	(0.9067)	(0.9578)
FDI Stock '99	0.0558	2.2152***
	(0.0743)	(0.3836)
Distance	5.8049*	-11.6204***
	(3.0600)	(3.8575)
Settlement Share	-0.0232	-0.0403
	(0.0311)	(0.0245)
Market Potential	1.6728**	1.5074*
	(0.7855)	(0.8228)
Distr. Tert. Share	0.3070***	0.2499***
	(0.0827)	(0.0914)
Constant	-65.7327***	72.2757***
	(18.3870)	(22.8300)
Observations	196	198
R^2	0.3148	
State FE	Yes	Yes
SE Clusters	State	State

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, German Federal Statistical Office, Glitz (2012), own calculations.

baseline: While the settlement share is not significant any more, the share of tertiary educated inhabitants in a district seems to matter for FDI decisions. These differences may be due to country-specific characteristics of FDI decisions by Russian parent firms.

To conclude, this subsection confirms the qualitative results of a positive FDI-migration link using the setting of a quasi-natural experiment.

1.6 Concluding Remarks

We have looked at the question whether the presence of immigrants helps to attract FDI from the immigrants' country of origin at the district level. Our model postulates that obtaining information about potential investment locations is costly, and that immigrants help in reducing the information cost. We are the first in the literature to provide comprehensive evidence in favour of this information hypothesis. In addition, the granular dataset allowed for a much more precise estimation of the effects compared to the previous literature. The methodology controls, in a more comprehensive way than previous papers, for various endogeneity problems that could conflate the analysis. In addition, a quasi-natural experimental setting in the 1990s of large-scale ethnic German migration from the former Soviet Union was exploited to confirm the qualitative results.

In the baseline specification, an increase in the share of immigrants in a district by one standard deviation raises FDI entry by 8.6% each year. Using further disaggregation, we show that the FDI-migration link is stronger if we are looking at a parent firm's first entry, but weaker if the parent firm already has experience. Furthermore, smaller affiliates are more dependent on immigrants, since they do not have the means to hire external help to obtain information, and are more likely to rely on informal contacts. In addition, affiliates with only one foreign parent firm as shareholder rely more on immigrants than joint-ventures, as the former are more likely to face informational barriers that can be overcome with immigrants. The effects are also more pronounced for services affiliates.

Lastly, a split by country groups reveals that the FDI-migration link seems stronger for parent firms from developing countries and East Asia.

While the positive FDI-migration link has already been well established in the literature, we are the first to provide comprehensive evidence in favour of the hypothesis that information provision is at the heart of the story. Therefore, we need to update our knowledge about the FDI-migration link: The ease of accessing information turns out to be extremely important in location decisions of multinationals. In that context, people and their connections matter. We also learned that once a link is established, parent firms do not continue to rely on immigrants. Firms themselves can then create virtuous cycles by pulling in more affiliates from their country of origin. This suggests that facilitating information provision and hosting immigrants may act as substitutes in attracting FDI. However, one has to bear in mind that it is mainly smaller affiliates that rely on the link with immigrants, so the value-adding impact to the local economy of immigrant-related FDI may be limited. Hence, for a more holistic policy design in attracting FDI, the role of immigrants will need to be seen in conjunction with other established location factors.

Chapter 2

Signing a Bilateral Investment Treaty - A Tradeoff Between Investment Protection and Regulation

2.1 Introduction

2.1.1 Motivation

Bilateral investment treaties (BITs) have come under the spotlight during the debate surrounding the Transatlantic Trade and Investment Partnership (TTIP), as the inclusion of a BIT between the United States and the European Union constitutes an important part of TTIP.

A BIT protects foreign direct investment (FDI) from expropriation by the government in the investment's host state.[1] For the vast majority of BITs, expropriation entitles the

[1]For more detailed definitions of expropriation, see section 2.1.2.

Table 2.1: Number of ratified bilateral investment treaties by country in 2014

	Country	# BITs
1.	Germany	132
2.	Switzerland	115
3.	China	106
4.	United Kingdom	95
4.	Netherlands	95
6.	France	94
7.	Czech Republic	84
8.	Italy	83
8.	South Korea	83
10.	Romania	81

Source: UNCTAD

investor to take legal action and demand monetary compensation for lost investments and profits. Investor-state dispute settlement (ISDS) takes place at arbitration tribunals in a third country, e.g. the International Center for Settlement of Investment Disputes (ICSID) in Washington.[2] The investor's rights under a BIT are confined to monetary compensation, and do not extend to enforcing the withdrawal of the original state action. In addition, BITs also often include most-favoured nation clauses, and they guarantee fair and equitable treatment and free transfer of capital without restrictions. The aim of BITs is to provide a safe and secure investment climate for foreign multinationals, with countries signing BITs in the hope of attracting FDI and protecting their investments abroad. Up to 2014, there were 2,311 ratified BITs. Table 2.1 ranks countries by the number of ratified BITs. European countries dominate, with Germany and Switzerland having signed the most BITs with other countries.

However, BITs are not without controversy: A major concern is the possibility of large compensation payments that the host state might face after regulating an industry, even

[2]The appointment of an arbitration tribunal in third countries is motivated by doubts about judicial independence in some countries, and the perception that domestic courts may be biased against foreigners in corporate litigation, even in developed countries (Moore, 2003; Bhattacharya et al., 2007). In the context of the EU-US BIT, even major EU countries such as Italy, Spain and Poland achieve only medium scores (3.2-4.1 on a scale from 1-7) on rankings of judicial independence, such as the WEF Global competitiveness index 2014-15. Additional advantages of international arbitration (as opposed to purely domestic arbitration) include the length of proceedings, the amount of expertise and the clarity of potential awards. For a more detailed discussion, see Lavranos (2015) and Wolkewitz (2015).

if the regulation was intended for public benefit. These concerns are based on high-profile cases such as Occidental vs. Ecuador, where the claimant was ultimately awarded \$1.8bn due to the unilateral termination of oil drilling rights by the government, or Vattenfall vs. Germany, where the energy company is claiming €4.7bn in lost profits due to the German phase-out of nuclear power in 2011.[3] As a result, governments might refrain from taking necessary regulatory action out of fear of compensation payments, resulting in so-called 'regulatory chill'.[4]

The economic literature has analysed BITs largely from an empirical perspective, with a number of papers dealing with the question of whether BITs have managed to attract FDI. While the early literature has found conflicting evidence (Hallward-Dreimeier, 2003), more recent papers with improved identification have concluded that BITs are indeed helpful in raising the flow of inward FDI (Neumayer and Spess, 2005; Busse et al., 2010; Egger and Merlo, 2012; Colen et al., 2016).

Economic papers with formalized theoretical models on BITs were traditionally sparse, but the literature has gained traction in recent years: Blume et al. (1984) and Miceli and Segerson (1994) started the older literature on efficient compensation rules after government interventions for public purpose, but restrict themselves to a purely domestic context. Aisbett (2007) and Tomz and Wright (2010) specifically look at BITs, and model expropriations as a tool for the state to deliberately obtain assets. In this setting, a BIT is seen as a commitment device to reduce inefficiencies stemming from time inconsistency problems. However, as we will discuss in section 2.1.2, this classical definition of expropriation fails to capture some of the more recent developments surrounding expropriations. Aisbett et al. (2010a) and Aisbett et al. (2010b) allow for a wider definition

[3] Vattenfall vs. Germany, ICSID ARB/12/12, is still ongoing as of today. A final verdict is not expected before 2017.

[4] Another criticism of BITs is directly targeted at the ISDS system. Problematic areas include the setup of arbitration courts, the transparency of proceedings and the lack of right of appeal. However, given that this is a chapter on the economic effects of a BIT only, the aforementioned criticisms are beyond the scope of this chapter. We will assume that the judicial system works properly for the purpose of this chapter, and leave potential judicial reform to other disciplines. In fact, the EU has proposed a new Investment Court System to the US in November 2015, which is aimed at remedying the shortcomings of the current ISDS system.

of expropriations, with the state expropriating for environmental reasons. Their solution to the investment-regulation tradeoff involves a ‘police powers carve-out’, which means that expropriations should not qualify for compensation when the public benefit of the regulatory measure is sufficiently high. However, this partial reversal of the scope of BITs may squander potential welfare gains, and differs from our proposed solution of a Pareto improving profit fee. In addition, while their paper contains a detailed discussion on international arbitration, their model is actually framed in a purely domestic context. More recently, Kohler and Stähler (2016) have developed a two-period model on investor-state dispute settlement, to argue that the government has an incentive to overregulate in the first period in order to leave more discretionary leeway for the second period, thereby reducing the expected amount of compensation payments. Janeba (2016) provides a detailed discussion on the definition and the likelihood of regulatory chill in connection with BITs, specifically focusing on the role of possibly biased and inefficient arbitration courts.

However, there is still a gap in the literature on theoretical models that focus on the inherent investment-regulation tradeoff in BITs in an international context, and that account for new types of expropriation stemming from regulatory measures. In addition, the empirical literature has so far abstained from estimating compensation costs under a BIT, despite the prominence of these costs in the political debate. We fill these gaps by analysing the welfare effects of a BIT from a theoretical perspective, while incorporating the expropriatory effects of regulatory measures in an international context. The model explicitly accounts for the tradeoff between attracting FDI with heterogeneous firms and the state’s scope for regulation. As a further contribution, we also add an empirical analysis to estimate the expected compensation payments that stem from a BIT. Our main results and simultaneously our contributions to the literature are as follows:

First, our base model shows that hitherto existing BITs can improve upon overall welfare by changing the state’s objective function, which reins in excessive regulation that has a negative external effect on firms. However, this makes the state unambiguously worse off, with the gains accruing solely on the firms' side.[5] This asymmetry in benefits may cause the state to refrain from signing a BIT. To reap the welfare gains despite this asymmetry, we then propose a profit fee to redistribute part of the welfare gains from BITs back to the state. This provides all parties with incentives in favour of a BIT, and causes a Pareto improvement compared to the no-BIT case. A redistributive fee enables the state to provide the positive insurance effect of a BIT to firms, while at the same time sharing the cost of doing so.

Second, the model reveals that the aggregate welfare effects of a BIT depend strongly on industry characteristics, which speaks in favour of considering industry-specific BITs. Our results show that BITs raise aggregate welfare for very productive industries, but lower it for less productive industries. The intuition is as follows: Less productive firms that enter due to a BIT generate only little economic profit. At the same time, these additional firms impose a cost on the government by limiting its scope for regulation, since the government needs to compensate these additional firms in case any new law conflicts with firm profits. For less productive industries, these costs then outweigh the benefits, implying negative social returns. In other words, over-entry renders the BIT inefficient for less productive firms. If we hypothetically rule out new firms entering after a BIT, we obtain the result that BITs definitely raise aggregate welfare, regardless of firm productivity. In that case, BITs simply internalize the externality that governments impose on already existing firms when regulating. This implies that instead of the attraction of additional FDI, the protection of already existing FDI is the only channel of unambiguous welfare improvement from a BIT. Given that attracting new FDI is often the main motivation for host states to sign a BIT, our findings of its ambiguous welfare effects and the positive welfare effects of alternative channels are important new insights.

[5]This is a feature of our base model, where the state does not directly benefit from FDI. This omission is made to highlight the main mechanism of welfare improvement, which consists of internalizing an externality. The assumption that the state does not benefit directly from FDI is relaxed in later extensions.

Third, several extensions are added to the base model. Extending the model to allow for the government benefiting directly from FDI through a tax creates multiple equilibria, with the possibility of the economy being stuck in a bad equilibrium. A BIT then causes the multiple equilibria to vanish, potentially leading the economy towards a more efficient equilibrium. Further extensions also show that under no BIT, an increase in the proportion of domestic firms reduces the government's incentive to regulate, but the effect is reversed as a BIT is introduced. Domestic firms can benefit from a BIT despite the fact that they are not eligible for compensation under BIT rules. We also demonstrate that an increase in the likelihood of expropriation makes exporting more attractive relative to FDI in the no-BIT case, but that the effect is reversed when a BIT is in place.

Lastly, in the empirical part we take the model to the data using a regression analysis in order to predict expected compensation payments. To our knowledge, we are the first to do so. Using past data on lawsuits and compensations from within-OECD BIT-pairs, we predict the expected annual cost for Germany from an EU-US BIT to be $27mn, and the compensating fee on firm profits to be 0.5%. This rather moderate estimate may help to put numbers into perspective and ameliorate concerns about potential lawsuits that pose an extreme financial burden on state budgets.

The remainder of this chapter is organized as follows: Section 2.1.2 establishes a definition of the type of expropriation that we are going to analyse. Section 2.2.1 to 2.2.5 outline the base version of our theoretical model on BITs. Extensions follow in sections 2.2.6 to 2.2.8. Section 2.3 is the empirical part containing the regression analysis, where compensation costs of a BIT are estimated. Section 2.4 then concludes.

2.1.2 Definitions

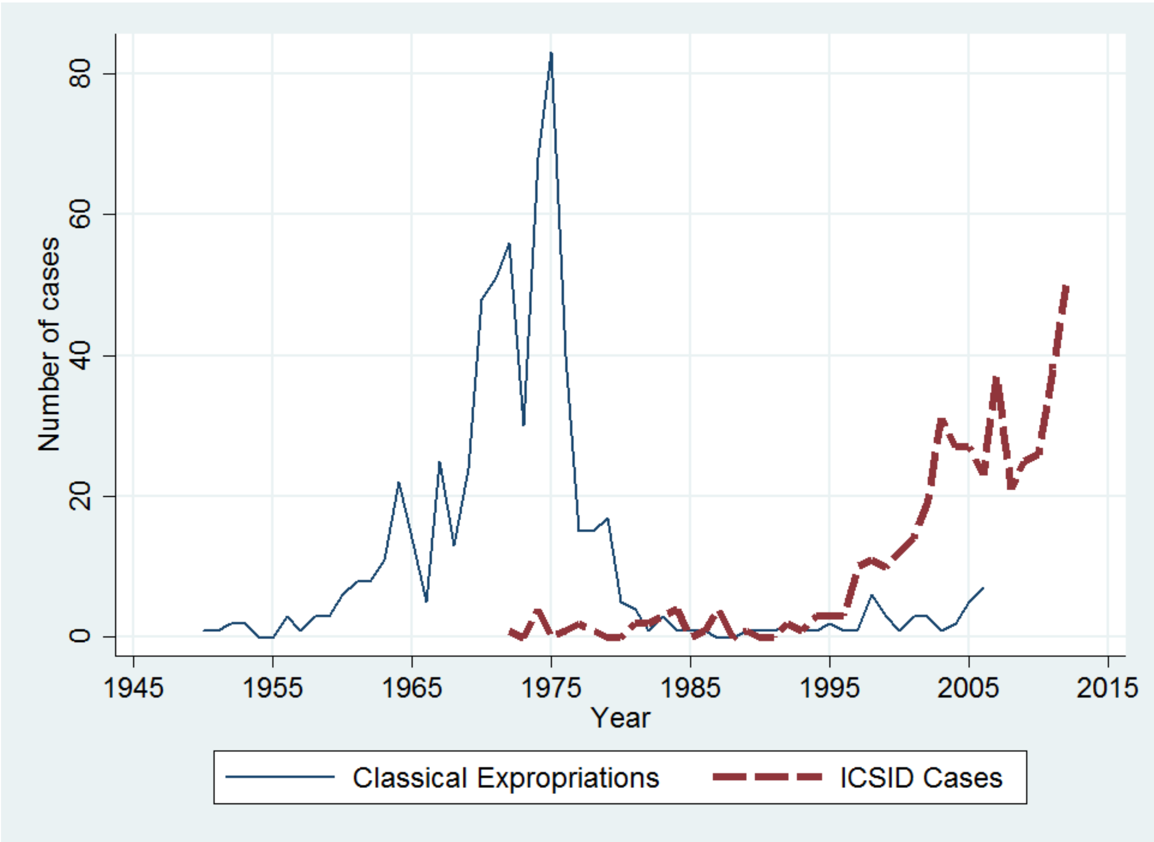
Table 2.2 defines different types of expropriation. What the first two definitions have in common is that the state is deliberately expropriating in order to gain some direct benefit. In the case of classical and cold/creeping expropriation, the state (or the domestic firms he wants to support) gains at the expense of those who get expropriated.

Table 2.2: Definition of types of expropriation

	Definition	**Motivation**	**Example**
Classical	Kobrin (1984): Involuntary forced divestment of FDI involving ownership transfer	Government gains assets	Nationalization of a factory or fully developed mine
Cold/ creeping	Involuntary forced reduction in asset value or profitability of FDI without de jure ownership transfer	Government gains assets or supports domestic competitors	Retroactive tax increase, exchange rate controls, discriminatory regulation
Regulatory	Involuntary forced reduction in asset value or profitability of FDI through regulatory measures without ownership transfer	Government regulates out of health and safety concerns. Expropriation as collateral damage	German nuclear power phase-out. Australian cigarette plain packaging

The third type of regulatory expropriation does not have expropriation as direct intention. Instead, the state exercises 'police powers' by regulating a sector out of health or environmental concerns for public purpose. As collateral damage, this regulation then has the unintended consequence of expropriating an investor. The German nuclear power phase-out in 2011 provides an illustrative example: After the Fukushima nuclear accident, the German government decided to drastically shorten the running time of all nuclear plants for safety concerns. Given that energy companies may have based investment decisions on different regulatory circumstances, this intervention can be seen as some form of expropriation. As a consequence, Swedish energy company Vattenfall is suing Germany for compensation. Crucially, it was not the government's intention to expropriate

Figure 2.1: Development of expropriations and ICSID lawsuits over time



Source: Minor (1994), Hajzler (2012) and ICSID.

the energy companies and gain control over the nuclear plants. Instead, the loss of firm profit happened as collateral damage of the original aim to protect the citizens.[6]

Classical expropriations have decreased in importance, as Figure 2.1 shows. The solid line plots the development of classical expropriations of foreign direct investments around the world and is based on Hajzler (2012) and Minor (1994), who extend the seminal work by Kobrin (1984). Classical expropriations were extremely common in the 1960s and 1970s, but have receded since. In contrast, the dashed line plots the number of lawsuits dealt with at the ICSID arbitration court, which accounts for two-thirds of all investor-state arbitration cases. The figure shows that the number of cases has risen strongly

[6]The legal literature has yet to converge on a common terminology for the third type of 'regulatory expropriations'. While some papers agree with our wording (Newcombe, 2005), some others may employ alternative terms such as 'regulatory takings' (Miceli and Segerson, 1994). From an economic perspective, the investment-related effects of regulatory measures that impact on firm profits are tantamount to the effects from classical expropriations. Hence, the wording of 'regulatory expropriations' seems adequate in an economic context.

in recent years, demonstrating that while classical expropriations have lost importance, some newer forms of expropriations are increasingly debated at arbitration courts. It underlines the need to move away from seeing expropriations as the ‘classical’ type and to pay more attention to alternative forms of expropriation.

In this chapter, we will focus our analysis on the new type of regulatory expropriation. This is because there is a gap in the literature on this new type, as previous papers were often exclusively restricted to classical expropriations in connection with BITs. However, we have seen that classical expropriations have decreased in importance. In addition, regulatory expropriations are the only type entering the debate surrounding BITs.[7] It is fair to say that BITs would be less controversial if their scope only extended to the first two types of expropriation, since they conflict with the notion of private property and serve no other goal than enriching the state. It is the possibility of a BIT extending to the third type of regulatory expropriation and the willingness of arbitration courts to interpret a BIT in this way that proves controversial, since it conflicts with the state’s sovereignty to pass laws intended for public benefit.[8]

2.2 Theory

2.2.1 Model Setup

This section lays out the base model which forms the main pillar of our analysis. Our model is partial equilibrium in nature. In later subsections, we will provide some extensions to the base model.

[7] For example, former Austrian chancellor Werner Faymann voiced his concerns in an interview to German newspaper Süddeutsche on 4th May 2015: ‘BITs can undermine the state’s power over the legislative process and can hence harm democracy. The threat of high compensation demands could have the state refrain from passing necessary laws in the area of environment, food standards and social security.’

[8] An example of regulatory expropriation with a subsequent successful trial on the investor’s behalf is provided by Metalclad Corporation v. The United Mexican States, ICSID Case No. ARB(AF)/97/1.

We consider an arbitrary industry k in a home country H. Inside the home country, there are foreign firms F that conduct FDI, and one domestic government G that regulates.

2.2.1.1 Government

The industry of the home country is hit by random industry-specific, policy-relevant shocks ε drawn from a continuous probability density function $f(\varepsilon)$ where $\varepsilon \in (-\infty, +\infty)$. Examples for such sector-specific shocks include the Fukushima nuclear accident, or a new study revealing that a certain food additive is a health hazard. These shocks may prompt calls for policy actions, requiring regulation. The government's goal is to satisfy its voters, by responding to these regulation demands.

The shocks will impact on the government's payoff according to function $g(\varepsilon)$. We have $g(0) = 0$ and $g'(\varepsilon) > 0$, with Figure 2.2 providing an example of function $g(\varepsilon)$. Negative shocks can be interpreted as adverse shocks that reveal potential dangers associated with a certain industry, with positive shocks revealing positive benefits of that industry. The more negative the shock, the stronger its potential negative effects.

When the shock hits, the government can choose to pass legislation to regulate the industry in question. This would then nullify the negative impact of the shock on the government's payoff, as potential dangers have been regulated to the satisfaction of the voters. The nullification of the shock's negative impact constitutes the positive effect of regulation.[9] However, there is also a negative effect, in accordance with the concept of regulatory expropriation: In this model, regulating the industry by passing legislation entails regulatory expropriation as collateral damage. When the government decides to regulate, all firms in the industry will be expropriated. Hence, the term 'regulation' will be synonymous with 'regulatory expropriation' for the remainder of the chapter.

[9] The setup resembles that in Kohler and Stähler (2016), where the government's payoff increases monotonically in the amount of regulation that it chooses.

Figure 2.2: Example of gov. payoff $g(\varepsilon)$

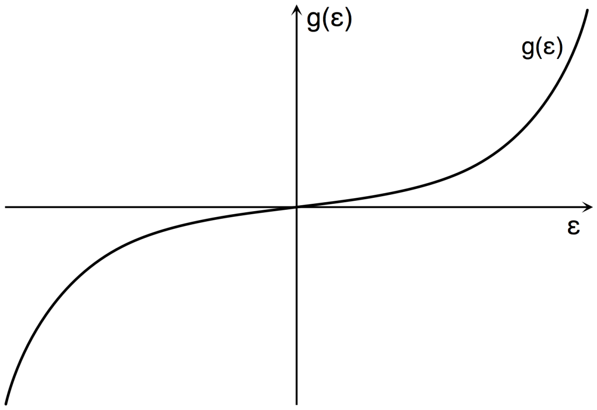
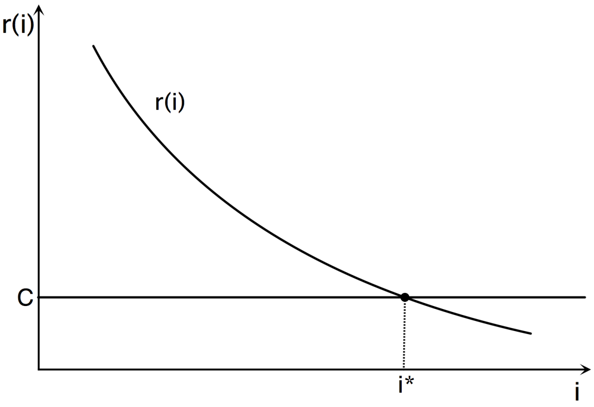


Figure 2.3: Example of firm revenue $r(i)$



The government does not directly benefit from FDI, we can think of all the benefits of FDI being internalized by the private investors. This is done to make the base model more tractable, and to demonstrate the potential welfare-improving effects of a BIT even in the absence of immediate benefits to the government. This assumption will be relaxed in the later extensions of the model.

The government's maximization problem is hence given by:

$$\max_{I_R} \quad u_G = (1 - I_R) \cdot g(\varepsilon) + T \tag{2.1}$$

Here, T denotes any additional monetary transfer, and I_R denotes an indicator function:

$$I_R = \begin{cases} 1 & \text{if } G \text{ chooses to regulate} \\ 0 & \text{if } G \text{ chooses not to regulate} \end{cases} \tag{2.2}$$

2.2.1.2 Firms

There is a continuum of profit-maximizing, risk-neutral foreign firms acting according to the expected utility hypothesis. At the beginning of the game, firms choose whether or not to invest in the home country H. Firms are heterogeneous, i.e. each firm i can expect an idiosyncratic revenue $r_i > 0$ from its investment. More productive firms can expect higher revenue. Without loss of generality, we assume that subscript i ranks firms according to their productivity in descending order, i.e. $(r_{i-1} > r_i \ \forall i)$. Each firm faces the same cost c when investing, and the cost is sunk after an investment decision has been made. We assume $\exists i : r_i > c$. If there is no regulation by the government, firms can realize their revenue. However, if the government decides to regulate, firms are expropriated and cannot realize their revenue and are left with their sunk costs. If a firm does not invest, its revenues and costs are 0. Hence, firm i's maximization problem is as follows:

$$\max_{I_I} \ \pi_i = I_I \cdot [(1 - I_R) \cdot r_i - c - T] \tag{2.3}$$

Again, T denotes any monetary transfer, and I_I stands for another indicator function:

$$I_I = \begin{cases} 1 & \text{if } F \text{ chooses to invest} \\ 0 & \text{if } F \text{ chooses not to invest} \end{cases} \tag{2.4}$$

The function $r(i)$ combines the r_i into a continuous revenue function for the whole industry, with $r(i_0) = r_{i_0}$ and $r'(i) < 0$. Figure 2.3 provides a graphic depiction. If there was no expropriation risk, the first-best solution would require the cutoff for investment to be at i^*, with $r(i^*) = c$. Productive firms with $i < i^*$ should invest, while less productive firms with $i > i^*$ should not.

2.2.1.3 Timing

There is only one time period, and all information is common knowledge. The time structure of the game is as follows:

1. Foreign firms decide whether or not to invest
2. Policy-relevant shock ε hits
3. Government decides whether or not to regulate
4. Payoffs are realized

In equilibrium, the government chooses, for a given ε, whether or not to regulate. The resulting equilibrium regulation threshold is called ε^{eq}. If $\varepsilon < \varepsilon^{eq}$, the government regulates. If $\varepsilon > \varepsilon^{eq}$, the government does not regulate. Firms choose their equilibrium investment level i^{eq} in response.

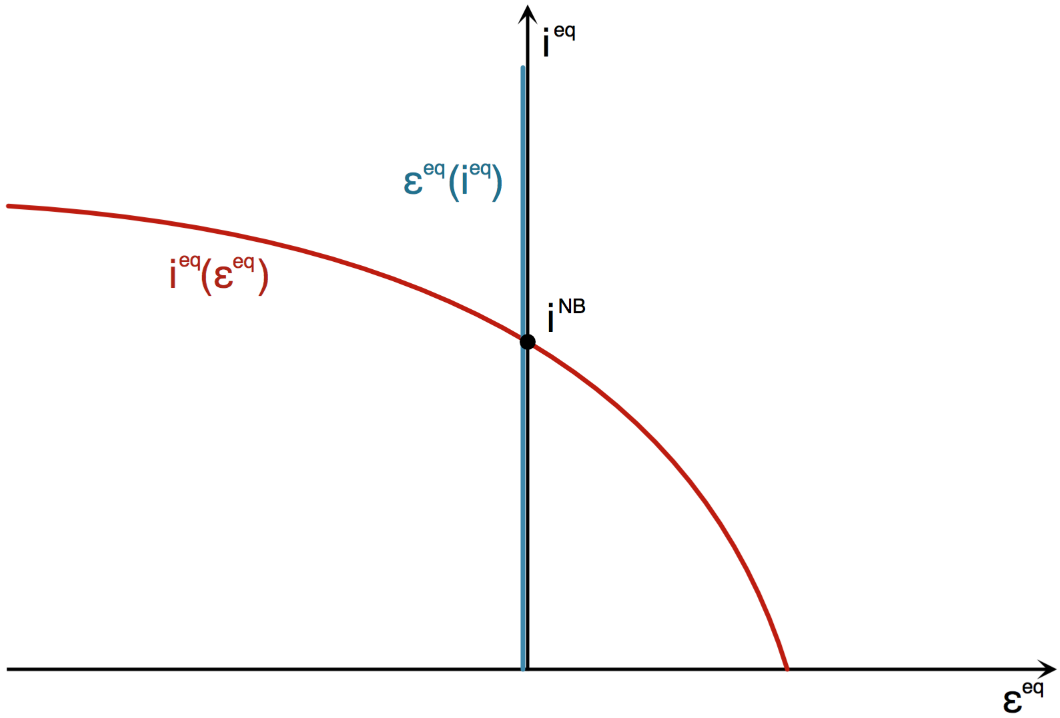
2.2.2 Base Model - No BIT

We can now solve for the subgame-perfect Nash equilibrium values of the game under no BIT (superscript NB). We have $T = 0$ in this case.

Proposition 2.1 (Base model - No BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{NB} = 0$
Firm investment $i^{eq*} = i^{NB} = r^{-1}[\frac{c}{p(\varepsilon>0)}]$

Proof $u_G = g(\varepsilon)$ if $I_R = 0$ and $u_G = 0$ if $I_R = 1$, with $g(\varepsilon) < 0$ if $\varepsilon < 0$. $i^{NB} = r^{-1}[\frac{c}{p(\varepsilon>0)}]$ since $E(\pi_i) = p(\varepsilon > 0) \cdot r_i - c$, which must be greater than zero for investment to happen. ∎

Figure 2.4: Base model - No BIT - Equilibrium



The regulation threshold is $\varepsilon^{NB} = 0$, so the government regulates whenever $\varepsilon < 0$.[10] Only the most productive firms have positive expected profits, so only firms with $i < i^{NB}$ will invest. The less productive firms refrain from realizing their profitable projects due to the risk of expropriatory regulation, leading to potential under-investment.

Corollary 2.2 (Base model - No BIT - Slope of investment)

Investment depends negatively on regulation: $\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} < 0$

Proof See Appendix B.2.1.1. ∎

Figure 2.4 provides a graphical depiction of the equilibrium. The $i^{eq}(\varepsilon^{eq})$ curve shows the firms' reaction function, how equilibrium investment depends on the regulation threshold. It has a negative slope, since a higher regulation threshold implies a higher likelihood of regulatory expropriation, which leads to less investment. The $\varepsilon^{eq}(i^{eq})$ curve shows the government's reaction function, how the regulation threshold in turn depends on

[10] The government cannot abuse its power by threatening regulation for $\varepsilon > 0$ in order to extract ex ante rents from firms. Due to the timing structure of the game, any threat by the government is not credible.

investment. Since the amount of investment does not enter the government's objective function, the regulation threshold is independent of investment, and always chosen at $\varepsilon^{eq*} = \varepsilon^{NB} = 0$, so it is lying on top of the y-axis.

By regulating, the government imposes a negative externality on the firm. The government does not take into account that, when regulating, it is preventing firms from realizing their profits.[11] For some range of negative shocks small in absolute value (ε negative but close to zero), this is inefficient, as the losses from firm profits outweigh the gains in the government's payoff. Hence, the following proposition applies:

Proposition 2.3 (Base model - No BIT - Efficiency)
In the no-BIT eq., there is overregulation. Aggregate welfare is inefficiently low.

