Foreign Direct Investment and Multinational Firms in the 21st Century - A European Perspective

A thesis presented

by

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to

University of Glasgow

Adam Smith Business School

in fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Economics

Abstract

This thesis provides an extensive discussion on how multinational firms impact the world and economies in the 21st century. The thesis consists of three empirical chapters, with each of them examining one particular aspect on how multinational enterprises (MNEs) are affected by certain aspects. Chapter 1 provides an introduction outlining the motivation, general background theories behind MNEs and FDI.

Chapter 2 analyses ORBIS data from the Czech Republic and Poland between 2009 and 2014. Its purpose is to answer the question of whether host nations benefit from the presence of foreign firms depending on the origin of the foreign firm. It raises the question whether investment coming from developing countries might have a positive effect on the economy in particular as spillovers might be more likely to occur. This is based on the believe that domestic firms have to overcome a technology gap in order to absorb new technology. This is believed to be smaller to foreign firms which are coming from developing countries. After estimating spillover effects for both countries using a simple model as a baseline, the study extends its approach following Javorcik and Spatareanu (2011) distinguishing the origin of FDI not by continent but by separating between developed and developing/merging economies. It is demonstrated that domestic suppliers in the Czech Republic benefit from backward spillovers coming from foreign investment from developing countries, an effect which is not revealed when the origin of FDI is not considered. This provides novel and deeper insight into the occurrence of spillovers in CEECs and shows evidence that the origin of a multinational might play a significant role for an economy's indigenous firms to benefit from productivity externalities.

Chapter 3 examines firm-level data retrieved from the ORBIS database for a selection of countries which are member of the euro zone for the years 2009 to 2018. Its purpose is to shed light on how firms are affected by financial pressure. With foreign firms being endowed with more capabilities to access new finances, domestic firms are potentially more exposed to financial shocks as they do not find various alternatives to finance themselves or seek new capital. After obtaining estimates of a firms TFP following the approach of Levinsohn and Petrin (2003), firms are separated by classifying them based on their global ultimate ownership. Additionally, firms are separated based on their regional location as either operating in a periphery or non-periphery country. This

study examines whether the Capital Enhancement Exercise by the European Banking Authority impacted the productivity of domestic firms in a negative way. The empirical results suggest that the EBA Exercise amplified the negative effect occurring through financial pressure occurring overall. When turning to both domestic and also foreign MNE, an increase in TFP can be observed, which is rather surprising and might be the result of down-sizing effects. For the geographic areas, it can be observed that firms operating in periphery countries are stronger affected by financial pressure than their non-periphery counterparts.

Chapter 4 reverts to firm-level data retrieved from the AMADEUS database comprising all member countries of the European Union for the years 2011 to 2020. Its purpose is to answer the question whether tax incentives and changes in the corporate tax rate are an effective instrument on attracting MNEs and increasing innovation within firms. It measures innovation in two different ways, which are applying a firm's intangible assets and measuring innovation with using the patents filed in a particular year by each company. This study does not only account for changes in the CIT for each country individually, but also manually constructs a measure for changes in the tax base by exploiting reports by the European Commission. The empirical results indicate that a change in the corporate tax rate is impacting the intangible assets of firms in a negative and statistically significant way overall. When examining different sub-samples, it can be seen that no effects occur for both domestic MNE and foreign MNE. When considering the presence of a patent box regime, the results indicate that this affects innovation in a positive and significant way. Surprisingly, a tax change under such regime is perceived more negatively, even by MNEs. Regarding the analysis with filed patents as a dependent variable, no robust results can be established, confirming the flaws which can occur when patents are used as a measure for innovation.

Chapter 5 presents the main findings of all three main Chapters and provides concluding remarks on how MNEs might be perceived in a globalized economy.

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Acknowledgement

Pursuing a PhD is a demanding journey. Requiring a lot of discipline, motivation and passion, this journey can take somewhat the path of a "mental rollercoaster" leading to many ups and downs. It can be rather formidable when pursuing this path, even under normal circumstances. Undoubtedly, the global pandemic did not make this journey easier in any way. With the academic landscape changing tremendously, many researchers had to adapt to new routines and working from home became the new standard. Accompanied by the Brexit and its resulting aftermath, many were forced to face new challenges and to make the best of the situation. All this did certainly not contribute to the pursue of a PhD in a positive way. Therefore, I am even more grateful for the enormous support from my friends and family. The past two years were challenging for all of us in various ways. This made true support and encouragement even more scarce. I want to thank my parents, without whom pursuing this path of a PhD would not have been possible for me. I am grateful to have true friends who supported me during this time. A special thank you goes to Arthur Galichère, Prateek Chandra Bhan, Adhiraj Singh Rathore, and Philipp Bergner, who were always there and helped to make those grim times less difficult than they had to be.

This special thank you extends further to my supervisors Céline Azemar and Marina Eliza Spaliara who kept believing in me and supported me with their valuable feedback and suggestions to continue. Without such encouragement and positive attitude this PhD would not have been possible to achieve.

Further, I am grateful for my partner Mariana Cendejas Orozco who provided me with nothing but good words and encouragements during this time. I could not have asked for a better partner on my side while going through these difficult and demanding times. Thank you!

After these years one comes to realize that a PhD is not only a demanding challenge on an academic level. It rather manifests itself as a test of character, strength, and persistence. This test can be a challenging enterprise with many pitfalls lurking on the way. It is precisely for this reason, however, that reaching the end of this path can even be more rewarding. And as every other "rollercoaster ride", no matter how many ups and downs it consists of, it has to come to an end.

Declaration

"I declare that, except where explicit reference is made to the contribution of others,this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution."

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List of Abbreviations

ABC ..... Absorptive Capacity

BvD ..... Bureau van Dijk

CEECs ..... Central and Eastern European Countries

CIT ..... Corporate Income Tax

EBA ..... European Banking Authority

ECB ..... European Central Bank

ETR ..... Effective Tax Rate

FDI ..... Foreign Direct Investment

GUO ..... Global Ultimate Owner

LevPet ..... Levinsohn & Petrin Productivity Estimator

PIT ..... Personal Income Tax

R&D ..... Research & Development

SME ..... Small and Medium-Size Companies

STR ..... Statutory Corporate Tax Rate

TFP ..... Total Factor Productivity

WIOD ..... World Input-Output Database

WRDS ..... Wharton Research Data Services

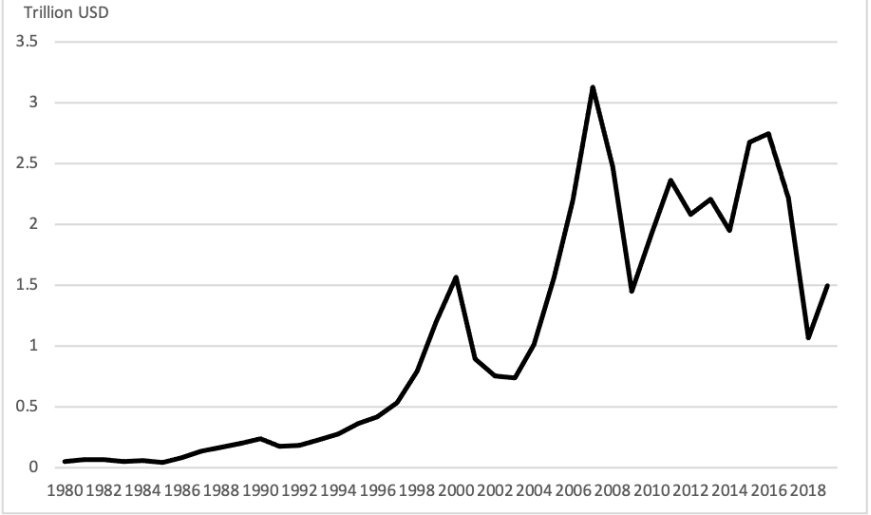
Chapter 1

Introduction

1.0.1 Background and Motivation

The 21st century is dominated by multinational enterprises (MNEs) which can be identified as key players within a globalized economy. In the past four decades, the net-inflows of foreign direct investment (FDI) increased substantially. While net inflows remained rather steady and without much change until 1990, a significant increase can be observed, with its highest point being reached in 2007, representing a total inflow of more than 3 trillion USD on a global level (see Figure 1.1).

Figure 1.1: *Foreign Direct Investment, Net Inflows (current USD), 1980-2020*



Notes: This figure provides a graphical illustration of the development of the global FDI net inflows in current US Dollars for the years 1980 to 2020.
Source: The World Bank (2020)

It comes to no surprise that such a massive increase in foreign investments inevitably reflects itself in many different aspects as well, such as the economy, society, policies or on a corporate level. For this reason, MNEs are often observed under a rather critical

lens, as policy makers or the public in general might have mixed feelings on how they should perceive such a phenomenon of globalization. Navaretti et al. (2004) points out that the perception of such large key players operating on a global level can be described as a "Dr. Jekyll and Mr. Hyde" perception. However, such perception often arises without any fundamental empirical reflection and analysis, but is rather created through an ambiguous feeling as MNEs often fail to reflect any national identity or spirit.

However, while some concerns are only stemming from a "bad feeling" which occurs on a subjective level, there are indeed legitimate concerns regarding MNEs and issues that might arise. This thesis intends to shed light on the realm of FDI and MNEs in the 21st in Europe. It analyses the effects and potential firm behavior empirically in order to establish deeper insight on how the enormous increase of FDI and the resulting high number of MNEs establishing new operations in Europe has impacted the local economies and policy perspectives.

In order to understand, how MNEs differ from domestic firms, a short introduction of the fundamental principles and mechanisms is established. Further, it is highlighted what forms of FDI can occur, as MNEs might have different intentions and strategies when they make a decision to invest or not to invest in a particular country or location. Therefore, this introduction outlines a quick overview of the basic fundamental of the theoretical background of FDI. It then outlines the structure of this thesis, its individual chapters and which aspects are examined.

1.0.2 The Modern Internalisation Theory of FDI

The modern internalisation theory of FDI, also often referred to as the transaction cost theory, presents the principle for multinational companies in terms of "the administered internalised deployment of its proprietary assets to evade the failure of certain arms-length markets. Premier among those assets is the knowledge embodied in new products, processes, proprietary technology and the like" (Caves, 1996).This implies that incoming MNEs are bringing certain, mostly intangible, assets which are then used to neutralize and outweigh any potential advantages of domestic firms based on incumbency. The most common and frequently cited assets in the literature on multinational enterprises are brand name capital, technological knowledge and also organisational capabilities (Conyon et al., 2002).

Generally, the transfer of brand name, reputation, and technological knowledge across markets is seen as quite problematic and difficult to achieve. Markets are known to have numerous forms and types of different failures, whilst the process of licensing a brand name is considered with a shared use of an intangible asset such as reputation, causing potential danger of horizontal externalities to occur (Geroski, 1995). Conyon et al. (2002) considers 'multinationality' to be associated with each. Empirical evidence shows the

tendency that multinational companies are more likely to enter and appear in industries with a high R&D and also advertising intensity (Caves, 1996).

Further, it is suggested and hypothesised that particularly multinational firms are enjoying competitive advantage due to superior and better organisational practices and routines, which can also be identified as intangible assets, being very difficult to transfer across markets. As an example, Basset (1986) highlights how the Japanese manufacturing industry developed superior logistical systems such as "just-in-time" inventory planning and was also able to implement and develop innovative work practices, including task flexibility and team work. In those particular industries these advantages appear to be very useful.

The measured productivity level of a MNE's local subsidiary can be used to assess and reflect the inward transfer of the previously mention intangible assets. Conyon et al. (2002) argue that both a direct and an indirect effect on the wage rate of the subsidiary would be expected. The indirect effect can be seen as additional surplus generated through a higher bargaining power compared to local firms. This implies that, given ceteris paribus, a higher level of productivity would generate and result in a greater surplus and therefore higher wage rates. However, also the relative bargaining power of the parties can be affected, as companies with affiliates located in multiple countries can influence negotiating results by changing and reconsidering expansion plans, credibility threatening or even reallocating production temporarily in the case of a strike (Huizinga, 1990).

When comparing wages or performance of domestic companies with foreign-owned firms, a clear tendency can be seen for superiority of the latter. However, both empirical evidence and theory show a tendency for multinational to be attracted by certain industries in different ways, which makes it necessary to implement precise industry controls. Davies and Lyons (1991), as one of many examples, find foreign companies in the UK to be 30 percent more productive than domestic-owned ones. They point out that 40 percent of that arises from locating in high-productive industries and see the remainder to be attributable to rather intrinsic advantages. In contrast to that, Vendrell-Alda (1979) finds market structural characteristics as crucial for multinational firms to enjoy advantages from productivity differentials.

1.0.3 The Different Forms of Foreign Direct Investment

Further, it is important to consider that FDI can occur in different ways. Primarily, the intention of a MNE for investing in a foreign country is used to identify which type of direct investment is conducted. In general, it is distinguished between two major forms of FDI, horizontal FDI and vertical FDI.

Horizontal Foreign Direct Investment

A fundamental question in the theory of FDI is why a company would make the decision to invest and produce in another country and become multinational, rather than just exporting or licensing its assets. One of the first general concepts is the Ownership-Location-Internalisation (OLI) paradigm realised by Dunning (1988). The OLI approach identifies three advantages which have to occur simultaneously that a company makes the decision to become multinational.

- The company has to own a specific asset or product (mostly intangible) which provides it with a specific advantage that other firms do not have. This can be a brand name, technology, or specific knowledge. The ownership of this asset gives the firm market power, makes it competitive and enables it to compensate for the lack of knowledge of the foreign markets (compared to domestic firms which have been operating in the market longer).

- The firm has a location advantage when it comes to locating its plants in another country rather than in the home country. Most commonly these advantages can be identified as lower labour costs or lower tax rates.

- The company has to find it more valuable to internalise its production by setting up an own plant in a foreign country rather than licensing, exporting or subcontracting their products or firm specific asset.

Dunning (1988) argues that a company having advantages but no location advantage decides to serve the foreign market through export and not set a plant. If the internalisation advantage is not present as well, a company decides to sell its specific asset to a local firm or license it.

Another approach of horizontal FDI is shown and discussed by Markusen (1984) and is known as the Proximity-Concentration Trade-off. This theory analyses the determinants a company considers when it comes to the question how it should serve a foreign market. It highlights the importance of trade costs, trade barriers, fixed costs of setting up a new plant, and economies of scales at the plant-level and also at the firm-level.

Brainard (1993) conducts a study and identifies how key determinants of the Proximity-Concentration Trade-off Theory impact the decision of a company to become multinational. He proposes a model in which he includes country and sector specific trade costs, economies of scale at the firm- and plant-level, and multiple control variables such as trade openness and corporate tax rates. His findings show strong support for the Proximity-Concentration Trade-off Theory, finding a positive and statistically significant correlation between economies of scale at the firm-level and the decision to become multinational. For economies of scale at the plant level, the correlation is negative and

significant. He concludes that his results are mostly consistent with the theoretical approach and suggests further research.

Vertical Foreign Direct Investment

While the Proximity-Concentration Trade-off gives an explanation why companies decide to become multinational and replicate their production in order to supply a foreign market directly (HFDI), vertical multinationals are emerging due to the existence of international factor price differentials. This form of direct investment is vertical in a way that a company performs different activities and production stages in different countries and connects these activities through trade linkages. Each production stage is located in a particular country that provides the highest comparative advantage. When fragmenting production, a company can benefit from lower production costs, however, it also faces additional disintegration costs. This includes costs caused by technical efficiency loss due to a higher level of complexity of the production and trade costs.

Yeaple (2003) contributes to the existing literature by replicating the study of Brainard (1993) using the same US data. He expands the previous study by not only considering a mixture of country and industry characteristics but also interacting them with each other. His findings are in line with the results of Brainard (1993), confirming the plausibility of Proximity-Concentration Trade-off Theory. Further, there is strong evidence that the pattern of US outward FDI is consistent with a comparative advantage chain. In conclusion, his findings are in line with both theories, the Proximity-Concentration Trade-off Theory for HFDI and the comparative advantage theory for VFDI.

Navaretti et al. (2004) provide an illustrative comparison of both horizontal and vertical FDI using a simple model. It shows when a company chooses to spilt its production process and decides to produce several parts in different locations. The model is set-up considering following aspects:

- There are two distinct stages in the production process: stage c represents the component production and a the assembly stage.
- Both stages require two input factors, labour and capital. w_i and r_i are the prices for country i.
- Both stages are assumed to operate with constant returns to scale, resulting in a unit cost function of $c(w_i, r_i)$ and $a(w_i, r_i)$.
- Technical substitution is not possible. This means that both production stages are required to produce one unit of final output. Therefore, both costs enter total costs additively.

- The shipment of final products creates trade costs, shipping components result in trade or disintegration costs.

Equation (1.1) represents the cost of unit of output delivered to country k. Here, country i produces the components, country j conducts final assembly and final consumption takes place in country k.

$$B_{ijk} = [c(w_i, r_i)\tau^c_{ij} + a(w_j, r_j)\tau^a_{jk}] \tag{1.1}$$

- τ^c_{ij} and τ^a_{ij} are the ad valorem trade cost factors for both upstream and also downstream products.

- Following assumptions are made: $\tau^c_{ii} = \tau^a_{ii}$, and τ^c_{ij}, $\tau^a_{ij} \geq 1$ with $i \neq j$.

To interpret this model one can assume following set-up. Country 1 produces the components, ships it to country 2 where then the assembly takes place. Then the final product is shipped back to country 1 for final consumption (this would mean B_{ijk} is B_{121}). The costs for the production of the components is in this case $c(w_1, r_1)$, the mark up τ^c_{12} which is the costs of shipping from country 1 to country 2. Assembly costs are $a(w_2, r_2)$. As the product is shipped back to country 1 for final consumption, further trade costs apply τ^a_{21}.

Considering this simple model and set-up one can ask the question now under which conditions and circumstances a firm fragments its production and produce in different countries. This question can be approached with a partial equilibrium framework. It is supposed that there are two countries, country 1 and country 2. Country 1 is considered to be the northern economy, meaning it has higher wages. In order to simply the model more, it is assumed that trade costs are the same in both directions, meaning $\tau^c_{ij} = \tau^c_{ji}$ and $\tau^a_{ij} = \tau^a_{ji}$. Therefore, it can be rewritten as τ^c and τ^a.

Two additional assumptions are made. Country 1 has a comparative advantage for the whole production, that is, if both stages need to be done in the same location (as disintegration costs are very high) and trade of the final product can be done without charge, then country 1 is the place which provides the cheaper production. Regarding the assembly, it is assumed that this particular stage is very labour intensive. Therefore, if fragmentation is conducted, assembly is the stage that will be moved to country 2, while production of the components stays in country 1.

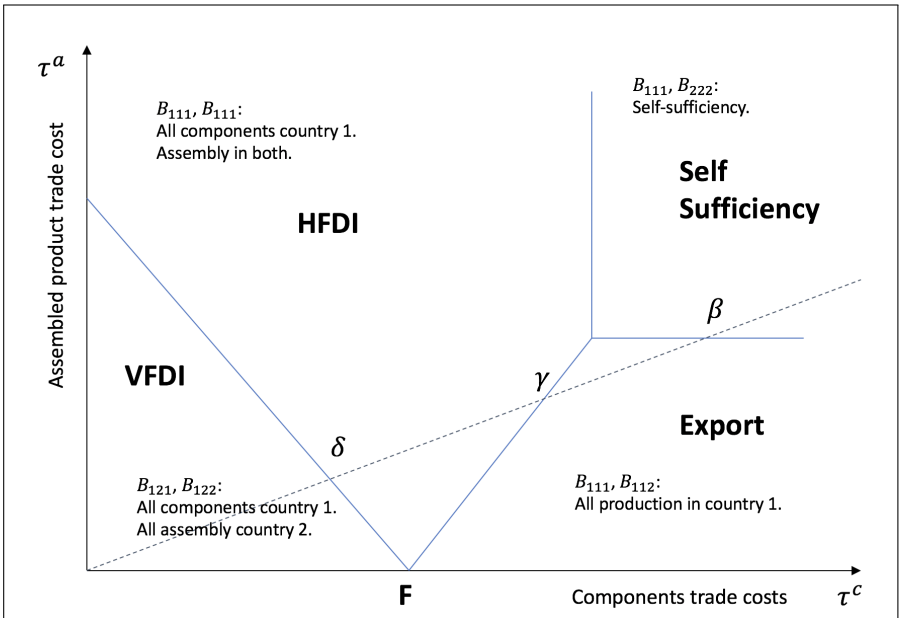
Figure 1.2 illustrates how the location on production and the trade pattern depends on τ^c and τ^a. While the x-axis represents disintegration costs (shipping costs for components), the y-axis represents the trade costs of the final product after assembly. The zones in this graph relate to different production patterns.

- **Export** – high disintegration costs but cheap trade costs for final product.

- **Self-Sufficiency** – both τ^a and τ^c are very high.
- **HFDI** – τ^c is relatively low, therefore all components are produced in country 1. However, τ^a is high enough that finally assembly takes place at the same place of final consumption.
- **VFDI** – both τ^c and τ^a are low. This represents an ideal scenario for fragmentation. Therefore, component production takes place in country 1 while assembly of the final good is done in country 2.

To summerize, a company which faces the question whether it should become multinational has several options. It can either become multinational and conduct FDI horizontally or vertically, or it can stay domestic and export its goods to foreign markets. Low transportation costs and low trade costs are both together an ideal scenario to conduct vertical FDI, while high transportation costs and a large market size are very attractive for conducting horizontal FDI. With low transportation costs but relatively high disintegration costs, exporting might be the best option for a company to supply a market abroad.

Figure 1.2: *Assembly Labour Intensive; Country 1 High Wage*



Notes: This figure illustrates under which conditions a company takes the decision to conduct either horizontal-FDI (HFDI), vertical-FDI (VFDI), export its products, or stay self-sufficient. This model follows the assumption that there are three stages in the process: production, assembly, and final consumption.
Source: Navaretti et al. (2004, p. 82)

1.0.4 Contribution and Structure

Considering this theoretical setup, this thesis combines three individual studies which analyze MNEs and domestic firms in order to establish significant differences and to answer the question whether the often rather negative perception of 'multinationality' is justified or rather only based on a subjective feeling and dislike. It contributes to the field of FDI by shifting the focus entirely on Europe, considering only countries which are member of the European Union. Even though the focus in the literature did shift from mostly analyzing MNE, FDI and firm behavior in the United States to investigating more and more European countries, the magnitude of these studies is still rather small when comparing them to the former.

This comes to no surprise, as the European Union failed to establish 'investment friendly" policies for most of the past decades (Andréosso-O'Callaghan, 2000). Even though, the EU is host of a number of countries which are considered to be tax havens, these countries are criticized by Brussel and perceived rather negatively. Therefore, this thesis analyzes firm-level data which consists of firms that are operating in the European Union. As there are various aspects which can be affected by the presence of MNEs, three different fields are identified and then addressed and examined individually in the following chapters.