Proof See Appendix B.2.1.2. ∎

Proposition 2.1 leads to the following corollary giving us the government's expected payoff U_G and expected total firm profits Π in equilibrium.

Corollary 2.4 (Base model - No BIT - Expected payoffs)

$$U_G = \int_0^\infty f(\varepsilon)g(\varepsilon)d\varepsilon \tag{2.5}$$

$$\Pi = \int_0^\infty f(\varepsilon)d\varepsilon \cdot \int_0^{i^{NB}} r(i)di - c \cdot i^{NB} \tag{2.6}$$

2.2.3 Base Model - With BIT

We will now introduce a BIT to internalize the negative externality that the government imposes by regulatory expropriation. With a BIT, the government will now have to fully compensate all firms in the industry for their forgone revenue r when regulating.[12] We

[11] This feature of the policymaker was coined 'fiscal illusion' by Blume et al. (1984).

[12] Note that for a BIT to maximize welfare, compensation needs to be paid for the whole revenue r, and neither just a fraction of it, nor just forgone profits $r - c$. This is because at the point when G decides about regulation, what is at stake is the whole potential revenue r, given that the investment cost is already sunk. Hence, for a BIT to completely internalize the externality, the government must be required to compensate all the forgone revenue r.

assume that there is a 100% chance that regulatory expropriations are followed by a lawsuit, and that regulation and expected revenue can be verified by impartial courts at zero cost. The government's maximization problem then becomes:[13]

$$\max_{I_R} \; u_G = (1 - I_R) \cdot g(\varepsilon) - I_R \int_0^{i^*} r(i)di \tag{2.7}$$

The government now chooses I_R by comparing the gains from regulation with the financial losses from doing so. It will decide that the financial loss from regulation is now sometimes not worth the gain in terms of nullifying the negative shock.

Proposition 2.5 (Base model - With BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{BIT} = g^{-1}[-\int_0^{i^*} r(i)di] < 0$
Firm investment: $i^{eq*} = i^* = r^{-1}(c)$

Proof $u_G = g(\varepsilon)$ if $I_R = 0$ and $u_G = -\int_0^{i^*} r(i)di$ if $I_R = 1$. Firms have guaranteed profits $E(\pi_i) = r_i - c$. ∎

Since $\varepsilon^{BIT} < \varepsilon^{NB} = 0$, regulatory expropriations happen less often than under the no-BIT case, and the inefficiency from excessive regulation is now avoided. Firms have guaranteed profits after the introduction of a BIT: Either their investments realize revenue, or they receive compensation after suffering from regulatory expropriation. This causes less productive firms from $i^{NB} < i < i^*$ to enter as well.

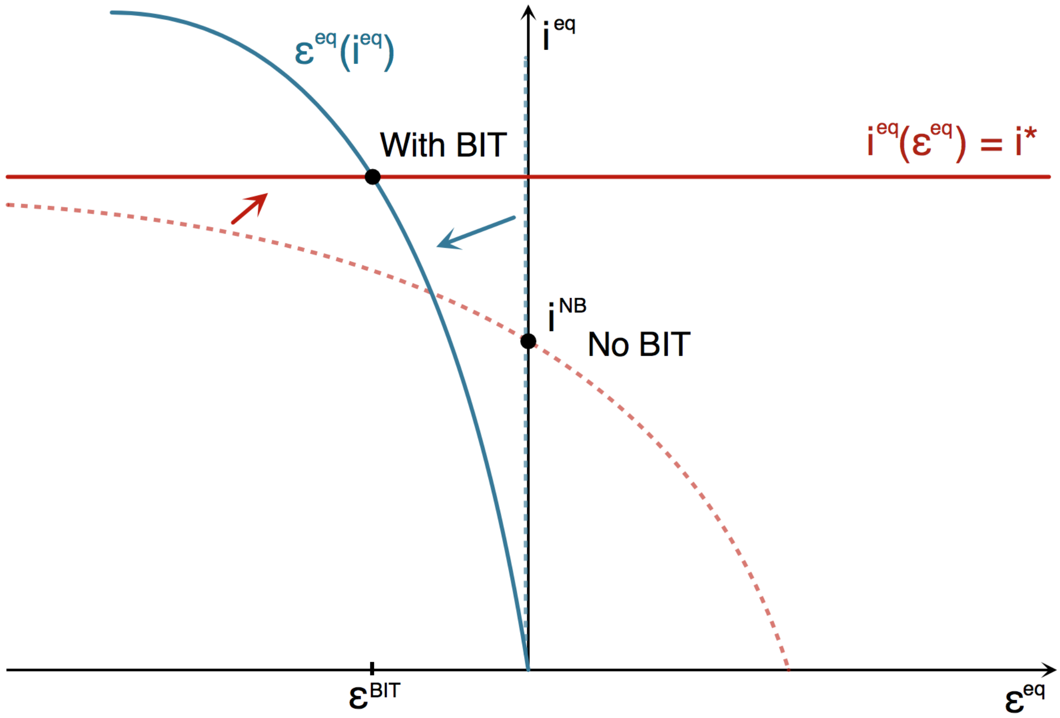
Corollary 2.6 (Base model - With BIT - Slope of regulation)
Regulation depends negatively on investment: $\frac{\partial \varepsilon^{eq}}{\partial i^{eq}} < 0$

Proof See Appendix B.2.1.3. ∎

Figure 2.5 shows graphically how we move from the no-BIT to the with-BIT equilibrium. The $\varepsilon^{eq}(i^{eq})$ curve pivots counterclockwise around the origin, with the negative slope reflecting the fact that the government now faces compensation charges from regulation. More investments make regulation more costly, thereby lowering the optimal regulation

[13] We already use the result that firms will now invest up the level $i = i^*$.

Figure 2.5: Base model - With BIT - Equilibrium



threshold. The $i^{eq}(\varepsilon^{eq})$ curve becomes a flat line parallel to the x-axis at i^*. This reflects the fact that firms now invest i^* regardless of the regulation threshold, as they now have guaranteed profits due to BIT protection. The new equilibrium is to the north-west of the old one, implying less regulation and more investment. Corollary 2.8 gives us the government's expected payoff U_G and expected total firm profits Π in the with-BIT equilibrium.

Corollary 2.7 (Base model - With BIT - Expected payoffs)

$$U_G = \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon - \int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*} r(i)di \tag{2.8}$$

$$\Pi = \int_0^{i^*} r(i)di - c \cdot i^* \tag{2.9}$$

In our model, there is a direct relationship between regulatory expropriations and lawsuits. The number of lawsuits L depends on the expected number of firms affected by regulatory expropriation and is given by $L = p[\varepsilon < g^{-1}(-\int_0^{i^*} r(i)di)] \cdot i^*$. Hence, our model makes the following predictions:

Proposition 2.8 (Base model - With BIT - Lawsuits)

1. L depends positively on $-g(.)$, the government's gain from regulating.

2. L depends negatively on firm productivity $r(i)$.

3. The effect of the amount of FDI i^* on L is ambiguous.

Proof See Appendix B.2.1.4. ∎

We will test these predictions in the empirical section later.

2.2.4 Comparison

We can now compare how payoffs change for each party under the no-BIT and with-BIT scenario.

Corollary 2.9 (Base model - With BIT - Government payoff difference)

$$\Delta U_G = \underbrace{-\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*} r(i)di}_{Compensation} + \underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)g(\varepsilon)d\varepsilon}_{Regulatory\ Chill} < 0 \tag{2.10}$$

Proof Calculate (2.8)-(2.5). $f(\varepsilon) > 0\ \forall\varepsilon$ and $r(i) > 0\ \forall i$ and $g(\varepsilon) < 0$ for $\varepsilon < 0$. Hence, $\Delta U_G < 0$. ∎

The government unambiguously loses from a BIT. The first term in ΔU_G denotes the loss from financial compensation that must be paid. The second term denotes the loss of abstaining from passing legislation for a range of small shocks and is negative. The cost of passing less legislation under a BIT is also called 'regulatory chill'. As the government regulates less due to the fear of compensation charges, it has to bear the negative impact of shocks more often.[14]

Corollary 2.10 (Base model - With BIT - Firm profits difference)

$$\Delta\Pi = \underbrace{\int_{i^{NB}}^{i^*}[r(i)-c]di}_{Additional\ FDI} + [\underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)d\varepsilon}_{Less\ regulation} + \underbrace{\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon]}_{Compensation}\int_{0}^{i^{NB}} r(i)di > 0 \tag{2.11}$$

Proof Calculate (2.9)-(2.6). $f(\varepsilon) > 0\ \forall\varepsilon$ and $r(i) > 0\ \forall i$ and $r(i) - c > 0$ for $i < i^*$. Hence, $\Delta\Pi > 0$. ∎

Firms unambiguously gain from a BIT. The first term in $\Delta\Pi$ denotes the gain for firms from realizing new, additional FDI. The second term contains the gain from having less regulatory expropriation, as well as financial compensation for already existing FDI.[15]

With firms definitely better off and the government definitely worse off under a 'standard' BIT, it is worth looking at what happens to aggregate welfare W, computed as the sum of total firm profits and the government's payoff. The change in aggregate welfare ΔW is given below:

Corollary 2.11 (Base model - Aggregate welfare difference)

$$\Delta W = \underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)d\varepsilon \cdot \int_{0}^{i^{NB}} r(i)di}_{Less\ regulation} + \underbrace{\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \cdot \int_{i^{NB}}^{i^*} r(i)di}_{Add.\ FDI\ revenue} + \underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)g(\varepsilon)d\varepsilon}_{Regulatory\ chill} - \underbrace{c(i^* - i^{NB})}_{Add.\ FDI\ cost} \tag{2.12}$$

Proof Calculate (2.10) + (2.11). ∎

The first two terms present the true economic gains from a BIT. They consist of gains from existing FDI suffering less regulatory expropriation, as well as the gains from new FDI taking place. The latter two terms present the true economic losses from a BIT.

[14] Anecdotal evidence for regulatory chill can be found in New Zealand: As Philip Morris challenged the Australian decision to introduce cigarette plain packaging in 2011 invoking a BIT as legal instrument, New Zealand announced that it would put similar planned measures on hold.

[15] Already existing FDI denotes FDI that would have taken place even in the absence of a BIT.

These include the cost of regulatory chill, as well as the cost of additional investments. It is worth noting that the compensation payments made by the state to the firms do not enter the equation, since they are just a transfer from one party to another, and hence cancel out.

Corollary 2.12 (Base model - Sign of aggregate welfare difference)
The sign of (2.12) *is ambiguous.*

Proof See Appendix B.2.1.5. ∎

The overall effect of a BIT on welfare is ambiguous. If ΔW is positive, then the with-BIT scenario implies higher welfare.

Corollary 2.13 (Base model - Aggregate welfare difference derivatives)

$$\frac{\partial \Delta W}{\partial r(i)} > 0, \ \frac{\partial \Delta W}{\partial c} < 0$$

Proof See Appendix B.2.1.6. ∎

Corollary 2.14 (Base model - Efficiency of a BIT)
A BIT raises aggregate welfare for highly productive industries (r(i) high, c low), but lowers it for less productive industries (r(i) low, c high).

Proof Follows from corollary 2.13. ∎

Corollary 2.14 may be surprising, since one might have initially expected that it should be precisely the less productive, marginally profitable industries that should receive protection by a BIT, in order to encourage more firms to invest. However, the exact opposite is true. The intuition is as follows: Under the no-BIT scenario, only the most productive firms profitable enough to withstand the risk of regulatory expropriation run their business. As a BIT is introduced, less productive firms with only little economic profit ($r - c$ is small) will enter. At the same time, these additional firms ramp up the regulation cost for the government, as there are now more firms around to be compensated in case of regulation. The higher cost of compensation causes the government to refrain from regulation, imposing an economic cost in the form of regulatory chill. For the less productive industries, it may be the case that the small profits they generate do not outweigh the costs of regulatory chill, thereby implying negative social returns. Hence, we see over-entry for less productive industries if a BIT is introduced. In contrast, highly productive industries deserve protection: Through the threat of substantial compensation payments, a BIT makes the government internalize the high cost of regulating a very productive industry. These results argue in favour of considering BITs on a by-industry basis.

While in general, there is ambiguity about the aggregate welfare effects of a BIT, we can show that if we hypothetically shut off the channel of additional FDI entering, the welfare effects of a BIT are unambiguously positive:

Proposition 2.15 (Base model - No new FDI)

Assume that no new FDI enters. Then ΔW is always positive.

Proof See Appendix B.2.1.7. ∎

Corollary 2.16 (Base model - No new FDI)

Protection of existing FDI is the only channel of unambiguous welfare gain of a BIT.

Proof Follows from proposition 2.15. ∎

Intuitively, if we assume that a BIT does not cause additional FDI to enter, the BIT still provides protection for already existing FDI. For this existing FDI, the BIT simply internalizes a negative externality, and this is definitely welfare-enhancing. This is an important result since the attraction of new FDI is often cited as the main advantage of a BIT. But instead of the attraction of new FDI, the protection of existing FDI is the actual channel of unambiguous welfare gain from a BIT.

2.2.5 Base Model - With BIT and Redistributive Fee

We will now focus on the case where ΔW is positive, implying that firms gain more than the state loses. This means that the BIT creates a welfare gain by avoiding excessive regulation. In that case, we can devise a fee h paid by firms and received by the government that redistributes the welfare gains, so that all parties are better off. The fee will be paid immediately after the firm decided to invest, and will be a fraction of expected profits.[16] This implies that the total amount each firm needs to pay would be $h(r_i - c)$, with $0 < h < 1$. A fee on profits ensures that firms' ex ante incentives are unchanged. In aggregate, the fee needs to be chosen such all parties are better off, implying that the fee intake needs to be greater than the government's loss from a BIT, but smaller than the firms' gain. Hence, the optimal fee h is pinned down as follows:

Proposition 2.17 (Base model - Redistributive fee)

$$\begin{aligned}\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*} r(i)di - \int_{\varepsilon^{BIT}}^{0} f(\varepsilon)g(\varepsilon)d\varepsilon \\ < \int_0^{i^*} h[r(i)-c]di < \\ \int_{i^{NB}}^{i^*}[r(i)-c]di + \int_{-\infty}^{0} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} r(i)di\end{aligned} \tag{2.13}$$

The fee redistributes the gain from avoiding inefficient regulation under small shocks, so that both firms and the government are better off. With such a redesigned BIT, both firms and the government will have an incentive to sign an agreement.

[16]Expected profits are assumed to be known since all information is common knowledge. It is important that the fee is paid by firms based on expected profits ex ante before the shock hits. This ensures that the government does not need to take a possible loss of fee income into account when deciding upon regulation. In reality, expected profits may not be known but can instead be based on past performance. This is similar to the setup of corporate tax rates in Germany, where advance tax payments for the current year are made based on the past year's profit.

2.2.5.1 Discussion

We can interpret the fee as some form of compulsory state insurance: The government acts as an insurance company by offering a BIT (the insurance), collecting the insurance fee, and then creating a fund which is used for compensation payments.[17] While previous standard BITs offered benefits to firms free of charge, this redesigned BIT forces the firms as the beneficiaries to make a financial contribution as well. While the government does not directly benefit from FDI, it now does so indirectly since it can monetize on the firms' gains from a BIT. With such a state insurance, the insurance fee will also be lower than under private insurance: This is because state insurance with a BIT changes the government's incentives to regulate, whereas a purely private insurance provider would only pool risks between the firms but not affect government incentives.

The insurance interpretation illustrates the advantage of letting the damage causing party offer insurance. In a standard insurance setup, we have the insurance seller, the insurance buyer, and nature as the damage causing party (e.g. natural disaster insurance). In many insurance contexts, the damage-causing party is identical with the insurance *buyer*, causing moral hazard problems (e.g. car insurance, health insurance). However, in our BIT setting, we are arguing in favour of letting the damage causing party (the government) become the insurance *seller*. The advantage is that this can align the government's incentives, remove moral hazard and cause a more efficient level of regulation.

Interpreting the BIT in such an insurance context turns the question of whether to have a BIT into one that asks which party should bear the risk of policy-relevant shocks, which is given by nature. Without a BIT, the government can act as it pleases, with the cost of reacting to the shock falling entirely on the firms, whose profits are slashed. The introduction of a BIT then moves the cost entirely to the government, since any reaction to the shocks requires the government to fully compensate the firms.

[17] We will be using the term 'insurance' despite the fact that with risk-neutral agents, there is no welfare gain per se from reducing risk. Introducing risk aversion in both parties is a possible extension of the model.

2.2.6 Extension: FDI Tax

2.2.6.1 General setup

In the following subsections, we add several extensions to the base model for a more realistic setup. Only one extension at a time is added to the base model for tractability. For each extension, we will only present the main results, and leave the mathematical details to section B.3 of the appendix.

In the base version of the model, the government did not benefit directly from FDI, and firms' revenues and profits were absent from the government's payoff function. We now add the feature that the government can benefit directly from FDI, by allowing it to tax firm profits with tax t. This creates a direct incentive for the government to attract FDI, as it now internalizes some of the firms' profits.[18]

2.2.6.2 No BIT

The government's maximization problem is given by:

$$\max_{I_R} \; u_G = (1 - I_R)\left\{g(\varepsilon) + \int_0^{i^{NB}} t[r(i) - c]di\right\} \tag{2.14}$$

When deciding whether to regulate, the government now takes the possible loss of the tax intake into account.

Proposition 2.18 (FDI Tax - No BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{NB} = g^{-1}[-\int_0^{i^{NB}} t[r(i) - c]di] < 0$
Firm investment: $i^{eq*} = i^{NB} = r^{-1}[\frac{1-p(\varepsilon>\varepsilon^{NB})t}{(1-t)p(\varepsilon>\varepsilon^{NB})}c]$

Proof See Appendix B.2.2.1. ∎

[18] The difference compared to the fee in section 2.2.5 is as follows: In the current section, the tax is collected *after* the realization of profits. This implies that by regulating, the government is bereaving itself of the chance to collect taxes from profitable investments.

Including an FDI tax lowers the regulation threshold in the no-BIT case compared to the base model, making regulatory expropriation less likely. This is intuitive, as the possibility of forgone tax revenues deters regulation.

Corollary 2.19 (FDI Tax - No BIT - Slope of regulation)
Regulation depends negatively on investment: $\frac{\partial \varepsilon^{eq}}{\partial i^{eq}} < 0$

Proof See Appendix B.2.2.2. ∎

Corollary 2.19 states that ε^{eq} depends negatively on i^{eq}. The intuition is that more investments can potentially generate more tax revenue, implying a higher opportunity cost of regulation. In addition, i^{eq} depends negatively on ε^{eq}, just as in the base model, since more regulation deters investment. This implies the following corollary:

Corollary 2.20 (FDI tax - No BIT - Multiple equilibria)
In the no-BIT case with an FDI tax, multiple equilibria can arise.

Proof See Appendix B.2.2.3. ∎

Figure 2.6 shows a graphical example.[19] The country may find itself in a 'high investment, low regulation' equilibrium, or a 'low investment, high regulation' equilibrium. As we move along the string of equilibria, we find that they are alternatingly stable and unstable.

2.2.6.3 With BIT

Introducing a BIT means that the government now needs to compensate firms for the after-tax revenue that they would have received in the absence of regulatory expropriation. The government's maximization problem is as follows:[20]

$$\max_{I_R} \; u_G = (1 - I_R) \cdot g(\varepsilon) - I_R \int_0^{i^*} r(i)di + \int_0^{i^*} t[r(i) - c]di \tag{2.15}$$

[19] Multiple equilbria did not exist in the base version under the no-BIT case. The reason is that the optimal level of regulation was unaffected by the amount of investment in the base model.

[20] Again, we use the fact that now firms have guaranteed profit and hence invest up to i^*.

Figure 2.6: FDI tax - No BIT - Multiple equilibria

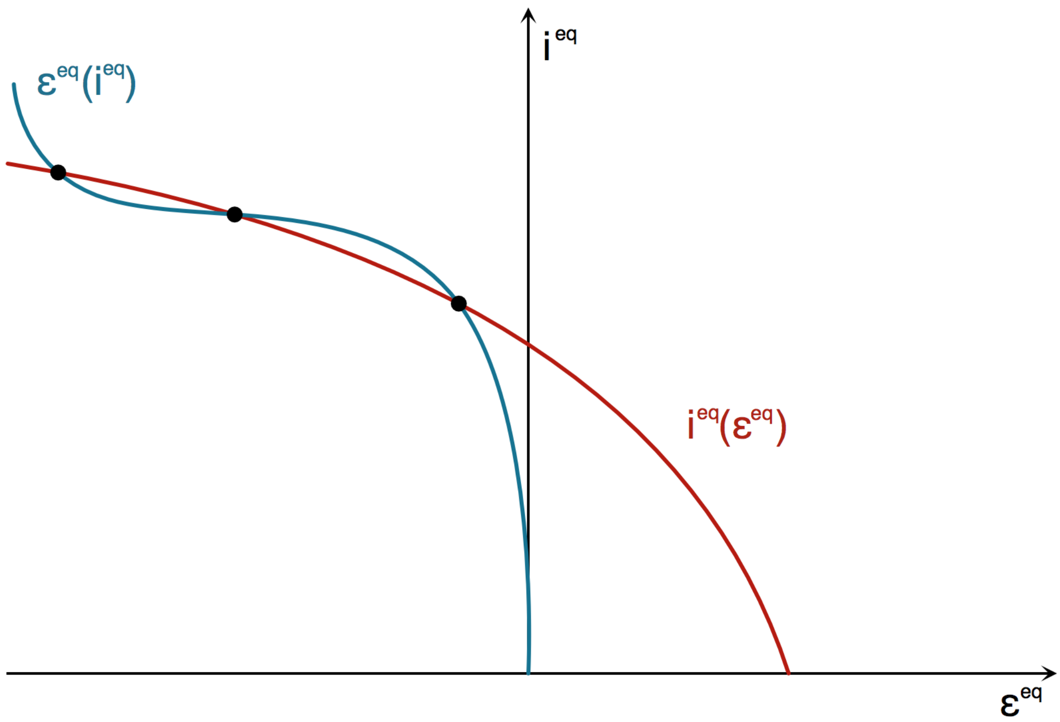
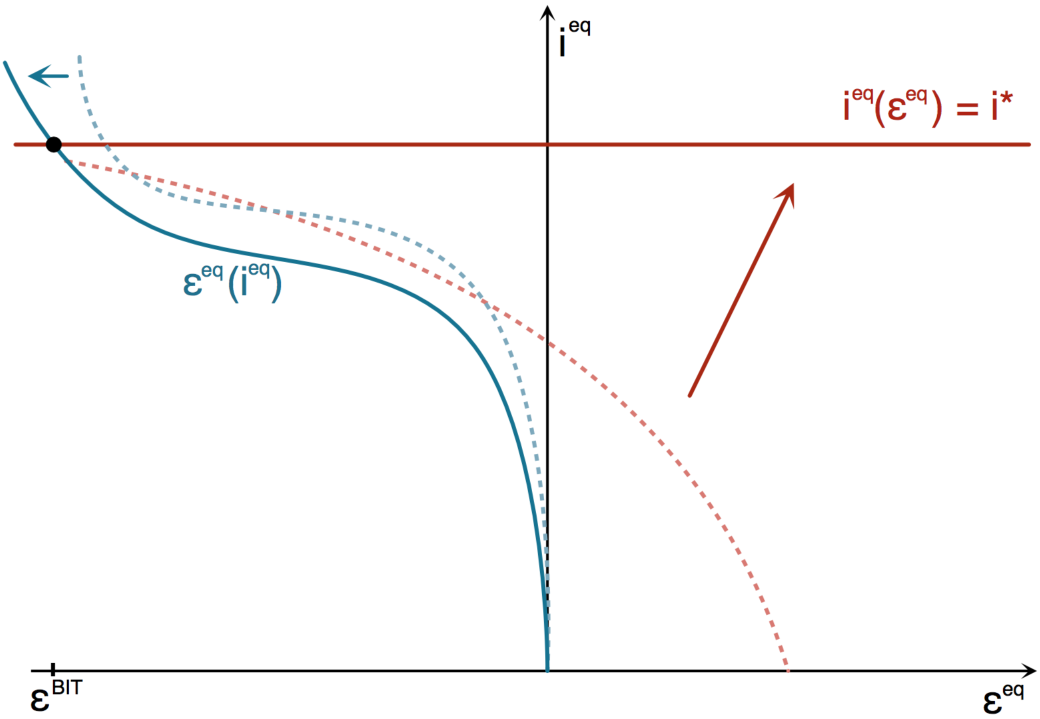


Figure 2.7: FDI tax - With BIT - Equilibrium



Proposition 2.21 (FDI Tax - With BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{BIT} = g^{-1}[-\int_0^{i^*} r(i)di] < 0$
Firm investment $i^{eq*} = i^* = r^{-1}(c)$

Proof See Appendix B.2.2.4. ∎

The presence of compensation costs will now lower the likelihood of regulation. Graphically (as in Figure 2.7), introducing a BIT shifts the $\varepsilon^{eq}(i^{eq})$ curve to the left, since for every level of investments, regulation becomes less likely. At the same time, firms now have guaranteed profits, causing the $i^{eq}(\varepsilon^{eq})$ curve to become a flat line parallel to the x-axis at $i^{eq} = i^*$.

Corollary 2.22 (FDI tax - With BIT - Unique equilibrium)
In the with-BIT case with an FDI tax, the resulting equilibrium is unique.

Proof Follows from proposition 2.21. ∎

The resulting unique equilibrium will always entail more investment and less regulatory expropriation than any of the no-BIT equilibria, as can be seen from proposition 2.21. Hence, the size of the change from introducing a BIT depends on which equilibrium the economy found itself in before. A BIT can help an economy to break out of a bad equilibrium, moving towards a more efficient direction.

Corollary 2.23 (FDI tax - With BIT - Government payoff difference)
With the FDI tax, the effect of a BIT on the government's payoff is ambiguous.

Proof See Appendix B.2.2.5. ∎

With the FDI tax intake, it is now possible that the government is better off with a BIT even without additional redistribution. This stands in contrast to the base model, where the government was unambiguously worse off due to a BIT. The possible gain stems from overcoming the time inconsistency problem: Without a BIT, the government would like to commit to a lower regulation level in order to attract FDI. However, once firms have made their investment decision, the government has an incentive to renege on that commitment by engaging in excessive regulation. Rational firms can foresee this behaviour. As a result, the government suffers from an inefficiently low level of investment and hence a low tax intake. A BIT credibly commits the government to low regulation, thereby achieving a higher equilibrium utility level for the government. This additional welfare-enhancing channel from removing time inconsistency was not present in the base model, since the government did not directly benefit from FDI then.

The other qualitative conclusions from the base model remain unchanged, even with the FDI tax. The overall welfare gain from a BIT is still ambiguous and depends on industry characteristics. If a BIT improves overall welfare, then it is still possible to redistribute the gain through a fee in order to achieve a Pareto improvement compared to the no-BIT case. Details of these results can be found in Appendix B.3.1.

2.2.7 Extension: Domestic and Foreign Firms

2.2.7.1 General setup

In this subsection, we extend the base model by adding a distinction between domestic and foreign firms in the industry. Like in the base model, we consider an arbitrary industry in the home country. Within the industry, a proportion μ of firms is of domestic origin, whereas a proportion $1 - \mu$ is foreign. Both types of firms are getting taxed, like in section 2.2.6.

There are two differences between domestic and foreign firms: First, we assume that the government 'cares' about domestic firms more than about foreign firms, since the stakeholders and shareholders of domestic firms are more likely to be part of the electorate due to the equity home bias (French and Poterba, 1991). In our model, this is reflected by the government completely internalizing the domestic firms' profits and losses in its own objective function. For foreign firms however, the government internalizes only the taxable part of the profit. A second difference concerns the legal scope: Under current BIT legislation, the rights conferred under a BIT only extend to foreign investors. Domestic investors do not have the right to apply to international arbitration courts, and will have to resort to domestic legal means, if available. For our model, this implies that under a BIT, foreign firms receive compensation after regulatory expropriation, whereas domestic firms do not. If the government decides to regulate the industry, this will amount to expropriation of all firms (domestic and foreign) in the industry.

2.2.7.2 No BIT

The government's maximization problem is given by:

$$\max_{I_R} \; u_G = (1 - I_R) \cdot \left\{ g(\varepsilon) + \mu \int_0^{i^{NB}} r(i)di + (1-\mu) \int_0^{i^{NB}} t[r(i) - c]di \right\} + \mu \int_0^{i^{NB}} (-c)di \tag{2.16}$$

We can now see that the base model is a special case of the extension discussed in this section, for $\mu = 0$ (all firms are foreign) and $t = 0$ (no taxes).

Proposition 2.24 (Domestic and foreign firms - No BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{NB} = g^{-1}[-\mu \int_0^{i^{NB}} r(i)di - (1-\mu) \int_0^{i^{NB}} t[r(i) - c]di]$
Firm investment: $i^{eq*} = i^{NB} = r^{-1}[\frac{1-p(\varepsilon > \varepsilon^{NB})t}{(1-t)p(\varepsilon > \varepsilon^{NB})} c]$

Proof See Appendix B.2.3.1. ∎

The regulation threshold is lower than in the no-BIT case of the base model, due to the explicit modelling for domestic firms. As the government taxes FDI, the possibility of multiple equilibria arises, just as in the extension in section 2.2.6.

Corollary 2.25 (Domestic and foreign firms - No BIT - Slope of regulation)
Regulation depends negatively on μ*:* $\frac{\partial \varepsilon^{eq}}{\partial \mu} < 0$

Proof See Appendix B.2.3.2. ∎

The higher the proportion of domestic firms, the *less* likely is regulatory expropriation, as a larger proportion of domestic firms implies that the government has more to lose from excessive regulation. This explains why a BIT is more needed in an international context, as opposed to a purely domestic context. Conversely, sectors with a higher share of foreign firms are more likely to become victims of regulatory expropriation, as the stakeholders and shareholders are more likely to be abroad, with the government not being directly accountable to them.