The main focus of Chapter 2 is on productivity spillovers occurring through the presence of MNEs. It intends to answer the question whether the presence of MNEs is desirable and provides policy implications for policy makers. Two main aspects or rather criticisms are often reflected on each other. A rather favorable argument can be established with MNEs being considered to bring new technology into a host country, providing and creating new jobs which consequently can be reflected positively in the unemployment rate (see Fons-Rosen et al. (2013)). This can particularly be the case in developing or transitioning markets, with policy makers rigorous competing with each other to provide the most favorable conditions for MNEs to consider their country as a market to enter, to invest, and to create a production plant or subsidiary.

However, while this appears to be rather promising at first glance at the positive aspects might beckon to a large degree, there are also potential downsides which can arise from MNEs entering a market which are often not thoroughly examined and therefore not taken into account as a consequence. While it is true that MNEs indeed are the predominant owners of technology and provides of employment, there are also ways in which they might be harmful for a local economy. For instance, being endowed with a high level of technology and operating in very efficient ways, MNEs might be outperforming domestic firms to such a large degree, that the underperformance of the latter might result in domestic firms disappearing from the market which might destroy a local industry entirely (see Aitken and Harrison (1999) and Figure 2.7). Therefore, Chapter 2 intends

to investigate how the presence of MNEs in a local economy can be perceived and how domestic firms are affected by them.

Chapter 2 analyzes potential spillover effects occurring in the Czech Republic and Poland, reverting to firm-level data obtained from the ORBIS database for the years 2009 to 2014. The importance of a firm's absorptive capacity is highlighted as not only the presence of MNEs and their technology they possess are of importance. Further, also the technological level of the already established domestic firms appear to be of significance when it comes to potential productivity spillovers occurring. Analyzing 20,295 firms operating in the Czech Republic and 14,865 in Poland, companies are identified by their ultimate ownership and classified respectively as either being domestic or foreign. Obtaining estimates for total factor productivity (TFP) on the firm level following the approach of Levinsohn and Petrin (2003), various measures for spillover linkages on the industry level are created exploiting data obtained from Input-Output Tables.

Besides only identifying firms on their ownership level and categorizing them into domestic and foreign, another step is applied by identifying the home country of a foreign company as either being a developed or a developing economy. This contributes to the existing literature in a way that not only MNEs are identified, but also the 'quality' of such investment and foreign presence can be accounted for, considering MNEs from developed countries being endowed with more technology than their counterparts from developing economies.

The empirical results confirm the importance of considering a firm's absorptive capacity (ABC) showing the presence of positive and statistically significant effects in the Czech Republic occurring through horizontal linkages. In contrast to that, the opposite effect can be established for Polish companies, which perceive negative horizontal spillover effects. When specifying the origin of a MNE, a positive and significant coefficient manifests itself for backward linkages, once it is accounted for ABC. Therefore, the evidence suggests that various aspects are important and impacting the effect of a local market becoming more and more the playground for MNEs. Not only the technological level and resulting absorptive capacity are found to be crucial factors, but also the origin of the foreign MNE itself.

Chapter 3 intends to shed light on whether MNEs are affected differently from external financial shocks than domestic companies are. With the world economy shaken by the global financial crisis in 2008, it can be established that multinationality and global operations do not necessarily provide enough flexibility to be equipped for strong economic shocks. When taking a more European perspective on this, the sovereign debt crisis can certainly be identified as one of the most significant shocks occurring in the second decade of the 21st century. Facing an issue which was no longer limited to only individual countries by themselves, a response on a European (or rather 'Euro') level had to be found.

Therefore, the European Banking Authority (EBA) announced its 'Special Capital Enhancement Exercise' in late 2011. With various banks now being forced to increase their core tier 1 capital ratio from previously 5 percent to 9 percent by no later than June 2012, a shortage of credit supply towards companies arose, as banks were applying a more restrictive policy regarding giving out loans or financing firms. Therefore, a form of financial pressure manifested itself, with companies themselves already being shaken by the financial crisis which only had happened two years before and its consequently aftermath.

This raises the question, how such financial pressure might impact firms themselves, and in what way the effects of such a shortage of financial access show themselves. Considering the fundamental principles of MNEs and their differences to their domestic competitors, there is a possibility that not all firms are affected by financial pressure in the same way. While MNEs are able to seek new capital or financial opportunities by giving out new stocks and increasing their capital in this way, domestic firms lack of such capabilities. Further, MNEs might be able to provide intra-company loans, for instance with the mother company being located in a country outside of the euro area, and being able to finance their operations in Europe in this way. For this reason, domestic firms might be affected more negatively by this capital exercise conducted by the EBA, taking all the negative consequences.

Chapter 3 analyses the effects of the capital enhancement exercise on firm-level productivity of companies which are operating in the countries which are considered to be a member of the euro zone. A firm-level dataset is created using data obtained from the ORBIS database. After conducting a comprehensive data cleaning procedure, the resulting dataset comprises 12 countries for a time period from 2009 to 2018. Due to poor data quality not all euro countries are included in the final dataset. After estimating the TFP on the firm level following the approach of Levinsohn and Petrin (2003), a measure for financial pressure is created. In order to examine how potential effects might occur depending on the type of firm which is considered, companies are identified by their global ultimate owner, following the same approach undertaken in Chapter 2. However, another distinction is implemented, not only identifying foreign MNEs but also MNEs which are foreign having their global ultimate owner located in a country which is part of the euro zone. Further, a distinction is done by identifying a country as either being considered a periphery country or a non-periphery country, in order to investigate whether certain geographical areas might be more affected than others.

The empirical results find evidence that a negative effect from financial pressure can be perceived, affecting a firm's TFP negatively. In times of the EBA exercise taking place, this effect appears to be even stronger. Surprisingly, MNEs appear to have even gained in their productivity, which can potentially be explained with them being more flexible

regarding accessing capital, and a 'downsizing'-effect taking place as a consequence of the crisis. Further, the effects appear to be stronger in periphery-countries, indicating that firms who operate in different areas of the euro zone differ vastly.

Chapter 4 takes a different perspective on multinationality, investigating how tax policy can shape and impact innovation. Considering MNEs operating on a global level, it can be observed that they are endowed with various ways to respond to certain tax incentives and structure their operations in a way, which allows them avoiding taxation and not being affected by potential changes in the corporate tax rate. Therefore, it raises the questions whether an increase or decrease of the corporate tax rate (CIT) even takes an effect on firms' decisions and characteristics at all. While the literature focuses vastly on the effect of changes in the statutory corporate tax rate (STR) on the effective rax rate (ETR), which is fundamentally the tax being paid, this study contributes to the literature by investigating how CIT changes impact innovation occurring on the firm level.

This bears interesting and important policy implications, as many countries compete vastly by lowering their CIT in order to attract MNEs. Another reason might be that a rather lax tax policy might result in firms undertaking more innovative processes and creating new innovations and technologies, impacting the local economy in a positive way as a consequence. Particularly during the past two decades various regions in Europe implemented certain tax policies which allow tax exemptions or tax holiday regarding innovative activities or research and development. This is commonly referred to as "Patent Box" (see Zegarowicz et al. (2018)).

However, the effectiveness of tax incentives can be rather controversial. With MNEs operating worldwide, their activities might be already allocated in an optimal way. In other words, a European country lowering its STR or implementing a patent box regime might appear quite attractive at first glance, but is not of any interest when having R&D activities already located or set up in a way, that no taxes on resulting outcomes or profits would have to be paid anyways. This effect can be observed with MNEs being located in tax havens in the EU only paying taxes of a neglectable magnitude, when comparing it with their profits obtained on European markets.

As the CTI is not only applied on foreign firms, but also on domestic firms equally, it might be the case that tax increases rather harm the local economy. However, consequently it can also be the case that tax cuts indeed manifest themselves on the innovation activity of domestic firms in a positive way. This is important to consider when it comes to policy changes, depending on what political agenda is currently desired and what outcome is desired to be achieved by the policy makers.

Chapter 4 obtains firm-level data from the AMADEUS database, which is the same set-up of data as ORBIS. However, AMADEUS only provides companies which are operating in Europe, while ORBIS comprises companies operating for all countries in the world. Besides financial and ownership data retrieved from AMADEUS, this study

also considers tax data on both STR and also tax base for all EU member countries. Four sub-samples are created, identifying firms based on their ownership characteristics but also on their size. This might be a crucial factor as well, as smaller firms potentially lack of capabilities to avoid the consequences of changes in the tax system. Due to poor data quality, this study cannot revert to R&D expenditures as a dependent variable and, therefore, uses a firm's intangible assets as a proxy for innovation. Besides that, novel data on patents which are matched to the firms obtained from AMADEUS is included, also examining the effect of tax changes and the presence of a patent box on the number of patents filed by a firm.

The results suggest that a tax increase overall is perceived by firms in a negative and statistically significant way. Surprisingly, tax base changes do not appear to have any significant effect on any type of firms being analyzed. While the presence of a patent box regime appears to have a positive effect on innovation overall, a tax increase under such regime appears to be even amplified. For the number of patents filed by a firm being affected by a change in the CIT, no consistent results can be obtained. This provides more evidence in favor of the argument that patents only reflect innovation to a small degree, as much of innovative processes are not patented in order to remain confidentiality and to avoid revealing secret technology publicly.

This thesis ends with Chapter 5 providing concluding remarks considering all three studies. While the three studies provide interesting and novel insight into the realm of MNEs, FDI, and domestic firms, they also bear important policy implications. Lastly, the limitations of these studies are highlighted and an outlook on potential future research is provided.

Chapter 2

Multinationality and Productivity Spillovers

2.1 Introduction

"Depending on the point of view, multinational enterprises (MNEs) are either the heroes or the villains of the globalized economy" (Navaretti et al., 2004). On the one hand, governments are competing heavily to attract multinationals to invest in their country, as they expect the presence of MNEs and a higher level of inward investment to be beneficial for their economy, local companies, and also for the government budget. On the other hand, they complain when firms come to the decision to become multinational, go global, and shift their activities into other countries in order to enhance the efficiency of certain processes, benefit from less costs, and maximize profit.

During the last two decades, foreign direct investment (FDI) conducted by multinational enterprises (MNEs) has increased enormously over the entire world (see The World Bank (2020) and Figure 1.1 in Chapter 1). As profit from more investment in other countries is not limited to the home country of an MNE, more and more studies also started addressing the effect of FDI on the host economy. FDI is often considered to have a positive impact on the host economy, as it can increase economic growth and stimulate development due to more competition. This is why many countries, developing countries in particular, are tempted to implement policies to attract FDI inflows, by providing tax exemptions or other potential benefits. On the other hand, FDI can be criticized for impacting domestic companies negatively, as they potentially drive local businesses out of the market.

As MNEs are usually more productive and are considered to have a higher level of technology, domestic companies might not be able to adapt to this technology and face the potential problem of not being able to compete and staying in business. Therefore,

it is still controversial whether FDI should be seen as a gift or a curse for domestic companies and the host economy (Navaretti et al., 2004).

Even though most direct investments in the past years had its origin in developed countries, firms from emerging markets have become major investors abroad, changing the general perception of their home countries being recipient of FDI to being rather a source. According to the UNCTAD's World Investment Report 2015, investments coming from emerging economies account for more than 35 percent of the global outward FDI in 2014, comprising $468 billion for that particular year (UNCTAD, 2015). This investment particularly takes place in least developed and transitioning countries. Even though this phenomenon is not new, the magnitude of FDI from developing countries is rather unprecedented.

As this occurrence is rather surprising and new, it raises the question if investment from developing countries might have different effects on an economy compared to the past, when investment was predominantly coming from developed countries. The idea is, that companies from developing countries are significantly different equipped and endowed with technology and production processes as their counterparts from developed countries (see Zhou et al. (2002) and Malik et al. (2012)). Bearing this in mind, the impact on the host economy and domestic firms could be fairly different.

Therefore, the purpose of this study is to investigate whether the origin of FDI matters regarding the occurrence of spillover effects and tries to answer the question if MNEs from developing countries have a different effect on a host country than MNEs from developed countries. Using firm-level data from the ORBIS database on the Czech Republic and Poland from 2009 to 2014, spillover effects are separated based on the origin of an MNE. Using an empirical approach following Javorcik and Spatareanu (2011) it is then demonstrated how different productivity spillovers occur through their respective channels, such has vertically or horizontally (for an overview of the spillover channels see Figure 2.1). It particularly contributes to the existing literature by using an empirical approach which separates MNEs by their geographical location and now transforms this approach in a way to account for the country classification 'developed' and 'developing' country. Further, when estimating total factor productivity a very extensive approach is undertaken to find measures for labour and capital input. This first step is often neglected in studies which estimate total factor productivity, as they refer directly to data retrieved from the ORBIS database, which is then used in the estimation (see Olley and Pakes (1992) and Levinsohn and Petrin (2003)).

Section 2.2 provides a general overview of the theory of FDI and productivity spillovers. It presents the channels through which spillovers can happen and the background information on why absorptive capacity is a major criterium for a firm to benefit for spillovers. Section 2.3 discusses key literature regarding FDI and spillovers and shows the gap in the existing literature this paper intents to fill. In section 2.4 the

used data is presented. After giving an overview about ORBIS and the way the data was retrieved, it is then shown how firm-level data is matched with industry-level data from the World Input-Output Table (Timmer et al., 2015) and how an extensive data cleaning process is undertaken. Section 2.6 shows then the empirical approach. First, it is discussed and presented how in the first step total factor productivity is estimated, while the second part shows a finalized model which is used for empirical estimation. The final results are shown in Section 2.7, including a modification of the model showing spillover effects based on the origin of a foreign company.

The results provide evidence that there are indeed horizontal spillovers occurring for the Czech Republic, while Polish domestic firms suffer from a negative market stealing effect. The results further show the importance of accounting for absorptive capacity when estimating spillover effects. When separating spillover linkages to linkages towards firms from developed countries and firms from developing/emerging economies, it can be seen that effects occur in different ways. Additionally, spillovers through backward linkages can now be identified. This confirms the need of considering the origin of an MNE, as it might be a crucial factor on how domestic firms are able to improve production processes or technological endowment.

2.2 Theoretical Background

This section provides a general overview of the theory of FDI and productivity spillovers. It illustrates how different mechanisms are at work and explains in detail through which channel and linkages spillovers can occur. At last, the relevance of the absorptive capacity is addressed as there is strong evidence that it plays a crucial role for domestic companies to benefit from the presence of MNEs and for spillovers to happen.

2.2.1 The Different Channels of Spillover Effects

Besides investigating how FDI is affecting growth, productivity and capital formation, numerous studies are also trying to assess and investigate the effect of FDI on domestic companies. The main reason for this is that FDI could not only contribute to economic growth in its direct way, but also have a positive impact on domestically owned firms, increase their productivity, and boost growth in an indirect way. These so-called 'spillover effects' can occur in different ways and through different channels and linkages.

Horizontal Effects

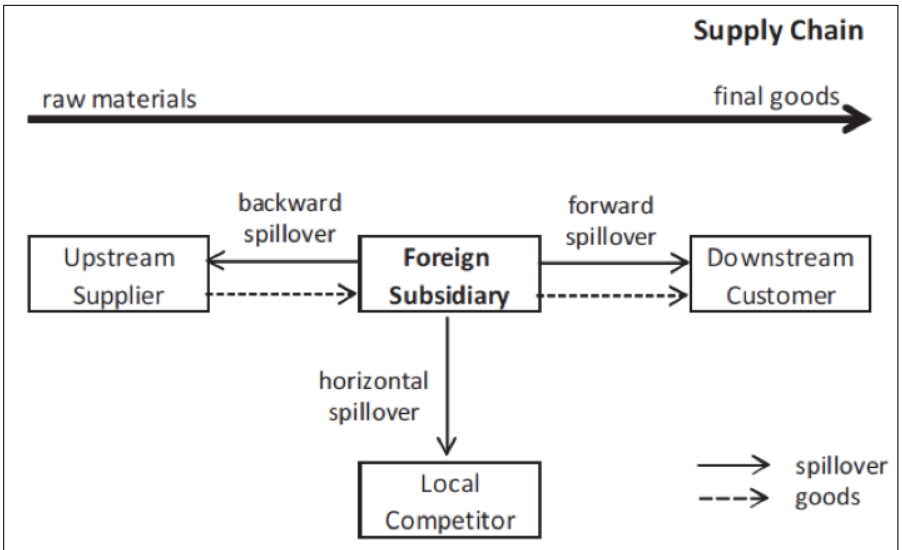
Horizontal spillovers are occurring through either imitation or competition effects. In order to stay competitive with a MNE, a domestically owned company might be copying the same technology the MNE is using in its affiliate and is replicating its production

process. In this case, the domestically owned company is imitating the technology (Görg et al., 2001). Further, a company might be forced to use existing technology and resources in a more efficient way, or conduct more research to find more effective and efficient technologies, due to an increase in competition and more pressure caused by the MNE entering the domestic market. In this case, a company is not imitating the technology of the MNE but rather upgrading their own. Further, Wang and Blomström (1992) highlight the importance of the technology gap between MNE and domestic firms. They argue that companies with a higher level of technology might be more likely to absorb technological spillovers, as they are already equipped with a fair technology level and can upgrade or imitate in a more efficient way. This effect and occurrence is discussed and illustrated in more detail in Section 2.2.2.

Vertical Effects

Besides horizontal effects, spillovers can also occur in a vertical way. This can happen through two different channels, forward linkages and backward linkages. Figure 2.1 illustrates the different types of spillover effects and shows in which direction they occur.

Figure 2.1: *Horizontal, Backward and Forward Spillovers in the Supply Chain*



Notes: This figure illustrates the linkages through which spillovers can occur. While forward spillovers refer to business relations of a MNE to local buyers, backward spillovers refer to the relations with the local suppliers. In contrast to that, horizontal spillovers occur intra-industry through competition in the same sector.
Source: Laenarts and Merlevede (2011)

Forward Linkages

Forward linkages refer to the relationship of the MNE to its local buyers (see Laenarts and Merlevede (2011) and Figure 2.1). Those are firms which use intermediate

or capital goods such as machinery produced by the MNE. Local business partners and distributers can potentially profit from marketing and also knowledge of the MNE. In terms of intermediate products, downstream firms are able to use intermediate goods with higher quality and/or lower prices in their own production process, which enables them to increase their own productivity and to provide the market with final products of high quality. However, studies such as Javorcik (2004) fail to find evidence for spillovers through this linkage and suggest that forward linkages are rather unlikely to be the main source for spillovers to occur.

Backward Linkages

In contrast to forward linkages, which relate to local buyers, backward linkages are referring to the relationship of MNEs to their local suppliers. In order to ensure an efficient production process, a MNE demands high quality products from its suppliers delivered on time (see Laenarts and Merlevede (2011) and Figure 2.1). This could be an incentive for the MNE to provide assistance, technology or information to a local supplier in order to help improving the product or facilitating innovations. Additionally, services and assistance regarding management and organisation processes can be provided. Further, a MNE can encourage and support a supplier in finding new customers and accessing new markets through exporting its products.

Labour Turnover

Labour turnover is another potential channel through which technology can be transferred and disseminated inside a host country. This can happen through demonstration of new techniques to local workers and more on-the-job training. If these workers drop out of the company and decide to seek employment at local firms or to start their own business, these knowledge and skills gets transferred and can be further used and implemented in a domestic company. Globerman et al. (1994) argue that affiliates of MNE usually try to keep such spillovers to a minimum by paying higher wages, which are efficient to prevent local workers to leave the company. Further, expatriate managers can be used in order to avoid the disclosure of secrets to local managers, if this is seen as an unacceptable risk. Gershenberg (1987) finds MNEs to be offering more training to their workers and managers than local private firms do. However, the results show that only a small fraction of job changes is occurring from multinationals to domestic firms. Therefore, it is more common for workers at MNEs to seek a new job at another MNE, which limits the technology via labour turnover to domestic companies (Gershenberg, 1987; Globerman et al., 1994)).

International Technology Spillovers

Besides creating technological spillovers in an indirect way, FDI might also contribute to the generation of innovation and knowledge in a host country, particularly and directly in developing countries. This could happen through the internalisation of the research and development activities (R&D) of MNEs. However, Freeman and Hagedoorn (1992) find that most MNEs are allocating their R&D activities in either their home country or another developed country. They find that only 6 percent of global R&D expenditures are accounted for by developing countries. According to UNCTAD (2015) R&D expenditures are highly concentrated even for developing countries. Estimates show that the top four developing countries, Brazil, China, Mexico and Singapore, account for almost 80 percent of the total R&D expenditures in developing economies.

2.2.2 Absorptive Capacity

Another key element regarding productivity spillovers is the capability of domestic companies to benefit from new technology brought by a MNE. The fundamental concept of absorptive capacity is addressed and outlined in more detail in two studies which are built on each other (Cohen and Levinthal, 1989, 1990)

The Two Faces of Research and Development

Cohen and Levinthal (1989) address that in economic research R&D is mainly perceived as generating a new product, namely new information. Despite that general assumption, they suggest that R&D is not only limited to generating new information but can also have an even more complex impact. Besides generating new information, they raise the assumption that R&D might also enhance a firm's capability to exploit and assimilate already existing information. They argue that this second effect of R&D suggests that the characteristics and effort of learning within a particular industry does not only affect R&D spending itself but also determines the impact of appropriability and technological opportunity conditions on R&D. They challenge the previous general assumption, just as stated by Tilton (1971) that "an R&D effort provided an in-house technical capability that could keep these firms abreast of the latest semi-conductor developments and facilitate the assimilation of new technology developed elsewhere". Considering this perception of R&D, it is argued that R&D indeed generates innovations, however, it further develops and expands a company's ability to identify, assimilate, and then further exploit knowledge which is already existing in the environment. This additional stage of R&D define Cohen and Levinthal (1989) as a firm's 'learning' or 'absorptive capacity'.

While absorptive capacity comprises a firm's abilities to imitate new product innovations and processes, it further includes a firm's ability to exploit existing outside knowledge which shows more of an intermediate character. As an example, basic research findings can be used as a source of knowledge providing the basis for following and subsequent applied research. Additionally, considering that industrial innovation depends on extramural knowledge, absorptive capacity can also represent a crucial part of a firm's capability to create and generate new knowledge. Therefore, absorptive capacity is representing a way of learning that is different compared to "learning-by-doing", which had mainly been the focus of previous literature upon then. "Learning-by-doing" is often referred to as an automatic process in which a firm gains practical knowledge and experience, consequently allowing them to be more efficient at doing a process and practice they have already done before. In contrast to that, absorptive capacity refers to a rather different kind of learning. A firm might be able to acquire and process outside knowledge which allows them to do something quite different and new such as a task which has not been done before.

In their model both the direct effect of the ease and the facility of learning on R&D and also the impact on how spillovers and technological opportunity influence R&D expenditures are considered. Regarding the latter, they find evidence that learning becomes more dependent on a firm's own conducted R&D. Further, increasing spillovers and more technological opportunity rather tends to generate more effort and investment in R&D. They highlight that under some conditions, spillovers might even encourage R&D. As absorptive capacity is considered endogenous, its presence may impact the qualitative effects of the rather traditionally determinants of inventive activity.