2.2.7.3 With BIT

With the introduction of a BIT, foreign firms now have the right to receive compensation upon regulatory expropriation. This changes the government maximization problem to the following:[21]

$$\begin{aligned} \max_{I_R} \; u_G = (1 - I_R) \cdot [g(\varepsilon) + \mu \int_0^{i^D} r(i)di] - I_R \cdot (1-\mu) \int_0^{i^*} r(i)di \\ +\mu \int_0^{i^D} (-c)di + (1-\mu) \int_0^{i^*} t[r(i) - c]di \end{aligned} \tag{2.17}$$

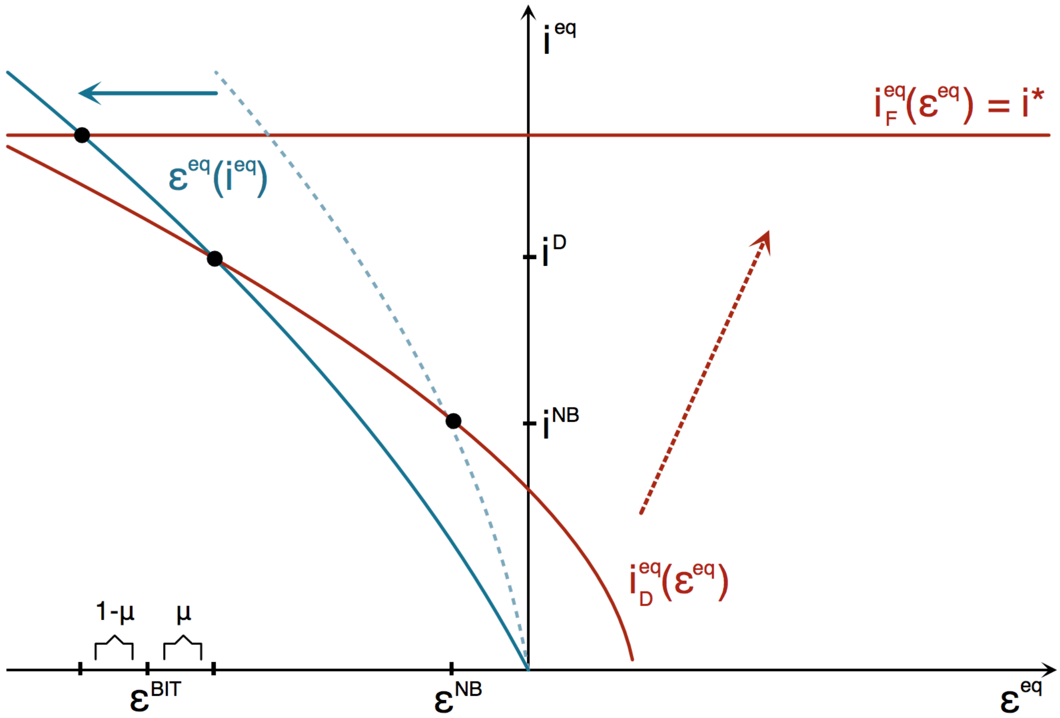
Proposition 2.26 (Domestic and foreign firms - With BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{BIT} = g^{-1}[-\mu \int_0^{i^D} r(i)di - (1-\mu)\int_0^{i^*} r(i)di]$
Domestic firm investment: $i^{eq*} = i^D = r^{-1}[\frac{1-p(\varepsilon>\varepsilon^{BIT})t}{(1-t)p(\varepsilon>\varepsilon^{BIT})}c]$
Foreign firm investment: $i^{eq*} = i^F = i^* = r^{-1}(c)$

Proof See Appendix B.2.3.3. ∎

The new regulation threshold is lower than in the no-BIT case. Foreign firms have guaranteed profit, and invest i^*. Domestic firms raise their investment to i^D due to the reduced probability of regulatory expropriations. Figure 2.8 shows the graphical development. Without a BIT, the equilibrium delivers the regulation threshold of ε^{NB} and the investment level i^{NB} for both types of firms. The introduction of a BIT causes the $i^{eq}(\varepsilon^{eq})$ curve for foreign firms to shift upwards and become a flat line parallel to the x-axis, since they have guaranteed profits. The $i^{eq}(\varepsilon^{eq})$ curve for domestic firms is

[21] We already use the result that domestic firms will invest up to i^D and foreign firms will invest up to $i^F = i^*$.

Figure 2.8: Domestic and foreign firms: Equilibrium



unchanged since they do not receive compensation. As regulatory expropriations now have become more expensive for the government for each level of investment, the $\varepsilon^{eq}(i^{eq})$ curve pivots to the left. This delivers the new regulation threshold of ε^{BIT} and investment levels i^D for domestic firms and i^* for foreign firms.

Corollary 2.27 (Domestic and foreign firms - With BIT - Slope of regulation)
Regulation depends positively on μ: $\frac{\partial \varepsilon^{eq}}{\partial \mu} > 0$

Proof See Appendix B.2.3.4. ∎

The BIT has reversed the relationship between the amount of regulation and the proportion of domestic firms: The higher the proportion of domestic firms, the *more* likely is regulatory expropriation. This is because domestic firms have lower amounts of investment than foreign firms in the BIT-scenario, so any relative increase in the domestic firms' presence lowers the cost of regulation for the government. Despite the fact that domestic firms do not obtain direct compensation from the government in the case of regulatory expropriation, they still benefit from the introduction of a BIT. The reason is that the presence of foreign firms in the same industry drives up the price of regulation for the government, and hence reduces regulatory expropriation overall. Foreign firms act like a protective shield for domestic firms in the same industry.

The overall welfare effect is calculated as the sum of the government's payoff from regulation, as well as the domestic and foreign firms' profit. The result from the base model that the overall welfare effect of a BIT is ambiguous and depends on industry characteristics still holds. If a BIT improves overall welfare, then it is possible to redistribute the gain through a fee in order to achieve a Pareto improvement compared to the no-BIT case. Details can be found in Appendix B.3.2.

2.2.8 Extension: Exports and FDI

2.2.8.1 General setup

In this extension, we add the feature that foreign firms can choose between exporting and FDI when deciding whether to serve the market. The classical choice between these two options is one of a proximity-concentration trade-off (Brainard, 1993): FDI entails no tariffs and transport costs, but has the fixed cost c of setting up a new plant in a new country. In contrast, exporters can use existing production facilities at their headquarter (so there are no fixed costs), but incur iceberg costs τ in serving the new market.[22] We assume that, apart from c and τ, each firm has the same expected revenue $r(i)$ from exporting as from investment. In our BIT context, there is an additional difference in compensation policies between the two: Firms with FDI in the host country qualify for compensation upon regulatory expropriation under a BIT, whereas exporters simply lose access to their business but receive no compensation.

[22] τ units need to be shipped for one unit to arrive.

2.2.8.2 No BIT

The government's payoff function is identical to the no-BIT case in the base version. In contrast, for a single firm, profits depend on its choice of serving the market, so it faces the following maximization problem:

$$\max_{I_F} \ \pi_i = p(\varepsilon > \varepsilon^{eq}) r_i \cdot (I_F + \frac{1 - I_F}{\tau}) - I_F \cdot c \tag{2.18}$$

Here, I_F stands for an indicator function:

$$I_F = \begin{cases} 1 & \text{if } F \text{ chooses FDI} \\ 0 & \text{if } F \text{ chooses export} \end{cases} \tag{2.19}$$

Proposition 2.28 (Exports and FDI - No BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{NB} = 0$
Firm investment: $i^{eq*} = i^{NB} = r^{-1}[\frac{\tau}{(\tau-1)p(\varepsilon>0)}c]$

Proof See Appendix B.2.4.1. ∎

The most productive firms with $i < i^{NB}$ will opt for FDI, whereas less productive firms choose to export. This result of firm sorting has been well-documented in the literature for most demand functions.[23] However, the value of i^{NB} is lower than in the base model, because some less productive firms will choose export instead of FDI, an option that was not available in the base model.

Corollary 2.29 (Exports and FDI - No BIT - Slope of regulation)
Investment depends negatively on regulation: $\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} < 0$

Proof See Appendix B.2.4.2. ∎

An exogenous increase in the probability of regulatory expropriations causes FDI to become *less* attractive relative to exports. The reason is that firms will want to avoid

[23] See Helpman et al. (2004) and Mrázová and Neary (2013) for further discussion.

losing the fixed cost c due to regulatory expropriation by choosing exports instead, where no c is lost if regulation happens.

2.2.8.3 With BIT

The introduction of a BIT changes the government's maximization problem to the following:[24]

$$\max_{I_R} \ u_G = (1 - I_R) \cdot g(\varepsilon) - I_R \int_0^{i^{BIT}} r(i)di \tag{2.20}$$

Proposition 2.30 (Exports and FDI - With BIT - Regulation and investment)
Regulation threshold: $\varepsilon^{eq*} = \varepsilon^{BIT} = g^{-1}[-\int_0^{i^{BIT}} r(i)di]$
Firm investment: $i^{eq*} = i^{BIT} = r^{-1}[\frac{\tau}{\tau - p(\varepsilon > \varepsilon^{BIT})} c]$

Proof See Appendix B.2.4.3. ∎

The government will regulate if $\varepsilon < \varepsilon^{BIT}$, which is a lower regulation level than under no BIT. Concerning the choice between FDI and exports, there are two effects due to a BIT: FDI becomes safer in absolute terms because of the prospect of compensation payments. Exports also become safer in absolute terms, which is due to the reduced probability of regulatory expropriation. However, since FDI becomes safer relative to exports, the FDI-increasing effect dominates:

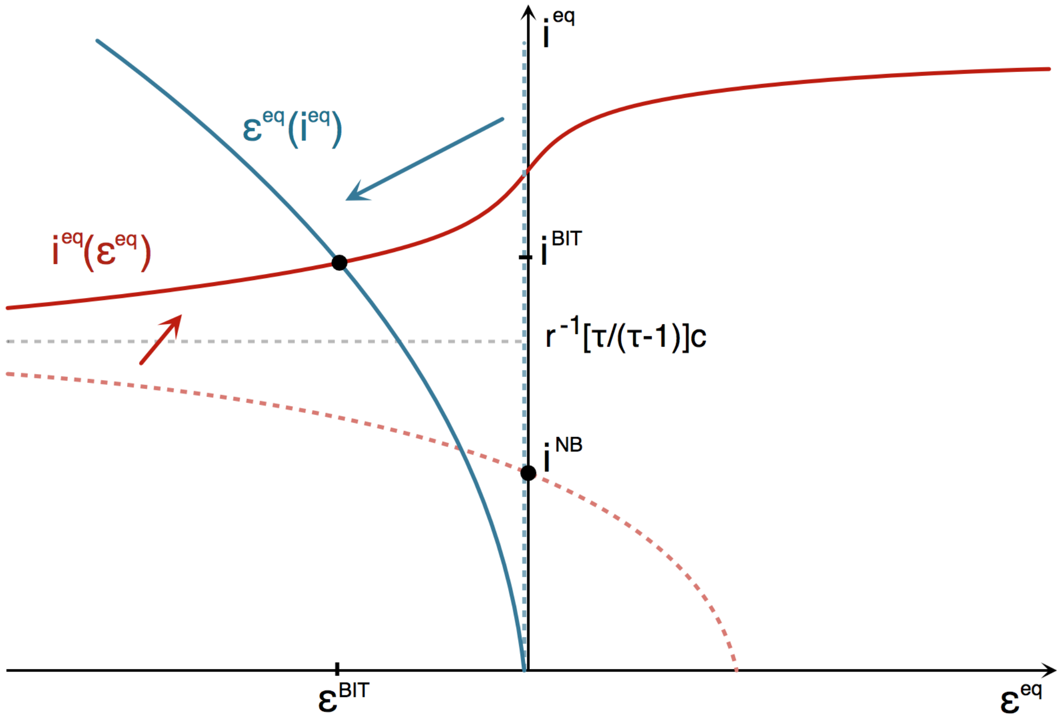
Corollary 2.31 (Exports and FDI - With BIT - Change in investment)
With-BIT investment is larger than no-BIT investment: $i^{BIT} > i^{NB}$

Proof See Appendix B.2.4.4. ∎

The with-BIT investment level i^{BIT} is definitely higher than the no-BIT investment level i^{NB}. A BIT will induce firms to switch from exporting to FDI.

[24] We already use the results that firms will invest up to i^{BIT}.

Figure 2.9: Exports and FDI: Equilibrium



Corollary 2.32 (Exports and FDI - With BIT - Slope of regulation)

Investment depends positively on regulation: $\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} > 0$

Proof See Appendix B.2.4.5. ∎

The introduction of a BIT reverses comparative statics: An exogenous increase in the probability of regulation now causes FDI to become *more* attractive relative to exports. Firms rush to make themselves eligible for compensation by choosing FDI, and this option becomes more attractive the more likely regulatory expropriations are.

Figure 2.9 provides a graphical depiction of the change in equilibrium after the introduction of a BIT. The change in the slope sign of the $i^{eq}(\varepsilon^{eq})$ curve represents the reversal in comparative statics discussed above. The new equilibrium implies less regulatory expropriations and more investment.

The results from this extension demonstrate that a BIT can also be seen as a device to make firms switch from exports to FDI. Governments may hence sign BITs in order to attract value-adding economic activity that would otherwise take place abroad. The other qualitative results of the base model remain. The overall welfare effect from a BIT is still ambiguous and depends on industry characteristics. If a BIT improves overall welfare, the gains can still be redistributed between firms and the government, so that both sides are better off. More details can be found in Appendix B.3.3.

2.3 Regression Analysis

2.3.1 Data and Specification

In this empirical section, we are going to use the base model from section 2.2 to estimate the expected compensation cost for Germany that would result from an EU-US BIT. Based on the expected cost, we will provide an estimate for the redistributive fee h proposed in section 2.2.5, which would cover the compensation cost.[25] In a first step, we will estimate the likelihood of a lawsuit based on country-specific variables. In a second step, we will then use data on tribunal costs and average awards from Hodgson (2014) to compute the overall expected cost of compensation payments. It is important to note that we do not strive to identify the true causal effects of various variables on the likelihood of a lawsuit. Instead, the aim of this empirical exercise is forecasting, so the weaker criterion of coefficient stability (instead of coefficient consistency) is satisfactory.[26]

We use data from the investment policy hub of UNCTAD on all past ratified BITs, as well as all lawsuits that invoke a BIT as legal instrument. Our sample consists of all countrypair-years that contain a ratified BIT from 1980 - 2014, with each countrypair generating two cross-sectional units in each direction.[27] The sample of all ratified BITs represents the population that could potentially generate lawsuits. We adjust for ter-

[25] This estimate of h will only provide a lower bound of the redistributive fee necessary to achieve a Pareto improvement from a BIT, for two reasons: First, we cannot quantify the cost of regulatory chill, which needs to be determined politically. Secondly, our dataset only includes listed arbitration cases. To the extent that firms and governments have out-of-court settlements that involve payments on the government's side, we would underestimate the true cost of a BIT.

[26] See Greene (2002).

[27] For example, Germany-Pakistan 2014 and Pakistan-Germany 2014 would be one observation each.

minated BITs, and we do not include BITs that have only been signed but not ratified, since only ratified BITs can be invoked in order to file a lawsuit. In total, there were 542 lawsuits invoking a BIT as a legal instrument as of 2014.[28] We conduct our analysis using data at the country level, and not on a by-industry level, due to data limitations.

We recall from proposition 2.8 that our model predicts lawsuits to depend on three parameters: The government payoff function $g(.)$, firm productivity $r(i)$ and the amount of FDI i^*. Predictions for the sign of the coefficients were obtained in proposition 2.8.

The function $g(.)$ denotes the government's gain from regulating in response to voter demands. The government gains more from regulating, the more accountable it is to its voters, which is more likely for more democratic countries. Hence, a democratization index can be used as empirical counterpart for $g(.)$. As democratic countries often also have strong property protection, which reduces the likelihood of expropriation, a control variable for property protection is also included to isolate the pure effect of democratization. We would then expect more democratic countries, ceteris paribus, to have more regulatory expropriations and hence face more lawsuits. Better property protection, however, should have a mitigating effect. We use the WGI World Bank voice and accountability index and the property rights index by the WEF Global Competitiveness Index.

Firm productivity is represented by $r(i)$. The more productive the foreign firms in the home country, the more profitable they are. More profitable firms are entitled to more compensation, so we would expect higher productivity of foreign affiliates leading to less regulatory expropriation. For productivity data, we will use the paper by Arndt and Spies (2012), who estimated total factor productivity of foreign affiliates in Germany for various country groups.[29] We expect higher productivity of the foreign affiliates in the home country to lead to less regulatory expropriation and hence less lawsuits.

[28] This includes lawsuits that use trilateral NAFTA as legal instrument.

[29] One could argue that productivity data on foreign affiliates in Germany are not representative for the whole sample. However, the later analysis will mainly be based on within OECD pairs only, where Germany is a more representative country.

Lastly, we have the role of FDI i^* in the home country. Higher amounts of FDI imply more firms that could potentially be hit by regulatory expropriation. At the same time, more FDI means that it is more costly for the government to regulate, resulting in less regulation overall. Since the product of the two gives us the number of firms eligible for lawsuits under a BIT, the overall effect of more FDI on lawsuits is ambiguous, as shown in Appendix B.2.1.4. An ideal empirical counterpart would use worldwide bilateral FDI data. However, bilateral FDI data are extremely patchy,[30] so aggregate inward FDI (of the host country) and aggregate outward FDI (of the source country) from UNCTAD were used as proxies.

The model specification assumes that each BIT-year could have potentially generated a lawsuit. The dependent variable of interest is the number of lawsuits from country j to country i in year t, which is a non-negative integer. This is a count variable, allowing for the arrival rate of lawsuits to be modeled as a Poisson process. However, the likelihood test of the dispersion parameter alpha indicates overdispersion, in that the conditional variance exceeds the conditional mean.[31] Hence, instead of a poisson regression, the following negative binomial regression is applied:

$$\begin{aligned} lawsuit_{ijt} = \beta_0 + \beta_1 fdi\_in_{it} + \beta_2 fdi\_out_{jt} + \beta_3 property_{it} \\ + \beta_4 democracy_{it} + \beta_5 productivity_j + \delta_t + \varepsilon_{ijt} \end{aligned} \tag{2.21}$$

- $lawsuit_{ijt}$: Number of lawsuits from j-country firms to country i in year t. Source: UNCTAD
- fdi_in_{it}: Log total inward FDI (\$mn) into country i in year t. Source: UNCTAD.
- fdi_out_{jt}: Log total outward FDI (\$mn) by country j in year t. Source: UNCTAD.
- $property_{it}$: Property rights index in country i in year t. Higher values imply better property protection. Source: WEF.

[30] This is true for the UNCTAD and OECD bilateral FDI datasets.
[31] Test statistics are available upon request.

- *democracy*$_{it}$: WGI voice and accountability index. Higher values imply better democratization. Source: World Bank.
- *productivity*$_j$: TFP of foreign affiliates in Germany. Source: Arndt and Spies (2012).
- δ_t: Year fixed effects.

Details about the data can be found in Appendix B.1. Table 2.3 presents summary statistics.

Table 2.3: Summary statistics

	N	Mean	Median	St Dev	Min	Max
Lawsuits	81,823	0.007	0	0.098	0	6
Log inward FDI	78,074	10.245	10.441	2.368	-11.512	15.412
Log outward FDI	72,611	8.893	9.153	3.804	-11.513	15.664
Property protection	77,514	4.605	4.433	1.173	1.558	6.606
Democracy	81,610	0.258	0.412	1.036	-2.284	1.826
Productivity	78,967	6.482	6.273	0.518	5.98	7.983

Source: UNCTAD, WEF, WGI World Bank, Arndt and Spies (2012).

2.3.2 Results

Results are presented in Table 2.4. We estimate the same regression using four different samples: Column (1) uses the full sample, with all available BIT-years. All coefficients have the expected signs. Countries with better property protection and higher productivity of their foreign affiliates see less lawsuits. On the other hand, being a more democratic country has, ceteris paribus, a positive effect on the number of lawsuits. From Figure 2.1 in section 2.1.2, we saw that the number of lawsuits increased markedly after the year 2000. In column (2), we look at a sample of post-2000 years only, to see whether a structural break took place. However, coefficients are stable over time, with no marked increase in the propensity for lawsuits in recent years, controlling for our covariates. Any

Table 2.4: Regression results

	(1) Full sample	(2) Post-2000	(3) OECD	(4) OECD post-2000
FDI In	0.353***	0.337***	0.738***	0.729***
	(0.0351)	(0.0365)	(0.0999)	(0.112)
FDI Out	0.502***	0.486***	1.001***	1.007***
	(0.0466)	(0.0473)	(0.0902)	(0.0966)
Property Rights	-0.841***	-0.865***	-0.448**	-0.427*
	(0.0669)	(0.0709)	(0.225)	(0.246)
Democracy	0.401***	0.379***	0.810***	0.860**
	(0.0795)	(0.0834)	(0.292)	(0.339)
Productivity	-0.625**	-0.584**	-0.708	-0.950
	(0.272)	(0.273)	(0.654)	(0.744)
Constant	-7.549***	-7.331***	-20.56***	-19.17***
	(2.072)	(2.084)	(4.827)	(5.536)
Observations	65,527	50,434	8,152	5,839
Year FE	Yes	Yes	Yes	Yes
Pseudo R^2	0.178	0.160	0.291	0.263

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: UNCTAD, WEF, WGI World Bank, Arndt and Spies (2012), own calculations.

increase in the absolute number of lawsuits in recent years can hence be explained by the rising absolute number of BITs and the rise in FDI.

Since our goal is to predict the number of lawsuits for Germany by US firms, restricting ourselves to a sample containing only within-OECD pairings might improve upon external validity. In this OECD-only sample in column (3), all coefficients retain their sign, with the productivity of foreign affiliates losing significance. A last sample in column (4) uses within-OECD pairings after 2000. Results from this last column will be used for our prediction, since it has the highest external validity for our prediction purposes.

Entering the corresponding values of 2014 (the most recent year) for all explanatory variables of a German-US pairing, we obtain a point estimate of 0.745 for the dependent variable. This means that if Germany were to sign a BIT with the USA, Germany could expect 0.745 lawsuits by US investors per year. According to Hodgson (2014), who examined all ICSID cases up to 2012 for which public information was available, the investor prevails in 41% of all cases. Conditional on winning, the average payment made to the investor is \$76.33mn, together with \$4.93mn in legal and tribunal costs. Therefore, the expected annual total cost from compensation payments for Germany from an EU-US BIT would be 0.745·(0.41 x \$76.33mn + \$4.93mn) = \$27mn.[32] While this point estimate of expected costs may mask considerable variance in actual outcomes, it is an accurate depiction of the average picture, taking into account the vast majority of low-profile cases and BITs that never invoke a lawsuit. As a sanity check, both the number of expected lawsuits and the expected compensation payments are about in line with the Canadian experience: As part of NAFTA, Canada grants investor protection to US firms, with the possibility of legal action against the Canadian government. Since 1994 (ratification of NAFTA), Canada has faced 33 lawsuits by US firms, having paid out C\$156mn in total to US firms over the last 20 years.[33]

We obtained that the expected annual cost that needs to be recovered by the fee is \$27mn. Given that total revenue by US affiliates in Germany from 2010-13 was €568.5bn,[34] their profit margin in 2010-13 was 3.5%,[35] and assuming an exchange rate of 0.9 dollars per euro, we find that we would need a redistributive fee on profits of $h = (4 \cdot 0.027bn \cdot 0.9)/(0.035 \cdot 568.5bn) = 0.49\%$ to cover the compensation costs. As pointed out at the beginning of this section, this estimate constitutes a lower bound on what is needed to achieve a Pareto improvement from a BIT. Due to possible out-of-court settlements and the unaccounted cost of regulatory chill, any Pareto improving h would need to be higher, and its value would need to be determined politically.

This back-of-the-envelope calculation helps us to put a ballmark figure on expected costs, alleviating potential concerns about the severity of financial liabilities resulting from a

[32]Current legal practice on the apportionment of legal cost at arbitration tribunals still varies. For our calculations, we assume the ‘pay your own way’ principle, as is adopted in the majority of cases.

[33]Source: Poulsen et al. (2013).

[34]Source: German Central Bank.

[35]Source: Amadeus database.

BIT. The fee is not simply an additional burden on firms with no benefits in return. Instead, the fee is part of a package that contains a BIT, with firms benefiting from the removal of uncertainty through a BIT. Given that most countries have already adapted corporate profit taxation, the implementation of an additional fee could be undertaken within the existing taxation framework.

2.4 Concluding Remarks

We have developed a theoretical model on bilateral investment treaties, explicitly modelling the trade-off between FDI and the state's ability to regulate in an international context. This helps to fill a gap in the theoretical literature on BITs, which so far has been sparse on newly evolving forms of expropriation in an international context. We also close a gap in the empirical literature on the estimation of compensation costs following a BIT.

In the model, firms can decide whether to invest, with the government deciding whether to regulate in response to shocks. A BIT forces the government to pay monetary compensation to firms in the case of regulatory expropriation. Our model provides important new insights on the welfare effects of a BIT: The model shows that a BIT can raise overall welfare by internalizing the negative externality that the government imposes on firms when regulating. The improvement in overall welfare is more likely to hold for highly productive industries, and less likely for less productive industries. Given the heterogeneous nature of aggregate welfare gains across industries, we recommend that industry-specific BITs should be considered. In addition, the model shows that attracting new FDI through a BIT may actually decrease overall welfare, with the protection of existing FDI constituting the only channel of unambiguous welfare gain. Several extensions of the base model, allowing for direct taxation of profits, the distinction between domestic vs. foreign firms, and the choice between exporting and FDI, are also included.

In hitherto existing BITs, the increase in aggregate welfare happens with firms gaining at the state's expense, which reduces the state's incentive to ratify a BIT. We hence propose to redesign BITs by including a fee on firm profits in order to redistribute the welfare gain from BITs among firms and the government, so that a Pareto improvement compared to the no-BIT case results. This fee-enhanced BIT can be interpreted as the government offering state insurance in the form of a BIT, and making firms contribute financially to it. This approach combines the advantage of a BIT in terms of efficiency gains, while at the same time removing the financial burden of compensation payments as one of the main obstacles in justifying BITs. In an empirical exercise, we estimate the annual German compensation cost from an EU-US BIT to be \$27mn, and the compensating fee on firm profits to be 0.5%.

Further research could extend the current theoretical setup to allow for a dynamic setting involving multiple time periods, in order to capture reputation and learning effects over time. The model could also be extended to a general equilibrium setting involving two countries, with two governments and firms originating from and investing in both countries. Firm profits would then be paid out as dividends to shareholders in the other country, and taxes would be invested in public goods or used as direct monetary transfer to consumers. However, we expect the qualitative results of the model to remain largely unchanged in both cases. As long as governments do not fully internalize the effects of regulating foreign firms, the problem of negative externalities and excessive regulation remains, even in a dynamic setting with reputational effects or in general equilibrium. In that case, a BIT could still help to achieve a Pareto improvement. Another possible extension would allow for risk aversion on either the firms' or the governments' side, with the BIT then providing further welfare gains by shifting the cost of bearing the risk of political shocks to the less risk averse party. For the empirical part, better data in terms of bilateral FDI and the productivity of foreign affiliates would be desirable and could potentially improve upon forecasting precision.

Chapter 3

The Interaction Between Patents and Foreign Direct Investment - Evidence from German Multinationals*

3.1 Introduction

3.1.1 Motivation

The analysis of the interplay between the patenting behaviour and foreign direct investment (FDI) decisions of multinational firms is a novel blend between two well-known strands of economic research: These include the literature on location determinants of FDI (for a survey, see Blonigen, 2005), as well as the literature on the location of research and development (R&D) activity (for a survey, see Hall, 2011; Belitz, 2014). While our knowledge about general FDI and its location factors is well established, the

*This chapter is based on joint work with Dietmar Harhoff and Monika Schnitzer.

direct comparison between general FDI and FDI associated with R&D or patenting activity ('patenting FDI') presents an interesting new field of research previously neglected by much of the literature. The juxtaposition enables us to gain valuable insights into previously undocumented heterogeneity within FDI in terms of its innovative potential.

In this chapter, we will be the first to directly contrast general and patenting FDI and to document and quantify the differences. First, we present descriptive statistics on the subtypes of patenting FDI (patent-applying, patent-inventing and patent-owning FDI)[1] and show how they differ from general FDI in terms of size, age, labour productivity, and their regional and sectoral distribution. Second, we undertake a regression analysis to see whether the subtypes of patenting FDI deviate from general FDI in their response to a set of location determinants at the country level. In doing so, we use a novel and extremely detailed firm-level dataset on the universe of German outward FDI and patenting activity abroad. The dataset was created by merging the MiDi dataset of the Deutsche Bundesbank (the German Central Bank), PATSTAT and the Bureau van Dijk Amadeus dataset. It contains 12,631 multinational parent firms and their patenting activity, 42,934 linked foreign affiliates, 202 countries and spans the years 1999-2011.

We show that within the same multinational parent, foreign affiliates associated with patenting activity are up to 39% larger, 13% older and have 14% higher labour productivity than the average affiliate. Across different parent firms, the differences are even larger. Patenting FDI is much more focused on developed host economies and the manufacturing sector. Concerning the dynamic relationship between patents and FDI, we find that affiliates where patenting activity occurred before the FDI entry are much larger and hold higher-quality patents than those affiliates where the timing order is reversed. In addition, our results show that patenting FDI reacts very differently to a whole set of location determinants: At the extensive margin, patenting FDI is more sensitive to changes in market size, local R&D spending, patent protection and the presence of home-country immigrants than general FDI. For distance and local profit taxes, the picture is reversed,

[1]For a detailed definition of the subtypes of patenting FDI, please see section 3.1.2.

with patenting FDI being less affected. Disaggregating the results by patent quality and patent motivation, we find that results on the importance of local R&D spending are largely driven by high-quality patents and patent applications which are motivated by research-related purposes. Results at the intensive margin demonstrate that once an investment decision has been made, fewer of the same location variables have an effect on affiliate size. There is some evidence that tax rates influence affiliate size negatively, while market potential, distance and patent protection have a positive effect.

The results underline the attractiveness of patenting FDI compared to general FDI: The size difference implies that patenting FDI entails more tax revenue and capital inflows, which is beneficial for the host economies of FDI (Borensztein et al., 1998; Markusen and Venables, 1999). The age difference implies less affiliate turnover and a more long-term investment relationship with the host economy. Patenting affiliates and their associated R&D activity may also entail positive spillovers for the local economy (Bottazzi and Peri, 2003; Thompson, 2006; Blalock and Gertler, 2008), and imply more highly skilled employment opportunities. As for location determinants, the presence of differential effects between general and patenting FDI calls for more tailored local policies in terms of FDI attraction. All these factors motivate our special focus on patenting FDI as an important subset of general FDI, with the research question being relevant for policymakers and researchers alike.

This chapter is a comparative analysis for two large branches of the academic literature. First, we add to the established branch of the literature on location determinants of general FDI. This literature has emphasized the role of market size, low distance, reliable institutions, good infrastructure and immigrants in attracting investments (Globerman and Shapiro, 2003; Yeaple, 2003; Bénassy-Quéré et al., 2007; Hernandez, 2014). Some papers looked especially at the role of tax policy, confirming its relevance in FDI location decisions (De Mooij and Ederveen, 2003; Desai et al., 2004; Bénassy-Quéré et al., 2005). For a more detailed review of the literature, see Blonigen (2005).

The second large branch is the literature on location determinants of R&D activity. Following the seminal papers of Kuemmerle (1999) and Kumar (2001), the literature has strived to identify major location characteristics that attract R&D activities by multinational companies (Cantwell and Piscitello, 2005; Demirbag and Glaister, 2010). In addition to the location determinants for general FDI, R&D activities respond favourably to the availability of science-related human capital, local R&D spending and science clusters. The strength of intellectual property protection rights was also shown to have an impact (Branstetter et al., 2011; Nabokin, 2014). There is also some evidence that R&D related tax incentives stimulate research (Bloom et al., 2002). For a comprehensive survey of the literature, see Hall (2011) and Belitz (2014).