They conclude that firms which invest in R&D do not only produce and process innovation. They further develop and maintain a broader spectrum of their capabilities allowing them to assimilate, adapt and exploit external information. Recognizing the dual-purpose of R&D implies that the factors affecting the ease and character of learning affects the incentives of a company to conduct R&D. A main hypothesis in their model is that such factors include the level and extent to which knowledge is linked and targeted to a company's own needs. As another point they see the character of knowledge within each of the existing scientific and technological areas on which innovation depends as crucial. Their model suggests that these factors are exercising both a direct effect on inventive activity but also condition the impact and influence of more conventional and rather traditionally considered determinants. It is further discussed, that previous applied economic research identified technological opportunity and appropriability as the key industry-level determinants of a company's inventive activities. In contrast to that, Cohen and Levinthal (1989) suggest that the influence of both of these variables are mediated and intensified by a firm's capacity to recognize, assimilate, adapt and in a last step exploit information. As the reason for this, they identify the dependency of these two classes

of variables on the assimilation of external knowledge. Hence, those variables affecting the character and difficulty of learning should determine how technological opportunity and appropriability conditions impact R&D expenditures. The results of their study indeed generally indicate that the influence of both appropriability and technological opportunity conditions are driven by determinants of the ease or difficulty of learning. As one of the main determinants they identify the targeted quality of knowledge inputs. This further suggests that these characteristics of knowledge affecting the ease of firm learning potentially represent an important category and determinant of R&D investment.

Observing the tendencies that R&D creates a certain capacity to assimilate and exploit new knowledge sheds new light on several questions. It can be seen as an explanation of why some companies might decide to invest in basic research even when the predominance of findings may spill out into the public domain. As an example, firms could tend to perform basic research not only for the particular results but rather because they want to be able to exploit and benefit from potentially useful scientific and technological knowledge generated by government laboratories, research projects or universities. This allows them to gain a first mover advantage in exploiting new technologies available, before their competitors can exploit them. Similarly, firms might be capable to appear as a rapid second mover in the face of spillovers coming from a competitor's new innovation due to basic research. This point of view has the implication that factors influencing a firm's learning incentives should also affect the incentive to perform basic research.

Besides providing both theoretical and empirical implications, Cohen and Levinthal (1989) emphasize that also lessons for technology policies can be learned. They claim that particularly welfare costs of policies such as patents have been disregarded for too long by policy makers. These costs are restricting the negative incentive effects regarding intra-industry spillovers by providing monopoly power. They compare their results with previous findings of Spence (1986) who highlights a different type of cost. When the appropriability of the rents are increased due to new and innovative knowledge, society forgoes the efficiency effects of spillovers associated with the reduction of unnecessary R&D effort. In contrast to that, Cohen and Levinthal (1989) add a new dimension to the assessment and evaluation of potential welfare effects of patents or other similar policies in their analysis of different roles R&D can play in the ways of how firms are learning. They conclude that this has the key implication that the negative incentive effects of spillovers and therefore also the benefits of implemented policies to ease these effects, might not be as large as it is supposed in previous research and the literature.

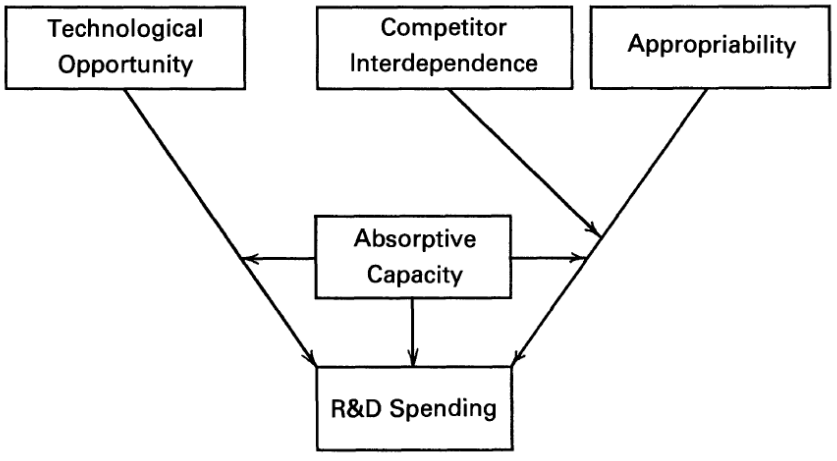
Absorptive Capacity, its Determinants and Linkages

Cohen and Levinthal (1990) introduce the concept of absorptive capacity and define it as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends". They suggest three main assumptions in their model:

- The ability to absorb new technology is based on the level of a company's prior related knowledge and learning incentives are expected to have a direct effect on R&D expenditures.
- Other determinants, for instance technological opportunities, which depend on a company's own or its competitors' assimilation of knowledge, are mediated by absorptive capacity and therefore by learning incentives as well.
- The effect of appropriability conditions are determined by competitor interdependence. The interdependence is defined as the degree to which a competitor's technological advances reduce and diminish a company's profit.

Figure 2.2 represents the principal model of how R&D expenditures are defined and determined by absorptive capacity.

Figure 2.2: *Model of Absorptive Capacity and R&D Incentives*



Notes: This figure illustrates the basic model of absorptive capacity and R&D incentives. It places absorptive capacity in the center when it comes to making a decision on how to determine R&D spending. While absorptive capacity has a direct link on R&D spending, it can be seen that it has an indirect impact as well, namely through its links with technological opportunities and appropriability.
Source: Cohen and Levinthal (1990)

Additionally, there are two factors which affect a firm's incentive to learn and therefore increase the incentive to expand their absorptive capacity via higher R&D expenditures. Firstly, the quantity of knowledge to be exploited and assimilated can be identified as a crucial factor. The more knowledge available, the higher is the incentive to adapt.

Secondly, knowledge is a complex factor which is not always easy to acquire. Some types of information can be more challenging and difficult to assimilate than others, implying that the cost of its absorption may depend on the characteristics of knowledge and therefore vary substantially. When learning and acquiring new knowledge becomes more difficult, a higher level of prior knowledge accumulated via R&D is essential in order to facilitate effective learning. Such a constellation makes learning more costly. In this scenario R&D is a much more decisive factor regarding the establishment of absorptive capacity. Further, more effort and investment into R&D is required to achieve a sufficient level of absorptive capacity. Therefore, the level of absorptive capacity diminishes in an environment where it is more difficult and expensive to adopt new knowledge. A more difficult learning environment is further assumed to increase the marginal effect of a company's R&D on its absorptive capacity.

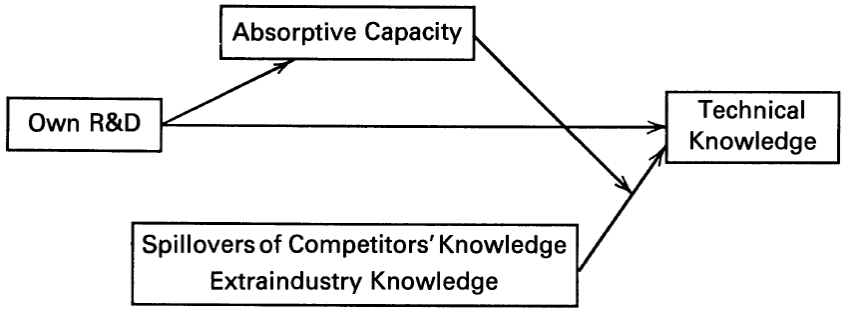
In contrast to that, a less demanding environment for learning is considered to make a company's R&D less effective and to have only a little impact on its own absorptive capacity. As an extreme case, if a firm can assimilate new knowledge without having any type of specialized expertise, investing into R&D would have no effect at all on its absorptive capacity. Cohen and Levinthal (1990) further argue that the complexity of learning is determined by multiple characteristics of the given scientific and technological knowledge. Even though it is challenging to determine and specify all significant characteristics of knowledge impacting the ease of learning, they would comprise the complexity of the knowledge to be incorporated and the level to which the external knowledge is specified and targeted to the needs and concerns of the company. Besides knowledge which is less targeted to the particular needs and concerns of a firm, a firms own R&D efforts are an essential factor regarding recognizing the value of new knowledge, further assimilating it, and finally exploiting it. As an example, a producer of less targeted knowledge could be a university lab which only conducts basic research. In contrast to that, a rather more targeted and specific knowledge producer can be a research lab or supplier of inputs. There is a positive correlation between the extend of how much new findings are built on prior findings and the necessity of understanding previous research in order to understand and exploit subsequent findings. Additionally, the pace of advance of a specific field can also be identified as a crucial determinant of the importance of R&D in order to develop more absorptive capacity. A reason for this is that the faster knowledge is generated the larger the number of employees is which is required to develop new technologies and to keep them up-to-date.

Following a previous approach by Nelson and Winter (1982) it is assumed that unspecific or more sophisticated knowledge is harder to assimilate. The investment of a company into R&D is assumed to be purposely and to generate profit, taking into account both its impact on generating new knowledge and also enhancing absorptive capacity. It is further considered that acquiring new knowledge is useful to a firm as it increases a

company's own knowledge which impacts its profit in a positive way. In contrast to that, a gain of knowledge for a firm's competitor is impacting the profit of a company in a negative way and diminishes it.

Considering these assumptions, Cohen and Levinthal (1990) postulate a simple model on how a company's technological knowledge considers the major source and origin of technological knowledge, which they see as a company's "own R&D knowledge that originates with its competitors' R&D, spillovers, and that which originates outside the industry."

Figure 2.3: *Model of Sources of a Firm's Technical Knowledge*



Notes: This figure shows how own R&D activities can impact technical knowledge in two ways. While there is a direct link to be seen in terms of the resulting technical knowledge, it shows that conducting R&D has a positive impact on absorptive capacity as well. With higher absorptive capacity a firm is more able to benefit from competitors' knowledge in form of spillovers.
Source: Cohen and Levinthal (1990)

Figure 2.3 illustrates a stylized representation of the proposed model. In this model, the firm first generates new knowledge by conducting its own R&D. Secondly, extramural knowledge is drawn from its competitors. Besides that, other extra-industry sources, such as university labs or the government, contribute to a firm's knowledge as well. One main feature of this proposed model is that the extent to which extramural knowledge can be utilized is determined by the absorptive capacity of a firm. This absorptive capacity on the other hand depends on a firm's own conducted R&D.

Considering these linkages and dependencies, a mediating function can be identified. The different effects of technological opportunity conditions and appropriability on R&D expenditures are influenced and considerably determined by absorptive capacity. Therefore, the effects originating from both appropriability and technological opportunity are autonomous and clearly depend on R&D.

One of the key assumptions in this model is that the interaction of a company's absorptive capacity with its competitor's spillovers enables the company to exploit its competitors research findings. This particular interaction implies that a firm is not capable to assimilate externally available knowledge in a passive way but rather only in an active one. In order to take advantage of the potentially available R&D output

of one of the firm's competitors, a firm is investing into its absorptive capacity. This is accomplished by conducting its own R&D.

Further, Figure 2.3 illustrates that similarly to its assimilation of the R&D output by its competitor's, a firm absorption of extra-industry knowledge is impacted and constrained by its absorptive capacity. However, it is important to consider the dimension of technological opportunity in this particular linkage. Therefore, according to the suggested model, all the factors which are impacting and determining learning incentives are influencing the different effects of appropriability and also conditions of technological opportunity on R&D.

The results of their empirical analysis suggest that firms are indeed sensitive to characteristics and aspects of the learning environment in which they are operating. Therefore, absorptive capacity can be seen as a part of a firm's planning process of allocating their resources for innovative activity. The benefits of absorptive capacity are happening in an indirect way and absorptive capacity itself is intangible. This is why, despite their findings, they stress that the appropriate level of investment in absorptive capacity is unlikely to be reached. It is more likely to be maintained or generated as a by-product of activities which are done on a regular basis or routines when the field of knowledge a firm wishes to exploit is strongly linked to its present knowledge base.

In contrast to that, a company has to dedicate and spend its efforts exclusively into creating its absorptive capacity when it desires to acquire, exploit and use new knowledge which is not related to any ongoing activity the company currently conducts. In this case, absorptive capacity is not a by-product but intentionally generated and developed. However, in this particular scenario absorptive capacity might not even be considered and thought of as an investment alternative. Even if it is considered as such, a company might tend to be quite reluctant to sacrifice its output or potential gains from specialization, because of the absorptive capacity's intangible nature. While their results and discussion address essential features of organizational structures which impact and determine a firm's absorptive capacity they leave the decision process which determines an organization's investment in its absorptive capacity as a gap in the literature.

2.2.3 Absorptive Capacity in the Context of FDI

While it is key to understand the fundamental idea of absorptive capacity it is yet a quite theoretical approach and rather abstract. In order to put the ideas of Cohen and Levinthal (1990) into the context of companies, productivity levels and multinationality, this section will use a more illustrative approach. It should be noted that this illustration is rather simplified and exaggerated, however, it is very useful to understand the idea of absorptive capacity which is applied in the model used in this study.

Even though R&D expenditures appear to be a good proxy for a company's absorptive capacity and is widely implemented in the literature, there are some limitations which have to be considered. Depending on the data source and quality of firm-level data, R&D might not be suitable as a measurement as it would result in excluding too many companies and shrinking the dataset significantly. Therefore, another method of considering a firm's capability of exploiting new technology can be applied. Girma et al. (2008) suggest a method which does not require data on R&D investments and allows to include companies which did not provide data for this. In a first step, they estimate a firm's total factor productivity (TFP), and then set it in ratio to the most productive company operating in their own industry.

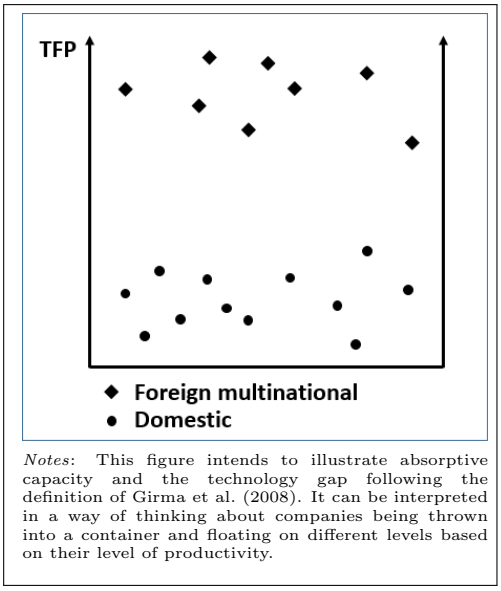
$$ABC_{ijt} = ln(\frac{TFP_{ijt}}{TFP_{jt_{max}}})$$

TFP_{ijt} is the total factor productivity of firm i operating in industry j in year t. $TFP_{jt_{max}}$ refers to the maximum total factor productivity in industry j in year t. This can be seen as a proxy of how large or small the difference between one's own productivity level and the productivity level of the most productive firm is. This difference is referred to as the productivity gap.

Figure 2.4a intends to present the concept of absorptive capacity in an illustrative way. One can imagine a container representing a country with firms floating on different heights based on their own productivity levels. Foreign multinationals are illustrated as diamonds and domestic firms indicated as dots. While the Y-axis shows the level of TFP a particular company has, the X-axis has no label and no particular meaning in this illustration. Following the assumption that foreign multinationals are endowed with more advanced and sophisticated technology it can be observed that foreign owned firms are more productive than indigenous companies (see Kokko (1996) and Barrios and Strobl (2002)). In this particular example, the productivity is rather large. Therefore, in this scenario it might be impossible for domestically owned firms to gain from potential productivity spillovers, as the gap might just simply be too large (see Figure 2.4b). One could think of magnets which are too far to attracting each other.

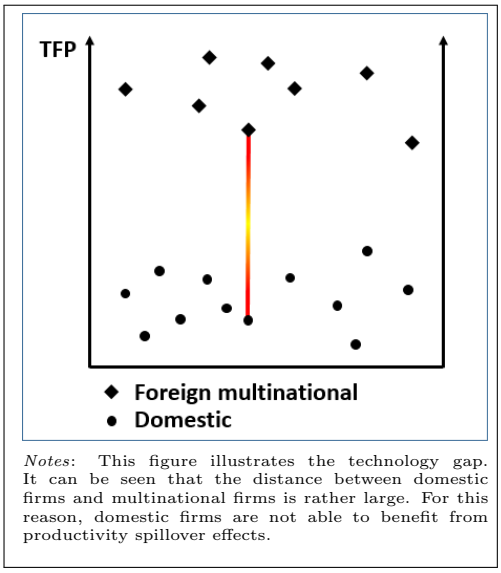
Here the distance between a domestic firm and a foreign firm is too large, disabling them to adapt new technology. This particular example shows a situation which potentially occurs in most developing countries or least developed countries. The productivity level of the indigenous companies is too low to gain from spillovers. Even though new investors are entering a market and foreign capital, which is associated with new technology and innovation, is brought into the country, domestic firms are not capable to benefit from such. The reason for this is that they are not developed enough and only endowed with a very low level of technology.

Figure 2.4: *An Illustrative Example of Absorptive Capacity*



Notes: This figure intends to illustrate absorptive capacity and the technology gap following the definition of Girma et al. (2008). It can be interpreted in a way of thinking about companies being thrown into a container and floating on different levels based on their level of productivity.

(a) *Firms and their TFP*



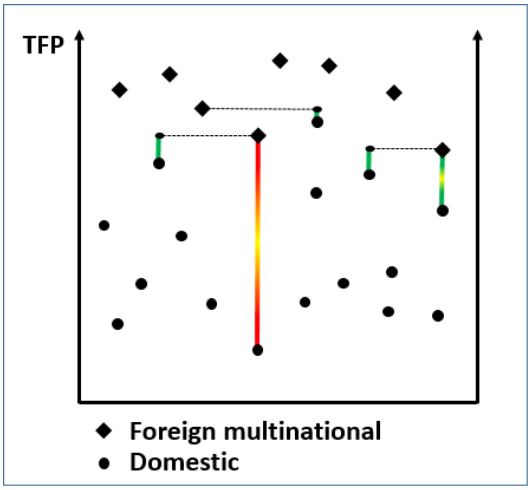
Notes: This figure illustrates the technology gap. It can be seen that the distance between domestic firms and multinational firms is rather large. For this reason, domestic firms are not able to benefit from productivity spillover effects.

(b) *Example: Developing Country*

The literature identifies this phenomenon as the main reason why simply attracting FDI might not be efficient at all and does not necessarily mean that local companies get more competitive and become more productive (Rugraff, 2008). Instead of solely attracting FDI by implementing policies such as financial incentives or tax exemptions it is also key for the indigenous economy to receive strong governmental support in order to develop and build up industries. Well established domestic firms with higher productivity and a more technological endowment show higher potential to benefit from spillovers through FDI. Rugraff (2008) reflects two different types of FDI-policy approaches. He defines the FDI policies implemented by Ireland as the Irish-Model and another approach summarizing policies of Taiwan, Korea and China as the TKC-Model. While the TKC-Model has been building up rather large and internationally competitive domestic companies in several industries the Irish-Model predominantly put its focus on attracting large amounts of inward-FDI. While most of these investments were done in high-technology industries, most Irish indigenous companies are operating in low-technology industries. He sees that as the reason why "spillovers to indigenous firms from huge amount of inward FDI over 30 years have been disappointing" (Rugraff, 2008).

Figure 2.5 illustrates an extension of Figure 2.4 . Again, domestic firms and MNEs are allocated regarding their TFP. Similar to Figure 2.4a, domestic companies are still less productive than MNEs. However, they show a higher level of productivity than in

Figure 2.5: *Example: Developed Country*



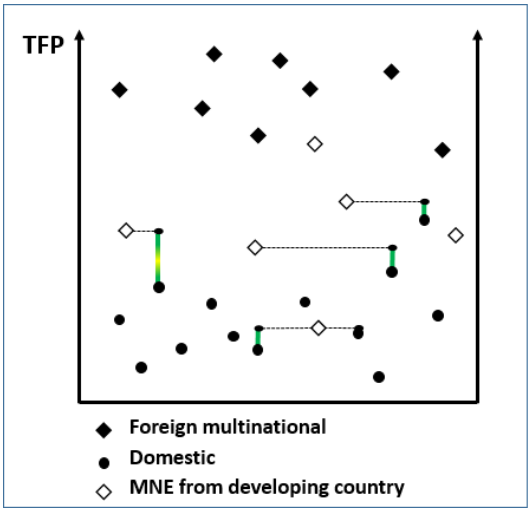
Notes: This figure continues along the assumptions illustrated in Figure 2.4 following the definition on absorptive capacity and technology gap of Girma et al. (2008). It now includes domestic firms with a higher TFP. It can be seen that some firms are close enough to the TFP of foreign multinational firms. This enables them to benefit from spillover effects. One can think of magnets which are now close enough to attract each other.

the example of Figure 2.4a and Figure 2.4b. This can be seen as an example of firms performing and operating in developed countries. Even though productivity levels of indigenous firms are still lower, some companies are able to adapt new technology and gain from spillovers. For many companies the productivity gap can still be too large and therefore prevent them from benefiting from spillovers, however, some domestic firms are established and developed enough, allowing them to face a rather small productivity gap. Under these circumstances spillovers are facilitated and are more likely to occur.

Besides domestic firms and MNEs, another type of company is introduced in Figure 2.6, namely multinational companies from developing countries.

This is of particular interest as it has not been researched whether the origin of a foreign company plays a significant role for spillovers to occur. Especially the question whether investors from developing countries might create different effects compared to investors coming from developed countries has not been asked and investigated yet, which leaves it as a gap in the literature. One can see a similar scenario, having domestic companies with a relatively low TFP and MNEs with high-technology being very productive. Additionally, MNEs from developing countries are more productive than domestic firms, yet not significantly more. Having this in mind, the productivity gap for domestic firms might actually be small enough for them to gain from new technology as it is less costly and it takes less effort for them to adapt new technology from these foreign companies. Bearing this concept of absorptive capacity in mind, the origin of a MNE

Figure 2.6: *Example: MNEs from Developing Countries*



Notes: This figure continues along the assumptions illustrated in Figure 2.4 and Figure 2.5 following the definition on absorptive capacity and technology gap of Girma et al. (2008). However, it is now extended by including MNE from developing countries. Following the assumptions of such companies being endowed with a smaller level of technology as their counterparts from developed countries, more domestic firms are now able to benefit from productivity spillovers. This is because the technology gap between domestic firms and MNEs from developing countries is smaller than the one domestic firms have with MNEs from advanced countries.

could indeed matter and be a crucial factor to consider when it comes to implementing certain policies.

2.3 Literature Review

This section reviews the key literature on FDI and productivity gains to domestic companies. Productivity spillovers can be seen as a very essential aspect and element to consider when it comes to designing and implementing policies to attract inward FDI. There is a large number of studies existing, trying to examine and investigate the magnitude of FDI spillovers, particularly for developing countries. This is because FDI inflows are considered to have a positive effect on the host economy and can rapidly boost economic growth in less developed countries. However, several studies in the literature research spillover effects occurring in developed countries, as companies located there might be able to absorb technology more easily which facilitates spillovers to occur and makes them more likely to happen. Even though the results found in the bulk of literature vary largely, there is a visible tendency that similar results are occurring when the studies are using the same econometric approach. Further, the concept of the absorptive capacity established itself in the literature in the past decade and is now seen as a key element for spillovers to happen.