Direct comparisons between the location determinants of general FDI and research-related patenting FDI are rare in the literature. Where comparisons have been made, they were often a by-product rather than the main focus of the analysis. The distinction between the two types of FDI has been made in the policy-related papers by Guimón (2009) and Guimón and Filippov (2012), which contain advice for government agencies about different kinds of FDI. Javorcik (2004b) specifically examines the role of intellectual property rights (IPRs) in attracting FDI in transition economies. Her results show that weak IPR protection in a country shifts the balance away from research-intensive FDI towards distribution-related FDI. Similarly, Nunnenkamp and Spatz (2004) look at the role of intellectual property protection for US outward FDI to find that strong protection is better at attracting high-quality, research-intensive FDI. Wellhausen (2013) employs US BEA data to analyse R&D-related FDI only, and shows that affiliate contributions to value added can be strong predictors for R&D FDI in later years. All these papers conduct their analyses using country-level data.

By demonstrating the existence of a 'patenting premium' for size, age and labour productivity of FDI affiliates, this chapter is also related to the 'exporter superstar' literature, such as Bernard et al. (1995) and Bernard et al. (2007). In this literature, exporters were shown to be larger, to pay higher wages and to be more productive than purely domestic firms. We extend this literature by showing that even within the already prominent sample of multinational firms, further disparities exist. In this context, we also relate to the 'selection vs. learning' literature on exporters, which has sought to explain the exporter premium as a result of either selection or learning effects (Bernard and Jensen, 1999; Van Biesebroeck, 2005).[2]

In the light of the existing literature, our contributions are as follows:

First, we are the first to conduct a direct comparative analysis between general FDI and research-related patenting FDI. Given the novelty of the dataset and research question, we are pioneers in quantifying the differential patterns. While two independent branches of the literature on FDI and R&D location determinants have existed so far, this chapter is the first, as of our knowledge, to pull both strands together in terms of descriptive statistics and regression analysis. In contrast to the existing separate strands of the literature, we are able to directly compare magnitudes for the effects of all explanatory variables on the location decision of general vs. patenting FDI.

Second, we apply a new approach to identify research-related FDI. The existing literature on R&D determinants has identified the dependent variable mainly using surveys, reported R&D expenditures and the number of patents. Our approach uses the presence of patents in foreign affiliates and inventor location to identify research-related FDI. This approach provides us with the unique opportunity to explore the interaction between investment and innovation within a multinational, and also allows for much better data availability. Harhoff and Thoma (2010) provide evidence that identifying R&D using inventor location can be superior to using R&D expenditures. Therefore, our approach

[2]Translated into our setting, our results pose a related question, which we leave for further research: Does the patenting premium exist because parent firms planned their patenting affiliates to be different right from the outset, or do patents themselves act as a catalyst and are thus a direct cause for affiliate growth and development?

enables a much larger sample and more precise estimation of the impact of the investment on the local economy through balance sheet data on revenue and invested capital.[3]

Third, we are the first to expand our analysis to novel types of research-related FDI, by looking at the new measures of patent applications and ownership. While we also use patent inventions, in line with the established literature, the new measures of patent applications and ownership can identify affiliates established out of different patent-related motivations, e.g. market size considerations for innovative products or tax effects and profit shifting. For this reason, affiliate characteristics and location determinants for patent-applying and patent-owning FDI could be quite different from those for patent-inventing FDI. The introduction of these new measures generates fresh insights into the heterogeneity within research-related FDI activities.

Fourth, we provide the first analysis on the dynamic relationship between patents and FDI. We split our sample of affiliates into different groups, depending on whether the affiliates saw patenting activity before FDI entry or vice versa, and show that the two groups of affiliates differ strongly from each other. In doing so, we present evidence that there is a wide range of expansion strategies by multinationals, from sophisticated planning years in advance to more ad-hoc decisions, and that this heterogeneity is reflected in affiliate characteristics.

Lastly, the creation of the dataset used in this chapter is also a major contribution to further research in itself. The dataset contains information on FDI and patents worldwide by German multinationals and was created by merging three large datasets using record linkage procedures. It is unique in its breadth, depth and comprehensiveness and allows for a wide range of research projects that would be beyond the scope of a single chapter.

The remainder of the chapter is organized as follows: Section 3.1.2 provides definitions and motivations of the various subtypes of patenting FDI. Section 3.2 describes the dataset and the merging process. Section 3.3 presents descriptive statistics on the differ-

[3]Previous papers on the location of R&D often only contained a few hundred observations due to the lack of reports, and covered only a few chosen countries.

ences between patenting and general FDI. Section 3.4 contains the regression analysis on location determinants of general and patenting FDI. Section 3.5 then concludes.

3.1.2 Definitions

This section sets out the definitions and motivations of the various subtypes of patenting FDI. In general, there are three possibilities to assign a patent to a particular country: Country of application, country of invention and country of ownership. While a patent may belong to the same country in all three dimensions, it may also be applied, invented and owned in different countries. As we will see, patent application, invention and ownership each stem from a very different set of motivations, so looking at all three subtypes provides us with interesting findings about the diversity within research-related investments. Hence, instead of singling out one subtype to represent patenting FDI, we are agnostic about any dominant concept and will analyse all three subtypes equally in the remainder of the chapter.

In Table 3.1, an overview of the definitions of patenting FDI, patent-applying FDI, patent-inventing FDI and patent-owning FDI is presented. Figure 3.1 presents a Venn diagram that visualizes the same relationship. The figure indicates that patenting FDI is a superset of its subtypes, and that there can be overlaps between the subtypes of patenting FDI.

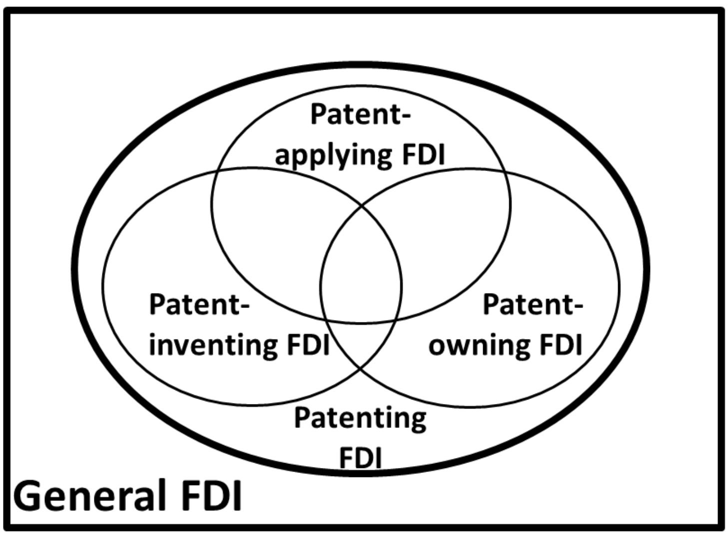
Patenting FDI encompasses any FDI by a parent firm that has applied for a patent at some point in its lifetime. This includes both FDI with and without patenting activity in a specific affiliate. It is thus the broadest definition of research-related FDI, since it even associates FDI that is only vaguely connected to patenting activity (through their parent) with it.

Patent-applying FDI is more specific, and is a subset of patenting FDI. It contains only affiliates of patenting parents in countries where actual patent protection has been applied for. It excludes affiliates of patenting parents in countries where no patent protection was

Table 3.1: Definition: Types of patenting foreign direct investment

	Definition
General FDI	All FDI
Patenting parent firm	A multinational parent firm that has applied for a patent at some point in its lifetime
Patenting FDI	All FDI by patenting parent firms
Patent-applying FDI/ Patent-applying affiliate	FDI by patenting parents in countries where affiliate applied for patents at some point
Patent-inventing FDI/ Patent-inventing affiliate	FDI by patenting parents in countries where affiliate invented patents at some point
Patent-owning FDI/ Patent-owning affiliate	FDI by patenting parents in countries where affiliate owned patents at some point

Figure 3.1: Venn diagramm for subtypes of patenting FDI



sought. Since multinational firms are selective about which countries to apply patents in because of cost considerations and heterogeneity in patent protection and imitational capabilities, the subset is mostly strict. We identify patent-applying FDI by looking at the country of application of a patent. A patent application grants protection of the intellectual property in the jurisdiction of the application authority. For multinational firms, applying for a patent in a particular country is usually driven by one of the following three motivations (Cohen et al., 2002; Blind et al., 2006; Rassenfosse et al., 2008): First, they file for patent applications in order to obtain the right for exclusive sale and production by protecting themselves from imitation. Second, they also often follow strategic motives, by using patents in order to preserve their own freedom of operation in research (defensive blocking) or to prevent competitors from using technical inventions (offensive blocking). To some extent, multinationals also consider patents as negotiation material in dealing with business partners. Other motivations, such as licensing revenues or internal motivation and reputation effects appear less important in the literature.

Patent-inventing FDI is another subset of patenting FDI. It contains only affiliates in countries where a patent invention took place, and excludes affiliates of patenting parents with no patent inventions. Patent inventions are identified by looking at the country of residence of the patent inventor. The underlying assumption is that the country of residence indicates the location of the actual innovative R&D activity. There may be overlaps with patent-applying FDI, but in general, the country of invention of a patent does not need to be the same as the country of application. The motivation for multinationals to invent a patent in a particular country (which implies having R&D activity in that country) is largely captured by two aspects (Le Bas and Sierra, 2002; Gugler and Michel, 2010): First, there is the knowledge-exploiting motive, where multinationals exploit their home-based advantage in the production of their core products. In that case, they invest in R&D abroad in order to adapt their products to local circumstances. Second, there is the knowledge-augmenting motive, where multinational firms want to tap local science-related human capital that can only be accessed by setting up foreign

R&D facilities. Multinationals hope to benefit from the technological superiority of foreign countries in certain fields, and wish to use foreign knowledge to improve upon their own products.

Patent-owning FDI is the third type of research-related FDI, and contains only affiliates in countries where patent ownership is present. Affiliates by patenting parents with no patent ownership are excluded. Patent ownership is identified by looking at the country of residence of the patent applicant, since the patent applicant is the legal owner of the patent at the point of application.[4] As before, there can be overlaps with other subtypes, but in general a patent can be owned in a country different from the country of application and invention. The motivation to have patent ownership in a particular country can be driven by profit shifting motives, since the owner of the patent is the relevant subject for taxation. Karkinsky and Riedel (2012) provide evidence that multinational firms indeed choose the location of patent ownership in response to tax differentials. Another motivation for patent ownership in a particular country may be legal specialization: Since only the legal owner of a patent can sue for patent infringement, multinationals have an incentive to pull patent ownership together in a single affiliate with specialized legal departments, in order to exploit economies of scale when prosecuting claims.

To summarize, each subtype of patenting FDI has a very distinct set of motivations. We hypothesize that this results in significant differences in terms of descriptive statistics, as well as the sensitivity to location determinants. The disparities extend to both the comparison between general and patenting FDI, as well as the comparison within the different subtypes of patenting FDI.

[4]The applicant can be a natural or a juridical person. While all the patents in our dataset ultimately belong to a German multinational via ownership linkages, the actual applicant might be a foreign affiliate of the German parent firm. We observe ownership at the point of application, but do not observe later potential ownership changes.

3.2 Data

3.2.1 Foreign Direct Investment

Data on outward German FDI is obtained from the 'Mikrodatenbank Direktinvestitionen' (MiDi) database, provided by the Research Data and Service Centre (RDSC) of the Deutsche Bundesbank (the German Central Bank). The MiDi database collects data on FDI stocks in accordance with the German Foreign Trade and Payments regulation. For outward FDI involvements, German parent firms directly owning shares above 10% in foreign affiliates with a balance sheet in excess of €3mn are required to report to the German Central Bank. Indirect participating interests need to be reported if they exceed 50%. The dataset provides information on the country of investment, the number of foreign affiliates, the year of entry and annual balance sheet data. We use the investment-reporting party as our parent firm unit. Due to the compulsory nature of reporting, the MiDi database constitutes a reliable, high-quality source of information on German FDI abroad. More detailed information about the MiDi dataset is provided in Schild and Walter (2015).[5] Special permission was obtained to match the MiDi database with additional firm-level data in this project.

3.2.2 Patents

Data on patents were collected from the European Patent Office's PATSTAT database. It contains bibliographical data, citations, and family links, as well as data on applicants and inventors of patents worldwide. In a preparatory step performed by the Max Planck Institute for Innovation and Competition, every patent was allocated to its global ultimate owner (GUO) using ownership links from the Amadeus database of Bureau van Dijk (BvD). The resulting BvD-Patstat dataset contained information on all patent applica-

[5]The MiDi database has the digital object identifier 10.12757Bbk.MiDi.9913.01.01.

tions filed in 1996-2011 by German firms or their foreign affiliates. More details about patent data processing can be found in Appendix C.1.1.

3.2.3 Matching

The MiDi and BvD-Patstat databases could not be merged directly due to the lack of unique identifiers. While the MiDi database employs an internal MiDi ID in order to identify single parent firms, the BvD-Patstat database uses a different BvD ID system. We thus had to perform an extensive 'fuzzy merge' based on firm name, city name and postcode. As a result, we managed to match 71% of all parent firms in MiDi with a corresponding BvD ID. Within the sample of manufacturing parent firms only, the match rate was 85%.[6] When matching patents, we managed to assign 67.1% of all available patent families to a corresponding parent firm in MiDi. Further details on the elaborate merging process and match quality can be found in Appendix C.1.2.

Due to the lack of a unique identifier for parent firms and affiliates, we do not directly observe patenting activity in an affiliate. Instead, the premise is that the presence of a foreign affiliate in a country (in the MiDi dataset) coupled with patent applications (inventions/ownership) in that country (in the Patstat dataset) is sufficient to assume patent-applying (-inventing/-owning) FDI. By aggregating multiple affiliates of the same parent firm in one country into one unit, we ensure that patents are correctly matched to a patenting affiliate.[7]

The final merged dataset contains 12,631 German multinationals and 42,934 foreign affiliates, with information on balance sheet data and patenting activity abroad by parent firm, country of the affiliate and year. In terms of the affiliates, we have locations with only FDI activity, with only patenting activity, and with both FDI and patenting activ-

[6] For the remainder of the chapter, the manufacturing sector is defined as parent firms with NACE 1.1 codes ranging from 1500 to 4999 or NACE 2 codes ranging from 1000 to 4499.

[7] While this may introduce a measurement error into our descriptive statistics and regressions, the bias is towards zero and hence we may actually be underestimating the difference between general and patenting FDI.

ity. In the sample, 2,228 multinationals are patenting parent firms, which is in line with the numbers found in Karkinsky and Riedel (2012) for patenting German multinationals. We have 202 countries in total, with the dataset ranging from 1999-2011.[8]

3.3 Descriptive Statistics

3.3.1 Prevalence

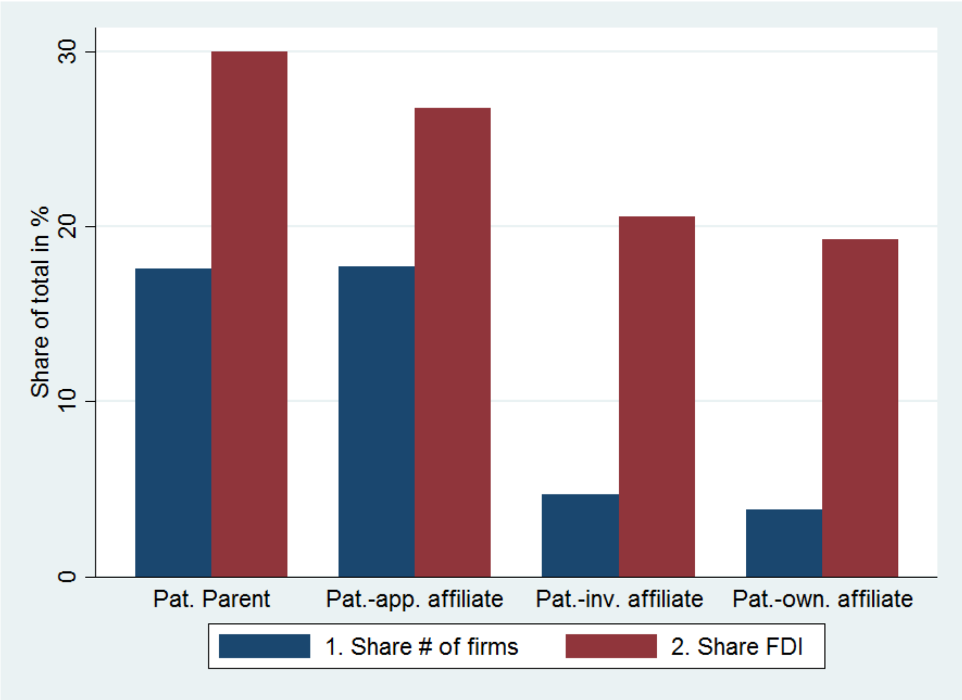
In this section, we present descriptive statistics on the difference between general FDI and patenting FDI, based on data from our finalized MiDi-Patstat dataset. First, we look at the prevalence of patenting FDI: Figure 3.2 provides information on the share of patenting FDI and its subtypes, both in terms of the number of parent firms / affiliates and the amount of FDI. While patenting parent firms make up only 17.6% of all parent firms, they account for 30% of the amount of FDI in the whole sample. Patent-applying affiliates represent 17.7% of all affiliates, but their share of FDI is 26.8%. Overrepresentation is even stronger for patent-inventing (patent-owning) FDI. Here, the respective numbers are 4.7% (3.8%) of all affiliates, but 20.6% (19.3%) of total FDI. From Figure 3.2, it also emerges that patent-applying FDI is most common, whereas patent-inventing FDI is much rarer, with patent-owning FDI being the rarest type. In Appendix C.2, we split the sample by parent firm size. Results show that the share of firms and FDI being associated with patenting activity is much higher for larger parent firms than for smaller parent firms.

Figure 3.3 shows the mean and median number of locations in which parent firms organize their patenting activities.[9] For each parent firm, we count the number of locations with patent applications (inventions/ownership), regardless of whether FDI activity occurs in that location. We can see that multinationals who engage in patent-applying activity do

[8] Due to technical and legal reasons, we were not able to access FDI data for the years before 1999, despite being able to match MiDi parent firms from 1996 to 1998 with the BvD-Patstat dataset.

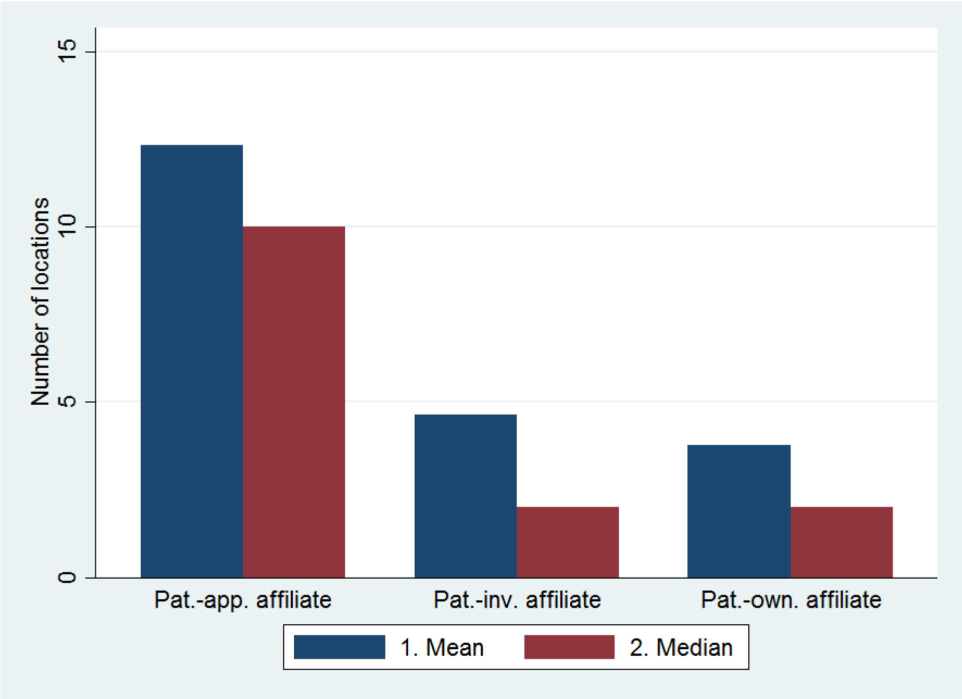
[9] A location denotes a single country in this context.

Figure 3.2: Prevalence of patenting FDI and its subtypes, in %



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Figure 3.3: Number of patent locations of parent firm by patenting subtype



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Table 3.2: Conditional prevalence of patenting FDI and its subtypes

Conditional on

Probability of event	Patenting parent	Pat.-applying affiliate	Pat.-inventing affiliate	Pat.-owning affiliate
Pat.-applying affiliate	0.69	1	0.91	0.94
Pat.-inventing affiliate	0.18	0.24	1	0.93
Pat.-owning affiliate	0.15	0.20	0.76	1

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

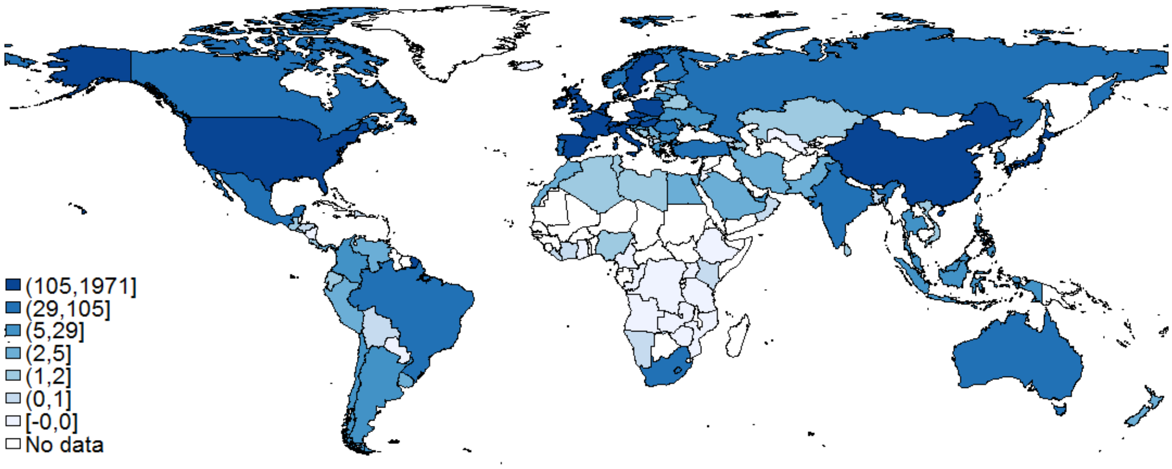
so in 12.3 different locations on average. For patent inventions and patent ownership, the average number of locations is 4.7 and 3.8, respectively. It confirms the picture from the previous figure that multinationals organize their patent applications in many locations, whereas patent inventions and ownership are focused on much fewer places. The difference between the mean and median values points at a skewed distribution, with few large multinationals with patenting activity in many locations dominating the picture.

Table 3.2 presents, at the affiliate level, the likelihood of a subtype of patenting FDI occurring, conditional on another subtype of patenting FDI having taken place. It gives us an impression of the incidence of each of the events and how they relate to each other. Again, we observe that patent-applying FDI is most common, with patenting multinationals applying for patents in 69% of their affiliates. In contrast, patent inventions (ownership) occur in only 18% (15%) of all affiliates of patenting parents. This picture is also reflected in the reciprocal relationship between patent-applying FDI on one side and patent-inventing (patent-owning) FDI on the other side. While there is only a 24% (20%) chance of patent inventions (patent ownership) to occur in a patent-applying affiliate, the reverse probabilities are above 91% and 94%, respectively. If a patent is invented (owned) in a particular location, it is highly likely that patent protection is also applied for at the same location, whereas the reverse is not true.

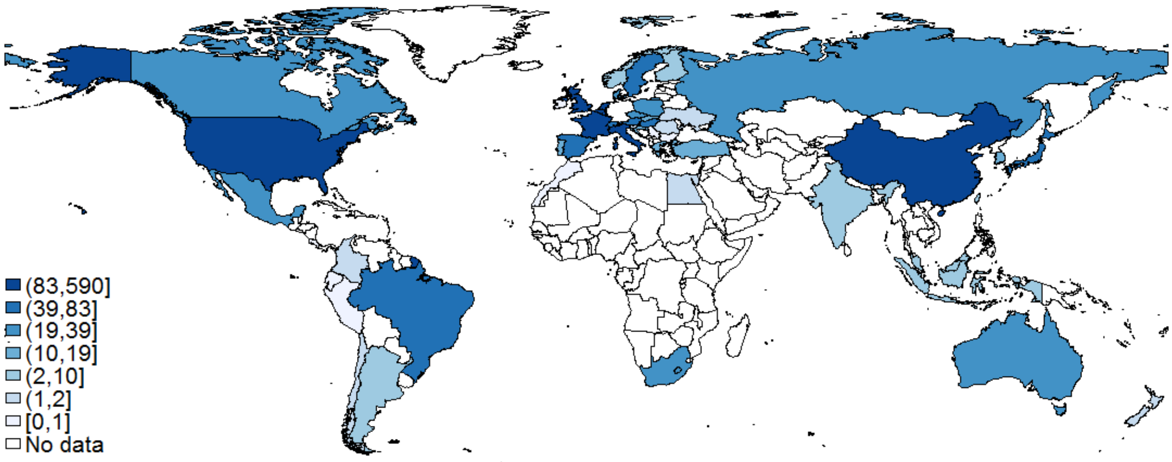
3.3.2 Regional Distribution

Figure 3.4: Regional distribution of general FDI and patent-applying FDI

General FDI



Patent-applying FDI



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Figure 3.4 shows us differences in the regional distribution between general FDI and patent-applying FDI. It contains outward German FDI stocks by country aggregated for the years 1999-2011 in €bn.[10] We can see that general FDI is fairly widespread, covering almost every world region: Europe presents a major hub of general FDI, with North America, East Asia and Brazil also receiving large amounts. Many smaller countries in

[10]Due to data confidentiality reasons of the MiDi dataset, countries with less than 4 foreign affiliates or 4 parent firms were omitted from the sample.

Latin America, Africa, the Middle East, Central and Southeast Asia are also recipients of positive FDI flows.

In contrast, patent-applying FDI is restricted to fewer countries. It is mainly limited to Europe, North America and East Asia. Different from general FDI, large swathes of Latin America, Africa, the Middle East and Central Asia are completely empty of any patent-applying FDI. Hence, it becomes clear that patent-applying FDI is mainly a characteristic of few large, developed host economies.[11]

3.3.3 Sectoral Distribution

Figure 3.5 shows us differences in the sectoral distribution between general FDI and subtypes of patenting FDI. The figure contains aggregated outward German FDI stocks by NACE 1.1 and NACE 2 sector for the years 1999-2011.[12] General FDI shows a rather diverse sectoral makeup, with financial services, transport manufacturing (which includes automobiles), chemistry, utilities and telecommunications being the largest sectors.

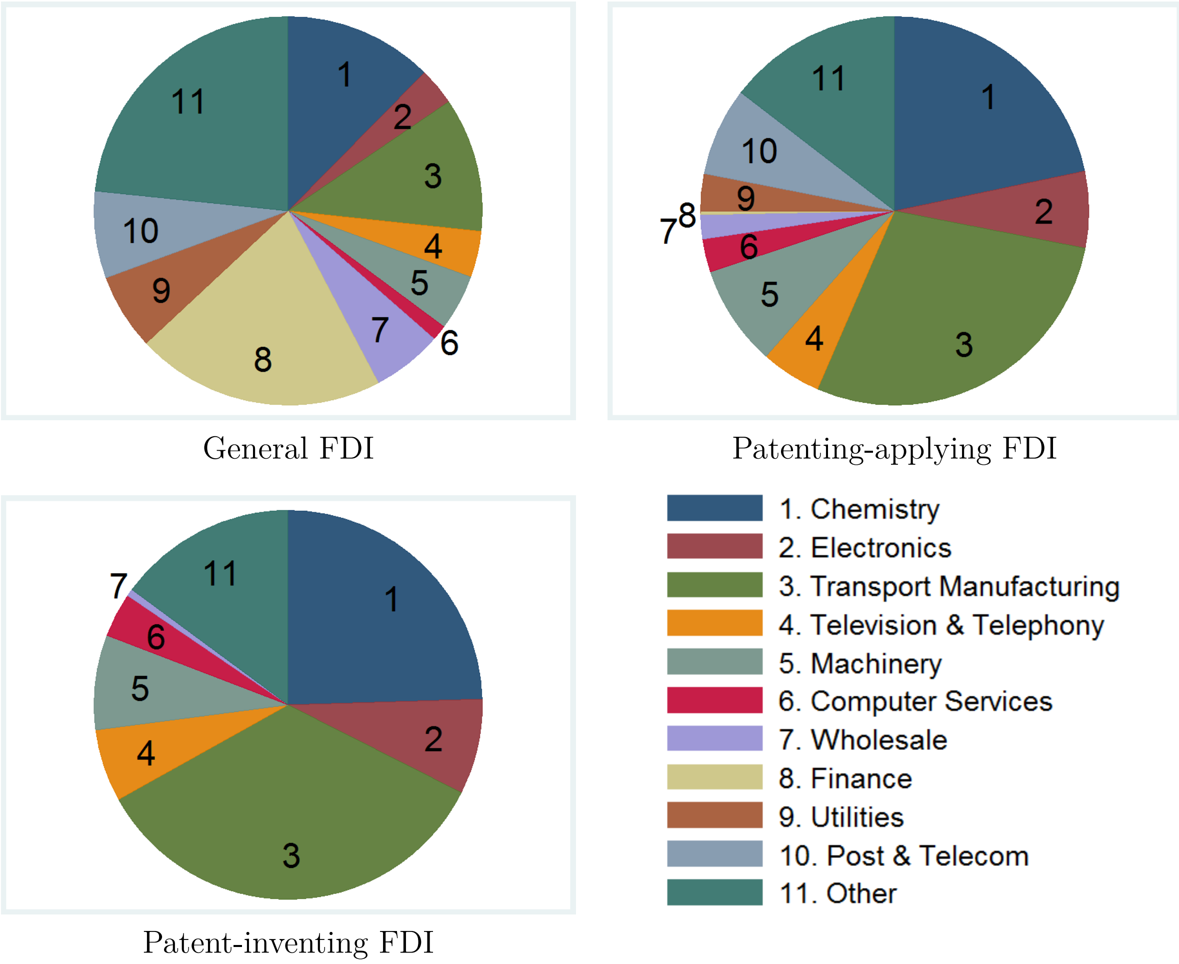
Looking at patent-applying and patent-inventing FDI, innovative manufacturing sectors begin to dominate the picture. Chemistry, electronics, transport manufacturing, television & telephony and machinery now account for the largest share of FDI stocks. While these 5 sectors make up only 35.1% of general FDI, they account for 69.9% of patent-applying and 80.1% of patent-inventing FDI. As one would expect, patenting FDI and its subtypes are composed of few dominant manufacturing sectors.[13]

[11] Pictures for patenting, patent-inventing and patent-owning FDI show a similar pattern, and are thus omitted. The same conclusions hold, however.

[12] NACE 1.1 was applied for data until 2008, with NACE 2 being applied for data in 2008 and after. Due to data confidentiality reasons of the MiDi dataset, sectors with less than 4 foreign affiliates or 4 parent firms were omitted from the sample.

[13] The sectoral picture of patenting FDI is very similar to that of patent-applying FDI. The sectoral picture of patent-owning FDI is very similar to that of patent-inventing FDI. Therefore, both are omitted for clarity of presentation.

Figure 3.5: Sectoral distribution of FDI by patenting subtype

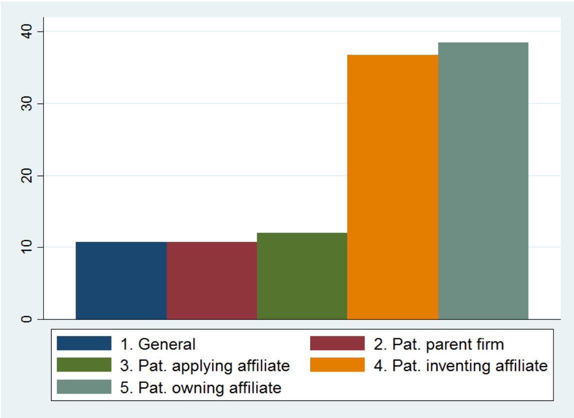


Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

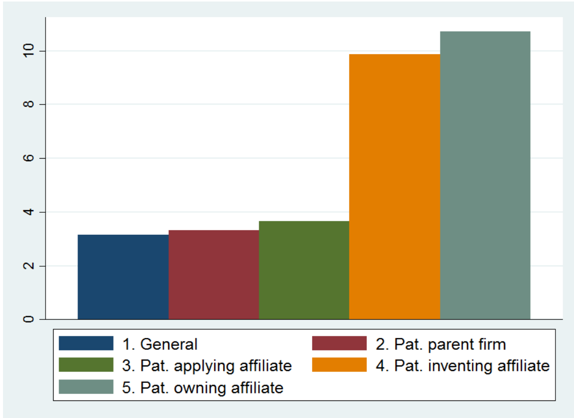
3.3.4 Size, Age and Productivity

In this subsection, we present differences in terms of size, age and labour productivity between general FDI and patenting FDI and its subtypes, across all affiliates and all years. Figure 3.6 a) shows us median affiliate revenue by patenting subtype. The median revenue of a foreign affiliate of the general FDI type is €10.8mn, with values for patenting and patent-applying FDI being slightly larger. In contrast, the median revenue for patent-inventing (patent-owning) affiliates is more than 3 times as high, standing at €36.8mn (€38.5mn). While these are comparisons across all affiliates in the sample, the same qualitative results hold if we compare affiliates within the same parent firm. Figure 3.7 a) compares statistics of patent-applying, patent-inventing and patent-owning affiliates

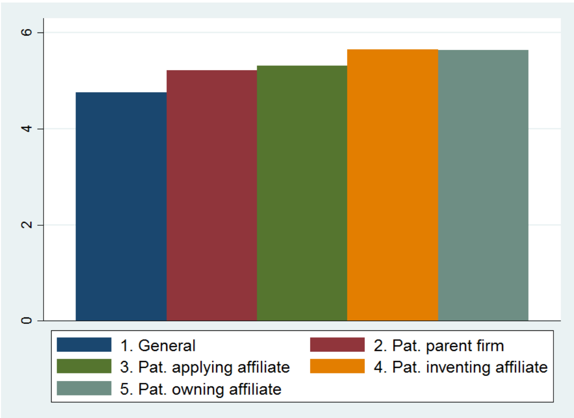
Figure 3.6: Size, age and labour productivity across all affiliates



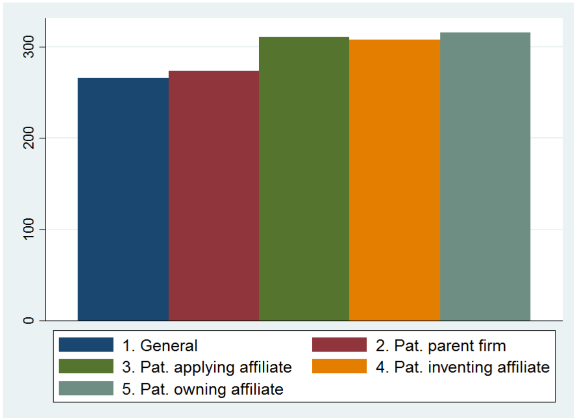
a) Median revenue in €mn



b) Median FDI in €mn



c) Mean age in years



d) Median labour prod., €th per worker

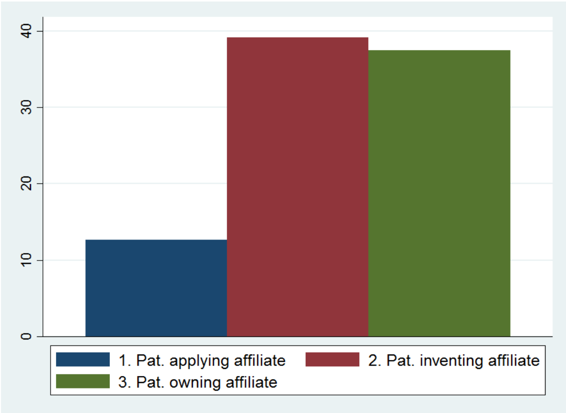
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

with their own parent firm's average. The respective median revenue differences are 12.7%, 39.1% and 37.5%. So even within the same parent firm, patenting affiliates have significantly larger revenues. The same size differences, both across all affiliates and within parent firms, can be observed if we look at the median amount of FDI (capital invested) in each affiliate in Figures 3.6 b) and 3.7 b). Similar to the revenue comparison, we can conclude that patenting affiliates are also much larger in terms of the amount of investment that they receive from their parent firms.

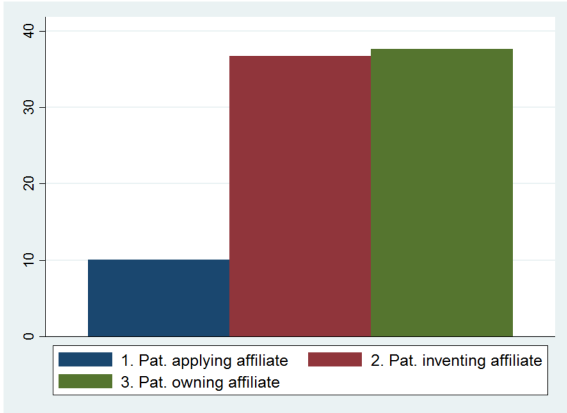
We also look at the same comparison for the mean age of affiliates.[14] The variable age is computed as the number of years that an affiliate has appeared in the dataset.

[14]Median statistics showed no difference between the FDI types for age due to the discrete nature of the age variable. Hence, mean statistics were chosen to allow for a more fine-grained picture.

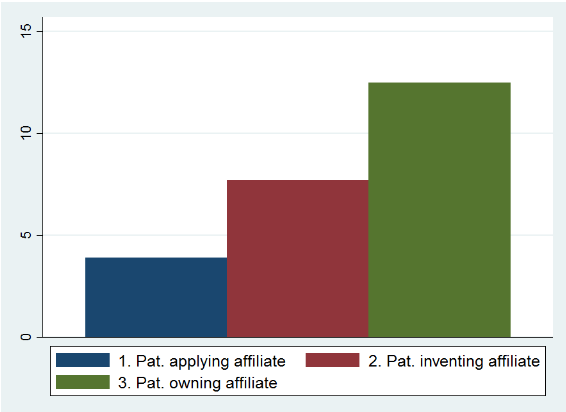
Figure 3.7: Size, age and labour productivity differences within the same parent firm



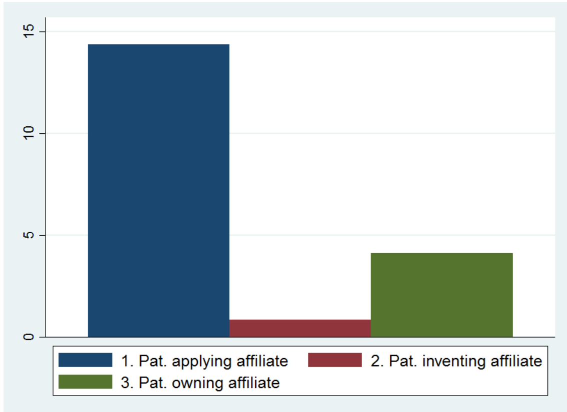
a) Median revenue difference in %



b) Median FDI difference in %



c) Median age difference in %



d) Median labour prod. difference in %

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Age is closely connected with entry and exit, as higher age implies lower entry and exit rates. Figure 3.6 c) shows that patenting affiliates are significantly older than non-patenting affiliates, implying less turnover. Multinational parents conduct more long-term investment relationships with their patenting affiliates. The qualitative results are the same if we look at within-firm comparisons, as can be seen in Figure 3.7 c). Patenting affiliates are up to 12.5% older compared to the other non-patenting affiliates of the same parent firm.

The last statistic to look at is median labour productivity, measured as revenue per employee. Again, labour productivity is significantly higher for patenting affiliates, both across parent firms (Figure 3.6 d)) and within the same parent firm (Figure 3.7 d)).

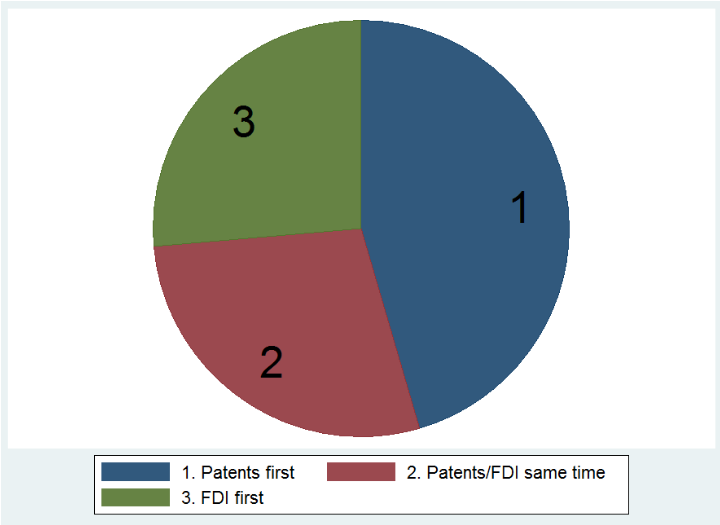
These differences are not simply the result of variations in parent firm size or sectors, since the within-firm comparison generated the same qualitative findings. The statistics demonstrate the economic importance of patenting FDI and its subtypes compared to general FDI, with patenting affiliates being larger, older and having higher labour productivity. We cannot make statements on causality here, whether patents are causal in affiliate development or whether multinationals set up their patenting affiliates to be different right from the start. Nevertheless, the differences exist and amplify the benefits of FDI to the local economy, thereby motivating our special emphasis on location determinants for patenting FDI, which is the focus of section 3.4.

3.3.5 Dynamic Relationships Between Patents and FDI

In this subsection, we analyse the dynamic relationship between patents and FDI: We ask the question whether innovation activity (as measured by patents) follows FDI or vice versa, and how affiliates who apply one timing order over the other differ from each other. For clarity of presentation, we restrict this analysis to the sample of patent-applying affiliates, since they comprise the largest sample (as seen in subsection 3.3.1) and since the results for patent-inventing and patent-owning affiliates are qualitatively similar.[15] For the analysis, we split our sample of patent-applying affiliates into three groups: The first group comprises all affiliates where patent applications occurred before the FDI entry. These are affiliates for which their parent firms seem to have thoroughly planned expansion strategies, with patent applications paving the way for future investments that need intellectual property protection. The second group comprises all affiliates where patent applications occurred after the FDI entry. These are affiliates where patenting activity may have not been planned from the outset, but where patent applications evolved later on in an ad-hoc fashion as the nature of the investment became clearer.

[15] Descriptive statistics for patent-inventing and patent-owning affiliates are available upon request.

Figure 3.8: Proportion of affiliates by relative order of patent applications and FDI



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

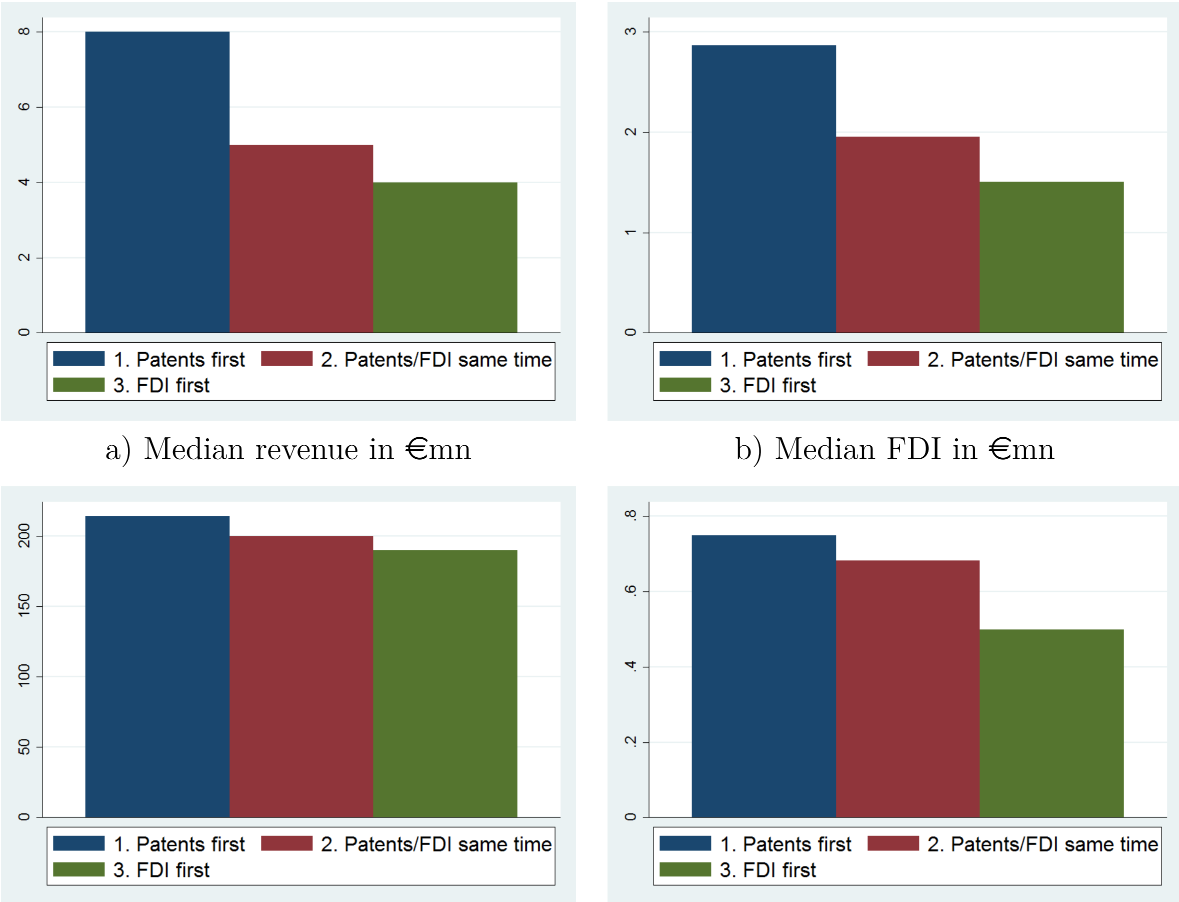
In the third group, both patent applications and FDI entry occurred in the same year, where motivations may be a mixture of the previous two groups.

Figure 3.8 presents a pie chart, showing the proportion of each group within the sample of patent-applying affiliates. We can see that all three groups occupy sizeable shares, so all three types of dynamic relations between patents and FDI exist. However, affiliates where patent applications happened before the FDI entry represent a significantly larger share at 45%. Hence, for almost half of patent-applying affiliates, parent firms may have known in advance that their affiliates would need patent protection.

Figure 3.9 presents median revenue, FDI (capital invested), labour productivity and patent citations at the affiliate level for each of the three groups, taking values at the point of FDI entry.[16] Looking at revenue and FDI in Figure 3.9 a) and b), we can see that affiliates where patent applications happened before the FDI entry are much larger at the point of entry. This is consistent with the story that these affiliates are part of more thoughtful expansion strategies, which justifies larger investments right

[16]Patent citations have been shown to be an appropriate measure for the quality and commercial value of patents (Trajtenberg, 1990; Harhoff et al., 1999). Since patent citations were not available in the year of FDI entry for affiliates where FDI occurred before patent applications, we used the average number of patent citations across the whole duration 1999-2011 for all three groups instead.

Figure 3.9: Size, labour productivity and patent quality by relative order of patent applications and FDI



a) Median revenue in €mn

b) Median FDI in €mn

c) Median labour prod., €th per worker

d) Median # of citations per patent

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

from the start. The same picture holds for labour productivity and the average number of citations per patent, as shown in Figure 3.9 c) and d). Here, affiliates that saw patent applications before FDI entry outperform those affiliates where the timing order was reversed. This provides another indication that affiliates of the first group were more elaborately planned, as parent firms used more high-quality and commercially more valuable patents to prepare their FDI entry than for affiliates of the other group, where innovation activity evolved only gradually over time.

3.4 Regression Analysis

3.4.1 Specification

In this section, we conduct a regression analysis to identify country-level location determinants of general FDI and patenting FDI and its subtypes. In particular, we directly compare the response of patenting FDI to that of general FDI, and see whether patenting FDI reacts more or less strongly to the same set of location determinants. In choosing the location variables, we take the literature on FDI and R&D location determinants as a guide (Blonigen, 2005; Hall, 2011; Belitz, 2014). Our motivation to devote special attention to patenting FDI stems from the findings in section 3.3.4, where we have shown that patenting affiliates are larger, involve more long-term investment relationships and have higher labour productivity, thereby entailing larger benefits to the local economy. In addition, patenting affiliates and their associated R&D activity may also imply positive spillovers effects and more highly skilled employment opportunities than general FDI (Bottazzi and Peri, 2003; Thompson, 2006; Blalock and Gertler, 2008).

In our baseline regression, we will be looking at the extensive margin, implying that we use the decision of FDI entry into a particular country as our binary dependent variable. As in Javorcik (2004b) and Nabokin (2014), this requires inflating the dataset, since we need to account for the counterfactual locations that could have alternatively been chosen for FDI entry. We assume that for each entry, the parent firm could have chosen among all available countries in that year. To facilitate computation, we dropped countries that have less than 15 FDI entries in total or less than 15 patent applications or inventions from 1999-2011.[17] In addition, we drop all investors that are households, government institutions, mining or agriculture companies. Private households and government institutions are dropped since they are not multinational companies. Mining and agriculture

[17] One might worry that this reduces the representativeness of our sample. However, given that many countries receive only very small FDI flows to begin with, their omission from the sample does little to reduce our coverage of total FDI.

companies base their location decisions on natural advantages, which we cannot capture in our analysis. This follows the same approach as in Gumpert (2015). The resulting dataset varies by entry, country and year, and contains 21,303 entries, 58 countries and spans the years 1999 - 2011.

In order to identify the differential effects between general and patenting FDI, we interact each location variable with a patent dummy that indicates whether an FDI entry observation belonged to a particular patenting FDI type. Having the three types of patent-applying, patent-inventing and patent-owning FDI, this requires three different dummy variables. To keep the interpretation of the coefficients clear, we will run a separate regression for each patenting subtype.[18] In each regression, the dummy variable will differ depending on the patenting subtype under analysis, while the dependent variable of FDI entry is the same in each case. Since we rely on the interaction terms for the identification of the differential effects, we use a linear probability model (LPM) for estimation as in Nabokin (2014). The LPM provides us with a straightforward interpretation of the interaction terms as marginal effects, which would not be the case with non-linear estimators such as Probit or Poisson (Ai and Norton, 2003). We lag all explanatory variables by one period, assuming that location variables in the previous period determine location decisions in the current period. Our specification then looks as follows:

$$entry_{ijt} = \alpha + \vec{\beta} \cdot \vec{x}_{jt-1} + \vec{\gamma} \cdot \vec{x}_{jt-1} \cdot dummy_i^k + \delta \cdot dummy_i^k + \vec{\lambda} \cdot \vec{\phi}_h + \mu_s + \eta_j + \theta_t + \varepsilon_{ijt} \quad (3.1)$$

Here, i stands for the entry, j for the country, and t for the year. Additionally, h denotes a parent firm, and s denotes a NACE 1.1/2 sector. k denotes the three different regressions, one for each patenting type, so we have $k \in$ (patent-applying, patent-inventing, patenting-owning). The dependent variable $entry_{ijt}$ is equal to one if an FDI entry occurred in country j in year t. It is zero for all other counterfactual locations that could

[18]Putting all three dummies into one single regression would run into multicollinearity and interpretation problems, since patent-applying, patent-inventing and patent-owning FDI flows often overlap.

have theoretically been chosen for FDI entry but were not. Vector $\vec{x}$ contains a set of explanatory country variables, selected based on the existing literature on FDI and R&D location determinants. The set of explanatory variables is as follows:[19]

- Market size: We use log GDP to measure the market size of a country. In a robustness check, weighted market potential is used. Source: IMF, own calculations.
- Transport cost: We use log distance (population-weighted, in km) of country j to Germany as a proxy for transport costs. Source: CEPII.
- Tax rate: The total tax rate (% of commercial profits), based on the statutory corporate tax rate, measures the attractiveness of a location in terms of profit retention. Source: World Bank.
- Science-related human capital: We use R&D expenditures as % of GDP as a measure for local R&D spending and the availability of science-related human capital. As a robustness check, we later use the number of researchers in R&D per '000 population. Source: World Bank.
- Patent protection: The strength of intellectual property protection is measured using the patent protection index developed by Park (2008).[20] For robustness purposes, we later also use the intellectual property rights index by PRA.
- Immigrants: There is evidence in the literature that home-country immigrants help to attract FDI (Hernandez, 2014; Li, 2015). We use the share of German immigrants in country j to capture this. Source: OECD.[21]

The variable $dummy_i^k$ denotes the type of the FDI entry concerning its patenting status. It is equal to one, if that FDI entry turned out to be of the patenting subtype under analysis. For example, in the regression for patent-applying FDI, the dummy would be equal to one for all factual and counterfactual locations of an entry if the FDI entry was

[19] A more detailed data description can be found in Appendix C.1.3.
[20] This follows the same approach as in Nabokin (2014).
[21] Despite being provided by the OECD, the data also contains observations on non-OECD countries.

of the patent-applying type.[22] In the regressions for patent-inventing and patent-owning FDI, the dummy is defined analogously. The coefficients on the interaction terms, $\vec{\gamma}$, are then the outcome of interest. They tell us whether there are any differential effects between general and patenting FDI in terms of their reaction to location variables.

Endogeneity issues such as reverse causality are less likely to be a problem given the firm-level dataset with the specification of FDI entry as the dependent variable. The conjecture is that a single affiliate is too small to influence macroeconomic country-level variables. This is even more likely to hold for large OECD countries where the majority of German investments are located. Another concern is that some countries could be more attractive investment locations due to variables that we have omitted in our analysis. This could bias our results if the omitted variables were correlated with our covariates. As a remedy, we exploit the panel structure of our dataset by including country- and year-fixed effects η_j and θ_t to account for country- and time-specific heterogeneity. A similar source of heterogeneity could exist at the parent firm level. While parent firm fixed effects were not feasible due to computational limitations, we included detailed sectoral fixed effects μ_s at the 4-digit NACE 1.1 and NACE 2 level and parent firm control variables $\vec{\phi}_h$ to mimic the effect of parent firm fixed effects.[23] We use parent firm size as our control, as measured by the logarithm of aggregate revenue across all affiliates. Standard errors are clustered at the parent firm level.

Table 3.3 presents summary statistics for the set of explanatory variables that we will use in the later regressions. The number N gives us the number of unique observations of each variable.[24]

[22]Patent-applying FDI means that the foreign affiliate that resulted from the entry saw at least one patent application at some point.

[23]NACE 1.1 was applied for data until 2008, with NACE 2 being applied for data in 2008 and after.

[24]Since the variables do not cover all countries in our sample, our regression shows less observations than the full sample of observations. In case of missing variables over time, the most recent value (or closest in time) was used.

Table 3.3: Summary statistics

Variable	N	Mean	Median	St Dev
FDI entry variables				
FDI entry	1,214,271	0.018	0	0.131
Affiliate-year variables				
Affiliate size (log revenue)	218,280	9.049	9.473	2.976
Parent variables				
Agg. parent size (log revenue)	12,433	10.612	11.082	3.567
Country-year variables				
Log GDP	734	5.821	5.692	1.387
Log market potential	715	5.956	5.739	1.286
Log distance (pop.-weight)	728	7.847	7.556	1.185
Total tax rate	617	0.461	0.451	0.166
R&D expenditure (% of GDP)	721	1.245	0.983	0.948
Researchers in R&D (per '000 pop.)	708	2.318	1.902	1.824
Patent protection (Park 2008)	676	3.978	4.130	0.619
Intellectual property rights index	734	6.278	6.200	1.554
German immigrants share in %	564	0.360	0.165	0.627

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, IMF, CEPII, World Bank, Park(2008), PRA, OECD, own calculations.

3.4.2 Results - Baseline

Table 3.4 presents the baseline results for regression specification (3.1), using FDI entry as the dependent variable. The three columns represent the three different regressions as discussed in the previous section. Each column depicts a regression for a particular subtype of patenting FDI, with only the patent dummy variable (Pat Dum) differing between the columns: In column (1), the dummy is equal to one if the FDI entry is of the patent-applying FDI type. In an equivalent fashion, columns (2) and (3) show regressions with dummies indicating patent-inventing and patent-owning FDI, respectively.

Looking at the first two rows, we confirm the standard result in the literature (e.g. Head and Mayer, 2004) that market size is a relevant determinant for the location of general FDI. An increase in log GDP by one standard deviation (sd) raises the probability of an affiliate being located in a country by up to 3.7 percentage points (pp). As a finding that is new to the literature, column (1) shows that the effects are even stronger for patent-

Table 3.4: Results - Baseline

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP	0.0259***	0.0269***	0.0269***
	(0.0028)	(0.0028)	(0.0028)
Log GDP * Pat Dum	0.0030***	0.0017	0.0018
	(0.0005)	(0.0011)	(0.0011)
Log Distance	-0.0053**	-0.0049**	-0.0049**
	(0.0022)	(0.0022)	(0.0022)
Log Distance * Pat Dum	0.0034***	0.0027***	0.0031***
	(0.0004)	(0.0007)	(0.0007)
Total Tax Rate	-0.0138***	-0.0124***	-0.0123***
	(0.0048)	(0.0048)	(0.0048)
Total Tax Rate * Pat Dum	0.0133***	0.0073	0.0035
	(0.0029)	(0.0047)	(0.0051)
R&D Expenditure	0.0002	0.0005	0.0005
	(0.0012)	(0.0012)	(0.0012)
R&D Expenditure * Pat Dum	0.0033***	0.0028***	0.0038***
	(0.0004)	(0.0008)	(0.0009)
Pat. Prot. (Park)	-0.0009	0.0002	0.0003
	(0.0012)	(0.0012)	(0.0012)
Pat. Prot. (Park) * Pat Dum	0.0075***	0.0042*	0.0032
	(0.0010)	(0.0024)	(0.0024)
German immigrants	-0.0011	-0.0008	-0.0008
	(0.0023)	(0.0023)	(0.0023)
German immigrants * Pat Dum	0.0035***	0.0062***	0.0074***
	(0.0009)	(0.0019)	(0.0021)
Observations	788,211	788,211	788,211
R^2	0.02	0.02	0.02
SE Cluster	Parent Firm	Parent Firm	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include parent firm size (log revenue), a patent dummy and constant. Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

applying FDI, as evidenced by the positive and significant interaction term between GDP and the patent-applying dummy. It adds another 0.4pp to the location probability for patent-applying FDI per 1-sd increase of log GDP. However, this is not true for patent-inventing and patent-owning FDI. We conclude that general FDI is attracted by large markets, with the relationship being even stronger for patent-applying FDI. A possible interpretation is that the decision for patent applications is often driven by profit considerations, with the presence of higher fixed costs for patent-applying FDI rendering large markets relatively more attractive.

The coefficients for distance have a negative sign, confirming the gravity-like behaviour of FDI found in the literature (Irarrazabal et al., 2013; Gumpert, 2015). Locations that are further away from Germany tend to receive less German general FDI. As a result that is new to the literature, we show that this relationship is weaker for all subtypes of patenting FDI, since the three interaction terms are positive and significant. While the overall effect is still negative, patenting FDI is less deterred by distance than general FDI, with the elasticity being less than half as high. Given that patenting FDI involves larger investments (see section 3.3.4), fixed costs are higher to begin with, causing distance-related costs to diminish in relative importance. Hence, multinationals may be less discouraged by distance than with general FDI investments.

The total tax rate on commercial profits has a negative impact on general FDI, with a 1-sd increase in the tax rate being associated with a 0.2pp reduction in the location probability of general FDI. Higher tax rates lead to a lower likelihood of FDI, confirming the consensus in the literature (De Mooij and Ederveen, 2003). However, the positive and significant coefficient for the interaction term of patent-applying FDI implies that the overall effect for this subtype is insignificantly different from zero. Thus, for patent-applying FDI, no significant effect of tax rates on entry decisions can be discerned. Summing the lower order and interaction terms for the other subtypes, we have some evidence that the negative effect of taxes on FDI entry is the strongest for patent-owning FDI.

This is in line with the expectation that patent-owning FDI is more strongly driven by tax considerations than other types (see section 3.1.2).

Concerning the R&D expenditures of a country, we find that the effects on general FDI are limited, as evidenced by the insignificant lower order terms. However, the interaction terms demonstrate that R&D expenditures do have a positive effect on all three subtypes of patenting FDI. Raising R&D expenditures as share of GDP by 1 sd would raise the probability of patenting affiliates locating in a country by up to 0.4pp. So while the provision of a favourable scientific environment in the form of high R&D expenditures has no effect on general FDI, we can show that it helps to attract the subset of patent-related FDI.

For patent protection, we find a similar picture: While general FDI is unaffected, the interaction terms for patent-applying and patent-inventing FDI are positive and significant. The coefficient is largest for patent-applying FDI, with a 1-sd increase in the strength of patent protection adding 0.5pp to location probability. The intuition is as follows: When considering where to apply for a patent, the strength of local patent protection is a direct predictor of application usefulness. In contrast, this relationship is less clear-cut for considering where to invent or own a patent. The result that general FDI is unaffected by patent protection can be reconciled with Nabokin (2014), since she also shows that the positive effect of patent protection on general FDI is entirely driven by sectors with high patent sensitivity.

Lastly, the role of immigrants in attracting FDI follows the same pattern: The presence of German immigrants abroad turns out to be a pull factor for patenting FDI, but not for general FDI. For patent-owning FDI, raising the share of German immigrants in a country by 1-sd implies a 0.5pp higher probability of investment entry. A possible explanation for the results can be found by considering the knowledge intensity and complexity of an investment decision: In general, larger multinationals are less dependent on informal networks in their investment decisions due to their size (Li, 2015). However, knowledge intensive industries are known to be more reliant on immigrant networks (Hernandez, 2014). Therefore, elevated levels of complexity or knowledge intensity, such as the inclusion of patenting activity in the investment decision, may cause even multinationals to fall back on informal networks such as immigrants to complement their location decision.