2.3.1 Overview and Key Literature on FDI Spillovers

While the idea of horizontal spillover effects was developed quite early, the focus on vertical spillover linkages was considered rather late. This literature review highlights the first existing literature on FDI and related spillovers, focusing solely on horizontal effects. Then it introduces and presents literature going one step further and including vertical spillovers as well, additionally to horizontal effects.

Intra-Industry Spillovers - The Idea of Horizontal Linkages

The first study assessing the impact of FDI on productivity of domestic firms is based on cross-sectional data and finds positive results. Caves (1974) examines the effect of foreign presence on the productivity level of domestically owned firms in both Canada and Australia, using value-added per worker as a proxy for productivity and conducting several OLS regressions. Even though he does not find any significant results for Canada, he finds a positive effect for Australian companies, using data for two years, 1962 and 1966 on a 2-digit level which comprises 49 industries. His results suggest that the disparity of value-added per worker between foreign companies and domestic firms disappears, as the foreign presence in a sector rises. This is consistent with the idea of positive spillovers caused by direct investment. For Canada he explains the insignificant effect as a result of Canadian tariffs and poor data quality. He concludes that his results provide evidence for spillover effects to be existent and suggest further research about their origin and determinants.

Globerman (1979) replicates the study of Caves (1974) using a similar approach and investigates Canadian companies from 49 different manufacturing industries for the year 1972. He extends the model of Caves (1974) and controls for capital intensity in his OLS-estimation of labour productivity. His findings show a positive and statistically significant effect of FDI on the productivity level of Canada, contradicting previous results found by Caves (1974). However, his positive findings seem to be rather weak as none of the proxies for foreign presence he uses in his model in a particular sector are statistically significant at a five percent level. He concludes that spillover effects do indeed occur in Canada and that his results show stronger support of the spillover-benefits hypothesis than the previous study conducted by Caves (1974). It is important to highlight that neither of these studies account for absorptive capacity and that the lack of spillovers in Canada might be explained by a low absorptive capacity of domestic firms.

One of the first studies investigating productivity spillovers in developing countries is carried out by Blomström and Persson (1983).Using data for the Mexican manufacturing industry comprising 215 industries on a 4-digit level for the year 1970 a OLS-regression is conducted with value added divided by the number of employees as a dependent variable. Their results show that the hypothesis, that labour productivity of domestic companies

in an industry is positively related to foreign presence in the same industry cannot be rejected. They confirm previous studies by finding a positive and statistically significant effect. However, they highlight that inter-industry spillovers are not considered in their study and argue that there is no reason to assume that suppliers of MNEs from other sectors would not be exposed to a positive effect.

Blomström (1986) investigates the effect of direct investment on structural efficiency, again using plant-level data for the Mexican manufacturing sector at a 4-digit level for the year 1975 comprising 145 industries. He finds positive and significant effect derived from OLS-estimates, arguing that industries which are dominated by MNE are more efficient on average and that average companies are more likely to come closer to best-practice firms. Further, he finds efficiency being positive related to a Herfindahl Index, an index of plant concentration. He argues that this index could reflect economies of scales, rather than the market power of MNE.

Examining spillover effects in Mexico, Kokko (1994) is able to include a measurement for the technology gap between indigenous companies and foreign owned firms. He applies a dataset comprising 230 4-digit manufacturing industries for the year 1970 and defines the technology gap as the average labour productivity of foreign owned subsidiaries in proportion to a domestic company's own labour productivity for each sector individually. Conducting an OLS-regression, he finds empirical evidence that foreign presences has a much larger impact on productivity in sectors where domestic firms have a small or moderate productivity gap. As a potential policy implication he suggests that merely attracting FDI through tax incentives does not necessarily result in higher productivity for indigenous firms. It would be more advisable to improve the capability of locally-owned firms to identify and employ new technology.

In a following study, spillovers occurring in Mexico are further researched by Kokko (1996).Applying the same data as in Kokko (1994), which comprises 230 4-digit industries for the year 1970, he confirms previous studies and finds a positive and statistically significant effect of foreign ownership on labour productivity at the industry level. Even though he carries out another econometric approach and conducts a 3SLS regression, his results are in line with the findings of Blomström and Persson (1983) and provide more evidence of spillover effects in the Mexican manufacturing industry. He further highlights the importance of the Wang-Blomström-Model that "the extent of spillovers is not determined by the degree of foreign precens alone. Instead, the results are related to a firm's investment decision" (Wang and Blomström, 1992). In other words, the more a company invests into new technology, the more potential it has to gain from productivity spillovers as the technology gap diminishes. He concludes that this can be seen as a potential reason for other studies to fail in finding spillover effects.

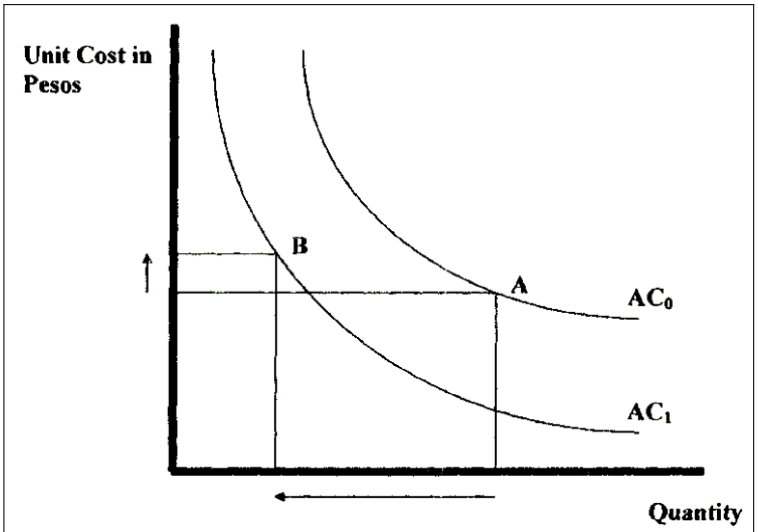
Considering the importance of the productivity gap and the findings of Kokko (1996), Barrios and Strobl (2002) highlight that Spain as an industrialized country

shows more potential for productivity spillovers to occur, as local Spanish firms have a greater absorptive capacity compared to domestic companies in developing countries. Their dataset comprises more than 11,400 observations consisting of 2,100 companies in the manufacturing industry with more than 200 employees for the years 1990 to 1998. Without controlling for sector-specific time-invariant effects in the OLS-estimation, they find foreign presence to have a negative effect on general productivity level of firms, indicating that any positive productivity spillovers are outweigh by a negative competition effect. When controlling for these effects, they find foreign presence to have a positive effect on productivity, underlining the theory of Aitken and Harrison (1999) that foreign companies are more likely to locate in certain sectors. Therefore, they include measures for market concentration and market openness. They find both openness and concentration to be statistically significant and positively correlated with total factor productivity, indicating that a greater degree of access and exposure to foreign markets and greater market concentration increase a firms' productivity. Additionally, they include measures for the absorptive capacity of a company and use the fact of whether a company conducts R&D and exports as proxies. Their results suggest that R&D active companies are neither more productive than companies which do not conduct R&D, nor they are able to benefit from FDI externalities. In a next step they use export as a proxy for absorptive capacity and find that TFP of domestic companies increases by 5 percent if foreign presence increases by 10 percent. They conclude that spillovers depend on multiple factors and highlight the importance of changes in the access to foreign markets and internal concentration. Finding companies which are more productive to benefit more from foreign presence, they conclude that a higher absorptive capacity is a crucial factor for a firm to benefit from positive externalities. However, they emphazise the difficulty to choose a suitable proxy to measure such capacity.

Aitken and Harrison (1999) are expand the literature by linking spillovers to two different opposing effects. They use annual census data on more than 4,000 companies in Venezuela for the time period from 1976 to 1989 with a total of more 69,000 observations, in order to assess the effects of foreign ownership on productivity. Their model consists of two offsetting effects, considering direct investment having potentially a positive but also a negative effect. Besides domestic firms benefiting from technology transfer from MNE, they also consider a reduction of productivity. Figure 2.7 shows the framework of the two effects.

All companies in the market face fix costs in their production. Further, foreign firms are more likely to have lower marginal costs which makes them more competitive. This provides an incentive for foreign firms to increase their production relative to domestically owned competitors. Further, this results in domestic firms being forced to cut their production because foreign owned MNEs are drawing demand from them and are gaining a larger market share. If the productivity decline caused by this demand-effect is quite

Figure 2.7: *Output Response of Domestic Firms to Foreign Entrants*



Notes: This figure illustrates the market stealing effect. Moving from average cost curve AC_0 to AC_1 a firm is able to produce at a lower unit cost. However, with a smaller market share due to MNEs entering and dominating the market, this firm would now produce less goods at a higher unit price than it did before on AC_0.
Source: Aitken and Harrison (1999)

large, then the net productivity of domestic firms can decline in total, even if MNEs are transferring technology. In this case the positive spillovers caused by technology transfer are outweighed by the effect caused of the decline in sales. A domestic company faces the average cost curve AC_0 and produces a quantity of goods to respective unit costs at Point A. As technology from a foreign company gets transferred, the domestic company's average cost curve falls, shifting from AC_0 to AC_1, which is a positive spillover effect. However, more competition caused by the foreign firm entering the market is forcing the domestic firm to reduce its output, moving up on its new average cost curve AC_1 and ending up at Point B. Here, the domestic firm produces a lower quantity to higher unit costs than it did previously at Point A and ends up worse off. In the literature, this is often referred to as a market stealing effect or a competition effect. In their empirical results, Aitken and Harrison (1999) find two main effects of the impact of FDI on the productivity of companies in Venezuela. On the one hand, they find that firms with larger foreign equity participation are exhibiting positive productivity. On the other hand, pure domestic companies in sectors which are showing a large amount of foreign ownership are significantly less productive than domestic companies in sectors with less foreign presence. Further, they distinguish between companies of different sizes in order to examine possible differences of the occurrence of spillovers.

While controlling for industry fixed-effects the OLS-results indicate that only smaller firms are affected in a negative way by the amount of direct investment in a sector, suggesting that smaller companies are suffering more from the market stealing effect and are less likely to stay competitive. Even though they address that investment in R&D

is a major element that contributes for spillovers to be present, it is not accounted for in their estimations.These results are in line with the assumption that the productivity gap between a domestic and multinational firm is essential when it comes to spillovers. As smaller companies suffer more from the market stealing effect it can be assumed that this is due to a high productivity gap. Small companies might simply not be big enough and do not have a sufficient level of technology to stay competitive with MNEs entering the market with new technology.

Inter-Industry Spillovers – The Idea of Vertical Linkages

While previous studies undertake the approach to investigate spillovers occurring horizontally, Javorcik (2004) contributes to the existing literature by introducing spillovers vertically. Using panel data consisting of more than 11,300 observations covering 4,000 Lithuanian firms for the years 1996 to 2000 she examines whether foreign presence is correlated with the productivity of domestic firms in downstream sectors and upstream industries. She argues that foreign affiliates might have an incentive to prevent technological spillovers and sees vertical spillovers more likely to happen as foreign and domestic companies are operating and competing in the same market. Therefore, a foreign company does not have any incentive to allow technological spillovers to happen and is more likely to prevent technology leakages. In contrast to that, she sees no reasons for a foreign affiliate to limit vertical spillovers. As foreign companies are benefiting from an improved performance of their intermediate input suppliers, they have no incentive to prevent or limit technology diffusion to the upstream sector. This is why she sees backward linkage as the channel with the most potential for spillovers to happen. Applying an OLS-regression with White's correction for heteroskedasticity, the obtained results show two major findings. Firstly, she finds a positive and significant relationship between the productivity of domestic firms and the extent of contacts with foreign companies as customers. This result provides evidence for the existence of positive spillovers caused by FDI occurring through backward linkages. Secondly, she does not find any evidence that the productivity of Lithuanian firms is correlated with foreign presence in the same industry or with the existence of foreign firms as suppliers of intermediate inputs. Therefore, the empirical analysis does not show any robust evidence for spillovers to occur through forward linkages or through the horizontal channel. This result is in line with previous firm-level studies finding no evidence of intra-sectoral spillovers in developing countries. Potential explanations for that could be both, a high productivity gap between domestic firms and multinationals or the market stealing effect outweighing the competition effect.

Barrios et al. (2004) expand a previous study by Barrios and Strobl (2002) researching efficiency spillovers in Greece, Ireland and Spain. They highlight that especially Spain

shows a high intensity of inward FDI in the early 1990s, representing two percent of its GDP on average. While they see policy incentives as a reason for FDI in Greece and Ireland, they argue that the massive FDI inflows in Spain are accounted for by a broader financial and trade liberalization process of the Spanish economy. Using the same firm-level panel data for Spain as Barrios and Strobl (2002), the dataset gets extended with over 2,300 Greek and 400 Irish firms in the manufactoring industry for the years 1992 to 1997, resulting in 6,730 total observations. The purpose of the analysis is to investigate how foreign presence impacts on labour productivity of domestic firms applying both a regular OLS and also an OLS first-difference estimation. They highlight the importance of controlling for sector-specific time-invariant effects as foreign presence might be generally higher in more productive sectors, such as in high-technology sectors. Their findings provide evidence for spillovers in Spain and Ireland, but no statistically significant effect for Greece. However, they highlight that this might be due to the fact that they define a company as "foreign owned" when more than 50 percent of its capital is owned by non-residence and also the absence of smaller companies in their data set due to a lack of data availability. This is crucial as smaller companies might be more responsive to spillovers. Additionally, they find companies with the technological ability to absorb spillovers to be more likely to benefit from multinational firms operating in their particular sector confirming previous results. Again, export is used as a proxy for absorptive capacity as they assume a company being exposed to foreign markets is very likely to already have a higher level of technology compared to companies which do not export and only operate in the local market.

Following the approach of Javorcik (2004), Girma et al. (2008) examine all types of spillovers, horizontal spillovers and also vertical spillovers through either forward or backward linkages. They use firm-level data from the manufacturing sector in the UK for the years 1992 to 1999, comprising 18,000 observations from more than 4,600 firms. They extend the literature by including a measure for the absorptive capacity of domestic firms, considering that more productive companies are more likely to benefit from spillovers than less productive firms. More specific, they put a company's own level of TFP in proportion to the TFP-level of the most productive company for each sector individually. In order to estimate TFP on the firm-level the approach of Olley and Pakes (1992) is applied. Further, they split domestic and also foreign companies into two different types, namely export oriented and non-export oriented companies. Their novel approach can be described as being the first one distinguishing between the particular type of FDI - vertical FDI and horizontal FDI. This allows them to investigate not only how but also what kind of foreign presence impacts total-factor productivity of domestic firms in more detail.

Their results show significant and positive spillovers from export-orientated MNE to exporting domestic companies, indicating horizontal spillovers stemming from vertical

FDI. For non-exporting domestic firms, there is no evidence for technology transfer to be seen. As a possible explanation Girma et al. (2008) argue that domestic exporters have a better organizational structure, management with more skills, are generally more productive and therefore able to absorb spillovers more effectively. These results are in line with the assumption and empirical findings (Barrios and Strobl, 2002; Barrios et al., 2004) that export orientation is beneficial for a company to benefit from productivity gains through spillovers. Additionally, they do not find any horizontal spillovers stemming from domestic-orientated MNEs. Those are companies trying to enter the local market rather than only exporting their final product, which can be seen as an indicator for horizontal FDI. This suggests that horizontal FDI is increasing competition on the domestic market and that the market stealing effect is predominant, outweighing potential positive externalities.

When it comes to vertical spillovers, they find positive effects through backward linkages from domestic market-oriented MNEs to both domestic exporter and non-exporters. Again, the results show that the absorptive capacity is a crucial determinant and higher for domestic exporters than for non-exporters. Further, it might be possible that MNEs pick upstream suppliers which are more productive and already have a substantial technology level in general in order to ensure to get intermediate inputs of high quality. Therefore, the technology gap for these domestic firms in the upstream supply level might be smaller in general and they are capable to benefit from spillovers. This is in line with the results of Javorcik (2004) for Lithuania, supporting the evidence that foreign companies affect the productivity level of their local suppliers.

When investigating export-oriented foreign firms (VFDI), they find MNEs having a negative impact on the productivity of their local suppliers. As a possible explanation they see MNEs having a greater bargain power than their domestic suppliers. Even though spillovers get transferred through backward linkages they might demand a lower price for intermediate inputs, hindering any increase in productivity or output. Additionally, they cannot find any evidence for the presence of vertical spillovers through forward linkages, neither for export-oriented MNEs (VFDI) nor for domestic market-oriented multinationals (HFDI). This is in line with the findings of Javorcik (2004) who does not find any robust evidence for spillovers to be present through forward linkages in Lithuania. Girma et al. (2008) conclude that export-orientation is a crucial factor for both foreign firms and domestic companies. This highlights that spillovers might be more likely to occur when vertical FDI is conducted (export-oriented MNE) and that exporting domestic companies are more likely to benefit from technology transfer, due to a higher absorptive capacity.

Using firm-level data for more than 60 countries worldwide, Fons-Rosen et al. (2013) intend to quantify the causal effect of FDI on total-factor productivity. Their data includes both developed and also merging economies over the period from 1996

to 2008 including more more than 400,000 observations for 62,000 companies. Other than in most previous studies, considering foreign presence with an indicator variable, their rich dataset allows to see the exact percentage of foreign ownership. This allows them to analyse heterogeneity in direct investment. In their results obtained from a GLS-estimation, they hardly find evidence for MNEs to be more productive than domestic firms and see positive selection as a reason for the positive correlation between foreign ownership and productivity. When it comes to spillovers they find positive and significant horizontal effects from MNEs to domestic firms in developed countries. However, those spillovers seem to be one-to-one offset by negative market stealing effects due to more competition. For emerging economies, they find negative horizontal effects, indicating that the competition effect is predominant and domestic companies are unable to absorb spillovers. Domestic suppliers seem to benefit from foreign presence, indicating vertical productivity spillovers through backward linkages. However, these effects seem to be minor. They conclude that direct investment might still enhance economic growth and generate employment, even though their results do not provide any evidence for total productivity to be affected by the presence of FDI. Their results support the assumption that companies in developed countries show higher potential to gain from technology transfers as they are on average more productive and have a higher level of technology than companies in developing or transitioning countries (Barrios and Strobl, 2002).

Tomohara and Yokota (2013) attempt to answer the question whether FDI supports the process of economic development in host countries. A firm-level dataset is constructed for more than 6,000 companies in Thailand between 1999 and 2003, comprising over 24,000 observations. They emphasise the importance of distinguishing between different characteristics of domestic companies when it comes to examining FDI benefits. They put their main focus on identifying conditions under which an indigenous company can benefit from different spillovers effects. In order to shed more light onto this, local firms are split into different subgroups. Depending on a company's ratio of exported output to total output, they identify a firm as either export-oriented or market oriented. The same is conducted to distinguish between high-imported material and low-imported material ratio using intermediate materials as a variable. An additional split depending on a company's age and also on its size measured with number of employees is conducted. This follows the idea of Barrios et al. (2004) and Girma et al. (2008) that export-orientations seems to be a relevant factor for a company to absorb new technology. This assumption is further expanded by investigating companies which import most of their intermediate inputs. Controlling for fixed-effects on the firm-level, their results show indeed that different types of local companies benefit from spillovers through different channels. Particularly the export-oriented split gives insight into the different channels through which spillovers arise. While vertical-forward spillovers seem

only to appear for export-oriented firms, horizontal and vertical-backward spillovers can be identified for market-oriented establishments. Observing the magnitude, they highlight that productivity gains for export-oriented domestic firms appear to be larger than the ones which can be observed at market-oriented companies. This again supports the assumption that domestic companies conducting export are able to benefit more from spillovers confirming previous studies. They conclude that their approach of splitting the sample into sub-groups can be applicable in numerous of situations, however, due to poor data quality this could not be conducted. As another distinction they suggest to investigate how spillovers vary depending on different degrees of foreign ownership which could be attractive for further research.

There are numerous studies investigating whether there are positive productivity spillover effects to the host economy stemming from the presence of MNE. It is clear to see that the literature shows very mixed results and evidence for spillovers to be present. However, these disparate findings can, at least partly, be explained by the different natures of estimation techniques and also the nature of the data. Generally, there is very strong evidence that a company's absorptive capacity is playing an important role for spillovers to occur. Further, export-orientation seems to be strongly linked to a higher level of technology and TFP which lowers the productivity gap and increases the capability of a domestic company to benefit from spillovers. Controlling for sector-specific effects seems to be another key point when it comes to choosing an appropriate estimation method. Additionally, vertical backward spillovers seem to be the most likely channel for spillovers to arise. For horizontal and forward spillovers the literature finds only very little evidence.

2.3.2 FDI Spillovers in Eastern European Countries

The literature on FDI spillovers occurring in Eastern European countries is extensive. As most of these countries had only been insufficiently developed in the late 20th century and were passing through economic and political development in the 1990s they became very attractive to be researched. Despite the vast literature, the findings for productivity spillovers stemming from FDI in CEECs is still inconclusive. A potential reason for that could be different econometrical approaches and time periods used for the firm-level dataset used in the analysis.

There are multiple reasons why inward FDI into transition countries in Eastern Europe is perceived positively by its policy makers (Konings, 2001).The effect of FDI on hardening budget constrains can be one of them. The financial linkages between government and a domestic company shirks with a higher foreign participation in equity of indigenous companies. This could potentially lead to harder budget constraints and therefore result in better performance (Dewatripont and Maskin, 1995). Further, the desire for strategic restructuring in transitioning or developing country can be a reason

for promoting FDI. Particularly Eastern European countries which had been part of the former Soviet Union were characterized by obsolete and old production processes and outdated insufficient machinery. In order to be competitive in a new market environment, strategic restructuring and improving efficiency became essential for domestic firms. This could mainly be achieved by updating both old production processes and equipment. One tool to conduct the process of restructuring can be foreign investment. Multinational companies possess both finances and technological know-how and equipment to trigger and boost this development. Additionally, foreign equity participation in local companies could impose an efficient corporate governance in privatized firms which might be averse to restructuring. As a third reason, why emerging countries perceive foreign investors in a very positive way comes from the assumption that multinational companies transfer knowledge and technology to indigenous firms, also referred to as spillovers effects. Even though transitioning countries in Eastern Europe have been studied extensively, results seem to vary vastly. The literature finds that, besides differences in estimation techniques and sources of data, the absorptive capacity of indigenous firms seems to be a major factor.