3.4.3 Results by Patent Quality

In this subsection, we analyse whether the differential effects between general and patenting FDI are largely driven by FDI involving high- or low-quality patents. The quality distinction is made using the average number of citations per patent 5 years after filing in a particular affiliate, with a higher number of patent citations denoting higher patent quality. The dependent variable is still FDI entry, and we again have three regressions, one for each subtype of patenting FDI. Within a regression, each location variable now gets interacted with two (quality-differentiated) patenting dummies, with the old dummy being a linear combination of the two new quality-differentiated dummies: If the number of citations per patent in an affiliate is above (below) the median, the corresponding 'high- (low-) quality patenting' dummy is equal to one. Again, the coefficients on the interaction terms give us the differential impacts that we are interested in.

Results are presented in Table 3.5. For clarity of presentation, and since we are mostly interested in the difference between high- and low-quality patents, we only show the interaction terms and omit the lower order terms.[25] Looking at the interaction terms with GDP, we find that high-quality patent-applying FDI is less strongly attracted to large markets than low-quality patent-applying FDI. An interpretation is that high-quality patents have larger revenue potential, implying that filing for protection is worthwhile in markets of any size, whereas the application of low-quality patents is only profitable in larger markets. Concerning distance, the smaller size of the interaction coefficient for high-quality patenting FDI indicates that multinationals keep high-quality research closer

[25] Full regression tables including the lower order terms are available upon request.

Table 3.5: Results by patent quality

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP * Pat Dum (low)	0.0035***	0.0011	0.0017
	(0.0007)	(0.0014)	(0.0014)
Log GDP * Pat Dum (high)	0.0025***	0.0023	0.0019
	(0.0007)	(0.0015)	(0.0016)
Log Distance * Pat Dum (low)	0.0036***	0.0033***	0.0034***
	(0.0005)	(0.0009)	(0.0008)
Log Distance * Pat Dum (high)	0.0030***	0.0020**	0.0028***
	(0.0005)	(0.0009)	(0.0011)
Total Tax Rate * Pat Dum (low)	0.0123***	0.0103*	0.0060
	(0.0032)	(0.0060)	(0.0063)
Total Tax Rate * Pat Dum (high)	0.0144***	0.0042	0.0008
	(0.0032)	(0.0075)	(0.0081)
R&D Expenditure * Pat Dum (low)	0.0021***	0.0026**	0.0054***
	(0.0005)	(0.0011)	(0.0012)
R&D Expenditure * Pat Dum (high)	0.0045***	0.0030***	0.0021*
	(0.0006)	(0.0011)	(0.0012)
Pat. Prot. (Park) * Pat Dum (low)	0.0057***	0.0059*	0.0036
	(0.0014)	(0.0030)	(0.0026)
Pat. Prot. (Park) * Pat Dum (high)	0.0095***	0.0024	0.0027
	(0.0014)	(0.0036)	(0.0041)
German immigrants * Pat Dum (low)	0.0025**	0.0058**	0.0058**
	(0.0012)	(0.0025)	(0.0028)
German immigrants * Pat Dum (high)	0.0047***	0.0066**	0.0091**
	(0.0013)	(0.0031)	(0.0036)
Observations	788,211	788,211	788,211
R^2	0.02	0.02	0.02
SE Cluster	Parent Firm	Parent Firm	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include GDP, distance, total tax rate, R&D expenditure, patent protection, German immigrants, parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank MiDi 1999-2011, Patstat, own calculations.

to their home base than low-quality research. For tax rates, we see some differences in coefficients between qualities, but the statistical hypothesis that the overall tax effect is zero cannot be rejected for either high- or low-quality patent-applying FDI. The interaction coefficients for R&D expenditures are much larger in size for high-quality patent-applying and patent-inventing FDI. As one would expect, high-quality patenting FDI is much more responsive to a favourable R&D environment than FDI involving patents of lesser quality. For patent protection, it turns out that high-quality patent-applying FDI is also more responsive to the strength of patent protection. This is intuitive, as high-quality patents with larger revenue potential will have more to gain from intellectual property rights that are properly enforced. Lastly, the role of German immigrants abroad is more important for FDI involving patents of higher quality, again indicating that more complex and knowledge-intensive decisions (involving patents of higher quality) are more reliant on informal networks.

3.4.4 Results by Patent Motivation

This subsection distinguishes patent-applying FDI by patent motivation. As outlined in section 3.1.2, patent applications are filed in a particular country mostly to obtain rights for exclusive sale and production (motivation 1 or type 1) or for strategic motives such as offensive or defensive blocking (motivation 2 or type 2). This implies that if an affiliate has patent applications, but no patent inventions, we presume that motivation 1 was driving patenting behaviour. The reason is as follows: If motivation 2 was present, we would expect patent inventions to follow the initial patent application so that the affiliate reaps the benefits from strategic blocking. If both patent applications and patent inventions are present in an affiliate, both motivation 1 and 2 may have been the drivers. In this section, we distinguish between patent-applying FDI with and without patent inventions in order to identify the different motivations. Since we look at the motivations for patent applications only, we have just one regression in this case. Similar to the quality differentiation in the previous section, we split the patent-applying dummy into two new ones: The 'with' ('without') dummy is equal to one if the affiliate is patent-applying and has (does not have) patent inventions as well.

Results are presented in Table 3.6. Again, we have only presented the interaction terms for clarity.[26] Concerning the scientific environment, we find that type-1 FDI is less responsive to changes in local R&D spending. This is expected, as it does not contain patent inventions, and is hence less dependent on the provision of local science-related human capital. Patent protection shows the opposite result, with type-1 FDI being more responsive to changes in this variable. Since type-1 FDI only contains patent applications, naturally the strength of local patent protection becomes a relatively more important driver for location decisions. This stands in contrast to FDI that also includes type 2, where additional considerations would be taken into account. For German immigrants, the results show that type-1 FDI is much less dependent on immigrants than FDI that additionally includes type 2. This again underlines the supposition that more complex and knowledge-intensive FDI decisions (i.e. those that involve both motivation 1 and 2) are more likely to require informal support.

3.4.5 Results for the Intensive Margin

In this section, we look at the impact of the location variables on the intensive margin of investment, using affiliate revenue as the outcome of interest. In doing so, we ask the following questions: Given that a parent firm has decided to enter a particular country, which variables influence the size of the affiliate? And does the importance of variables differ between general and patenting FDI? This two-step approach of estimating the intensive margin after the extensive margin follows Javorcik (2004b) and Nabokin (2014). The regression equation for the intensive margin resembles regression Equation (3.1), with two differences: First, the dependent variable for the intensive margin regression is the

[26] Full tables including the lower order terms are available upon request.

Table 3.6: Results by patent application with and without patent invention

Dependent variable: FDI entry	(1) Patent-applying FDI
Log GDP * Pat Dum (with)	0.0036***
	(0.0011)
Log GDP * Pat Dum (without)	0.0029***
	(0.0006)
Log Distance * Pat Dum (with)	0.0038***
	(0.0006)
Log Distance * Pat Dum (without)	0.0033***
	(0.0004)
Total Tax Rate * Pat Dum (with)	0.0120**
	(0.0050)
Total Tax Rate * Pat Dum (without)	0.0137***
	(0.0026)
R&D Expenditure * Pat Dum (with)	0.0039***
	(0.0007)
R&D Expenditure * Pat Dum (without)	0.0031***
	(0.0005)
Pat. Prot. (Park) * Pat Dum (with)	0.0065***
	(0.0020)
Pat. Prot. (Park) * Pat Dum (without)	0.0078***
	(0.0012)
German immigrants * Pat Dum (with)	0.0097***
	(0.0020)
German immigrants * Pat Dum (without)	0.0019**
	(0.0010)
Observations	788,211
R^2	0.02
SE Cluster	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include GDP, distance, total tax rate, R&D expenditure, patent protection, German immigrants, parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

logarithm of affiliate revenue (in thousand euros). Second, instead of a dataset of inflated entries, we now have all observations on actual annual FDI stocks in our sample.

Results are presented in Table 3.7. The coefficients on the GDP variable show that affiliates in larger markets tend to be larger in size themselves, corroborating the results in Nabokin (2014). For general FDI, a 1% increase in GDP is associated with a 1.4% larger affiliate size. As a result that is new to the literature, we find that the relationship is even stronger for the subtypes of patenting FDI, with the elasticity being up to 0.25pp higher for patent-inventing FDI. For distance, there is some evidence that affiliates in destinations further away from Germany tend to be larger. While we know from section 3.4.2 that distance has a negative effect at the extensive margin, results in this section suggest the opposite effect at the intensive margin for patenting FDI. A possible interpretation is that only large affiliates can be profitable in very distant locations, as investing in remote places involves higher fixed costs. This effect is then even stronger for patenting FDI, which has higher fixed costs to begin with. Concerning tax rates, we have weak evidence that higher tax rates influence affiliate size negatively. This is intuitive, as higher tax rates lower the incentive to declare large revenues. For patent protection, we find some evidence that for general FDI, affiliate size increases with rising patent protection. Similar results were also obtained in Nabokin (2014). Lastly, the presence of German immigrants abroad has weak negative effects on affiliate size for patent-applying and patent-inventing FDI. This may have to do with the fact that while immigrants help to attract FDI at the extensive margin, they are more successful in doing so for smaller affiliates, as these affiliates have limited alternative channels of information. Our results are in line with those in Li (2015), where it has also been shown that immigrants are more likely to attract smaller affiliates.

Table 3.7: Results intensive margin

Dependent variable: Log affiliate revenue	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP	1.404***	1.414***	1.412***
	(0.217)	(0.217)	(0.217)
Log GDP * Pat Dum	0.145***	0.246***	0.239**
	(0.0495)	(0.0784)	(0.0955)
Log Distance	0.193	0.212	0.207
	(0.167)	(0.168)	(0.168)
Log Distance * Pat Dum	0.0369	0.113**	0.121*
	(0.0409)	(0.0558)	(0.0666)
Total Tax Rate	-0.882*	-0.871*	-0.900*
	(0.476)	(0.475)	(0.474)
Total Tax Rate * Pat Dum	-0.0126	-0.317	0.0589
	(0.238)	(0.404)	(0.501)
R&D Expenditure	0.0762	0.0898	0.0893
	(0.0752)	(0.0740)	(0.0739)
R&D Expenditure * Pat Dum	0.0658	0.0677	0.0749
	(0.0530)	(0.0813)	(0.0938)
Patent Prot.	0.103*	0.103*	0.106*
	(0.0587)	(0.0577)	(0.0573)
Patent Prot.* Pat Dum	-0.0705	-0.152	-0.319
	(0.134)	(0.191)	(0.241)
German immigrants	0.128	0.121	0.119
	(0.0792)	(0.0785)	(0.0783)
German immigrants * Pat Dum	-0.112*	-0.164*	-0.153
	(0.0582)	(0.0920)	(0.105)
Observations	148,780	148,780	148,780
R^2	0.30	0.30	0.30
SE Cluster	Affiliate Firm	Affiliate Firm	Affiliate Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents an ordinary least squares regression with log affiliate revenue as dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

3.4.6 Robustness Checks

A number of robustness checks are presented in Appendix C.3 to test for the sensitivity of the results. First, we check whether our findings are robust to changing our variable specifications of market size, science-related human capital and patent protection. Tables C.3 to C.5 provide the robust results. Another concern would be that our outcomes are largely driven by sectoral differences, especially between manufacturing and services. To show that this is not the case, we have conducted a regression in Table C.6 containing only manufacturing parent firms, with qualitative results robust to this restriction. A last check involves the aggregation of the dataset: All parent firms who belong to the same global ultimate owner are aggregated together into one large 'global ultimate' parent firm. This accounts for the fact that for some multinationals with elaborate internal ownership linkages, we may have treated parent firms and affiliates separately when they are in fact ultimately subject to the same decision-making body. Results are presented in Table C.7, with all qualitative results unaltered.

3.5 Concluding Remarks

In this chapter, we use a novel firm-level dataset on German outward investment and patents to analyse the differences between general FDI and subtypes of patenting FDI in terms of descriptives and location determinants. To our knowledge, we are the first to systematically document and explore this particular heterogeneity within multinational firms. We merge previously independent strands of the literature on FDI and R&D location determinants. Similar to the literature on the exporter premium, we demonstrate that a patenting premium exists for multinationals: Within the same parent firm, affiliates that engage in patenting activity are up to 39% larger, 13% older and have 14% higher labour productivity. Across all parent firms, the differences are even more pronounced, with the corresponding figures being 256%, 19% and 19%, respectively. Patenting FDI is particularly focused on large developed markets and innovative sectors in manufacturing. Of all patent-related activities, patent applications are the more common type, with patent inventions and patent ownership being much rarer. We have also shown that affiliates where patenting activity occurred before FDI entry are much larger and hold higher-quality patents than those where the timing order is reversed.

In our regression analysis, we find that the sensitivity of FDI entry decisions with respect to a set of location determinants differs markedly between general and patenting FDI: Patenting FDI turns out to be more strongly attracted by increases in market size, local R&D spending, the strength of patent protection and the presence of home-country immigrants than general FDI. The effects are weaker relative to general FDI for changes in distance or local profit tax rates. Further disaggregation by patent quality and patenting motivation reveals that the results on the importance of the scientific environment are driven by high-quality patents and patent applications that are motivated by research-related purposes. At the intensive margin, we find some evidence that market size, distance and the strength of patent protection have a positive effect on affiliate size conditional upon entry. The results are robust to using an alternative set of explanatory variables, restricting the sample to manufacturing parent firms only, and using a dataset with parent firms being aggregated up to the global ultimate owner level.

The findings in this chapter provide a number of relevant insights for policy design: The existence of a patenting premium for FDI can justify a special focus on efforts to attract patenting multinationals. Establishing local hubs for R&D with real innovative activity in the form of patent inventions is particularly desirable, given that patent-inventing affiliates involve larger investments and a more long-term investment relationship than mere patent applications. In addition, patent-inventing FDI may hold positive spillovers for the wider economy. Attracting patent ownership may also be interesting for its elevated investment size and tax-generating purposes. In terms of policies, we recommend intensifying R&D investments and strengthening intellectual property rights. These factors are particularly well-targeted at attracting patenting FDI, while they simultaneously have a more muted impact on general FDI. Increases in market size, which are conducive for both general and patenting FDI, can be achieved by further market integration through free trade agreements involving investment provisions. Policymakers need to worry less about possible detrimental effects of local profit tax rates and transport costs (as measured by distance), at least when the focus is particularly on patenting FDI. Our results suggest that the relevance of these two factors is much diminished when it comes to patent-related investments. The importance of immigrants for complex and knowledge-intensive investment decisions such as patent-related FDI points towards the presence of information frictions, which informal immigrant networks help to overcome. This implies that apart from managing immigration itself, policymakers can also harvest this immigrant effect by reducing informational barriers for investment. Suggestions include renewed efforts to harmonize regulation across countries, the provision of government services for investors in multiple languages and the strengthening of investment promotion agencies abroad.

Our results also open up several paths for follow-up research questions: First, by demonstrating the differences between patenting FDI and general FDI, the question of 'selection vs. learning' automatically arises. One can ask whether patents are directly causal in generating these differences, or whether multinationals simply select more promising affiliates to host patenting activity. The question could be analysed by applying the methodology on the equivalent topic in the exporter literature (Bernard and Jensen, 1999; Van Biesebroeck, 2005). The findings would hold useful insights into the ability of innovation to generate local benefits and spillovers.

Second, another follow-up project would be to build upon the results on the dynamic relationship between patents and FDI as described in section 3.3.5. We have shown that affiliates where patent applications occurred before FDI entry exist alongside affiliates where the order is reversed. We have also provided evidence that the former group is larger and holds higher-quality patents at the point of entry, hinting at a higher degree of sophistication in terms of expansion strategies. The findings invite further investigation: One question is whether the results can be explained by sectoral or regional peculiarities, e.g. with parent firms in specific sectors always patenting before FDI entry, and firms in other sectors following the reverse order. Another question is whether these gaps are persistent or narrow over time as the laggards grow faster. This analysis can be combined with examining the general expansion pattern of innovation and investments, to see whether expansion occurs simultaneously in all affiliates, or one after another. Similar to the literature on sequential exporting (Albornoz et al., 2012), we could then see whether multinationals experiment and learn during their expansion process. As a result of this analysis, we may be able to explain why multinationals enter some locations but not others, and policymakers can obtain additional advice on whether innovation-related investments are particularly desirable.

Lastly, the role of local tax rates for patents and investments deserves further attention. While our holistic approach concerning location variables has produced mixed results for tax effects, a more focused research design with a special emphasis on tax rates and profit shifting might provide more clear-cut conclusions. Possible questions include the effect of corporate tax rates on patent location and ownership, and how the incentive to own tax haven affiliates depends on patenting activity. Similar to Karkinsky and Riedel (2012) and Gumpert et al. (2016), we can use alternative tax definitions such as within-firm tax averages or differentials to measure incentives for profit shifting in large multinationals. We can exploit exogenous policy changes such as the introduction of the European patent box for identification, where preliminary empirical evidence is still scarce (Alstadsaeter et al., 2015).

To conclude, all these aforementioned research questions are inspired by the findings in this chapter and are promising avenues to follow. Each question is possible to analyse using the rich and unique dataset on German multinationals that was compiled and used for this chapter.

Appendix A

Appendix to Chapter 1

A.1 Data Appendix

A.1.1 District Mergers

The data on immigrants were provided based on the districts existing at the time of data collection. However, during the time period of analysis, several German states have enacted reforms that merged and restructured the existing districts. This applies to Saxony-Anhalt in 2007, Saxony in 2008, Mecklenburg-Vorpommern in 2011 as well as the cities of Hannover and Aachen who were merged with their surrounding rural districts. We reallocated old district immigrant data to the newly formed districts where possible, so the analysis is based on the new, reduced number of districts as of 2011. The old district of Anhalt-Zerbst was divided almost equally into 3 parts, and each of the 3 parts got merged into a different new district. Hence, this district could not be properly allocated to a new one and hence any observations relating to this district were dropped from the sample.

A.1.2 Weighting Variables

In order to employ geographical weighting of variables, a first step required obtaining coordinates for longitude and latitude for each district from the German Federal Statistical Office. These data were only available at the municipal level, so population-weighted centroids at the district level were computed from the raw data. In a next step, Stata's geodist command was used to translate these coordinates into distances between districts.[1] A district is hereby assumed to be small enough so that a district is a mathematical point and has zero distance to itself. For the immigrant variable, weighted measures were computed including immigrants in all German districts. For the market potential variable, in addition to the GDP of all German districts, we also included the GDP of all countries bordering Germany.

The weighting function used was a negative exponential function, which is different from the common inverse function mostly used in the literature (Amiti and Javorcik, 2008). Using the negative exponential function has the advantage of removing the tradeoff that exists when using an inverse function in the form of ${d_{hi}}^{-k}$, as is common in the literature. When using ${d_{hi}}^{-k}$, there is a problem of choosing the appropriate units in which distance is measured. If units are chosen too large (e.g. '000 km), there is the problem that when computing district i's market potential, a close district h may obtain a weight larger than one. On the other hand, if the units are chosen too small (e.g. km), weights would fall off very quickly with distance even for districts that are close nearby.[2]

The weighted total number of immigrants from country j in district i is given by:

$$weighted\, immigrants_{ijt} = \sum_{h=1}^{H} e^{-\frac{d_{hi}}{k}} \cdot immigrants_{hjt} \tag{A.1}$$

[1]Distances of each district to each country were computed in the same way.

[2]Robustness checks employing an inverse function for generating weights were also conducted. Results are largely unchanged and can be presented upon request.

Here, h denotes a district and H is the total number of districts. d_{hi} gives us the distance (in km) between district i and h, and k is some chosen weight. A larger k implies a larger weight applied to nearby districts. In the baseline specifications, $k = 20$ was chosen, but robustness checks are conducted for other weights. The weighted variable for GDP is computed in the same way.

For the immigrant share and immigrant intensity, the weighted measure was computed as:

$$weighted\,immigrant\;share_{ijt} = \frac{\sum_{h=1}^{H} e^{-\frac{d_{hi}}{k}} \cdot immigrants_{hjt}}{\sum_{h=1}^{H} e^{-\frac{d_{hi}}{k}} \cdot population_{hjt}} \tag{A.2}$$

A.2 Robustness Checks

Table A.1 presents some robustness checks. Columns (1) and (2) exclude particular groups from the sample. As we have seen in section 1.4, the distribution of FDI in Germany is skewed towards large cities. In order to make sure that the FDI-migration link is not only driven by those large metropolitan areas, column (1) contains the regression results excluding the 10 largest cities in Germany. While the model loses some of its explanatory power, the coefficient on the immigrant share becomes even larger and retains its significance. The link between FDI and immigrants seems to be even stronger outside the metropolitan areas, indicating that in the absence of the advantages of well-connected large cities, the benefits provided by own-country immigrants become even more relevant. In column (2), East German states were excluded to obtain a more homogenous sample, given that East Germany has a somewhat different immigration history.[3] Results are largely robust to the exclusion.

Column (3) presents results with an additional explanatory variable, called 'other immigrants'. For observation ijt, the variable contains the share of all immigrants (excluding immigrants of country j itself) in district i at time t. Including this variable works as a

[3] The ratio of people with migrational background vs. foreign passport holders is much lower in East Germany, as significant migration to East Germany only started after reunification in 1990.

Table A.1: Results - Robustness checks

Dependent variable: FDI entry	(1) PPML Ex Large cities	(2) PPML Ex East Germany	(3) PPML Full sample	(4) PPML 2-year	(5) PPML 3-year
Immigrants Share(t-1)	0.4593***	0.2949***	0.2799***	0.3569***	0.3102***
	(0.0750)	(0.1119)	(0.1015)	(0.1057)	(0.1045)
FDI Stock(t-1)	0.0221***	0.0049***	0.0050***	0.0017***	0.0007
	(0.0030)	(0.0009)	(0.0009)	(0.0005)	(0.0004)
Other Immigrants(t-1)			-0.0435***		
			(0.0161)		
Distance	-0.4657***	-0.6117***	-0.5896***	-0.6073***	-0.6335***
	(0.0598)	(0.0784)	(0.0701)	(0.0692)	(0.0691)
Settlement Share	0.1151***	0.1144**	0.0859**	0.1084***	0.0893**
	(0.0364)	(0.0521)	(0.0423)	(0.0419)	(0.0439)
Market Potential	0.3988	0.4683	1.7216*	-0.7349	-0.0576
	(0.7867)	(1.0299)	(0.9921)	(0.9030)	(0.9980)
Distr. Tert. Share	0.0189	0.0138	-0.0142	0.0037	-0.0159
	(0.0276)	(0.0304)	(0.0256)	(0.0271)	(0.0271)
Constant	-9.9231	-11.1691	-20.2147**	3.7506	-1.5133
	(7.5619)	(11.8548)	(9.2123)	(8.5433)	(9.3165)
Observations	317,800	304,320	386,780	193,390	128,152
R^2	0.2531	0.4921	0.4849	0.5964	0.6663
District FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
SE Clusters	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.	Ctry.-Dist.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

placebo test, which can show that our results are indeed driven by country-specific immigrants, and not by immigrants in general. The coefficient on own-country immigration is still positive and significant, as in the baseline regression, so we confirm that our results are not driven by immigration in general, but by country-specific immigrants instead.

For the results in columns (4) and (5), years were collapsed into fewer time periods. Aggregating years raises the proportion of observations with non-zero entries of the dependent variable, thereby increasing the stability of the coefficients. It can also help to mitigate endogeneity problems: If the FDI decision to set up an affiliate at time t was actually made at time $t-2$, and hence precedes the migration decision, but caused immigrants to arrive at $t-1$ already, we would have reverse causality. Collapsing time periods implicitly extends the lag of the explanatory variables, making the above reverse causality channel less likely. In column (4), two years are collapsed into one time period, whereas in column (5), three years are collapsed into one time period. The results show that collapsing years into fewer time periods preserves the qualitative results, with the FDI-migration link increasing slightly in importance.

In addition, we present results on the FDI-migration link using different lags. In the baseline regression, we used a lag of $t-1$ of the stock of immigrants to explain the entry of FDI at time t. However, one could argue that the FDI-migration link takes longer to materialize, requiring longer lags. Extending the lag can also similarly help to mitigate the endogeneity problem of the FDI decision preceding the migration decision as described in the previous paragraph. We will hence re-estimate the baseline regression using lags on the immigration variable ranging from $t-2$ (386,780 obs.) to $t-7$ (196,224 obs.).[4] Figure A.1 presents the results of the immigrant coefficients for different lags, with point estimates on the immigration coefficient ranging from 0.20 to 0.35. As we can see, the peak is reached at lag $t-2$, implying that the FDI-migration link materializes in

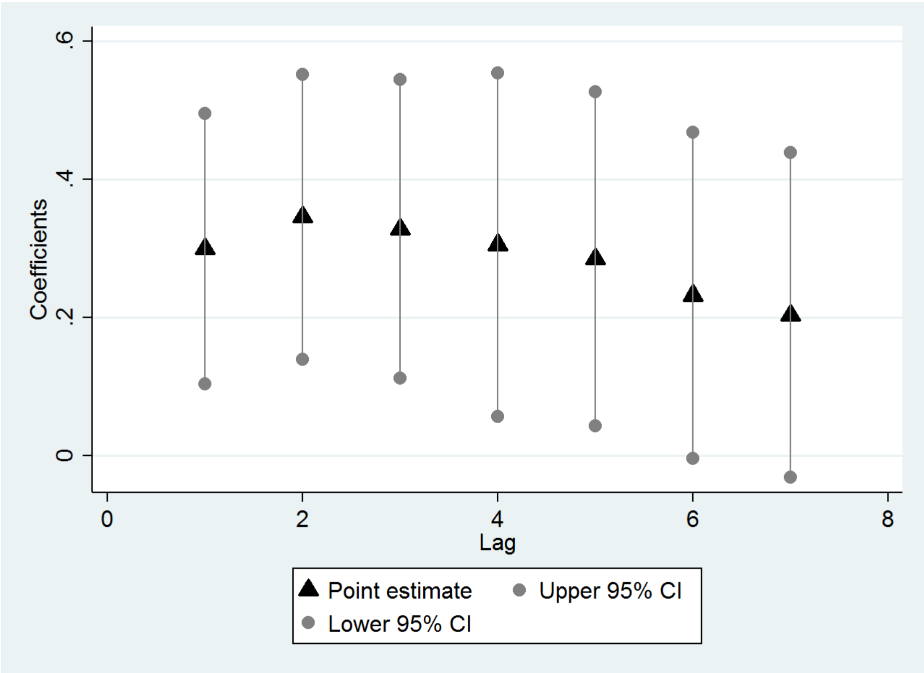
[4]We have the same number of observations for lag $t-2$ as in the baseline regression since our district data reaches back to 1998.

a relatively short time. Hence, we conclude that the results are robust to using different lags, with coefficients losing significance at higher lags.

As discussed before, the immigrant variable does not only account for immigrants in the particular district under observation, but also in neighbouring districts. The weighting function used in the baseline regression is a negative exponential function. To show that the results do not depend on our particular choice of weight, Figure A.2 presents results on the immigrant coefficient by varying weight k as described in Equation (A.2) from 20 to 50.[5] A larger k implies that neighbouring districts get relatively larger weight. The point estimates on the regression coefficients range from 0.30 to 0.34, and are always significant at the 5% level. We can hence see that the link is robust to varying weights, with the coefficients increasing slightly as neighbouring districts get more weight. This points to the importance of immigrants not only in the own district, but in districts located further away as well.

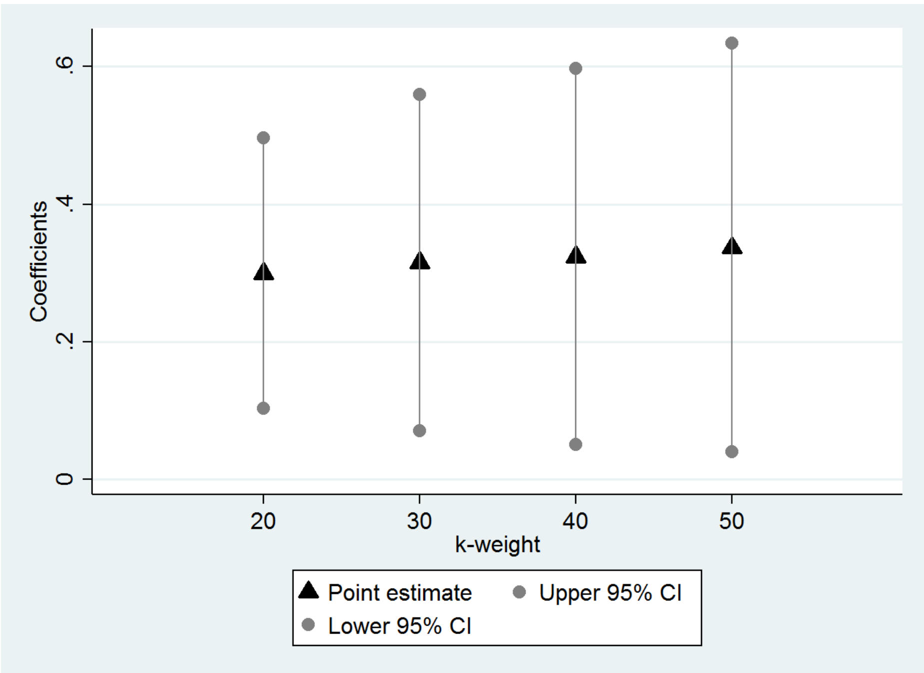
[5]The number of observations is always 386,780.

Figure A.1: Immigration coefficient for varying lags, with 95% CI



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

Figure A.2: Immigration coefficient for varying weights k, with 95% CI



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, German Federal Statistical Office, own calculations.

Appendix B

Appendix to Chapter 2

B.1 Data Appendix

Data on ratified BITs and a list of lawsuits invoking a BIT or NAFTA were obtained from the investment policy hub of UNCTAD at www.investmentpolicyhub.unctad.org. Data on inward and outward FDI were provided by UNCTADstat at unctadstat.unctad.org/EN. The property rights index (Series Code A.01.01.01) from the Global Competitiveness Index by the World Economic Forum (WEF) was available at reports.weforum.org/global-competitiveness-report-2014-2015. It is an aggregate measure of the perception of physical and intellectual property rights, with a value of 1 denoting extremely weak protection, and a value of 7 denoting strong property rights. The voice and accountability index was obtained from 'Worldwide Governance Indicators', a research programme of the World Bank. It reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Estimate of governance ranges from -2.5 (weak governance performance) to +2.5 (strong governance performance). The TFP values for various country groups were obtained from Arndt and Spies (2012), with our regression using the TFP measures from the OLS approach. If the values for a variable were missing in a particular year, the most recent values (or values closest in time) were used.

Later calculations of the compensating insurance fee used data from the German Central Bank and Amadeus. The German Central Bank publishes inward FDI data into Germany by source country in their annual publication 'Bestandserhebungen über Direktinvestitionen', which gives us total revenue of US affiliates in Germany. We used the 2013 edition to obtain revenue for 2010-13. The Amadeus database contains, amongst others, information on firms in Germany by ownership. Restricting ourselves to US-owned firms by using the 'US global ultimate owner' filter and aggregating the profit margin in 2010-13 across all firms delivers the profit margin of 3.5% used in the later calculations.