Kinoshita (2000) highlights the significance of the absorptive capacity and the importance of R&D expenditures for technology spillovers. She focuses on the "two faces of R&D", that is, innovation and absorptive or learning capacity. The main idea of those two faces is proposed by Cohen and Levinthal (1989) suggesting that R&D is not only essential for stimulating innovation but also a key factor to exploit outside knowledge and adopt new technology. In her analysis, she considers two channels. The direct channel impacts productivity by more innovation, the indirect channel increases the absorptive capacity which potentially induces a greater extend of spillovers. Using a firm-level panel dataset on the Czech manufacturing sector from 1995 to 1998 consisting of around 1,200 observations, she analyses both the effect of foreign presence and also the impact of R&D investment on TFP of a company conducting an OLS-regression while controlling for sector fixed-effects. Foreign presences is indicated by a dummy variable when more than 50 percent of a company's equity is held by foreign investors. Additionally, foreign presence for each sector is controlled for with a variable indicating the share of employment by foreign firms to total employment. The results show that once the indirect learning effects are accounted for in the model, the direct effects of R&D investment on TFP growth become insignificant. Foreign presence within a company and foreign presence in a sector show no statistical significance by themselves. However, once foreign presence in a sector is interacted with R&D investment, it becomes statistically significant and positive. This indicates that the indirect effect of R&D expenditures is far more important than its direct effect, implying that R&D plays a key role for intra-industry spillovers to occur. Further, the respective industry a company operates in appears to be a significant factor for spillovers as well. While oligopolistic sectors such as radio and TV or electrical machinery show a high responsiveness to spillovers,

firms in less oligopolistic sectors do not show any significant results, despite the large presence of foreign investors. These results suggest that the absorptive capacity is a key determinant for FDI spillovers to occur and that not every industry can benefit from them equally. Her findings are in line with previous literature such as Kokko (1994) or Barrios et al. (2004) who find spillovers to be conditional on the technology level of an indigenous firms relative to the level of foreign firms.

Djankov and Hoekman (2000) extend the literature on spillovers in the Czech Republic by investigating different effects occurring in FDI and joint ventures. They use a panel dataset consisting of firm-level data of 513 companies in the Czech Republic from 1992 to 1997. After a significant liberalization in 1992, inward FDI was increasing tremendously within ten years by more than 800 percent. They argue that such an enormous increase of direct investment inflows clearly shows the need for further research of transition economies. Conducting both an OLS and also a Random-Effects estimation, they find productivity growth positively and statistically significant affected by the presence of foreign companies in the same sector. Further, they conduct a sample split and find different effects depending on the type of ownership of a company. While the effect on all affiliates is positive, they find the effect on domestic firms only to be negative. They conclude that foreign affiliates might benefit more from other foreign companies entering the market than domestic companies do. This is also in line with the competition effect discussed by Aitken and Harrison (1999). Further, they find FDI to raise TFP growth, indicating that knowledge is transferred from a parent firm to its partner firm. This effect appears to be weaker for joint ventures, indicating that joint ventures obtain less knowledge from their partners than affiliates obtain from their parent. An important factor to consider is that, other than Kinoshita (2000), they do not control for the technology gap between domestic and foreign firms, however, highlight its importance and suggest that further research is required.

Konings (2001) analyses how the productivity performance of domestic firms is influenced by foreign direct investment for three economies in Eastern Europe namely Bulgaria, Poland and Romania. Using an unbalanced firm-level panel-dataset covering firms between 1994 and 1997 with a total of around 6,400 firms and 16,000 observations, he limits his research not only on the direct effect of foreign equity share. Further, he sheds light on the occurrence of potential spillovers to domestic firms while controlling for both sector and regional fixed-effects and applying a GMM-estimation. However, the importance of the absorptive capacity is not addressed or accounted for in his model. He finds no evidence for foreign firms to perform better than indigenous companies with the exception for Poland, which he identifies as the most advanced transitioning country used in his sample. As a reason for that, he sees lags in restructuring in these transitioning countries and suggests that it might take more time for ownership effects to impact performance. He further does not find any empirical evidence for positive

productivity spillovers but rather finds non or even negative effects for Bulgaria and Romania. The competition effect outweighing the technology effect can be a potential reason for that. Further, a large technology gap could be a reason why domestic firms are not capable to benefit from technology leakages. He sees Bulgaria and Romania as less developed countries and argues that the technology gap might be too large for domestic companies to absorb positive technology spillovers. This provides more evidence for the theory of Wang and Blomström (1992), emphasizing that a decent and developed technology level already needs to be present in order to benefit from potential knowledge and technology dispersion from foreign companies. However, it is important to highlight that this potential explanation is not accounted for or researched in his study and therefore provides a potential gap in the literature

Damijan et al. (2003) investigate through which channels technology is transferred into eight Eastern European transitioning countries, comprising over 8,100 firms in the manufacturing industry for the time period from 1994 to 1998. They emphazise the importance of direct effects arising from FDI as they find them to be the most significant source for productivity spillovers. Further, they highlight the suggestion of Kinoshita (2000) that many studies fail to find spillovers as they do not consider and account for the innovative and absorptive capacity of domestically owned companies. Using the return of R&D investments they account for this in their probit-estimations. Their results show the absence of horizontal knowledge spillovers or in some cases even negative effects. These results are in line with previous findings by Konings (2001) who could not find evidence for positive productivity spillovers in the Czech Republic either. Therefore, they conclude that it is doubtful that FDI-promoting policies are generally appropriate to promote spillovers to local firms. Even though this paper focuses exclusively on CEECs the dataset only covers the years 1994 to1998, a period of time in which the Eastern Enlargement of the European Union had not been performed yet. As inward FDI for most CEECs significantly increased after their accession in 2004, the time period used in their study might be a potential reason why horizontal spillovers could not be found yet.

Rugraff (2008) emphazises the structural change CEECs were undergoing in the late 1990s and that spillovers might take more time to occur and cannot be observed immediately. He challenges the efficiency of FDI policies of CEECs by comparing two different types of FDI-policies, defining them as the Irish model and the TKC model (referring to Taiwan, South Korea and China). Comparing various studies examining productivity spillovers, he argues that the new member states of the European Union, except Slovenia, have adopted an export-led strategy similar to the Irish model, which played a significant role for reintegration in both European and international trade. Like Ireland, these countries attracted foreign multinationals with very liberal and permissive FDI policies, low corporate tax rates, and fiscal incentives like tax reductions. Comparing nine published papers focusing on spillover effects in CEECs he finds it conclusive that

the results show generally non or only very little evidence for horizontal spillovers as MNEs have an interest in preventing technology transfer to potential local competitors. Therefore, vertical linkages might be more likely to be the source of spillovers, even though there is only little evidence to be seen in the data.

Nicolini and Resmini (2010) research spillovers occurring in three new EU member states in Eastern Europe, namely Bulgaria, Rumania and Poland. Using a rich panel dataset for the years 1998 to 2003 comprising over 40,000 firms with a total of 98,000 observations, they do not only investigate the presence of inter- and intra-industry spillovers but also distinguish between high-tech and low-tech sectors. Their results highlight the importance of the absorptive capacity and technological competence of a domestic firm as it shows that indigenous companies being endowed with a low standard of technology are unable to benefit from potential productivity gains. As a proxy they include a dummy variable taking the value of 1 if a company's TFP is below the average productivity of its industry, indicating less productive firms. Besides that, they also shed light on the questions of which foreign firms are able to generate spillovers. While controlling for fixed-effects on the firm level they find a tendency for firms operating in high-tech manufacturing sectors to be more likely to create spillovers. As a potential reason for that, they argue that companies operating in high-tech sectors are receiving more technology from the parent house than companies operating in low-tech industries. In their final step, they analyse whether the size of an indigenous firm matters to benefit from technology transfers. They split domestic companies into three groups based on their number of employees. The results show that medium-sized indigenous companies operating in low-tech industries in Bulgaria benefit from FDI induced spillovers regardless of their absorptive capacity. Further, they find negative effects for small companies regardless of the industry they are operating in. For Romania, they find both intra- and inter- industry spillovers, however, the latter only for companies operating in high-tech sectors. They conclude that their results show more potential for inter-sectoral spillovers to occur than intra-sectoral in general. Surprisingly, they do not find spillovers in Poland, which is the most developed country in their sample. Their results support the technology gap hypothesis, suggesting that a large technology gap enhances the capability to pick up new technology and hence benefiting from productivity gains. With the technology gap being relatively narrow in Poland, they conclude that the competition effect is outweighing potential technology transfers.

The impact and importance of firm heterogeneity on both direct effects and spillover effects of FDI is addressed by Damijan et al. (2013).Their study shows that results are indeed affected by heterogeneity of firms in terms of size, productivity level or absorptive capacity. Analyzing a dataset consisting of 90,000 firms from ten transitioning countries in Eastern Europe comprising a total of 314,000 observations for the years 1995 to 2005, they emphasize that no other previous study in the literature has used such a large

and extensive panel dataset. Their findings obtained from a first-difference approach provide evidence that horizontal spillovers have become more important over time, having the potential to even succeed the importance of vertical spillovers. This expands the literature as most previous studies fail find evidence for the presence of horizontal and forward spillovers and highlight that backward linkages show the highest potential for spillovers to occur. This is in line with Rugraff (2008), who suggests that it might take more time for horizontal spillovers to occur. They find both positive and negative horizontal spillovers depending on the size of a company. While small companies rather suffer from negative horizontal effects, implying that the competition effect is outweighing any benefits through technology transfers, they find positive effects rather occurring for companies with higher productivity levels and a sufficient absorptive capacity. Further, their findings suggest that both horizontal and vertical FDI spillovers seem to be less common for foreign companies than they are for domestic firms. They conclude that a potential reason for this effect might be that foreign affiliates are not entirely integrated into the local environment and rely on direct links with their parent company in their home country. They suggest further research regarding this effect.

Using firm-level data from 17 countries, of which 15 are located in Eastern Europe, Gorodnichenko et al. (2014) examine under which conditions FDI spillovers appear to be positive. As firm-level data is retrieved for a large number of countries, the underlying dataset applied in this study comprises more than 7,000 companies and about 20,000 observations for the years 2002 to 2005. They provide a deeper insight by not only considering manufacturing sectors but also including service sectors in their data, which are usually neglect in most studies. In their extensive analysis they analyze both horizontal and vertical spillovers, the significance of the technology gap, a potential difference between fully-owned affiliates and joint ventures and also a country's institutional environment by applying a first-difference approach and controlling for fixed-effects on the firm level. They find that interactions with foreign firms can benefit an indigenous company in two ways namely through its direct interaction with a MNE and also through interactions of other domestic companies with foreign firms. Further, their results are in line with previous literature showing forward linkages and spillovers through the horizontal channel to be insignificant. This is consistent with the notion that these spillovers are less likely to occur than backward spillovers do. Examining the service sectors, they find domestic companies to be benefiting from the presence of foreign competitors and also from backward spillovers. Key institutional variables appear to have only a very little effect on a company's efficiency. In conclusion, they stress that there are indeed significant effects in specific firm categories detectable, despite the existing literature often reporting insignificant spillovers.

2.3.3 Spillover Effects Based on the Quality of FDI

Besides the capability of a domestic company to absorb and benefit from new technology, the origin of FDI (in other words the home country of a MNEs) can also be considered a crucial factor that impacts productivity spillovers. On the one hand, MNEs coming from developed countries are considered to be endowed with a higher technology level and therefore bring more technological opportunities into a host country. On the other hand, this high level of technology might result in a productivity gap between foreign and domestic firms which is too large and rather hinders spillovers to arise. As companies from less developed countries might bring a lower level of technology, it can be possible that this actually enables indigenous firms to benefit from spillovers as the technological frontier is closer to their own technology level.

Javorcik and Spatareanu (2011) examine whether the origin of a foreign investor plays a significant role regarding the degree and magnitude of spillovers in upstream sectors (backward linkages). Using a data set consisting of around 60,000 manufacturing firms operating in Romania in the years 1998 to 2003 with a total of more than 39,000 observations, FDI is separated into three different groups of origin, namely Europe, America, and Asia. In their estimation strategy they control for fixed-effects on the firm level and include a Herfindahl Index in order to account for market competitiveness. Their results indicate that there are two potential ways in which the origin of FDI may matter for spillovers to domestic suppliers. The distance of the host and the home country of a foreign investor can be identified as one reason. Multinationals are more likely to source a greater amount of intermediate inputs from domestically owned firms the larger the distance between the two countries gets. Secondly, preferential trade agreements are very likely to influence sourcing patterns of foreign affiliates as well. Particularly the Associate Agreement between Romania and the EU indicates that investors from the EU are able to supply intermediate inputs from their home country on preferential terms. Such privilege does not apply to investors from Asia or America. Considering both effects, it can be expected that both Asian and American companies rather source from companies located in the host country. The empirical results provide evidence in favour of this assumption. The presence of Asian and American companies in the downstream industries has a positive and statistically significant effect on the productivity of Romanian companies in the supplying sectors. Considering European investors, this effect becomes negative, indicating that Romanian suppliers suffer from the presence of MNEs from Europe in the downstream sector. It can be concluded that the nationality of a foreign investor does indeed matter.

Besides the Gorodnichenko et al. (2014) consider the quality of FDI comparing FDI from OECD countries versus non-OECD countries applying firm-level data for 17 countries for the years 2002 to 2005 including more than 7,000 firms. Their results

obtained from a frist-difference estimation indicate that there is no systematic difference in spillovers from FDI having its origin in an OECD- country, compared to a non-OECD. They identify two potential reasons for that. Firstly, it might be possible that companies from OECD countries are more capable to protect their proprietary asset and technology and thus suppress a potential technology transfer. Secondly, domestic firms might be able to absorb technology from non-OECD countries more easily as the technology gab is considered to be smaller. However, they are not able to distinguish between these two hypotheses and research them in more detail due to data limitations.

2.3.4 Novelty of This Study

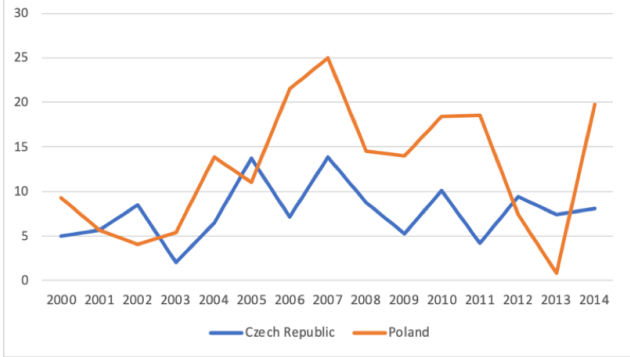
Even though the literature on FDI and its resulting spillovers is very extensive, there are still numerous questions unanswered. While the distinction between indigenous firms and MNEs is rather simple, not many studies focused on the specific home country of foreign firms. This study extends the existing literature by not only distinguishing between multinational and domestic firms but also focusing on the origin of a foreign company. The literature considers the quality of FDI based on the origin a foreign investor comes from, that is, a MNEs home country. Here, investment from developed countries is usually considered as the one with higher quality as it is considered to bring more advanced and sophisticated technology. However, this also implies that the productivity gap between domestic firms and foreign firms is larger, potentially too large for domestic firms to actually benefit from spillover effects. Therefore, investment from less developed countries might have another effect on the host economy, as the productivity gap can be smaller and therefore enable domestic firms to absorb new technology as a consequence.

This study focuses on two countries, namely the Czech Republic and Poland. It examines firm-level data for the time period from 2009 to 2014 obtained from ORBIS. This selection of countries is motivated by the analysis of Rugraff (2008) who highlights a structural change occurring in CEECs in the late 1990s. He stresses the importance of the technological endowment of domestic firms and points out that solely attracting FDI is no guarantee to create productivity spillovers. He finds little evidence for spillover to be present and concludes that based on that structural change and firms adapting, it might take more time for spillovers to occur.

Figure 2.8 shows the net FDI inflows for both Poland and the Czech Republic over the past two decades. A large increase of FDI can be observed for the early 2000s starting in 2003. While Poland perceived an increase from 5bn USD in 2003 to almost 25bn USD in 2007 at its peak, the Czech Republic perceived an increase from 2.5bn USD to 14bn USD. This represents an increase 400 percent increase of FDI inflow for Poland and a 460 percent increase for the Czech Republic in less than 5 years.

Considering the large increase of FDI inflows and the findings of Rugraff (2008) this study examines these two countries, investigating whether more time is necessary for spillovers to manifest themselves.

Figure 2.8: *Foreign Direct Investment, Net Inflows Czech Republic and Poland (BoP, current US Dollar)*



Notes: This figure illustrates the FDI net inflows for both the Czech Republic and Poland in current US Dollars (billion) for the years 2000 to 2014.
Source: The World Bank (2020)

2.4 Data

This part discusses the data sources and illustrates which data is used and how it is gathered. In a next step, it describes how the retrieved data is processed, cleaned and matched into a final panel dataset which is then used for the econometric analysis.

For the empirical analysis this study uses data retrieved from several sources for the Czech Republic and Poland for the time period from 2009 to 2014. Firm-level data is gathered from the ORBIS database in order to create a panel dataset on the firm-level. Additionally, information on the interactions between several sectors within a country is required. This information is provided in input-output databases. There are multiple sources which provide such tables, however, one of the most comprehensive is probably the World Input-Output Database (Timmer et al., 2015). As it provides a great coverage and is publicly available this study makes use of this particular database as the source of information on sectoral inputs and outputs.

2.4.1 ORBIS Database

ORBIS is an extensive database providing firm-level data. It contains information on more than 280 million companies worldwide of which 99 percent are private.

Data Retrieving

Even though the ORBIS database is widely used in the literature as a reliable source of information, most studies barely address how the data was accessed and retrieved. Kalemli-Ozcan et al. (2015) point out that different ways of accessing and gathering the data can result in different compositions of the dataset. Generally, there are three different ways how firm-level data from ORBIS can be accessed and retrieved.

- BvD's proprietary web platform. It can be accessed by direct subscription.
- BvD's historical vintages. This historical data is available on historic CD-ROM disks (or harddrives/blueray disks), which can be bought from BvD.
- Through WRDS archives (Wharton Research Data Services from the Wharton School at the University of Pennsylvania - only comprising European countries).

In order to achieve the maximum coverage of companies for European countries, a combination of all three ways of how to gather ORBIS data is necessary. Kalemli-Ozcan et al. (2015) point out that ORBIS only covers information on the past 5 years and suggest extending such data with BvD's historical vintage data. However, when accessing ORBIS using the web platform, it shows that there is data available for the past 10 years as well. Indeed, the ORBIS database now covers company data reaching back 10 years and additionally offers historical data through a subscription to ORBIS Historical" (Bureau van Dijk, 2018*b*).

Keeping these aspects in mind, this study retrieves company data entirely through the web platform access, as it provides full coverage of 10 years. Further, the web platform access was updated with an entirely new user interface which allows more flexibility in selecting data and filtering or defining certain variables. Not all variables in ORBIS are fix defined and can be defined individually. For instance, the global ultimate owner of a company is defined according to the percentage of how many shares an owner of a company holds. This variable can be altered to different percentages. By default, the global ultimate owner of a firm is defined as the entity that holds 51% or more of the equity.

Financial Data

The financial sub-database consists of detailed information retrieved from several resources. Besides address, legal form, year of incorporation and general information on a firm's characteristics, it further extends to the number of employees and various financial data from numerous balance sheet items. It includes data from the profit and loss account, cash flow statements, and also the yearly reported balance sheet.

As balance sheet variables are all at book value and by default reported in the currency a company originally reported its numbers it can be difficult to match and combine data from different countries. BvD provides the option to select in which currency to download the data, providing all financial data in USD by default, using an exchange rate. Kalemli-Ozcan et al. (2015) advice not to select the exchange rate of BvD as it could cause potential errors when matching data from the historical disks.

Even though this study entirely uses date retrieved from the web subscription and such merging errors are therefore not of concern, the financial data will still be retrieved in a countries national currency and then later converted to USD using the exchange rate provided by BvD to avoid problems regarding deflating nominal values (Gal, 2013).

Despite of BvD's claim to frequently update the database, Kalemli-Ozcan et al. (2015) point out that there is a reporting lag of two years on average. This is important to consider, as recent years might have a sever lack of reported data and show a significant number of missing values. As this study matches ORBIS data with data from other sources, this reporting lag does not appear to be a problem. As data from the World Input-Output Database is used, the years after 2014 cannot be considered as this database only reports until this particular year.

Ownership Data

Besides financial data, ORBIS provides various variables on ownership information (Bureau van Dijk, 2018*a*). The ownership database of ORBIS contains information on each firm's equity ownership structure. This includes the name of an owner, their ownership shares, the way and level of ownership, and their country of origin. Generally, three types of ownership can be identified, namely direct ownership, indirect ownership, and total ownership. While direct ownership refers to a direct participation in another firm's equity (for example firm A owns 100% equity of firm B), indirect ownership considers also further linkages (for example firm A owns 100% of firm B's equity. Firm B owns 80% of Firm C's equity. Therefore, Firm A owns Firm C indirectly). Total ownership considers both direct and indirect linkages and is therefore used as a measurement for ownership in this study (Bureau van Dijk, 2018*a*).

Even though the ownership information in the ORBIS database is extensive, it shows some issues regarding building a panel dataset. Ownership data is only provided as a static variable, meaning it only shows the ownership conditions "as of date". This raises the issue that changes in ownership over the years is not considered. As an example, one can think of having panel data on a company for ten years. For the first eight years this company is owned domestically and then bought by a foreign investor. Observing the data, it is not possible to see when this change of ownership happened. Instead, the company appears to be foreign owned for the entire ten years in the dataset. This

is a common problem working with data from ORBIS and frequently addressed in the literature. Even though the ownership information shows this flaw, it can be considered as a minor problem as it is assumed that sever changes in the ownership structure are rather rare.

To sum up, ORBIS is an extensive database with a comprehensive set of data on companies operating worldwide. Its rich data on financial data allows to control for firm heterogeneity in the empirical analysis. Its filters and identifiers allow an efficient selection of particular companies and their ownership linkages allow to distinguish between domestic firms and multinational enterprises. Furthermore, a distinction of the particular country a GUO is located at can be made. This allows to identify companies from specific countries and investigate their effect on the local economy in more detail.

2.4.2 World Input-Output Database

The World Input-Output Database (WIOD) is the result of a project which was carried out and finalized by researchers of 12 European research institutes headed by the University of Groningen. It was funded by the European Commission, Research Directorate General from 2009 to 2012 as part of the 7th Framework Programme, Theme 8: Socio-Economic Sciences and Humanities, grant Agreement No. 225 281.

An Input-Output Table shows information on purchase relationships between producers and consumers within the same economy. More precisely, it provides data on how much a particular sector delivered to another sector including both final and intermediate output. Figure 2.9 illustrates the main structure of an Input-Output Table (IOT). It describes the relationship of sales and purchases between producers and consumers within an economy. The WIOD covers 43 countries and separates sectors into 56 categories according to the International Standard Industrial Classification revision 4 (ISIC Rev. 4). The latest release (Release 2016) covers a time period from 2000 to 2014.

The WIOD is put together with data from officially published input-output tables merged with international trade statistics and national accounts data. Further, it is extended with data on factor inputs. As it is composed of publicly available and official data from statistical institutes a high level of data quality is ensured (Timmer et al., 2015).

While domestic input-output tables solely include transactions between industries within an economy the WIOT provides a "comprehensive summary of all transactions in the global economy between industries and final users across countries" (Timmer et al., 2015). Besides industry transactions of intermediate good, a second WIOT includes a second part including final consumption by country. Therefore, it can be clearly calculated how much of the total output is sold or exported for final consumption and

Figure 2.9: *Schematic Outline of a World Input - Output Table (WIOT)*

			Use by country-industries							Final use by countries			Total use
			Country 1			...	Country M			Country 1	...	Country M	
			Industry 1	...	Industry N	...	Industry 1	...	Industry N		...		
Supply from country-industries	Country 1	Industry 1											
		...											
		Industry N											
	.....												
	Country M	Industry 1											
		...											
		Industry N											
Value added by labour and capital													
Gross output													

Notes: This figure illustrates the basic setup of an input-output table. It presents the interactions between industries in terms of how much of the output produced within a particular sector is delivered to another sector.
Source: Timmer et al. (2015)

which ratio has its destination in another industry as an intermediate good. This plays an important role when calculating measures for spillover effects.

As the WIOD does not allow to select several possible standards of industry classifications, adjustments have to be made. The WIOD only reports in the ISIC style. As ORBIS does not allow to select this standard, industries need to be matched.

2.4.3 Data Cleaning

After retrieving firm-level data from ORBIS the raw data consists of 2,382,996 observations of 397,166 companies for the Czech Republic and 791,742 observations of 131,957 companies for Poland for the time period from 2009 to 2014. However, an extensive data cleaning is essential. Kalemli-Ozcan et al. (2015) point out that the way ORBIS provides data is not particularly designed for economic research and therefore a substantial cleaning has to be undertaken. Following their suggestion and the approach most literature using ORBIS data does, only companies with at least 5 employees is kept in the dataset. Further, all observations that show either a missing value or zero for revenue, material input and tangible fixed assets and value added are dropped.

In a first step, this study estimates productivity level for each firm and the respective year. However, ORBIS has limitations regarding reporting and data availability which can make it more difficult to conduct this first step. As the estimation method is explained in Section 2.5.1, this part keeps its focus on the variables used for the estimation, which are *Value Added*, *Capital Stock*, *Costs of Employees* and *Material Costs*.

To extend the data coverage and avoid extreme loss of data, additional imputations can be executed in order to extend the coverage. As this study applies *Value Added* as a depended variable for estimating total factor productivity (TFP), sufficient reporting

and availability of this financial figure is crucial in the dataset. Gonnard and Ragoussis (2013) suggest that the best way to substitute *Value Added* is to exploit its definition based on factor incomes. This required to add up factor incomes going to both employees and capital owners. For the former this is expressed as the wage bill wL with w being the average labour cost and L the number of employees. For the latter rK is representing the profits, the rate of return r times the capital stock K. With this at hand, Value Added AV can be defined as

$$VA = wL + rK \tag{2.1}$$

Obtaining data from ORBIS, the empirical counterparts in the dataset are *Costs of Employees* and *EBITDA* (Earning Before Interest Taxes Depreciation and Amortisation). Making use of these variables and the definition of *Value Added* VA in (3.1), *Value Added* can be computed by applying

$$VA_{csit}^{InternallyImputed} = CostofEmployees_{csit} + EBITDA_{csit} \tag{2.2}$$

where c denotes the country, s the sector, i the firm and t the time. Gonnard and Ragoussis (2013) point out that this way of computing VA is applicable as it shows strong correlation with the real VA for companies that had this figure reported. According to Gal (2013), who estimates TFP for several OECD countries, these internally imputed values show indeed high correlation on the log-level, 0.98 for an average country and year.

Regarding labour input, ORBIS does not provide a detailed reporting on numbers of hours worked. Only the number of employees is reported, while it is not possible to distinguish between low skilled and high skilled or white-collar and blue-collar jobs. This makes it impossible to obtain information on the characteristics of the employees or the type of employment. Gal (2013) suggests that this obstacle could principally be circumvented by using *Costs of Employees*. However, this can mislead as it is directly affected by changes in the regulatory environment (minimum wages, social security contributions etc.). In order to account for these changes, labour cost is deflated with a labour cost index provided by Eurostat (2019*b*). This index "measures the cost pressure arising from the production factor 'labour'", considering wage and salary components and also social contributions by the employer. In this way, the problems mentioned by Gal (2013) can be accounted for. As this index is only available with 2012 as a base year, it gets adjusted before its application, having its base year as 2010. This is important in order to ensure that all financial data is deflated to the same year as other deflators applied for other variables are reported with this year as their base.

Regarding capital goods, ORBIS only allows a distinction between being tangible or intangible. Unfortunately, there is no way to differentiate between the type of asset (e.g.

structures or equipment). Therefore, only data on tangible assets is used in order to avoid conceptual difficulties in valuing and measuring intangible assets, which further are poorly reported in ORBIS. In order to calculate the *Capital Stock* on the firm-level, the standard Perpetual Inventory Method (PIM) is applied. The level or real capital stock K_{it} in firm i in year t is defined as

$$K_{it} = K_{i,t-1}(1 - \delta_{it}) + I_{it} \tag{2.3}$$

where I_{it} represents real investments. It is defined as

$$I_{it} = \frac{(K_{it}^{BV} - K_{i,t-t}^{BV} + DEPR_{it}^{BV})}{PI_t} \tag{2.4}$$

It is calculated with the difference between the current (K_{it}^{BV}) and the lagged book value ($K_{i,t-t}^{BV}$) of the tangible fixed assets adding depreciation ($DEPR_{it}^{BV}$). Both variables are available in ORBIS which allows the application of the PI Method to be rather straight forward. It gets then deflated by a country and industry specific investment deflator PI_t which is obtained by the OECD STAN-Database (OECD, 2019). The depreciation rate in (2.3) is defined as

$$\delta_{it} = \frac{DEPR_{it}^{BV}}{K_{i,t-t}^{BV}} \tag{2.5}$$

The book value of depreciation $DEPR_{it}^{BV}$ is divided by the book value of the tangible fixed assets $K_{i,t-t}^{BV}$. For the first observed year, there is no definition for $K_{i,t-1}$ in (2.3). Therefore, the real capital stock K_{i0} gets defined as the net capital stock (tangible fixed assets K_{i0}^{BV}) and deflated by the investment price index PI_0

$$K_{i0} = \frac{K_{i0}^{BV}}{PI_0} \tag{2.6}$$

Regarding intermediate inputs, there is no detailed reporting on the purpose of inputs available. It is not differentiated between material, purchased services and energy, solely material costs can be observed. This lack of availability limits and prevents the application of a more sophisticated production function, as material costs only captures a part of the intermediate inputs. According to Gal (2013), this causes problems for estimating TFP using output as dependent variable in particular. Therefore, this study estimates TFP using *Value Added* as dependent variable in order to minimize potential problems arising from the limited reporting and measurement of intermediate inputs. After conducting these steps and dropping all observations which report a missing value for any of these variables the dataset now consists of 84,972 observations of 20,572 firms for the Czech Republic and 30,669 observations and 16,402 firms for Poland.

To control for outliers, Gal (2013) suggests two approaches which can possibly be done. In a first step, data can be filtered for extreme cases regarding ratios such as *Capital/Labour* or *Material/Output*. This first filtering is conducted before estimating TFP. As a second step, extreme levels of TFP can be filtered and dropped, which can then be done after the TFP estimation and obtaining results.

This study will apply both suggestions and drop the highest and the lowest one percent regarding *Material/Output* , *Capital/Labour* and *Capital/Output*. After this first filtering, the estimation of TFP is conducted and the highest and lowest one percent of TFP is dropped. This step reduces the dataset to 83,366 observations of 20,290 firms for the Czech Republic and 30,057 observations and 16,070 firms for Poland.

In order to distinguish domestic and foreign firms, the variable *Global Ultimate Owner* (GUO) is used. An indicator variable is created having the value of zero if the country code of the GUO is the same as the country a firm operates in. It takes the value one if the country code differs from the code of the host country. For missing values, it is assumed that a company is domestic and does not show any form of foreign ownership, following the suggestion of Kalemli-Ozcan et al. (2015). Companies with have their GUO specifically highlighted as "unknown country" are excluded. This reduces the dataset to 83,612 observations of 20,516 firms for the Czech Republic and 30,011 observations and 16,043 firms for Poland.

Matching Industry Classifications

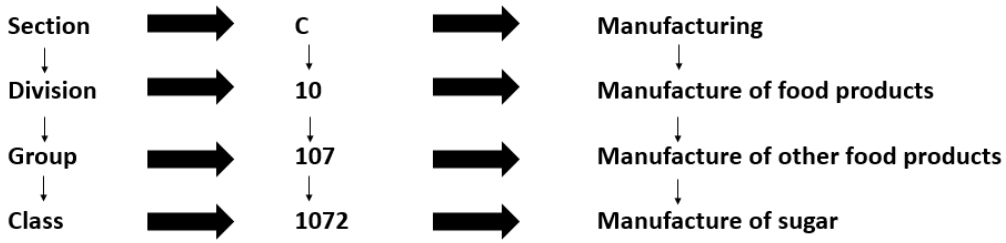
The ORBIS database provides industry classifications in three different standards. The NACE Rev.2 standard is the statistical classification of economic activities in the European Community released by EUROSTAT in 2008. It is commonly used for European countries. Further, the US SIC standard is provided. However, since the US SIC system has not been updates since 1987, the NAICS 2017 (North American Industry Classification System) is more widely used (Baker, 2017).

Even though ORBIS provides a rather large degree of flexibility on industry classifications there are some obstacles which have to be addressed. As firm level data from ORBIS has to be matched with input-output data from the WIOD, both types have to be reported in the same industry classification standard. However, the input-output tables are solely reported in the ISIC format (International Standard Industry Classification). Therefore, this study retrieves data from ORBIS using the NAICS 2017 standard to identify a firms respective industry and then converts it into the ISIC standard.

The United States Census Bureau, which is a part of the U.S. Department of Commerce provides tables with detailed descriptions of the relationships between classification systems (United States Census Bureau, 2018). These tables provide

an elaborate comparison of NAICS 2017 and ISIC industries and allow to transform a company to its equivalent ISIC standard on the highest digit-level. Nevertheless, some industries cannot be transformed precisely as there is no 1:1 transformation and additional factors have to be considered. This, however, appears to be a minor problem as these issues only occur on the Class-Level.

Figure 2.10: *The Four-Level Structure of the ISIC Code*



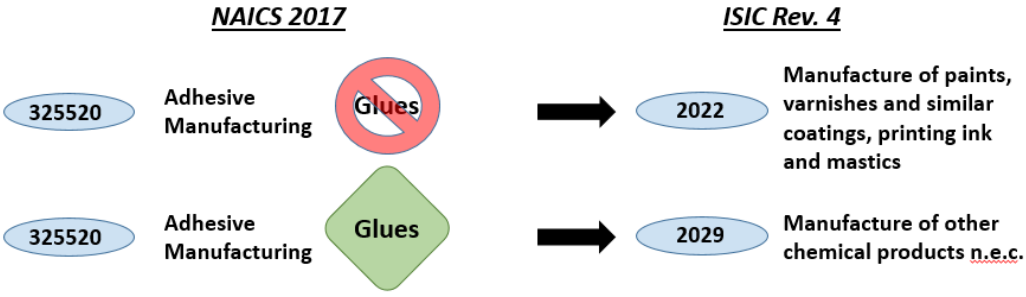
Notes: This figure presents the structure of the ISIC Code (International Standard Industrial Classification). It follows the information provided by Baker (2017) and the United States Census Bureau (2018). It can be seen that the lowest level (section) is categorized with a letter. A particular industry is then more specified up to a four-digit level (class).

Figure 2.10 provides an overview of the ISIC Code structure. The lowest level is the Section-Level which is indicated by a capital letter. The next level is the Division-Level, splitting the Section-Level into different subsections. For instance, all manufacturing sectors are assigned to the Section C and then split into Divisions which are labelled with a two-digit identification (the divisions of the manufacturing section are ranging from 10-33). Further, these Divisions are split into Groups, which allows to classify industries in even more detail. The Class-Level is the last and most detailed stage, identifying sectors on a four-digit level.

The NAICS 2017 industries are converted into the ISIC code on the Class-Level in order to ensure that the conversion is as accurate as possible. However, not all industries can be directly converted to their corresponding ISIC code as there are several exceptions which cannot be considered due to data limitation.

Figure 2.11 shows an example of such a conversion issue. The adhesive manufacturing sector in the NAICS 2017 can be potentially converted to two different ISIC classifications. Depending on whether a company manufactures glues or not, it is either classified as the four-digit class 2022 or 2029. As the firm-level data from ORBIS does not provide information in such detail, it is unclear to which exact four-digit category a firm should be assigned to. However, this study separates industries on the Division-Level, that is, the two-digit level. In this case, the issue of converting the industry classification to another standard is no longer problematic as both Classes 2022 and 2029 belong to the Division 20 (Manufacture of chemicals and chemical products). Even though the conversion on the four-digit level can be ambiguous in some cases, it does not cause any problems on a two-digit level.

Figure 2.11: *Adhesive Manufacturing Conversion*



Notes: This figure provides an example of a potential conversion issue when converting an industry classification from the NAICS 2017 standard to the ISIC Rev.4 standard. On the lowest level (class level) a precise conversion can be cumbersome. However, as this study classifies an industry on the two-digit level (division) a precise conversion is possible. The conversion follows the information provided by Baker (2017) and the United States Census Bureau (2018).

Industrial Producer Price Indices

As this study uses firm-level panel data it is important to adjust nominal values to real values. ORBIS reports financial data for each year, however, this data does not get adjusted to current values. In other words, ORBIS only provides data in the exact way it is reported by a company for each year and keeps this value fixed without updating or adjusting it.

By default, all financial variables in ORBIS are provided in thousands of USD converted from a firm's host country's currency by using the market exchange rate in each particular year (Gonnard and Ragoussis, 2013). In order to compare values over time they need to be adjusted for price changes. Therefore, it is necessary to deflate all nominal variables using price indices. As most firm-level datasets, ORBIS does not provide firm-level price indices. Therefore, Gal (2013) suggests using external data for deflating nominal values as best practice, applying 2-digit industry deflators retrieved from the OECD-STAN database (OECD, 2019). These deflators are provided for several values individually, namely output, intermediate input, investment and value added. For each variable this study adopts the respective price index, deflating all values using 2010 as the base year. However, Gal (2013) points out that these price indices refer to the national currency of the particular country. Therefore, he suggests converting all values to their original currency in which they are reported, and then deflate them. As ORBIS provides for each company the exchange rate which is used for the conversion from the local currency to either euro or USD, this exercise can be executed without facing the burden of retrieving exchange rates from additional sources.

Following Gal (2013), the USD/local currency conversion is denoted by $(\$/local)_{ct}$. Then for each variable X_{it} for firm i and year t a conversion from the dollar-based value $(X_{it}^{\$})$ to a country's local currency value (X_{it}^{local}) can be conducted

$$X_{it}^{local} = \frac{X_{it}^{\$}}{(\$/local)_{ct}} \tag{2.7}$$

After the conversion, deflation over time can be implemented

$$X_{it}^{local,t_0} = \frac{X_{it}^{local}}{P_{cjt}^{t_0}} \tag{2.8}$$

where $P_{cjt}^{t_0}$ represents the respective deflator retrieved from the OECD-STAN database (e.g. output, intermediate input etc.) in year t with t_0 as reference year in industry j in country c.

All price indices are provided for each industry classification on the 2-digit level following the ISIC format. As all industries in the dataset are converted into this format, the nominal values can directly be deflated as deflators can precisely be assigned to each particular industry. In some rare cases, there are no deflators reported for a particular industry. In this case the deflators from the next highest category is applied.

Measures for Spillovers

A measurement for horizontal spillovers is created following a similar approach like Javorcik (2004) or Laenarts and Merlevede (2011). In their approach, the output of a company is weighted with its foreign equity share and then divided by the sum of the total output within an industry for each particular year. As this study uses information on global ultimate ownership in order to identify whether a firm is foreign or domestic, an exact share of equity is not available. Therefore, a variable *Horizontal* is defined as

$$Horizontal_{jt} = \frac{\sum\limits_{i\,for\,all\,i\,\epsilon\,j} Foreign_{it} * Y_{it}}{\sum\limits_{i\,for\,all\,i\,\epsilon\,j} Y_{it}} \tag{2.9}$$

where *Foreign* represents a dummy variable with the value of 1 if company i in industry j is a foreign MNE and 0 if it is identified as a domestic one. It is calculated for each industry j and year t individually and basically represents the share of output Y_{it} within an industry that is produced by foreign owned firms.

In contrast to the *Horizontal* measurement, which is a proxy for intra-industry spillovers, the variable for backward linkages is a proxy for foreign presence in a sector which is supplied by another sector. The intention behind such measurement is to capture the degree of contacts between domestic suppliers and foreign owned customers.

$$Backward_{jt} = \sum_{k\,if\,k \neq j} \alpha_{jkt}\, Horizontal_{kt} \tag{2.10}$$

α_{jkt} is defined as the share of industry j's total intermediate supply, which is supplied to each receiving industry k in year t. For the calculation of this proportion it is important to exclude products for final consumption, however, the import of intermediate products is included. As the formula already shows, inputs which are supplied within the same sector are not included as this effect is already expressed by the *Horizontal* variable.

To illustrate the meaning of this particular variable in a simple way, one can suppose that the leather industry sells half of its production to car manufacturers and the other half to manufacturers of furniture. If no foreign companies are producing furniture but half of the output in the automotive industry is produced by multinationals (which would be reflected by *Horizontal*), the backward variable for the leather industry would be:
$\frac{1}{2} * 0 + \frac{1}{2} * \frac{1}{2} = 0.25$

However, Barrios et al. (2011) point out that the definition of the Horizontal and the Backward variable require three definitions to hold.

- Domestically produced inputs and imported inputs are used in the same proportion.
- There is no difference in sourcing behaviour when comparing domestic and foreign firms.
- The share of total production by foreign companies in an industry is reflective of their demand for inputs produced locally.

These assumptions can be easily violated though. As an example, Barrios et al. (2011) highlight that previous studies have shown that companies are quite likely to outsource several stages of production abroad. Bearing this caveat in mind, these types of measurements for spillovers are still the most established once in the literature and are implemented in this study as well.

The variable for the forward linkages is created following Stancik (2007) who shows a simplified version of the proxy previously created by Javorcik (2004).

$$Forward_{jt} = \sum_{m\,if\,m \neq j} \sigma_{mjt}\, Horizontal_{mt} \tag{2.11}$$

Forward is defined as the weighted share of output in supplying industries produced by companies with foreign capital participation. It is quite similar to the *Backward* variable, however, σ_{mjt} now represents the inputs that industry j buys from sector m in ratio to sector j's total inputs sourced in year t.

Javorcik (2004) points out that only intermediate good which are sold in the domestic market should be considered and therefore excludes goods produced for export by multinationals. Again, inputs provided by a sector to itself are excluded for the same reason as mentioned at the *Backward* linkage. The variable *Forward* increases with the share of foreign firms in the domestically sold output of the upstream industry.

The absorptive capacity of a firm turns out to be a key determinant when it comes to spillover effects, as not every company can potentially benefit from foreign presence in the same way. This paper follows the approach of Girma et al. (2008) and defines the absorptive capacity of each company the following

$$ABC_{ijt} = ln\Big(\frac{TFP_{ijt}}{TFP_{max,jt}}\Big) \tag{2.12}$$

Here, absorptive capacity ABC_{ijt} of firm i in industry j in year t is defined as the logarithm of firm i's own productivity in year t in ratio to the total factor productivity level of most productive firm ($TFP_{max,jt}$) operating in the same industry j. Table 2.1 shows the descriptive statistics of ABC. It is computed by using the values for TFP obtained following the approach of Levinsohn and Petrin (2003) in Section 2.5.1. As these estimation results for TFP are obtained as log values, these values cannot be used directly to define ABC. Therefore, for each estimation result the natural exponential is applied. After setting them into ratio with the maximum TFP present in the respective sector, it is then taken the natural logarithm again.

Table 2.1: *Descriptive Statistics - Absorptive Capacity*

Country	Mean	Std. Dev.	Min	Max
Czech Republic	−2.237	0.694	−6.897	0
Poland	−3.017	1.430	−9.976	0

Notes: This table presents the summary statistics of the variable *ABC* (Absorptive Capacity) for the Czech Republic and Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. *ABC* is calculated by dividing a firm's own total factor productivity (TFP) by the maximum TFP within its industry in a given year (see Equation 2.12).

It can be seen that the values of ABC are all negative. This is given by the nature of calculation. The maximum value can be zero, which is then referring to the most productive firms in each sector. As an example, if firm i is also the most productive one (meaning it is giving the TFP_{max}) then both values, the numerator and denominator take the same value resulting in a ratio of 1. As the natural logarithm is applied, this case would result in the ABC_{max} of 0.

2.4.4 Final Dataset

Applying all cleaning, filtering and adjustments discussed in Section 2.4.3 the final unbalanced panel datasets consists of 20,295 companies operating in manufacturing sectors and construction in the Czech Republic for a time period from 2009 to 2014, having 83,271 observations in total. For Poland, an unbalance panel dataset comprising 14,865 firms with a total of 27,559 observations for the same time period is obtained.

Table A.1 illustrates the number of companies operating for each industry included in the dataset, Table A.2 for Poland respectively (see Appendix).

Further, the horizontal linkage gives interesting insight on how much output in each industry is produced by a foreign owned company.

Table 2.2: *Foreign Output and Presence per Industry – Czech Republic*

Sector	Horizontal	Foreign Presence in %
Manufacture of food products, beverages and tobacco products	0.213	4.61
Manufacture of textiles, wearing apparel and leather products	0.526	16.79
Manufacture of wood and of products of wood and cork, except furniture	0.460	7.42
Manufacture of chemicals and chemical products	0.300	14.65
Manufacture of basic pharmaceutical products and pharmac. preparations	0.694	37.71
Manufacture of rubber and plastic products	0.605	25.45
Manufacture of other non-metallic mineral products	0.647	24.20
Manufacture of basic metals	0.450	36.97
Manufacture of fabricated metal products, except machinery and equipment	0.518	13.00
Manufacture of computer, electronic and optical products	0.751	28.55
Manufacture of electrical equipment	0.783	25.20
Manufacture of machinery and equipment n.e.c.	0.499	18.02
Manufacture of motor vehicles, trailers and semi-trailers	0.733	18.69
Manufacture of other transport equipment	0.725	26.64
Manufacture of furniture; other manufacturing	0.471	16.45
Construction	0.263	4.05

Notes: This table presents the summary statistics of the variable *Horizontal* (Horizontal Spillovers) for the Czech Republic. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. *Horizontal* is calculated by dividing the sum of all output produced by foreign firms in a particular sector by the total output in this sector. It measures how much of the output in an industry is produced by foreign firms (see Equation 2.9).

Table 2.2 shows the horizontal value for each industry averaged over all years for the Czech Republic, indicating how much output over the sample period is produced by companies which have their ultimate owner in another country. It is further shown how much foreign presence in each industry is represented. It can be seen that foreign presence is particularly high in Pharmaceuticals, Electrical Equipment and also in Computer and Electronics. These sectors are classified as high-tech sectors by Eurostat (2019*a*). This high presence of foreign investors in these particular sectors is in line with the theory of FDI, suggesting that FDI tends to take rather place in high-tech industries.

Table 2.3 shows the same variables reported for Poland.