B.2 Proofs

B.2.1 Base Model

B.2.1.1 Base Model - No BIT - Slope of Investment

Proof of corollary 2.2:

$$\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} = \frac{\partial r^{-1}[\frac{c}{p(\varepsilon > \varepsilon^{eq})}]}{\partial \varepsilon^{eq}} = [r^{-1}]' \cdot [-\frac{c}{(1 - F(\varepsilon^{eq}))^2}] \cdot [-f(\varepsilon^{eq})]$$

and since $r'(.) < 0$, we have $[r^{-1}]'(.) < 0$ by the formula for the derivative of the inverse, and hence the whole expression is negative. ∎

B.2.1.2 Base Model - No BIT - Efficiency

Proof of proposition 2.3:

For a fixed given level of i^{NB}, the government regulates too often in the absence of a BIT. The level of investment i^{NB} can be seen as fixed because investment decisions have already been made at the point when G decides about regulation. Aggregate welfare is calculated as the sum of government payoff and firm profits. With an arbitrary regulation threshold $\bar{\varepsilon}$, aggregate welfare is given by:

$$\int_{\bar{\varepsilon}}^{\infty} f(\varepsilon)[g(\varepsilon) + \int_{0}^{i^{NB}} r(i)di]d\varepsilon - c \cdot i^{NB} \tag{B.1}$$

Now define $\varepsilon^{NB} = g^{-1}[-\int_0^{i^{NB}} r(i)di] < 0$. For $\varepsilon^{NB} < \bar{\varepsilon} < 0$, the expression in brackets $[g(\varepsilon)+\int_0^{i^{NB}} r(i)di]$ from Equation (B.1) is then positive. Since in the no BIT equilibrium, we have $\bar{\varepsilon} = 0$, aggregate welfare can be raised by lowering $\bar{\varepsilon}$, which implies regulating less often. ∎

B.2.1.3 Base Model - With BIT - Slope of Regulation

Proof of corollary 2.6:

$$\frac{\partial \varepsilon^{eq}}{\partial i^{eq}} = \frac{\partial g^{-1}[-\int_0^{i^{eq}} r(i)di]}{\partial i^{eq}}] = [g^{-1}]' \cdot [-r(i^{eq})] < 0$$

Since $g'(.) > 0$, we have $[g^{-1}]'(.) > 0$ by the formula for the derivative of the inverse, and hence $\frac{\partial \varepsilon^{eq}}{\partial i^{eq}} < 0$. ∎

B.2.1.4 Base Model - With BIT - Lawsuits

Proof of proposition 2.8. Recall that L, the expected number of lawsuits is given by:

$$L = p[\varepsilon < g^{-1}(-\int_0^{i^*} r(i)di)] \cdot i^* = F[g^{-1}(-\int_0^{i^*} r(i)di)] \cdot i^* \tag{B.2}$$

where $F(.)$ is the cdf of $f(.)$.

1. L depends positively on $-g(.)$, the government's gain from regulating.

Proof sketch We have

$$\frac{\partial L}{\partial g^{-1}(.)} = f[g^{-1}(-\int_0^{i^*} r(i)di)] \cdot i^* > 0$$

And since $\frac{\partial L}{\partial g^{-1}(.)} > 0$, we have $\frac{\partial L}{\partial g(.)} < 0$, and hence $\frac{\partial L}{\partial [-g(.)]} > 0$. $\blacksquare$

2. L depends negatively on firm productivity $r(i)$.

Proof sketch Let $z = -\int_0^{i^*} r(i)di$. We have:

$$\frac{\partial L}{\partial r} = \frac{\partial L}{\partial g^{-1}} \cdot \frac{\partial g^{-1}(z)}{\partial z} \cdot \frac{\partial z(r)}{\partial r}$$

We further have $\frac{\partial L}{\partial g^{-1}} > 0$ from above, $\frac{\partial g^{-1}(z)}{\partial z} > 0$ since $g'(.) > 0$ and by the formula for the derivative of the inverse, and $\frac{\partial z(r)}{\partial r} < 0$ since $z(r) = -\int_0^{i^*} r(i)di$. Hence, the sign of $\frac{\partial L}{\partial r}$ is negative. $\blacksquare$

3. The effect of the amount of FDI i^* on L is ambiguous.

Proof sketch Let $z = -\int_0^{i^*} r(i)di$ and Let $y = F[g^{-1}(-\int_0^{i^*} r(i)di)]$. We have:

$$\frac{\partial L}{\partial i^*} = \frac{\partial y}{\partial i^*} \cdot i^* + y = \frac{\partial y}{\partial g^{-1}} \cdot \frac{\partial g^{-1}}{\partial z} \cdot \frac{\partial z}{\partial i^*} \cdot i^* + y$$

We further have $\frac{\partial y}{\partial g^{-1}} > 0$ and $\frac{\partial g^{-1}(z)}{\partial z} > 0$, and $\frac{\partial z}{\partial i^*} = -r(i^*) < 0$. Hence, the first term in the summation, $\frac{\partial y}{\partial i^*} \cdot i^*$ is negative, while the second term y is positive. Hence, the overall sign is ambiguous. ∎

Example

We further demonstrate the result by showing ambiguity for a specific example. Let
$\varepsilon \sim f(\varepsilon) = \frac{1}{1000}$, $\varepsilon \in [-1000, 0]$, $g(\varepsilon) = \varepsilon$, $g^{-1}(\varepsilon) = \varepsilon$
$r(i) = ae^{-i}$, $r^{-1}(i) = ln(\frac{a}{i})$, $a > 1$, $c = 1$, $i^* = ln(a)$
Then we have:

$$L = F(-\int_0^{i^*} ae^{-i}di) \cdot i^* = [\frac{1}{1000}a(e^{-i^*} - 1) + 1] \cdot i^* \tag{B.3}$$

Taking the derivative of L with respect to i^*:

$$\frac{\partial L}{\partial i^*} = \frac{1}{1000}ae^{-i^*}(1 - i^*) - \frac{1}{1000}a + 1 \tag{B.4}$$

The sign of $\frac{\partial L}{\partial i^*}$ in (B.4) is ambiguous and depends only on parameter a (since $i^* = ln(a)$) . If $a < 994.1$, then $\frac{\partial L}{\partial i^*} > 0$ and if $a > 994.1$ then $\frac{\partial L}{\partial i^*} < 0$. ∎

B.2.1.5 Base Model - Sign of Aggregate Welfare Change

Proof of corollary 2.12. Ambiguity can be seen from the parameter definitions. Alternatively, we prove the statement by demonstrating ambiguity for a specific example. Let
$\varepsilon \sim f(\varepsilon) = \frac{1}{1000}$, $\varepsilon \in [-500, +500]$, $g(\varepsilon) = \varepsilon$, $g^{-1}(\varepsilon) = \varepsilon$
$r(i) = ae^{-i}$, $r^{-1}(i) = ln(\frac{a}{i})$, $a > 1$, $c = 1$
Then we have:
$i^{NB} = r^{-1}[\frac{c}{p(\varepsilon>0)}] = r^{-1}(2) = ln(\frac{a}{2})$, $i^* = r^{-1}(c) = ln(a)$
$\varepsilon^{BIT} = g^{-1}[-\int_0^{i^*} r(i)di] = -\int_0^{ln(a)} ae^{-i}di = -[(-ae^{-ln(a)}) - (-ae^0)] = 1 - a$

This gives us for aggregate welfare change ΔW:

$$\begin{aligned}
\Delta W &= \int_{1-a}^{0} \frac{1}{1000} d\varepsilon \cdot \int_{0}^{ln\frac{a}{2}} ae^{-i}di + \int_{1-a}^{500} \frac{1}{1000} d\varepsilon \cdot \int_{ln\frac{a}{2}}^{ln(a)} ae^{-i}di + \int_{1-a}^{0} \frac{1}{1000} \varepsilon d\varepsilon - [ln(a) - ln\frac{a}{2}] \\
&= \frac{1}{1000}(a-2)(a-1) + [\frac{1}{2} + \frac{1}{1000}(a-1)] - \frac{1}{2000}(1-a)^2 - ln2 \\
&= (a-1)^2 + 1000 - 2000 \cdot ln2
\end{aligned} \tag{B.5}$$

If $a > 20.654$, then ΔW is positive. Otherwise, ΔW is negative. Hence, the overall welfare effect is ambiguous and depends on parameter a. $\blacksquare$

B.2.1.6 Base Model - Aggregate Welfare Change Derivatives

Proof of corollary 2.13:

$$\frac{\partial \Delta W}{\partial r(i)} = \int_{\varepsilon^{BIT}}^{0} f(\varepsilon)d\varepsilon \cdot i^{NB} + \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \cdot (i^* - i^{NB}) > 0$$

$$\frac{\partial \Delta W}{\partial c} = -(i^* - i^{NB}) < 0$$

$\blacksquare$

B.2.1.7 Base Model - No New FDI

Proof of proposition 2.15.

Assume that, for some exogenous reason, no additional FDI can enter after a BIT is introduced. Firm investment stays at i^{NB}. Then, the government regulates if $\varepsilon < \varepsilon^{BIT} = g^{-1}[\int_0^{i^{NB}} r(i)di] < 0$. Total firm profits are given by:

$$\int_0^{i^{NB}} r(i)di - c \cdot i^{NB} \tag{B.6}$$

The government's payoff is given by:

$$\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon - \int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} r(i)di \tag{B.7}$$

And the change in aggregate welfare (computed as (B.6) + (B.7) - (2.6) - (2.5)) under a BIT is then given by:

$$\Delta W = \int_{\varepsilon^{BIT}}^{0} f(\varepsilon)[g(\varepsilon) + \int_0^{i^{NB}} r(i)di]d\varepsilon \tag{B.8}$$

Since we integrate from ε^{BIT} to 0, we have that ε lies between the two integration limits. For $\varepsilon^{BIT} < \varepsilon < 0$, we have that $g(\varepsilon) + \int_0^{i^{NB}} r(i)di$ is positive by the definition of ε^{BIT} and hence ΔW is positive. If no new FDI enters, aggregate welfare is always increased with the introduction of a BIT. $\blacksquare$

B.2.2 FDI Tax

B.2.2.1 FDI Tax - No BIT - Regulation and Investment

Proof of proposition 2.18:

$u_G = 0$ if $I_R = 1$ and $u_G = g(\varepsilon) + \int_0^{i^{NB}} t[r(i) - c]di$ if $I_R = 0$. Firms have $E(\pi_i) = p(\varepsilon > \varepsilon^{NB})[r_i - t(r_i - c)] - c = (1-t)pr_i - (1-pt)c$, which must be greater than zero for investment to happen. $\blacksquare$

B.2.2.2 FDI Tax - No BIT - Slope of Regulation

Proof of corollary 2.19:

$$\frac{\partial \varepsilon^{eq}}{\partial i^{eq}} = \frac{\partial g^{-1}[-\int_0^{i^{eq}} t[r(i) - c]di]}{\partial i^{eq}} = [g^{-1}]' \cdot [-t(r(i^{eq}) - c)]$$

Since $g'(.) > 0$, we have $[g^{-1}]'(.) > 0$ by the formula for the derivative of the inverse, and hence $\frac{\partial \varepsilon^{eq}}{\partial i^{eq}} < 0$ ∎.

B.2.2.3 FDI Tax - No BIT - Multiple Equilibria

Proof of corollary 2.20

We prove the statement by showing that a specific example has multiple solutions. Let
$\varepsilon \sim f(\varepsilon) = \frac{1}{1000}, \varepsilon \in [-1000, 0]$, $g(\varepsilon) = \varepsilon$, $g^{-1}(\varepsilon) = \varepsilon$
$r(i) = ae^{-i}$, $r^{-1}(i) = ln(\frac{a}{i})$, $a > 1$, $c = 1$

Then we have in the FDI tax, no BIT case:

$$i^{NB}(\varepsilon^{NB}) = r^{-1}[\frac{1 - p(\varepsilon > \varepsilon^{NB})t}{(1-t)p(\varepsilon > \varepsilon^{NB})}c] = ln[\frac{a}{\frac{1-(-\frac{1}{1000}\varepsilon^{NB})t}{(1-t)(-\frac{1}{1000}\varepsilon^{NB})}}] = ln[-\frac{a(1-t)(\varepsilon^{NB})}{1000 + \varepsilon^{NB}t}] \quad \text{(B.9)}$$

$$\varepsilon^{NB}(i^{NB}) = g^{-1}[-\int_0^{i^{NB}} t[r(i) - c]di] = -t\int_0^{i^{NB}} (ae^{-i} - 1)di = -t(-ae^{-i^{NB}} - i^{NB} + a) \quad \text{(B.10)}$$

Substituting (B.10) into (B.9):

$$i^{NB} = ln[at(1-t)(-ae^{-i^{NB}} - i^{NB} + a)] - ln[1000 - t^2(-ae^{-i^{NB}} - i^{NB} + a)] \quad \text{(B.11)}$$

Choosing $a = 200$ and $t = 0.125$ turns (B.11) into:

$$i^{NB} = ln(-4375e^{-i^{NB}} - 21.875i^{NB} + 4375) - ln(3.125e^{i^{NB}} + 0.015625i^{NB} + 996.875) \quad \text{(B.12)}$$

There are two solutions for (B.12): $i_1^{NB} = 0.443$ and $i_2^{NB} = 1.026$. Substituting back into (B.10) gives $\varepsilon_1^{NB} = -8.886$ and $\varepsilon_2^{NB} = -16.027$. Hence, we have shown that multiple equilibria exist for the FDI tax, no BIT case. ∎

B.2.2.4 FDI Tax - With BIT - Regulation and Investment

Proof of proposition 2.21:

$u_G = -\int_0^{i^*}[r(i) - t(r(i) - c)]di$ if $I_R = 1$ and $u_G = g(\varepsilon) + \int_0^{i^{NB}} t[r(i) - c]di$ if $I_R = 0$. Firms have guaranteed profits $E(\pi_i) = (1 - t)(r_i - c)$. ∎

B.2.2.5 FDI Tax - With BIT - Government Payoff Difference

Proof of corollary 2.23.

The difference in government payoff is given by:

$$\underbrace{-\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*}[r(i) - t(r(i) - c)]di}_{Compensation} \\ \underbrace{+\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)[g(\varepsilon) + \int_0^{i^{NB}} t(r(i) - c)]d\varepsilon}_{Regulatory\ chill\ /\ Tax\ income\ less\ regulation} \\ \underbrace{+\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{i^*} t[r(i) - c]di}_{Tax\ income\ additional\ FDI} \tag{B.13}$$

The first term represents the loss from compensation payments and is negative, as we have $f(.) > 0$, $[r(i) - t(r(i) - c)] > 0 \; \forall i$. The second term represents regulatory chill plus new tax income resulting from less regulation, and is negative by revealed preference. The third term represents the tax income resulting from additional investments and is positive. Hence, the overall sign is ambiguous. ∎

B.2.3 Domestic and Foreign Firms

B.2.3.1 Domestic and Foreign Firms - No BIT - Regulation and Investment

Proof of proposition 2.24:
$u_G = g(\varepsilon) + \mu \int_0^{i^{NB}} [r(i) - c]di + (1 - \mu) \int_0^{i^{NB}} t[r(i) - c]$ if $I_R = 0$ and $u_G = \mu \int_0^{i^{NB}} (-c)di$ if $I_R = 1$. $E(\pi_i) = p(\varepsilon > \varepsilon^{NB})[r_i - t(r_i - c)] - c = (1 - t)pr_i - (1 - pt)c$, which must be greater than zero for investment to happen. ∎

B.2.3.2 Domestic and Foreign Firms - No BIT - Slope of Regulation

Proof of corollary 2.25:

$$\frac{\partial \varepsilon^{eq}}{\partial \mu} = [g^{-1}]' \cdot [-\int_0^{i^{NB}} r(i)di + \int_0^{i^{NB}} t(r(i) - c)di] = [g^{-1}]' \cdot [-\int_0^{i^{NB}} [r(i) - t(r(i) - c)]di]$$

Since $g'(.) > 0$, we have $[g^{-1}]'(.) > 0$ by the formula for the derivative of the inverse, and hence $\frac{\partial \varepsilon^{eq}}{\partial \mu} < 0$. ∎

B.2.3.3 Domestic and Foreign Firms - With BIT - Regulation and Investment

Proof of proposition 2.26:
$u_G = g(\varepsilon) + \mu \int_0^{i^D} [r(i) - c]di + (1 - \mu) \int_0^{i^*} t[r(i) - c]di$ if $I_R = 0$ and $u_G = \mu \int_0^{i^D} (-c)di - (1 - \mu) \int_0^{i^*} [r(i) - t(r(i) - c)]di$ if $I_R = 1$. We further have $E(\pi_i^D) = p(\varepsilon > \varepsilon^{BIT})[r_i - t(r_i - c)] - c = (1 - t)pr_i - (1 - pt)c$ for domestic firms, and $E(\pi_i^F) = (1 - t)[r_i - c]$ for foreign firms, which must be greater than zero for investment to happen. ∎

B.2.3.4 Domestic and Foreign Firms - With BIT - Slope of Regulation

Proof of corollary 2.27:

$$\frac{\partial \varepsilon^{eq}}{\partial \mu} = [g^{-1}]' \cdot [-\int_0^{i^D} r(i)di + \int_0^{i^*} r(i)di]$$

Since $g'(.) > 0$, we have $[g^{-1}]'(.) > 0$ by the formula for the derivative of the inverse, and since $i^* > i^D$, we have $\frac{\partial \varepsilon^{eq}}{\partial \mu} > 0$. ∎

B.2.4 Exports and FDI

B.2.4.1 Exports and FDI - No BIT - Regulation and Investment

Proof of proposition 2.28:

$u_G = g(\varepsilon)$ if $I_R = 0$ and $u_G = 0$ if $I_R = 1$. $E(\pi_i) = p(\varepsilon > 0)r_i - c$ if $I_F = 1$ and $E(\pi_i) = p(\varepsilon > 0)\frac{r_i}{\tau}$ if $I_F = 0$. ∎

B.2.4.2 Exports and FDI - No BIT - Slope of Regulation

Proof of corollary 2.29:

$$\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} = [r^{-1}]' \cdot [-\frac{\tau c}{((\tau - 1)p(\varepsilon > \varepsilon^{eq}))^2}] \cdot (\tau - 1) \cdot [-f(\varepsilon^{eq})]$$

Since $r'(.) < 0$, we have $[r^{-1}]' < 0$ by the formula for the derivative of the inverse, so $\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} < 0$. ∎

B.2.4.3 Exports and FDI - With BIT - Regulation and Investment

Proof of proposition 2.30:

$u_G = g(\varepsilon)$ if $I_R = 0$ and $u_G = -\int_0^{i^{BIT}} r(i)di$ if $I_R = 1$. $E(\pi_i) = r_i - c$ if $I_F = 1$ and $E(\pi_i) = p(\varepsilon > \varepsilon^{BIT})\frac{r_i}{\tau}$ if $I_F = 0$. ∎

B.2.4.4 Exports and FDI - With BIT - Change in Investment

Proof of corollary 2.31:

$$
\begin{aligned}
i^{NB} = r^{-1}[\frac{\tau}{(\tau-1)p(\varepsilon>0)}c] &< r^{-1}[\frac{\tau}{\tau-p(\varepsilon>\varepsilon^{BIT})}c] = i^{BIT} \\
\frac{1}{(\tau-1)p(\varepsilon>0)} &> \frac{1}{\tau-p(\varepsilon>\varepsilon^{BIT})} \\
(\tau-1)p(\varepsilon>0) &< \tau - p(\varepsilon>0) - p(\varepsilon^{BIT}<\varepsilon<0) \\
\tau p(\varepsilon>0) &< \tau - p(\varepsilon^{BIT}<\varepsilon<0) \\
\frac{1}{\tau}p(\varepsilon^{BIT}<\varepsilon<0) + p(\varepsilon>0) &< 1
\end{aligned}
\tag{B.14}
$$

Given that $p(\varepsilon > 0) + p(\varepsilon^{BIT} < \varepsilon < 0) \leq 1$ and $\frac{1}{\tau} < 1$, inequality (B.14) must hold and hence $i^{BIT} > i^{NB}$. ∎

B.2.4.5 Exports and FDI - With BIT - Slope of Regulation

Proof of corollary 2.32:

$$
\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} = [r^{-1}]' \cdot [-\frac{\tau c}{(\tau - p(\varepsilon > \varepsilon^{eq}))^2}] \cdot f(\varepsilon^{eq})
$$

Since $r'(.) < 0$, we have $[r^{-1}]' < 0$ by the formula for the derivative of the inverse, so $\frac{\partial i^{eq}}{\partial \varepsilon^{eq}} > 0$. ∎

B.3 Model Extensions

B.3.1 Extension: FDI Tax

B.3.1.1 No BIT

Government payoff function:

No regulation: $u_G = g(\varepsilon) + \int_0^{i^{NB}} t[r(i) - c]di$

Regulation: $u_G = 0$

Regulation threshold is $\varepsilon^{NB} = g^{-1}[-\int_0^{i^{NB}} t[r(i) - c]di]$. If the shock is below ε^{NB}, the government will regulate.

Expected profit for a single firm:

$\pi_i = p(\varepsilon > \varepsilon^{NB})[r_i - t(r_i - c)] - c = (1 - t)pr_i - (1 - pt)c$

Firm investment is $i^{NB} = r^{-1}[\frac{1-p(\varepsilon>\varepsilon^{NB})t}{(1-t)p(\varepsilon>\varepsilon^{NB})}c]$. The most productive firms $i < i^{NB}$ will invest, others refrain from doing so.

Government welfare under no BIT:

$$\int_{\varepsilon^{NB}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon + \int_{\varepsilon^{NB}}^{\infty} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} t[r(i) - c]di \tag{B.15}$$

Firm profits under no BIT:

$$\int_{\varepsilon^{NB}}^{\infty} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} [r(i) - t(r(i) - c)]di - ci^{NB} \tag{B.16}$$

B.3.1.2 With BIT

Government payoff function:

No regulation: $u_G = g(\varepsilon) + \int_0^{i^*} t[r(i) - c]di$

Regulation: $u_G = -\int_0^{i^*} [r(i) - t(r(i) - c)]di$

Regulation threshold is $\varepsilon^{BIT} = g^{-1}[-\int_0^{i^*} r(i)di]$.

Expected profit for a single firm:

$\pi_i = (1 - t)[r_i - c]$

Firm investment is $i^* = r^{-1}(c)$.

Government welfare with BIT:

$$\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon + \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_0^{i^*} t[r(i) - c]di - \int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*} [r(i) - t(r(i) - c)]di \tag{B.17}$$

Firm profits with BIT:

$$\int_0^{i^*} [r(i) - t(r(i) - c)]di - ci^* \tag{B.18}$$

B.3.1.3 Comparison

No-BIT of the extended model vs. base model:

$\varepsilon_{Ext}^{NB} < \varepsilon_{Base}^{NB} = 0$ and $i_{Ext}^{NB} > i_{Base}^{NB}$

With-BIT vs. No-BIT of the extended model:

$\varepsilon^{BIT} < \varepsilon^{NB}$ and $i^{NB} < i^{BIT} = i^*$

With-BIT of the extended model vs. base model:

$\varepsilon_{Ext}^{BIT} = \varepsilon_{Base}^{BIT}$ and $i_{Ext}^{BIT} = i_{Base}^{BIT} = i^*$

Difference in government payoff from introducing a BIT in the extended model (sign ambiguous):

$$\underbrace{-\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*} [r(i) - t(r(i) - c)]di}_{Compensation}$$
$$\underbrace{+\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)[g(\varepsilon) + \int_0^{i^{NB}} t(r(i) - c)]d\varepsilon}_{Regulatory\ chill\ /\ Tax\ income\ less\ regulation} \tag{B.19}$$
$$\underbrace{+\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{i^*} t[r(i) - c]di}_{Tax\ income\ additional\ FDI}$$

The government loses from from compensation payments and regulatory chill. It gains from new tax intakes due to additional investments.[1]

Difference in total firm profit from introducing a BIT in the extended model (sign positive):

$$[\underbrace{\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon}_{Compensation} + \underbrace{\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)d\varepsilon}_{Less\ regulation}] \cdot \int_0^{i^{NB}} [r(i) - t(r(i) - c)]di + \underbrace{\int_{i^{NB}}^{i^*} (1 - t)(r(i) - c)di}_{Additional\ FDI} \tag{B.20}$$

Firms gain from compensation payments, less regulatory expropriation on existing investments, and profits from new investments.

Aggregate welfare change is given by:

$$\Delta W = \underbrace{\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} r(i)di}_{Less\ regulation} + \underbrace{\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{i^*} r(i)di}_{Add.\ FDI\ revenue} + \underbrace{\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)g(\varepsilon)d\varepsilon}_{Regulatory\ chill} - \underbrace{c(i^* - i^{NB})}_{Add.\ FDI\ cost} \tag{B.21}$$

This is almost identical to the welfare change in the base model.

[1] The gain in tax from investments that now do not suffer from regulatory expropriation any more is outweighed by the loss from regulatory chill (the second term). This can be seen by revealed preference.

B.3.2 Extension: Domestic and Foreign Firms

B.3.2.1 No BIT

Government payoff function:

No regulation: $u_G = g(\varepsilon) + \mu \int_0^{i^{NB}} [r(i) - c]di + (1-\mu) \int_0^{i^{NB}} t[r(i) - c]$

Regulation: $u_G = \mu \int_0^{i^{NB}} (-c)di$

Regulation threshold is $\varepsilon^{NB} = g^{-1}[-\mu \int_0^{i^{NB}} r(i)di - (1-\mu) \int_0^{i^{NB}} t[r(i)-c]di]$. If the shock is below ε^{NB}, the government will regulate.

Expected profit for a single firm: $\pi_i = p(\varepsilon > \varepsilon^{NB})[r_i - t(r_i - c)] - c = (1-t)pr_i - (1-pt)c$

Firm investment is $i^{NB} = r^{-1}[\frac{1-p(\varepsilon>\varepsilon^{NB})t}{(1-t)p(\varepsilon>\varepsilon^{NB})}c]$. The most productive firms $i < i^{NB}$ will invest, others refrain from doing so.

Government welfare under no BIT:

$$\int_{\varepsilon^{NB}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon + \int_{\varepsilon^{NB}}^{\infty} f(\varepsilon)d\varepsilon[\mu \int_0^{i^{NB}} (r(i) - c)di + (1-\mu) \int_0^{i^{NB}} t(r(i) - c)di] + \int_{-\infty}^{\varepsilon^{NB}} f(\varepsilon)d\varepsilon \mu \int_0^{i^{NB}} (-c)di \tag{B.22}$$

Firm profits under no BIT:

$$\int_{\varepsilon^{NB}}^{\infty} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} [r(i) - t(r(i) - c)]di - ci^{NB} \tag{B.23}$$

B.3.2.2 With BIT

Government payoff function:

No regulation: $u_G = g(\varepsilon) + \mu \int_0^{i^D} [r(i) - c]di + (1-\mu) \int_0^{i^*} t[r(i) - c]di$

Regulation: $u_G = \mu \int_0^{i^D} (-c)di - (1-\mu) \int_0^{i^*} [r(i) - t(r(i) - c)]di$

Regulation threshold is $\varepsilon^{BIT} = g^{-1}[-\mu \int_0^{i^D} r(i)di - (1-\mu) \int_0^{i^*} r(i)di]$.

Expected profit for a single domestic firm: $\pi_i^D = p(\varepsilon > \varepsilon^{BIT})[r_i - t(r_i - c)] - c = (1-t)pr_i - (1-pt)c$

Domestic firm investment is $i^D = r^{-1}[\frac{1-p(\varepsilon > \varepsilon^{BIT})t}{(1-t)p(\varepsilon > \varepsilon^{BIT})}c]$.

Expected profit for a single foreign firm: $\pi_i^F = (1-t)[r_i - c]$

Foreign firm investment is $i^F = i^* = r^{-1}(c)$.

Government welfare with BIT:

$$\begin{aligned} &\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon + \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon[\mu \int_0^{i^D} (r(i)-c)di + (1-\mu)\int_0^{i^*} t(r(i)-c)] \\ &\quad + \int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon[\mu \int_0^{i^D} (-c)di - (1-\mu)\int_0^{i^*} (r(i) - t(r(i)-c))] \end{aligned} \tag{B.24}$$

Domestic firm profits with BIT:

$$\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_0^{i^D} [r(i) - t(r(i)-c)]di - ci^D \tag{B.25}$$

Foreign firm profits with BIT:

$$\int_0^{i^*} [r(i) - t(r(i)-c)]di - ci^* \tag{B.26}$$

B.3.2.3 Comparison

No-BIT of the extended model vs. base model:

$\varepsilon_{Ext}^{NB} < \varepsilon_{Base}^{NB}$ and $i_{Ext}^{NB} > i_{Base}^{NB}$

With-BIT vs. No-BIT of the extended model:

$\varepsilon^{BIT} < \varepsilon^{NB}$ and $i^{Foreign} = i^* > i^{Domestic} > i^{NB}$

With BIT of the extended model vs. base model:

$\varepsilon_{Ext}^{BIT} > \varepsilon_{Base}^{BIT}$ and $i_{Ext}^{Domestic} < i_{Base}^{BIT} = i_{Ext}^{Foreign} = i^*$

Government welfare difference from introducing a BIT in the extended model (sign ambiguous):

$$\underbrace{-(1-\mu)\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_0^{i^*}[r(i)-t(r(i)-c)]di}_{Compensation}$$
$$\underbrace{+\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)[g(\varepsilon)+\mu\int_0^{i^{NB}} r(i)+(1-\mu)\int_0^{i^{NB}} t(r(i)-c)]d\varepsilon}_{Regulatory\ chill\ /\ Tax\ income\ less\ regulation}$$
$$\underbrace{+\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon[\mu\int_{i^{NB}}^{i^D}[r(i)-c]di+(1-\mu)\int_{i^{NB}}^{i^*} t[r(i)-c]di]}_{Tax\ income\ additional\ FDI} + \underbrace{\mu\int_{-\infty}^{\varepsilon^{BIT}}\int_{i^{NB}}^{i^D}(-c)di}_{Domestic\ add.\ FDI\ cost} \tag{B.27}$$

The government loses from compensation payments to foreign firms and regulatory chill. It gains from new tax intakes due to additional investments by both foreign and domestic firms. The overall sign is ambiguous.[2]

Foreign firm difference in profit from introducing a BIT in the extended model (sign positive):

$$[\underbrace{\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon}_{Compensation} + \underbrace{\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)d\varepsilon}_{Less\ regulation}]\int_0^{i^{NB}}[r(i)-t(r(i)-c)]di + \underbrace{\int_{i^{NB}}^{i^*}(1-t)(r(i)-c)di}_{Additional\ FDI} \tag{B.28}$$

Foreign firms gain from compensation payments, less regulatory expropriation on existing investments, and profits from new investments.

Domestic firm difference in profit from introducing a BIT in the extended model (sign positive):

$$\underbrace{\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)d\varepsilon\int_0^{i^{NB}}[r(i)-t(r(i)-c)]di}_{Less\ regulation} + \underbrace{\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon\int_{i^{NB}}^{i^D}[r(i)-t(r(i)-c)]di}_{Add.\ FDI\ revenue} - \underbrace{c(i^D-i^{NB})}_{Add.\ FDI\ cost} \tag{B.29}$$

[2]The gain in tax from investments that now do not suffer from regulatory expropriation any more is outweighed by the loss from regulatory chill (the second term). This can be seen by revealed preference.