Interestingly, the foreign presence appears to be larger for almost every industry. Figure 2.8 (see Section 2.3.4) shows the net FDI inflows for both Poland and the Czech Republic over the past two decades. It is clear to see that FDI inflow for Poland is significantly higher during the mid 2000s, suggesting that more foreign presence is found in Poland than in the Czech Republic. Comparing both datasets, the data is in line with this assumption.

Table 2.3: *Foreign Output and Presence per Industry – Poland*

Sector	Horizontal	Foreign Presence in %
Manufacture of food products, beverages and tobacco products	0.359	11.65
Manufacture of textiles, wearing apparel and leather products	0.322	16.33
Manufacture of wood and of products of wood and cork, except furniture	0.646	11.51
Manufacture of chemicals and chemical products	0.717	24.10
Manufacture of basic pharmaceutical products and pharmac. preparations	0.518	28.80
Manufacture of rubber and plastic products	0.429	24.54
Manufacture of other non-metallic mineral products	0.652	22.10
Manufacture of fabricated metal products, except machinery and equipment	0.527	25.00
Manufacture of computer, electronic and optical products	0.868	26.36
Manufacture of electrical equipment	0.740	33.33
Manufacture of machinery and equipment n.e.c.	0.542	20.72
Manufacture of motor vehicles, trailers and semi-trailers	0.865	25.51
Manufacture of other transport equipment	0.703	24.67
Manufacture of furniture; other manufacturing	0.416	18.38
Construction	0.219	5.13

Notes: This table presents the summary statistics of the variable *Horizontal* (Horizontal Spillovers) for Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. *Horizontal* is calculated by dividing the sum of all output produced by foreign firms in a particular sector by the total output in this sector. It measures how much of the output in an industry is produced by foreign firms (see Equation 2.9).

When observing the estimates for TFP obtained from the Levinsohn-Petrin approach, one can see that foreign presence goes in hand with higher productivity in the Czech Republic (see Table 2.4). For instance, the most productive sector in the Czech manufacturing industries is Basic Pharmaceutical. Observing foreign presence in Table 2.2, it can be noted that this is also the sector with the most foreign presence. Furthermore, Chemical Production, Electrical Equipment and Manufacturing of Motorvehicles show a high level of TFP as well. This is in line with the classifications of Eurostat (2019*a*) that these sectors are characterized of being high-tech. Industries classified as rather medium-low or low technology like Textile Production or Manufacturing of Basic Metals are showing a rather low productivity level for each year, when comparing them with the other sectors in the economy.

Table 2.5 provides estimates for TFP in Poland. Surprisingly, unlike the Czech Republic, the most productive industry can be identified as the Food and Beverages manufacturing industry. This can potentially be explained by Poland's strong agricultural industry, which represents 13 percent of total employment and accounts for 3.2 percent of the GDP in the year 2011 (Trading Economics, 2019). Besides food production dominating, Manufacturing of Chemicals, Basic Pharmaceuticals and Motorvehicles belong to the group of the most productive industries, again being in line with the classification and assumption of them being of high-technological nature.

Table 2.4: *Total Factor Productivity – Czech Republic*

Sector	*Total Factor Productivity*					
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Manufacture of food products, beverages and tobacco products	1.037	1.188	1.322	1.294	1.272	1.249
Manufacture of textiles, wearing apparel and leather products	0.805	0.790	0.755	0.718	0.703	0.650
Manufacture of wood and of products of wood and cork, except furniture	1.001	1.152	1.148	1.121	1.062	1.002
Manufacture of chemicals and chemical products	1.315	1.176	1.006	1.011	1.019	1.212
Manufacture of basic pharmaceutical products and pharmac. preparations	2.803	2.948	3.042	3.013	3.014	3.140
Manufacture of rubber and plastic products	1.025	1.177	1.212	1.180	1.152	1.093
Manufacture of other non-metallic mineral products	1.433	1.452	1.530	1.486	1.480	1.474
Manufacture of basic metals	0.893	1.100	0.950	0.991	1.043	0.965
Manufacture of fabricated metal products, except machinery and equipment	0.983	1.129	1.158	1.133	1.167	1.175
Manufacture of computer, electronic and optical products	0.902	1.236	1.356	1.204	1.131	1.218
Manufacture of electrical equipment	1.367	1.494	1.557	1.537	1.525	1.571
Manufacture of machinery and equipment n.e.c.	0.990	1.147	1.302	1.289	1.256	1.263
Manufacture of motor vehicles, trailers and semi-trailers	1.450	1.580	1.752	1.701	1.636	1.520
Manufacture of other transport equipment	1.268	1.391	1.497	1.444	1.484	1.593
Manufacture of furniture; other manufacturing	1.108	1.171	1.258	1.280	1.292	1.305
Construction	0.995	1.022	1.041	1.001	1.021	1.069

Notes: This table presents the average total factor productivity (TFP) by sector and year for the Czech Republic for the years 2009 to 2014. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. TFP is obtained by following the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). TFP is estimated for each industry individually.

Table 2.5: *Total Factor Productivity – Poland*

Sector	*Total Factor Productivity*					
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Manufacture of food products, beverages and tobacco products	2.849	3.116	3.116	3.012	2.959	2.986
Manufacture of textiles, wearing apparel and leather products	0.581	0.686	0.717	0.764	0.886	1.178
Manufacture of wood and of products of wood and cork, except furniture	1.176	1.121	1.222	1.106	1.099	1.167
Manufacture of chemicals and chemical products	1.566	1.577	1.443	1.557	1.599	1.563
Manufacture of basic pharmaceutical products and pharmac. preparations	1.959	2.116	2.009	1.946	1.861	1.434
Manufacture of rubber and plastic products	0.931	1.055	1.013	1.025	0.947	0.948
Manufacture of other non-metallic mineral products	1.107	1.494	1.510	1.445	1.544	1.681
Manufacture of fabricated metal products, except machinery and equipment	0.375	0.385	0.350	0.435	0.624	0.662
Manufacture of computer, electronic and optical products	0.439	1.212	1.201	1.143	1.196	1.136
Manufacture of electrical equipment	0.712	1.042	1.202	1.281	1.353	1.425
Manufacture of machinery and equipment n.e.c.	2.013	2.355	2.415	2.340	2.310	2.250
Manufacture of motor vehicles, trailers and semi-trailers	2.656	3.145	3.184	2.92	2.952	3.182
Manufacture of other transport equipment	1.600	2.024	2.030	1.923	1.936	1.758
Manufacture of furniture; other manufacturing	1.738	2.104	2.180	2.052	2.061	2.014
Construction	1.920	2.060	2.058	1.956	1.953	1.994

Notes: This table presents the average total factor productivity (TFP) by sector and year for Poland for the years 2009 to 2014. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. TFP is obtained by following the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). TFP is estimated for each industry individually.

2.5 Econometric Framework

This section highlights the several econometrical approaches undertaken in this study. First, it gives an insight on how total factor productivity is estimated and then highlights how several measurements for spillover linkages are defined and created. At last, it presents the final model which is used for the estimation of spillovers.

2.5.1 Estimating Total Factor Productivity

When estimating total factor productivity on the firm-level, the literature suggests concerns regarding potential correlation between input levels and unobserved firm-specific productivity shocks when using an OLS or FE approach (see Olley and Pakes (1992) and Levinsohn and Petrin (2003)). Assuming there are differences in productivity across firms, and firms are making decisions on input demand and liquidation based on their own productivity level, then this results in simultaneity and selection biases as productivity cannot be observed and is only known by the firm itself (Breunig et al., 2005).

Simultaneity Problem

Firm productivity can be correlated with inputs in both ways, contemporaneously and serially. If this is the case, the OLS estimation provides inconsistent estimates of the input coefficients as the OLS takes the assumption that there is no correlation between input demands and unobservable productivity. This bias has been know and considered in the literature for quite long and is identified by Marschak and Andrews (1944).

If companies which are more productive are hiring more workers and increase their investment in capital as a response to higher current and expected profitability in the future, contemporaneous correlation arises. This particular problem is most likely more sever for inputs that can rather be adjusted rapidly such as labour. If the productivity of a firm is correlated over time, then its input choices on a productivity term is serially correlated. This would lead to upwards biased OLS estimates in a single input case, in a multivariate setting the direction of this inconsistency would be indeterminate. Breunig et al. (2005) provide the example that if there is a positive correlation between labour and capital, but labour shows a stronger correlation with the productivity term than capital does, then the coefficient for labour would be overestimated and the coefficient for capital underestimated.

Selection Issue

Besides the simultaneity problem, a selection issue can arise. Breunig et al. (2005) highlight that only firms which are staying in business can be observed and considered

in an econometric analysis. They make the assumption that a company decides to stay in business and continue its operation when its expected profits in the future are larger than its liquidation value. Given a company's future returns are positively correlated to its capital stock size at any given productivity level, then companies with a larger capital stock are more likely to endure productivity realisations which are rather low. Therefore, the "expectation of productivity conditional on the surviving firms is thus decreasing in capital, leading to a negative bias in the capital coefficient" (Van Beveren, 2012). Particularly in balanced panel datasets this problem of selection becomes more of a concern, as it avoids dealing with the entry and exit issue by definition. This is because it only considers firms that are operating during the entire sample period.

The literature shows multiple approaches on how to deal with and solve these problems. Particularly Olley and Pakes (1992) can be seen as the pioneers of considering these biases in their productivity estimation. Even though the selection bias has been addressed at least since Wedervang (1965), they are the first ones that explicitly take this bias into account in their algorithm. The simultaneity problem is solved by using investment as a proxy for unobserved productivity shocks.

This method appears to be quite attractive at the first sight. However, it reveals more difficulties when it comes to its application with firm-level data. Applying the Olley and Pakes (1992) productivity estimator requires information on a firm's investment decisions. This appears to be quite problematic, as information on investment is mostly not reported and often missing in firm-level panel datasets. Therefore, pursuing this method might result in an enormous loss of data, as many observations would drop out of the sample.

An alternative approach is offered by Levinsohn and Petrin (2003), whose estimation technique is very close to the one of Olley and Pakes (1992). Rather than using investment as a proxy for unobserved productivity shocks, they suggest intermediate inputs. Arnold (2005) points out that this has the advantage that datasets typically show way less missing values for materials than in firm-level investment. Petrin et al. (2004) provide a user-friendly plugin for STATA allowing to estimate productivity in a very straight forward and unsophisticated way. It further allows to choose between several options and specifications. One of the most crucial is that both data on revenue and value added can be applied. However, the estimation techniques differ slightly, depending on the choice of variables.

As their approaches suggest that using value added as output in a production function provides consistent coefficients and causes less difficulties and potential obstacles compared to using revenue, the former of both methods is used for estimating TFP.

The production function is assumed to be a Cobb-Douglas function.

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_m m_t + \omega_t + \eta_t \tag{2.13}$$

with y_t as the log form of a firm's output, l_t and m_t as the log value of the free variable inputs labour and the intermediate input, k_t the logarithm of the variable capital. The error term is separated into two components. ω_t represents the transmitted productivity component while η_t is an error term which is uncorrelated with the choices of input. The major difference between both terms is that the former is a state variable and therefore has an impact on a company's decision rules. As it is not observable by the econometrician and can influence the choices of inputs, it can be seen as the root of the simultaneity problem.

Further, it is assumed that the demand for the intermediate input depends on a firm's state variables k_t and ω_t.

$$m_t = m_t(k_t, \omega_t) \tag{2.14}$$

Making several assumptions about a firm's production technology, it can be shown that the demand function is monotonically increasing in ω_t (Levinsohn and Petrin, 2003). Therefore, the intermediate demand function can be inverted and re-written as

$$\omega_t = \omega_t(k_t, m_t) \tag{2.15}$$

Performing this inversion shows that the unobservable productivity term can now be expressed as a function of two observable inputs.

A final identification restriction is adapted following the previous approach undertaken by Olley and Pakes (1992). It is assumed that productivity is directed by a first-order Markov process

$$\omega_t = E\Big[\omega_t|\omega_{t-1}\Big] + \xi_t \tag{2.16}$$

In (2.16), ξ_t is representing an innovation to productivity which is not correlated with k_t, however, not necessarily with l_t. This occurs as a result of the simultaneity problem.

Denoting value added (gross-output net of intermediate inputs) as v_t the production function can be rewritten as

$$\begin{aligned} v_t &= \beta_0 + \beta_l l_t + \beta_k k_t + \omega_t + \eta_t \\ &= \beta_l l_t + \phi_t(k_t, m_t) + \eta_t \end{aligned} \tag{2.17}$$

where

$$\phi_t(k_t, m_t) = \beta_0 + \beta_k k_t + \omega_t(k_t, m_t) \tag{2.18}$$

As a next step, it is possible to estimate consistent parameters for (2.17) using OLS. For this, $\phi_t(k_t, m_t)$ is substituted with a third-order polynomial approximation in k_t and m_t resulting in

$$v_t = \delta_0 + \beta_l l_t + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \delta_{ij} k_t^i m_t^j + \eta_t \tag{2.19}$$

where the intercept of $\phi_t(k_t, m_t)$ is not separately identified from β_0.This comprises the first step of the Levinsohn and Petrin (2003) estimation routine, providing an estimate for β_l and for ϕ_t.

In order to identify the coefficient for β_k, the second stage of the estimation routine is applied. It starts by computing the estimated value of ϕ_t using

$$\begin{aligned} \widehat{\delta_0} &= \widehat{v_t} - \widehat{\beta}_l l_t \\ &= \widehat{\delta_0} + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \widehat{\delta_{ij}} k_t^i m_t^j - \widehat{\beta}_l l_t \end{aligned} \tag{2.20}$$

A prediction for ω_t for all time periods t can then be computed for any candidate value β_k^* applying

$$\widehat{\omega_t} = \widehat{\phi_t} - \beta_k^* k_t \tag{2.21}$$

With these values, a consistent nonparametric approximation to $E\widehat{\left[\omega_t|\omega_{t-1}\right]}$ is provided by the predicted values from

$$\widehat{\omega_t} = \gamma_0 + \gamma_1 \omega_{t-1} + \gamma_2 \omega_{t-1}^2 + \gamma_3 + \omega_{t-1}^3 + \epsilon_t \tag{2.22}$$

which is then denoted as $E\widehat{\left[\omega_t|\omega_{t-1}\right]}$

Now, as there is given $\widehat{\beta}_l$, β_k^* and $E\widehat{\left[\omega_t|\omega_{t-1}\right]}$, the sample residual of the production function can be rewritten as

$$\widehat{\eta_t + \xi_t} = v_t - \widehat{\beta}_l l_t - \beta_k^* k_t - E\widehat{\left[\omega_t|\omega_{t-1}\right]} \tag{2.23}$$

Further, by minimizing

$$\min_{\beta_k^*} \sum_t \left(v_t - \widehat{\beta}_l l_t - \beta_k^* k_t - E\widehat{\left[\omega_t|\omega_{t-1}\right]} \right)^2 \tag{2.24}$$

the estimate $\widehat{\beta_k}$ of β_k can be defined.

Total factor productivity is estimated for each industry individually for both the Czech Republic and Poland. The estimated coefficients for *Labour Input* and *Capital Stock* can be see in Table A.3 and Table A.4 in the Appendix. All coefficients for all industries show high significance, indicating that the estimation method using the approach of Levinsohn and Petrin (2003) is reliable. In some cases, mostly due to the lack of data quality, inputs appear to be insignificant. In this case, the literature suggests to exclude a respective

industry from the dataset, as the estimated total factor productivity is biased (see (Gal, 2013)) .

2.5.2 Estimating Spillover Effects

In a second step, consistent estimates of TFP obtained from the Levinsohn-Petrin approach are used as a dependent variable and regressed on several measurements for spillovers. The econometric approach is similar to the one conducted by Girma et al. (2008) who stress the importance and significance of including a measure for the absorptive capacity.

The variable *Foreign* indicates whether a company is classified as a domestic or foreign firm und measures the direct effect of foreign ownership on TFP. The measure *localMNE* is an indicator variable with the value of 1 if the firm is not foreign owned yet has multiple affiliates worldwide. Furthermore, a variable indicating a firm's capability to absorb new technology ABC is included and interacted with each measurement. The nature of these measurements and the way how they are computed is explained in Section 2.4.3 in more detail. As a first step, a simple model is defined as a baseline

$$\begin{aligned} ln(TFP_{ijt}) =& \beta_0 + \beta_1 Foreign_{ijt} + \beta_2 Horizontal_{jt} + \beta_3 Backward_{jt} \\ &+ \beta_4 Forward_{jt} + \beta_5 Age_{ijt} + \beta_6 Size_{ijt} + \beta_7 Herfindahl_{jt} \\ &+ \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{2.25}$$

with $Horizontal_{jt}, Backward_{jt}$, and $Forward_{jt}$ for industry j in year t as defined in Equation 2.9, Equation 2.10 and Equation 2.11. As a dependent variable the natural logarithm of TFP_{ijt} obtained using the estimation approach of Levinsohn and Petrin (2003) is used.$Foreign_{ijt}$ is a dummy variable indicating whether a firm is foreign owned or not, α_j a control for industry fixed-effects and θ_t a control for time fixed-effects. Further, common control variables are implemented, such as $Size_{ijt}$ (measured in $TotalAssets_{ijt}$), the Age_{ijt} of a firm, and a $Herfindahl_{jt}$ Index in order to control for competition within a sector.

The *Age* of a firm is defined in a straight-forward way by using the difference in years between the incorporation-year and the year for which financial data is reported. The variable $Herfindahl$ is a measure for market concentration and is defined for each industry individually in the following way.

$$Herfindahl_{jt} = \sum_{i=1}^{N} a_{ijt}^2 \tag{2.26}$$

with

$$a_i = \frac{x_{ijt}}{\sum_{k=1}^{N} x_{kjt}} \tag{2.27}$$

$Herfindahl_{jt}$ is the Herfindahl Index for an industry in a respective year. a_{ijt} is defined as the market share of each firm within its own industry it operates in. Therefore, the Herfindahl Index can be described as a sum of the squared market shares of all companies within a sector.

$Horizontal_{jt}$ can be expected to be either positive or negative. This depends on whether firms within an industry are able to benefit from foreign companies being present and adopt new technology or whether they are negatively affected by the market stealing effect (see Aitken and Harrison (1999) and Figure 2.7). Further, no effect at all is a potential outcome as well, meaning that the presence of MNEs has no affect on the productivity levels of local firms. $Backward_{jt}$ and $Forward_{jt}$ are expected to be either positive and significant or not significant at all. This depends on whether spillovers occur in that way or not. In the absence of productivity gains through forward and backward linkages, no effect at all is expected, meaning that no negative effects are expected to happen in that way (see Javorcik (2004)).

For the control variables, Age_{ijt} and $Size_{ijt}$ are expected to be positive and significant. This is based on the stylized fact that larger and older (and therefore more experienced firms) operate at a higher productivity level than smaller and younger firms do. For the index variable $Herfindahl_{jt}$ a positive sign can be expected. This is based on the presumption that firms have to operate more productively in the presence of more competition in an industry (see Barrios and Strobl (2002) and Barrios et al. (2004)).

2.6 Empirical Results

Table 2.6 and Table 2.7 represent the estimation results of the simple baseline model shown in Equation 2.25 for the Czech Republic and Poland respectively. The estimation is executed in four different ways. Column (1) refers to the estimation without considering industries dummies, nor control variables. Then, column (2) extends the analysis by controlling for fixed effects on the sector level, while column (3) also includes control variables. After considering the entire sample, these estimations are then repeated only including domestic firms in column (4) to (6). Column (7) and (8) are further considering firm-fixed effects in order to allow a better comparison with the more extensive analysis following on.

Examining the results obtained using data on firms from the Czech Republic, it can be seen that the OLS regressions in column (1) and column (4) do not find any significant spillover effects, neither horizontally nor vertically through backward or forward linkages.

Table 2.6: *Estimation - Baseline Model - Czech Republic*

Depended Variable $ln(TFP_{ijt})$	**Czech Republic**							
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) FE	(8) FE
$Foreign_{ijt}$	0.289*** (0.006)	0.264*** (0.005)	0.260*** (0.005)	–	–	–	–	–
$Horizontal_{jt}$	0.661 (0.493)	0.307 (0.264)	0.332 (0.274)	−0.053 (0.044)	0.270 (0.217)	0.274 (0.218)	1.182* (0.707)	0.847 (0.523)
$Backward_{jt}$	0.709 (0.533)	1.725 (1.209)	1.758 (1.211)	0.801 (0.606)	1.686 (1.198)	1.693 (1.204)	1.291 (0.909)	1.814 (1.137)
$Forward_{jt}$	−0.483 (0.318)	−0.714 (0.532)	−0.699 (0.479)	−0.173 (0.121)	−0.580 (0.411)	−0.540 (0.404)	−1.440 (1.016)	−0.736 (0.491)
Control Variables								
$Size_{ijt}$	–	–	0.289*** (0.102)	–	–	0.271*** (0.096)	0.270*** (0.095)	0.266*** (0.097)
Age_{ijt}	–	–	−0.002*** (0.001)	–	–	−0.003*** (0.001)	0.057*** (0.002)	0.066*** (0.001)
$Herfindahl_{jt}$	–	–	−4.566*** (0.131)	–	–	−4.481*** (0.105)	−2.985*** (0.125)	−2.637*** (0.009)
R^2	0.12	0.26	0.26	0.05	0.18	0.18	0.05	0.03
Sample	*All*	*All*	*All*	*Domestic*	*Domestic*	*Domestic*	*All*	*Domestic*
Observations	83,271	83,271	83,271	72,211	72,211	72,211	83,271	72,211
Firms	20,295	20,295	20,295	17,960	17,960	17,960	20,295	17,960
IndustryDummies	*no*	*yes*	*yes*	*no*	*yes*	*yes*	–	–
ControlVariables	*no*	*no*	*yes*	*no*	*no*	*yes*	*yes*	*yes*

Notes: This table shows the estimation results of the baseline model presented in Equation 2.25 for the Czech Republic. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. While column (1) to (6) apply an OLS approach, (7) and (8) consider firm level fixed-effects. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable *Foreign* is a dummy variable taking the value 1 if a firm's global ultimate owner (GUO) can be identified as being from another country than the Czech Republic. The variable *Horizontal* measures the foreign presence in a particular sector. It is calculated by dividing the output of foreign firms in an industry by the total industry-output (see Equation 2.9). In contrast to that, *Backward* is calculated as the sum of the intermediate supply share to all other industries weighted with their foreign presence (see Equation 2.10). *Forward* is calculated in a similar manner. It considers the sum of the intermediate supply share from all industries weighted with their foreign presence (see Equation 2.11). The control variable *Age* is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable *Size* is defined as the log of total assets of a firm in a given year. The control variable *Herfindahl* represents a Herfindahl-Index which measures market concentration. It is defined as the sum of the squared market shares of all companies within a sector (see Equation 2.26).
Robust standard errors are presented in parenthesis.
Each regression includes year fixed-effects.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Foreign ownership appears to be positive and statistically significant at a one percent level when considering the entire sample. This is in line with the theory that foreign ownership or foreign equity participation affects productivity in a positive way. On average foreign firms have a 28 percent larger productivity than domestic firms when considering the entire sample, holding everything else constant.