Domestic firms gain from less regulatory expropriation on existing investments, and profits from new investments. The sum of the latter two terms gives the profits from new investments and is positive by revealed preference.

Overall welfare is calculated as the sum of the government's payoff from regulation, and domestic and foreign firm's pre-tax profit. In the aggregate welfare comparison, the with-BIT scenario is better than no-BIT if the following inequality holds:

$$\underbrace{\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)d\varepsilon \int_{0}^{i^{NB}} r(i)di}_{\textit{Less regulation}} + \underbrace{\mu \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{i^{D}} r(i)di}_{\textit{Domestic add. FDI revenue}} + \underbrace{(1-\mu) \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{i^{*}} r(i)di}_{\textit{Foreign add. FDI revenue}}$$
$$> \underbrace{-\int_{\varepsilon^{BIT}}^{\varepsilon^{NB}} f(\varepsilon)g(\varepsilon)d\varepsilon}_{\textit{Regulatory chill}} + \underbrace{\mu c(i^{D} - i^{NB})}_{\textit{Domestic add. FDI cost}} + \underbrace{(1-\mu)c(i^{*} - i^{NB})}_{\textit{Foreign add. FDI cost}} \tag{B.30}$$

The LHS (left-hand side) gives us the gain in aggregate welfare from a BIT. It includes the gain from having less regulatory expropriations on existing projects, as well as the gain from (unexpropriated) additional investments by domestic and foreign firms. The RHS (right-hand side) gives us the loss in aggregate welfare. It consists of regulatory chill and the cost of new projects for domestic and foreign firms. Again, whether a BIT improves upon aggregate welfare depends on industry characteristics. If it does, a fee on firm profits can help to redistribute the gains.

B.3.3 Extension: Exports and FDI

B.3.3.1 No BIT

Government payoff function:

No regulation: $u_G = g(\varepsilon)$

Regulation: $u_G = 0$

The regulation threshold is $\varepsilon^{NB} = 0$. If $\varepsilon < 0$, the government will regulate.

A firm can choose between FDI and exporting. FDI has a fixed cost c, while exporters face iceberg transport costs τ.

FDI: $\pi_i = p(\varepsilon > 0)r_i - c$

Export: $\pi_i = p(\varepsilon > 0)\frac{r_i}{\tau}$

Comparing the two, we find that firms with $i < i^{NB} = r^{-1}[\frac{\tau}{(\tau-1)p(\varepsilon>0)}c]$ choose FDI. Less productive firms will choose to export.

Government welfare under no BIT:

$$U_G = \int_0^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon \tag{B.31}$$

Firm profits under no BIT:

$$\int_0^{\infty} f(\varepsilon)d\varepsilon \int_0^{i^{NB}} r(i)di - ci^{NB} + \int_0^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{\infty} \frac{r(i)}{\tau}di \tag{B.32}$$

It consists of profits from firms engaging in FDI and firms choosing exports.

B.3.3.2 With BIT

Government payoff function:

No regulation: $g(\varepsilon)$

Regulation: $-\int_0^{i^{BIT}} r(i)di$

The regulation threshold is $\varepsilon^{BIT} = g^{-1}[-\int_0^{i^{BIT}} r(i)d]$.

A firm can choose between FDI and exporting. FDI now has the additional benefit of getting compensation in case of regulatory expropriation, delivering a guaranteed profit.

FDI: $\pi_i = r_i - c$

Export: $\pi_i = p(\varepsilon > \varepsilon^{BIT})\frac{r_i}{\tau}$

Comparing the two, we find that firms with $i < i^{BIT} = r^{-1}[\frac{\tau}{\tau - p(\varepsilon > \varepsilon^{BIT})}c]$ choose FDI. Less productive firms will choose to export.

Government welfare with a BIT:

$$\int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)g(\varepsilon)d\varepsilon - \int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_{0}^{i^{BIT}} r(i)di \tag{B.33}$$

Firm profits with a BIT:

$$\int_{0}^{i^{BIT}} r(i)di - ci^{BIT} + \int_{\varepsilon^{BIT}}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{BIT}}^{\infty} \frac{r(i)}{\tau}di \tag{B.34}$$

B.3.3.3 Comparison

No-BIT of the extended model vs. base model:
$\varepsilon^{NB}_{Ext} = \varepsilon^{NB}_{Base} = 0$ and $i^{NB}_{Ext} < i^{NB}_{Base}$

With-BIT vs. No-BIT of the extended model:
$\varepsilon^{BIT} < \varepsilon^{NB} = 0$ and $i^{BIT} > i^{NB}$

With BIT of the extended model vs. base model:
$\varepsilon^{BIT}_{Ext} > \varepsilon^{BIT}_{Base}$ and $i^{BIT}_{Ext} < i^{BIT}_{Base} = i^{*}$

Government welfare difference from introducing a BIT in the extended model (sign negative):

$$\underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)g(\varepsilon)d\varepsilon}_{Regulatory\ chill} - \underbrace{\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_{0}^{i^{BIT}} r(i)di}_{Compensation} \tag{B.35}$$

The government loses from regulatory chill and from compensation payments.

Firm difference in profit from introducing a BIT in the extended model (sign positive):

$$\underbrace{\int_{-\infty}^{\varepsilon^{BIT}} f(\varepsilon)d\varepsilon \int_{0}^{i^{NB}} r(i)di}_{Compensation} + \underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)d\varepsilon \int_{0}^{i^{NB}} r(i)di}_{Less\ regulation\ FDI} + \underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)d\varepsilon \int_{i^{BIT}}^{\infty} \frac{r(i)}{\tau}di}_{Less\ regulation\ exporters}$$
$$+ \underbrace{\int_{i^{NB}}^{i^{BIT}} [r(i)-c]di - \int_{0}^{\infty} f(\varepsilon)d\varepsilon \int_{i^{NB}}^{i^{BIT}} \frac{r(i)}{\tau}di}_{Export\ to\ FDI\ switchers} \tag{B.36}$$

Firms gain from compensation payments and less regulatory expropriation on existing investments, less regulatory expropriation on exporters, and switching from exporting to FDI.

In the aggregate welfare comparison, the with-BIT scenario is better than no-BIT if the following inequality holds:

$$\underbrace{\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)d\varepsilon[\int_{0}^{i^{BIT}} r(i)di + \int_{i^{BIT}}^{\infty} \frac{r(i)}{\tau}di]}_{Less\ regulation} + \underbrace{\int_{0}^{\infty} f(\varepsilon)d\varepsilon[\int_{i^{NB}}^{i^{BIT}} r(i)di - \int_{i^{NB}}^{i^{BIT}} \frac{r(i)}{\tau}di]}_{Export\ to\ FDI\ switchers}$$
$$> \underbrace{-\int_{\varepsilon^{BIT}}^{0} f(\varepsilon)g(\varepsilon)d\varepsilon}_{Regulatory\ chill} + \underbrace{c(i^{BIT} - i^{NB})}_{Add.\ FDI\ cost} \tag{B.37}$$

The aggregate gain from a BIT on the LHS includes gains from less regulatory expropriation and firms switching from exporting to FDI. The aggregate loss on the RHS includes regulatory chill and the cost of new investments. The overall sign of the change depends on industry characteristics, but any aggregate welfare gain can be redistributed with a fee on firm profits.

Appendix C

Appendix to Chapter 3

C.1 Data Appendix

C.1.1 Patents

The PATSTAT data provided by the Max Planck Institute for Innovation and Competition consisted of three parts: The first dataset, bvd_docdb.dta contained a match of DOCDB patent family IDs (Paris convention priorities) with Bureau van Dijk ID numbers.[1] The second dataset, patstat_basic.dta included patent applications with information on the filing date, application authority and associated patent family. A third dataset, refcit.dta contains patent applications with the number of citations after 3, 5 and 10 years. Two more datasets, tls206.dta and tls207.dta were added to match applicant and inventor location to each patent application.

We assigned patent families to countries in three different ways: Country of application, country of residence of the inventor and country of residence of the applicant. Patenting activity is treated as a binary measure, implying that we only distinguish between zero and a positive number of patents. For example, a single patent invention in a foreign

[1] A patent family is a set of patent applications taken in multiple countries to protect a single invention by a common inventor and then patented in more than one country (Source: European Patent Office).

affiliate would be sufficient to categorize this particular investment as 'patent-inventing FDI'. For patents that were applied, invented or owned in multiple countries, we assign a full patent to each respective country.[2]

When a patent had the European Patent Office ('EP') as the country of application, we counted this as equivalent to a patent application in each member state of the European Patent Office as of 1st Jan 2000. Dates for patent applications are directly retrieved from the filing date of each application, with the date for patent invention and ownership being given by the filing date of the earliest application within the patent family. The total number of citations for a patent family was counted as the sum of the citations of its constituent patent applications, 5 years after the first filing date. This number was then divided by the number of underlying patent applications to obtain a measure for patent quality.

C.1.2 Matching

The process to create our final dataset consisted of several steps. In a first step, a MiDi ID - BvD ID key was generated, by matching parent firms on parent firm name, city name and postcode using record linkage procedures. This was done using Stata's 'reclink2' command. The MiDi dataset, containing MiDi ID, firm name, city and postcode for 16,291 multinational parent firms, was used as master dataset. The BvD dataset, containing BvD ID, firm name, city and postcode for 2 million German firms (including patenting and non-patenting firms), was the using dataset. Name pre-processing was undertaken for both datasets, by standardizing firm names and legal forms (e.g. GmbH, AG) in order to facilitate matching. Both datasets were split into 26 starting letters, and matched by each letter. We undertook 4 rounds of algorithmic matching, with results being presented below.

[2]Given our binary measure of patenting activity, assigning a full patent in case of multiple countries gives us the same results as a fractional count.

1st round matching

Matching variables:	Firm name, city, postcode
Blocking:	Block on first 7 letters
Perfect matches (score = 1):	8,096
Good matches ($0.996 < \text{score} < 1$):	1,563

2nd round matching

Matching variables:	Firm name, city, postcode
Excluded observations:	Matches from round 1
Blocking:	Block on first 3 letters
Good matches ($0.996 < \text{score} < 1$):	203

3rd round matching

Matching variables:	Firm name, city
Excluded observations:	Matches from round 1+2
Blocking:	Block on first 3 letters
Perfect matches (score = 1):	1,155
Good matches ($0.998 < \text{score} < 1$):	201

4th round matching

Matching variables:	Firm name, city, postcode
Excluded observations:	Matches from round 1+2+3
Blocking:	Block on first letter
Good matches ($0.997 < \text{score} < 1$):	90

In sum, the algorithmic matching process assigned 11,241 parent firms (69% of all MiDi parent firms) from the BvD dataset to the MiDi dataset, after accounting for duplicate matches. We then conducted match quality checks for selected subsamples: For the top 5% of parent firms in terms of FDI (# foreign affiliates), the algorithmic matching process had a success rate of 74.1% (77.9%). Unmatched large parent firms were mostly found in the banking and insurance sector. This is reassuring since those are sectors without much patenting activity. We then used clerical review procedures to manually add remaining parent firms in the top 5% groups to the MiDi-BvD key. The same procedure was undertaken for the largest parent firms in terms of patenting activity.[3] This implied manually looking through a further 3,500 firms, resulting in 309 more matches that were added through clerical review. In total, our final MiDi-BvD key achieved a coverage of the MiDi dataset of 71%. For manufacturing only, the coverage is 85%.

The next step involved matching patenting BvD firms and their patents to the newly generated MiDi-BvD key. There were 827,598 patent families over the period 1996-2011 by 18,211 firms. Since not all patenting BvD firms are multinationals appearing in MiDi, we do not expect all patenting firms to be matched to a MiDi equivalent. In the end, we obtained 2,228 patenting BvD firms that could be matched to the MiDi dataset. This final number is in line with the number of patenting German multinationals in Karkinsky and Riedel (2012). In terms of patents, we managed to assign 555,734 of all patent families (67.1% of the total) to a corresponding parent firm in MiDi. In a last step, we added FDI balance sheet data from the MiDi database using the unique MiDi ID.

Table C.1 reports mean and median values for revenue, the number of employees and foreign affiliates for MiDi parent firms by matching group of the first matching step. MiDi parent firms are separated into two groups, depending on whether they could be matched with a corresponding BvD firm. The values were aggregated for each parent across all foreign affiliates. As we can see, parent firms in the matched group are much larger across all dimensions. Table C.2 shows mean and median values of patent families for BvD firms by the matching group of the patent matching step. This implies a sample split along the lines of whether a patenting BvD firm could be matched with a MiDi counterpart. We can see that matched BvD firms are much more innovative than the group of unmatched firms. Given these statistics, we can be confident that our matching process was successful in covering the most sizeable and innovative German multinationals.

[3] Firms with more than 100 patent applications over the years 1996-2011.

Table C.1: FDI statistics of MiDi firms by matching success

Group	Statistic	N	Revenue €mn	# Employees	# Affiliates
No BvD match	Mean	4,741	63	250	4.4
No BvD match	Median	4,741	7	27	2
BvD match	Mean	11,550	340	1022	10.6
BvD match	Median	11,550	23	106	3

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011.

Table C.2: Patent statistics of BvD firms by matching success

Group	Statistic	N	# Patent families
No MiDi match	Mean	15,703	17.3
No MiDi match	Median	15,703	4
MiDi match	Mean	2,508	221.6
MiDi match	Median	2,508	23

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, BvD, Patstat.

C.1.3 Other Data

Data on GDP were obtained from the International Monetary Fund's World Economic Outlook Database, with the market potential variable based on own calculations using the same methodology as in Li (2015) with a negative exponential function and weight $k = 100$.

Data on tax rates, R&D expenditures and researchers in R&D were sourced from the World Bank's World Development Indicators. The total tax rate measures the amount of mandatory contributions and taxes payable by firms as a share of commercial profits, after accounting for exemptions and allowable deductions. It is based on the statutory corporate tax rate and provides a comprehensive measure of the cost of all the taxes a business bears. R&D expenditures contain capital expenditures, as well as wages and associated costs of researchers, technicians, and other supporting staff. It also includes purchases of materials, supplies, and minor equipment to support R&D such as utilities, reference materials and subscriptions to libraries and scientific societies. The number of researchers in R&D is defined as professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students engaged in R&D are included. Both R&D-related data are obtained through regular surveys on R&D performing entities, and cover basic research, applied research, and experimental development.

The OECD has a database on immigrants in OECD and non-OECD countries (DIOC-E), where we sourced the data on German immigrants abroad. The OECD defines a German immigrant to be a person born in Germany but now living abroad. The CEPII GeoDist database provided the population-weighted bilateral distance measure between countries that we used in our analysis, with more details to be found in Mayer and Zignago (2011). Lastly, patent protection indicators were obtained from Park (2008), with the intellectual property rights index (IPR) by the Property Rights Alliance (PRA) used for a robustness check. The index by Park (2008) consists of an unweighted sum of 5 different scores: Extent of coverage, membership in international treaties, duration of protection, enforcement mechanisms and possible restrictions to protection, with the final index ranging from 0 to 5. The index has been used widely in the literature, e.g. Kumar (2001) and Javorcik (2004b). The IPR by the Property Rights Alliance adds perceptions about patent protection and the actual level of intellectual property rights violations, thereby giving a better picture of how successful protection works out in practice. The final index varies from 0 to 10.

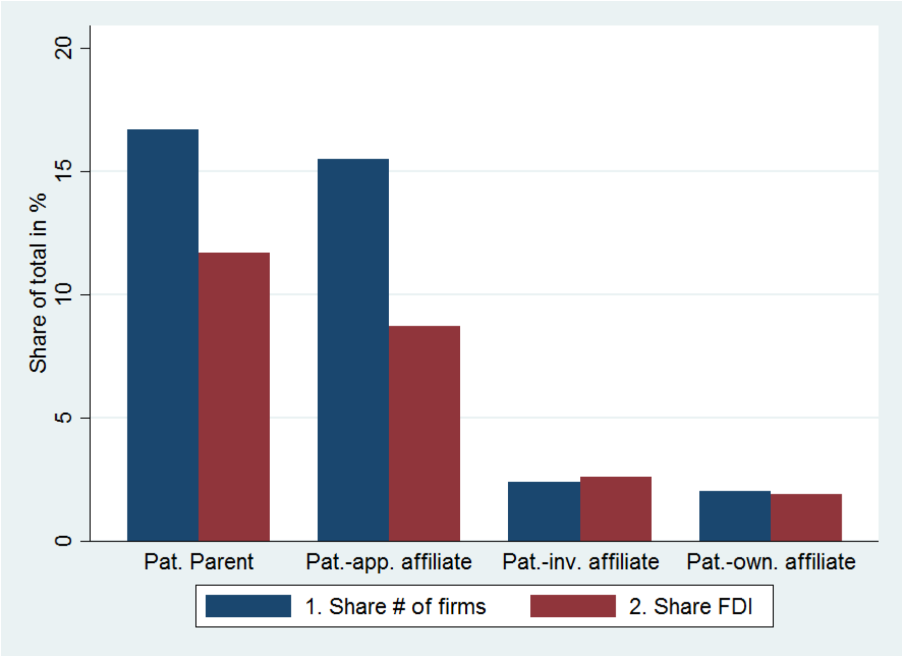
C.2 Prevalence by Firm Size

Figures C.1 (large firms) and C.2 (small firms) present the same statistics on the prevalence of patenting FDI as in section 3.3.1, but with the sample split by parent firm size. All parent firms with aggregate revenue (across all years and all affiliates) above the median are counted as large firms, whereas all parent firms with aggregated revenue below the median are counted as small firms. We can see that the share of patenting

Figure C.1: Large parent firms: Prevalence of patenting FDI and its subtypes

Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Figure C.2: Small parent firms: Prevalence of patenting FDI and its subtypes



Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

firms and patenting FDI is much higher for larger firms. For example, patenting firms make up 23.4% of all large parent firms, but only 16.7% of small parent firms. In terms of FDI, patenting FDI represents 32.3% of large parent firms' FDI, but only 11.7% of small parent firms' FDI. The underrepresentation of patenting FDI among small parent firms suggests that small parent firms may be investing relatively less in their patenting affiliates, hinting at possible differences in patent motivation or patent quality between large and small parent firms.

C.3 Robustness Checks

In this section, we present a number of robustness checks. First, we replace some of the explanatory variables with alternative measures to show that our results are not specific to the way market size, science-related human capital and patent protection are measured.[4] In Table C.3, we replace GDP with a market potential measure accounting for neighbouring economies, using same approach as in Li (2015), with a negative exponential weighting function and $k = 100$. In Table C.4, we replace R&D expenditures with the number of researchers in R&D per 1,000 population as an alternative measure for the science-related human capital of an economy. Table C.5 uses the intellectual property rights index (IPRI) by the Property Rights Alliance for patent protection. While the index by Park (2008) mainly reflects the law on the books, the IPR index considers perceptions and actual violations of intellectual property rights, thereby giving a better reflection of how well protection works out in reality. In all three tables, the replacement variables show the same sign and significance as the original variables. Other controls are also largely unchanged. Patent protection is an exception, with the variable being significant even for general, patent-inventing and patent-owning FDI in some of the robustness specifications. Hence, we may have even underestimated the importance of patent protection in the baseline regression.

[4] The number of observations in the results may vary due to differences in data coverage.

Table C.3: Results - Market potential

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Market Potential	0.0225***	0.0235***	0.0235***
	(0.0028)	(0.0028)	(0.0028)
Market Potential * Pat Dum	0.0025***	0.0009	0.0009
	(0.0006)	(0.0012)	(0.0012)
Log Distance	-0.0075***	-0.0073***	-0.0073***
	(0.0017)	(0.0017)	(0.0017)
Log Distance * Pat Dum	0.0036***	0.0028***	0.0032***
	(0.0003)	(0.0006)	(0.0006)
Total Tax Rate	-0.0158***	-0.0141***	-0.0139***
	(0.0046)	(0.0046)	(0.0046)
Total Tax Rate * Pat Dum	0.0163***	0.0086*	0.0045
	(0.0022)	(0.0044)	(0.0046)
R&D Expenditure	0.0010	0.0014	0.0013
	(0.0011)	(0.0011)	(0.0011)
R&D Expenditure * Pat Dum	0.0035***	0.0028***	0.0038***
	(0.0004)	(0.0008)	(0.0008)
Pat. Prot. (Park)	-0.0004	0.0008	0.0009
	(0.0012)	(0.0012)	(0.0012)
Pat. Prot. (Park) * Pat Dum	0.0085***	0.0055**	0.0047**
	(0.0010)	(0.0027)	(0.0023)
German immigrants	0.0003	0.0007	0.0007
	(0.0024)	(0.0024)	(0.0024)
German immigrants * Pat Dum	0.0036***	0.0057***	0.0066***
	(0.0009)	(0.0020)	(0.0023)
Observations	766,908	766,908	766,908
R^2	0.02	0.02	0.02
SE Cluster	Parent Firm	Parent Firm	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Table C.4: Results - Researchers in R&D

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP	0.0266***	0.0275***	0.0276***
	(0.0031)	(0.0031)	(0.0031)
Log GDP * Pat Dum	0.0030***	0.0016	0.0018
	(0.0005)	(0.0011)	(0.0012)
Log Distance	-0.0050**	-0.0045**	-0.0045**
	(0.0022)	(0.0022)	(0.0022)
Log Distance * Pat Dum	0.0032***	0.0025***	0.0029***
	(0.0004)	(0.0007)	(0.0007)
Total Tax Rate	-0.0146***	-0.0130***	-0.0128***
	(0.0049)	(0.0049)	(0.0049)
Total Tax Rate * Pat Dum	0.0167***	0.0104**	0.0065
	(0.0024)	(0.0049)	(0.0053)
Researchers/th	0.0002	0.0004	0.0004
	(0.0005)	(0.0005)	(0.0005)
Researchers/th * Pat Dum	0.0015***	0.0011***	0.0015***
	(0.0002)	(0.0004)	(0.0004)
Pat. Prot. (Park)	-0.0013	0.00001	0.0001
	(0.0012)	(0.0012)	(0.0012)
Pat. Prot. (Park) * Pat Dum	0.0095***	0.0065**	0.0056**
	(0.0012)	(0.0026)	(0.0027)
German immigrants	-0.0010	-0.0006	-0.0006
	(0.0023)	(0.0023)	(0.0023)
German immigrants * Pat Dum	0.0040***	0.0067***	0.0081***
	(0.0009)	(0.0019)	(0.0021)
Observations	766,908	766,908	766,908
R^2	0.02	0.02	0.02
SE Cluster	Parent Firm	Parent Firm	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

Table C.5: Results - IPR patent protection

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP	0.0226***	0.0235***	0.0235***
	(0.0025)	(0.0025)	(0.0025)
Log GDP * Pat Dum	0.0023***	0.0013*	0.0011
	(0.0004)	(0.0008)	(0.0008)
Log Distance	-0.0117***	-0.0116***	-0.0116***
	(0.0016)	(0.0016)	(0.0016)
Log Distance * Pat Dum	0.0021***	0.0017***	0.0021***
	(0.0004)	(0.0006)	(0.0006)
Total Tax Rate	-0.0113**	-0.0099**	-0.0098**
	(0.0046)	(0.0045)	(0.0045)
Total Tax Rate * Pat Dum	0.0105***	0.0039	0.0009
	(0.0020)	(0.0041)	(0.0049)
R&D Expenditure	-0.0004	-0.0001	-0.0001
	(0.0010)	(0.0010)	(0.0010)
R&D Expenditure * Pat Dum	0.0033***	0.0037***	0.0048***
	(0.0005)	(0.0009)	(0.0010)
Pat. Prot. (IPRI)	0.0048**	0.0051***	0.0051***
	(0.0019)	(0.0019)	(0.0019)
Pat. Prot. (IPRI) * Pat Dum	0.0011***	-0.0005	-0.0007
	(0.0003)	(0.0007)	(0.0007)
German immigrants	-0.0017	-0.0016	-0.0016
	(0.0023)	(0.0023)	(0.0023)
German immigrants * Pat Dum	0.0019**	0.0053***	0.0066***
	(0.0009)	(0.0019)	(0.0022)
Observations	873,423	873,423	873,423
R^2	0.02	0.02	0.02
SE Cluster	Parent Firm	Parent Firm	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

In another robustness check, we analyse whether our results could be driven by the difference between services and the manufacturing sector, with patents playing no role in addition to sectoral differences. Table C.6 presents results using the same regression specification as Equation (3.1), but with the sample restricted to manufacturing parent firms only. While the effects on GDP and R&D expenditures are largely unchanged, distance now has a positive effect on the location decision of patenting FDI. With manufacturing parent firms possibly facing even higher fixed costs than parent firms in the services sector, distance-related costs diminish in relative importance, so the elasticity of location decisions with respect to distance decreases. For patenting manufacturing multinationals, it seems that the overall sign is even reversed, with channels of the classical proximity-concentration tradeoff dominating (Brainard, 1993). Destinations closer to home are served by exports instead. Concerning tax rates, coefficients are more negative than in the baseline, reflecting a higher sensitivity of FDI to tax changes by manufacturing parent firms. For patent protection, we see larger coefficients than in the baseline results, with even some significant coefficients for general FDI. This stronger response concerning the strength of patent protection is expected, as manufacturing parent firms are more patent intensive than the firm population as a whole. Larger coefficients for the interaction terms of German immigrants suggest that the complexity gap between general and patenting FDI, which may necessitate informal links for decision-making, is even more pronounced for manufacturing parent firms. Therefore, we conclude that despite some differences in magnitude, differential effects between patenting and general FDI still persist even within the group of manufacturing parent firms.

A last robustness check uses a modified dataset, where parent firms were aggregated up to the global ultimate owner (GUO) level using the Amadeus data on ownership links. Up to now, we have used the direct investment-reporting party as our parent firm unit. However, in large multinationals, investing and patenting activity may sometimes not occur within the same legal entity. Hence, we may have failed to account for the elaborate internal ownership linkages of large multinationals. We may have treated parent firms

Table C.6: Results - Manufacturing sample

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP	0.0204***	0.0218***	0.0219***
	(0.0047)	(0.0047)	(0.0047)
Log GDP * Pat Dum	0.0030***	0.0014	0.0018
	(0.0007)	(0.0012)	(0.0012)
Log Distance	0.0032	0.0041	0.0041
	(0.0033)	(0.0033)	(0.0033)
Log Distance * Pat Dum	0.0036***	0.0021***	0.0028***
	(0.0005)	(0.0007)	(0.0007)
Total Tax Rate	-0.0233***	-0.0194**	-0.0190**
	(0.0080)	(0.0079)	(0.0079)
Total Tax Rate * Pat Dum	0.0153***	0.0044	0.0008
	(0.0029)	(0.0052)	(0.0056)
R&D Expenditure	0.0008	0.0018	0.0018
	(0.0019)	(0.0019)	(0.0019)
R&D Expenditure * Pat Dum	0.0036***	0.0028***	0.0038***
	(0.0005)	(0.0008)	(0.0009)
Pat. Prot. (Park)	0.0004	0.0039*	0.0041**
	(0.0022)	(0.0020)	(0.0020)
Pat. Prot. (Park) * Pat Dum	0.0106***	0.0054**	0.0044*
	(0.0014)	(0.0025)	(0.0025)
German immigrants	0.0004	0.0020	0.0021
	(0.0034)	(0.0034)	(0.0034)
German immigrants * Pat Dum	0.0083***	0.0093***	0.0110***
	(0.0010)	(0.0020)	(0.0023)
Observations	249,395	249,395	249,395
R^2	0.02	0.02	0.02
SE Cluster	Parent Firm	Parent Firm	Parent Firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include parent firm size (log revenue), a patent dummy and constant.
Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

and affiliates separately when they are in fact ultimately subject to the same decision-making body. To check whether the results are robust to varying investor specifications, we aggregate all parent firms who have the same GUO into one 'global ultimate' parent firm. A new parent firm then constitutes the GUO of the original investment-reporting party. Previously separate affiliates in the same country that belong to the same GUO would now form one unit. Additional observations may result from ownership changes, as a change in ownership is equal to the entry of a new owner in this GUO dataset.

The regression specification is the same as in Equation (3.1), and results are presented in Table C.7. Almost all variables of interest retain sign and significance. The notable exception is the tax rate, where the coefficients on the lower order terms are now insignificant, rendering the overall effect of taxes for patent-applying FDI positive. At the GUO level, taxes seem to be less of a deterrent than in the baseline results. A possible interpretation is that larger conglomerates are less concerned about tax rates in a particular jurisdiction, since they have more opportunities for profit shifting. Evidence in the literature suggests that profit shifting with intangible assets such as patents is indeed taking place (Karkinsky and Riedel, 2012). Large conglomerates may then safely choose high-tax destinations, which are often important developed economies, knowing that profit shifting opportunities enables them to avoid paying these high taxes on a large share of their revenues. Overall, we conclude that the differential effects between general and patenting FDI still persist, even if we use the altered GUO dataset.

Table C.7: Results - Global ultimate owner dataset

Dependent variable: FDI entry	(1) Patent-applying FDI	(2) Patent-inventing FDI	(3) Patent-owning FDI
Log GDP	0.0218***	0.0206***	0.0206***
	(0.0025)	(0.0024)	(0.0024)
Log GDP * Pat Dum	0.0035***	0.0015*	0.0010
	(0.0004)	(0.0009)	(0.0009)
Log Distance	-0.0062***	-0.0056***	-0.0056***
	(0.0017)	(0.0017)	(0.0017)
Log Distance * Pat Dum	0.0038***	0.0031***	0.0036***
	(0.0003)	(0.0005)	(0.0005)
Total Tax Rate	-0.0049	-0.0014	-0.0013
	(0.0034)	(0.0033)	(0.0033)
Total Tax Rate * Pat Dum	0.0150***	0.0050*	0.0030
	(0.0015)	(0.0029)	(0.0032)
R&D Expenditure	-0.0010	0.0001	0.00004
	(0.0010)	(0.0010)	(0.0010)
R&D Expenditure * Pat Dum	0.0046***	0.0028***	0.0037***
	(0.0003)	(0.0005)	(0.0005)
Pat. Prot. (Park)	-0.0006	0.0010	0.0011
	(0.0010)	(0.0010)	(0.0010)
Pat. Prot. (Park) * Pat Dum	0.0088***	0.0041***	0.0029**
	(0.0007)	(0.0013)	(0.0013)
German immigrants	-0.0019	-0.0013	-0.0012
	(0.0019)	(0.0019)	(0.0019)
German immigrants * Pat Dum	0.0046***	0.0046***	0.0067***
	(0.0006)	(0.0013)	(0.0014)
Observations	1,110,666	1,110,666	1,110,666
R^2	0.04	0.04	0.04
SE Cluster	GUO parent firm	GUO parent firm	GUO parent firm

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: This table presents a linear probability model with FDI entry as binary dependent variable. All specifications are estimated with country, sector and year fixed effects. Further controls include global parent firm size (log revenue), a patent dummy and constant. Source: RDSC of the Deutsche Bundesbank, MiDi 1999-2011, Patstat, own calculations.

List of Figures

List of Tables

Bibliography

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