Aitken and Harrison (1999) and Barrios and Strobl (2002) point out that foreign firms might be more attracted to allocate themselves in certain sectors. Therefore, the model is extended considering now industry dummies for the entire sample in column (2) and for domestic firms only in column (5). It shows that the positive effect of foreign ownership remains positive and significant while spillovers remain absent. Interestingly, even though

staying statistically insignificant, the horizontal effect for domestic firms in column (5) is changing from a negative to a now positive effect (see comparison with column (4)). This effect highlights the importance of controlling for invariant industry-specific effects and is in line with the literature. Aitken and Harrison (1999) stress that controlling for such effects can significantly alter the magnitude and even the effect itself using data on Venezuelan firms.

Further, even when extending the model including the control variables presented in Section 2.6, the effects remain similar, showing no changes in significance (see column (3) and (6)).The effect of $Size$ is positive and significant which is in line with the expectation. A one percent increase in a firm's size measured in its total assets is associated with a 0.29 percent increase in its total factor productivity, holding everything else constant. Age appears to be negative and significant, however, of very little magnitude.Considering firm-fixed effects in column (7) and (8), horizontal spillovers are now statistically significant at a 10 percent level and positive when considering the entire sample. A one percentage point increase in foreign presence within an industry is associated with a 1.2 percent increase in firm productivity, holding everything else constant.

For domestic firms only, this effect appears to be positive as well, however does not show any significance. However, it gives an indication, that positive effects outweigh the negative competition effect horizontally. Further, when observing the results from the fixed effects regression it can be seen that the direct effect of foreign ownership is excluded in column (7). While column (8) only considers domestic firms and the absence of the result is self-explanatory, the missing result for the entire sample might appear surprising at first sight. However, this is because of the nature and definition of the variable $foreign$. As there is no specific data on foreign equity share of the global ultimate owner present in the dataset, this study classifies foreign ownership as a dummy variable which takes the value of 1 if the firm is foreign and 0 if it is domestic. This data can only be obtained as "current state" and is not reported for each year individually. Therefore, it is consistent over time and drops out when applying firm fixed-effects. The measure for the hefindahl index $Herfindahl$ is negative and statistically significant, indicating a reduction of 4.5 percent in a firms TFP associated by a 1 percentage point increase in the index. Further, a decrease in R^2 can be observed when applying an estimation approach considering fixed-effects on the firm level. This low R^2 is in line with previous results in the literature (see Javorcik (2004) and Laenarts and Merlevede (2011)), which show similar low results with an R^2 below 10 percent.

Table 2.7 shows the same set up as Table 2.6 only considering now companies from Poland. The results obtained are very similar to the once for the Czech Republic. Without considering neither industry dummies nor control variables, column (1) and column (4) do not show any significant spillover effects. Further, the direct effect of foreign ownership

in column (1) is positive and significant at a one percent level, indicating that foreign firms have a 25 percent higher level of TFP. When extending the estimation by including industry dummies, it can be seen that the direction of the horizontal effects is changing even though they remain statistically insignificant.

Table 2.7: *Estimation - Baseline Model - Poland*

Depended Variable $ln(TFP_{ijt})$	**Poland**							
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) FE	(8) FE
$Foreign_{ijt}$	0.253*** (0.142)	0.260*** (0.011)	0.265*** (0.013)	–	–	–	–	–
$Horizontal_{jt}$	−0.534 (0.351)	0.378 (0.277)	0.430 (0.281)	0.102 (0.088)	−0,114* (0.068)	−0.113* (0.066)	0.172 (0.153)	−0.681* (0.401)
$Backward_{jt}$	−2.189 (1.471)	−0.898 (0.561)	−0.886 (0.549)	−0.619 (0.653)	−0.474 (0.603)	−0.470 (0.593)	0.774 (0.529)	0.501 (0.436)
$Forward_{jt}$	−1.356 (0.887)	−1.124 (0.860)	−1.121 (0.862)	0.586 (0.400)	0.445 (0.332)	0.431 (0.301)	−1.009 (0.665)	0.411 (0.287)
Control Variables								
$Size_{ijt}$	–	–	0.340*** (0.119)	–	–	0.299*** (0.135)	0.320*** (0.119)	0.310*** (0.111)
Age_{ijt}	–	–	0.002*** (0.000)	–	–	0.002*** (0.000)	0.018*** (0.002)	0.002*** (0.000)
$Herfindahl_{jt}$	–	–	0.186 (1.139)	–	–	0.193 (1.125)	0.166 (0.126)	0.180 (0.112)
R^2	0.28	0.51	0.52	0.27	0.49	0.50	0.02	0.03
Sample	*All*	*All*	*All*	*Domestic*	*Domestic*	*Domestic*	*All*	*Domestic*
Observations	27,559	27,559	27,559	22,893	22,893	22,893	27,559	22,893
Firms	14,865	14,865	14,865	12,921	12,921	12,921	14,865	12,921
IndustryDummies	*no*	*yes*	*yes*	*no*	*yes*	*yes*	–	–
ControlVariables	*no*	*no*	*yes*	*no*	*no*	*yes*	*yes*	*yes*

Notes: This table shows the estimation results of the baseline model presented in Equation 2.25 for Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. While column (1) to (6) apply an OLS approach, (7) and (8) consider firm level fixed-effects. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable *Foreign* is a dummy variable taking the value 1 if a firm's global ultimate owner (GUO) can be identified as being from another country than Poland. The variable *Horizontal* measures the foreign presence in a particular sector. It is calculated by dividing the output of foreign firms in an industry by the total industry-output (see Equation 2.9). In contrast to that, *Backward* is calculated as the sum of the intermediate supply share to all other industries weighted with their foreign presence (see Equation 2.10). *Forward* is calculated in a similar manner. It considers the sum of the intermediate supply share from all industries weighted with their foreign presence (see Equation 2.11). The control variable *Age* is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable *Size* is defined as the log of total assets of a firm in a given year. The control variable *Herfindahl* represents a Herfindahl-Index which measures market concentration. It is defined as the sum of the squared market shares of all companies within a sector (see Equation 2.26).
Robust standard errors are presented in parenthesis.
Each regression includes year fixed-effects.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

While the negative effect for the entire sample in column (1) is now turning positive, the effect for domestic firms is now negative and statistically significant at a 10% level. This effect remains present, even when considering control variables in column (6). A one percent increase of foreign presence in an industry is expected to cause a 0.1 percent decrease in TFP, holding everything constant. *Size* is positive and statistically significant at a 1 percent level, indicating that a one percent increase in a firm's total assets is

associated with a 0.3 percent increase in its productivity. *Age* appears to be positive and statistically significant, however, in its magnitude close to zero. The measure for competition in a market $Herfindahl$ appears to be insignificant.

In a last step, firm-fixed effects are considered in column (7) and (8). While there is no change to be seen for effects on the entire sample, the horizontal effect for domestic firms remains negative and statistically significant at a 10 percent level. This gives an indication that the market stealing effect in Poland outweighs potential technological spillovers and that particularly domestic firms are affected negatively as they possibly struggle from more competition and lose market share. Even though the magnitude declines when considering fixed-effects on the firm level, there is still a decrease of 0.68 percent in TFP associated by a one percent increase of foreign presence in an industry, holding everything else constant.

Extending this first analysis, the previous simple model is extended considering a measure for a firm's absorptive capacity. ABC_{ijt} is defined as a company's own capability to potentially absorb new technology following the approach of Girma et al. (2008) which is outlined in Equation 2.12 in Section 2.4.3.

$$\begin{aligned} ln(TFP_{ijt}) = &\beta_0 + \beta_1 Foreign_{ijt} + \beta_2 Horizontal_{jt} + \beta_3 Backward_{jt} + \beta_4 Forward_{jt} \\ &+ \beta_5 ABC_{ijt} + \beta_6 Horizontal_{ij} * ABC_{ijt} + \beta_7 Backward_{jt} * ABC_{ijt} \\ &+ \beta_8 Forward * ABC_{ijt} + \beta_9 Age_{ijt} + \beta_{10} Size_{ijt} + \beta_{11} Herfindahl_{jt} \\ &+ \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{2.28}$$

This measure is interacted with all three proxies for spillover effects in the baseline model (see Equation 2.25 for the explanation of the variables) in order to see whether the effect also depends on a firm's own abilities to process and implement new knowledge. Following Girma et al. (2008) a positive and significant effect for the interaction terms with ABC_{ijt} can be expected, considering that a firms absorptive capacity is a key determinant of its own capability to adopt new technology (see Cohen and Levinthal (1989) and Cohen and Levinthal (1990)).

Table 2.8 presents the estimation results for both Czech Republic and Poland. Column (1) and (2) refer to OLS regressions for both considering the entire sample and only domestic firms while column (3) and (4) present results considering firm fixed-effects.

Considering the entire sample, both OLS and fixed-effects regression (column (1) and (3)) show positive and statistically significant results horizontally for the Czech Republic. In contrast to that, effects through backward and forward linkages remain absent like in the previous estimations. Examining the interactions of spillover linkages with absorptive capacity it can be seen that the effect is positive and statistically significant at a 1 % level. As an example, a firm with an average productivity (see Table 2.1) perceives an increase

Table 2.8: *Estimation - Considering Absorptive Capacity*

Depended Variable $ln(TFP_{ijt})$	**Czech Republic** (1) OLS	(2) OLS	(3) FE	(4) FE	**Poland** (5) OLS	(6) OLS	(7) FE	(8) FE
$Foreign_{ijt}$	0.087***	–	–	–	0.089***	–	–	–
	(0.004)				(0.008)			
$Horizontal_{jt}$	2.520***	1.414*	2.268***	1.343**	1.006	−0.826*	0.973	−0.788**
	(0.923)	(0.739)	(0.591)	(0.643)	(0.762)	(0.496)	(0.687)	(0.384)
$Backward_{jt}$	1.397	1.328	0.709	0.714	2.202	1.347	1.504	1.263
	(0.988)	(1.189)	(0.533)	(0.510)	(1.598)	(0.858)	(1.008)	(0.798)
$Forward_{jt}$	−2.469	−1.993	−0.662	0.144	1.345	1.033	1.167	1.008
	(2.201)	(1.532)	(0.452)	(0.096)	(0.946)	(0.764)	(0.931)	(0.741)
$Horizontal_{jt} * ABC_{ijt}$	0.663***	0.517**	0.378***	0.293***	0.361	0.129**	0.348	0.118**
	(0.082)	(0.259)	(0.074)	(0.103)	(0.243)	(0.062)	(0.239)	(0.058)
$Backward_{jt} * ABC_{ijt}$	0.204	0.183	0.230	0.191	2.874	3.776	2.278	3.555
	(0.194)	(0.148)	(0.157)	(0.139)	(1.791)	(2.691)	(1.456)	(2.494)
$Forward_{jt} * ABC_{ijt}$	−0.022	0.197	−0.020	0.177	1.260	1.612	1.219	1.601
	(0.105)	(0.151)	(0.098)	(0.126)	(0.947)	(0.994)	(0.922)	(0.986)
Control Variables								
$Size_{ijt}$	0.286***	0.267***	0.269***	0.263***	0.333***	0.298**	0.317***	0.311***
	(0.105)	(0.101)	(0.097)	(0.099)	(0.123)	(0.139)	(0.120)	(0.115)
Age_{ijt}	−0.002**	−0.002**	−0.058***	−0.065***	0.002***	0.002***	0.017***	0.002***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.005)	(0.000)
$Herfindahl_{jt}$	−4.563***	−4.463***	−2.984***	−2.636***	0.188	0.192	0.168	0.183
	(0.133)	(0.106)	(0.126)	(0.102)	(0.140)	(0.127)	(0.127)	(0.114)
R^2	0.73	0.68	0.14	0.09	0.81	0.79	0.04	0.03
Sample	*All*	*Domestic*	*All*	*Domestic*	*All*	*Domestic*	*All*	*Domestic*
Observations	83,271	72,211	83,271	72,211	27,559	22,893	27,559	22,893
Firms	20,295	17,960	20,295	17,960	14,856	12,921	14,856	12,921
IndustryDummies	*yes*	*yes*	–	–	*yes*	*yes*	–	–

Notes: This table shows the estimation results of the baseline model presented in Equation 2.28 for both the Czech Republic and Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. While column (1) and (2) apply an OLS approach, (3) and (4) consider firm level fixed-effects. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable *Foreign* is a dummy variable taking the value 1 if a firm's global ultimate owner (GUO) can be identified as being from another country than the Czech Republic or Poland respectively. The variable *Horizontal* measures the foreign presence in a particular sector. It is calculated by dividing the output of foreign firms in an industry by the total industry-output (see Equation 2.9). In contrast to that, *Backward* is calculated as the sum of the intermediate supply share to all other industries weighted with their foreign presence (see Equation 2.10). *Forward* is calculated in a similar manner. It considers the sum of the intermediate supply share from all industries weighted with their foreign presence (see Equation 2.11). The measure for absorptive capacity *ABC* is calculated by dividing a firm's own total factor productivity (TFP) by the maximum TFP within its industry in a given year (see Equation 2.12). The control variable *Age* is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable *Size* is defined as the log of total assets of a firm in a given year. The control variable *Herfindahl* represents a Herfindahl-Index which measures market concentration. It is defined as the sum of the squared market shares of all companies within a sector (see Equation 2.26).
Robust standard errors are presented in parenthesis.
Each regression includes year fixed-effects.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

of 1.4 percent in its productivity when foreign presence in its own industry increases by one percentage point.[1] This indicates that firms with a higher absorptive capacity, which is equivalent to their own productivity relative to the most productive firm in their sector, benefit more from spillover effects. This effect holds for both, OLS and FE estimation. It further confirms the result found in Table 2.6. When examining domestic firms only, a positive effect horizontally is now present and significant. Again, firms with a higher absorptive capacity benefit more from spillovers as their less productive counterparts. A domestic firm with average productivity perceives a 0.7 percent increase in its productivity with a one percentage point increase in foreign presence in its industry. These effects show that in the Czech Republic firms rather benefit from foreign presence in their own sector instead of suffering. This indicates that the competition effect is absent and foreign presence is positively affecting an industry and its firms operating in.

The *Age* of a company seems to have a rather small but significant impact on a firm's productivity in a negative way. A potential reason for this could be that the Czech Republic was undergoing a massive transition fairly late, namely in the late 1990s. With a massive FDI inflow, rather young companies brought in new technology and a substantial know-how which was superior compared to their domestic competitors (see Rugraff (2008)). Therefore, many firm's with high productivity are still quite young, while older companies are only slowly adopting new technology and improving their production processes.

The Herfindahl Index appears significant and negative for all estimation methods and both samples. This index can take a value between 0 and 1. The higher the Herfindahl Index is, the more concentrated a market is. Therefore, a small Index indicates a lot of competition, while a high value suggests the presence of a monopole, with only little or no competition present. As this coefficient is negative, it indicates that that less competition (meaning a high Herfindal Index) causes a negative effect on a firm's productivity, implying that a lot of competition is perceived as beneficial in the Czech economy. This is also in line with the results of Djankov and Hoekman (2000) indicating that horizontal spillovers outweigh a market stealing effect.

Size appears to be positive and significant, showing similar results as in Table 2.6. A one percent increase in a firms size is associated with a 0.2 percent increase in its productivity.

In comparison to the Czech Republic, Poland shows rather different results. While the direct effect of foreign ownership remains positive and statistically significant, its magnitude is way smaller than in previous estimations. Regarding spillover effects, there are no spillovers present considering the entire sample. Focusing only on domestic firms, there are negative horizontal spillover present, suggesting that domestic firms suffer

[1] This is calculated in following way: $02.268 + 0.378 * (-2.237) = 1.422$. The mean of TFP for firms in the Czech Republic is -2.237 (see Table 2.1).

from losses in productivity with a higher presence of foreign firms in their own sector. Considering fixed effects on the firm level (see column (8)), a domestic firm with average productivity (-3.017, see Table 2.6) perceives an 1.14 percent decrease in its productivity when foreign presence in its industry increases by one percentage point.[2]

This might be the case because foreign firms gain too much market power or that productivity and the technological level of indigenous Polish firms might not sufficient enough to compete. This is in line with previous results obtained by Nicolini and Resmini (2010) who suggest that the competition effect might outweigh potential technology transfers intra-industry wise, resulting in negative spillover effects horizontally to be seen. When interacted with ABC, there is a positive and significant effect for spillovers horizontally. This provides insight on how absorptive capacity impacts the negative effect through foreign presence. Even though, the main $Horizontal$ effect appears to be negative, its interaction with ABC is positive. Therefore, with a higher absorptive capacity, meaning a higher technological level, suffer less from foreign presence than companies with a very low productivity level. The effects of the control variables are rather similar as the results obtained for the Czech Republic, with the age being significant however having a rather neglectable effect. Further, the Herfindahl Index does not appear to be statistically significant.

2.6.1 Modification - Spillovers Split by a Company's Origin

The previous results obtained from the baseline model and its extension provovide a first insight into whether spillover effects are present and in which way they are occurring. In a next step the origin of a foreign company is considered in order to investigate whether the origin of a foreign investor might have an impact on spillovers occurring to domestic firms. This could potentially be the case as different countries or country types have different intentions when conducting an investment. Further, they might be endowed with different types and levels of technology, to which then domestic firms might respond in different ways. Particularly the absorptive capacity can be a key determinant here. Table A.5 and Table A.6 show the composition of companies operating in the Czech Republic and Poland (see Appendix). The country of origin is identified by taking advantage of ORBIS reporting a firm's $GlobalUltimateOwner$. Considering this, the variables $Horizontal$ and $Backward$ are re-defined following the approach of Javorcik and Spatareanu (2011).

$$Horizontal\_Dev_{jt} = \frac{\sum_{i\,for\,all\,i\,\epsilon\,j} Foreign\_Dev_{it} * Y_{it}}{\sum_{i\,for\,all\,i\,\epsilon\,j} Y_{it}} \tag{2.29}$$

[2]This is calculated in following way: $-0.788 + 0.118 * (-3.017) = -1.144$. The mean of TFP for firms in the Poland is -3.017 (see Table 2.1)

$$Backward\_Dev_{jt} = \sum_{k\,if\,k\neq j} \alpha_{jkt} * Horizontal\_Dev_{kt} \tag{2.30}$$

These definitions follow the previous calculations illustrated in Equation 2.9 and 2.10. However, instead of identifying a firm as being foreign, it now only considers firms which are foreign and having a *GlobalUltimateOwner* from a developing country.

This study does not follow the approach separating countries by region or continent (see Javorcik and Spatareanu (2011)). Instead, the sample is separated by distinguishing firms coming from developing and developed countries. The indication of *GlobalUltimateOwner* is used for this purpose.

Additionally, a procedure of how to define a developing country has to be established. The United Nations (2014) provides an overview of every country and its classification in their "World Economic Situation and Prospects" – Report. Further, the International Monetray Fund (2009) gives a definition of developing countries as well. As this study uses data covering the years 2009 to 2014, the 2009 classification of the IMF is used when identifying a country in the sample as either developed or developing / merging. As the data sample already lies 10 years in the past, using current classification might lead to potential biases, as some countries would now be considered as "developed" even though they were still in the stage of transition in 2009. After defining these new linkages, the same linkages are defined only for advanced economies.

$$Horizontal\_Adv_{jt} = \frac{\sum_{i\,for\,all\,i\,\epsilon\,j} Foreign\_Adv_{it} * Y_{it}}{\sum_{i\,for\,all\,i\,\epsilon\,j} Y_{it}} \tag{2.31}$$

$$Backward\_Adv_{jt} = \sum_{k\,if\,k\neq j} \alpha_{jkt} * Horizontal\_Adv_{kt} \tag{2.32}$$

These definitions follow the previous calculations illustrated in Equation 2.9 and 2.10 as well. However, instead of identifying a firm as being foreign, it now only considers firms which are foreign and having a *GlobalUltimateOwner* from an advanced/developed country.

This allows to control for spillovers occurring in these ways as well. In order to refer to both types of companies, MNE_dev is used as an abbreviation for firm's having their parent in a developing country and MNE_adv for firms with a parent in an advanced economy.

With these new proxies, a new model is defined following the approach of Javorcik and Spatareanu (2011)

$$\begin{aligned} ln(TFP_{ijt}) = \alpha_0 &+ \beta_1 Horizontal\_Dev_{jt-1} + \beta_2 Backward\_Dev_{jt-1} \\ &+ \beta_3 Horizontal\_Adv_{jt-1} + \beta_4 Backward\_Adv_{jt-1} + \beta_5 Size_{ijt-1} \\ &+ \beta_6 Age_{ijt-1} + \beta_7 Herfindahl_{jt-1} + \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{2.33}$$

with both horizontal and backward spillovers now being separated into two channels, spillovers occurring through linkages with MNEs from developing countries (see Equation 2.29 and Equation 2.30) and linkages with MNEs from advanced/developed economies (see Equation 2.31 and Equation 2.32). α_i controls for firm specific fixed-effects and θ_t for time fixed effects. As potential knowledge externalities coming from foreign investment might need time to establish and manifest themselves, all spillover proxies are lagged one period. As forward linkages did not show any significant effects in previous estimation results, they will be excluded from this model and further examinations. This is in line with the general conclusion in the literature that forward spillovers are very unlikely to happen and that vertical spillovers, if they are present, would rather occur through backward linkages. This is also in line with the approach of Javorcik and Spatareanu (2011) who only researched the occurrence of horizontal spillovers and vertical spillovers through backward linkages, not considering forward linkages.

$Horizontal\_Dev_{jt-1}$ and $Backward\_Dev_{jt-1}$ are expected to be more likely to show a positive and significant coefficient than $Horizontal\_Adv_{jt-1}$ and $Backward\_Adv_{jt-1}$. This is based on the theory of the technology gap between domestic firms and foreign firms from developing countries to be smaller compared to the technology gap between domestic firms and foreign firms from advanced countries (see Girma et al. (2008) and Figure 2.4a to 2.6 in Section 2.2.3).

Table 2.9 shows the estimation results of the new model for both Czech Republic and Poland. Again, the estimation is first executed without considering absorptive capacity.

Investigating the results for the Czech Republic, it can be seen that there are horizontal spillover effects occurring in both ways, from foreign companies coming from developing countries and also from firms with their parent being located in a developed country. Interestingly, the effect from MNE_dev appears to be way larger than the effect coming from MNE_adv. As the entire sample is considered, a potential explanation could be that the presence of MNE_dev also has a very strong effect on MNE_adv. A one percentage point increase in the presence of MNEs from developing countries in a sector is associated with an increase of 3.5 percent in TFP holding everything else constant. With more competition, a MNE_adv might fear to lose market share and tries to implement new technologies or conducts more R&D to stay competitive. As it can be assumed that MNE_adv are more advanced and productive than MNE_dev, the positive effect of MNE_adv on MNE_dev and domestic firms might be rather small. When only

considering domestic firms, it can be seen that firms benefit from positive externalities as well, however, only thought the presence of MNE_dev in their own sector. A one percentage point increase in the presence of MNEs from developing countries in a sector is associated with an increase of 2.9 percent in TFP for domestic firms holding everything else constant. While the presence of MNE_adv has a statistically insignificant effect, it is interesting to see that now the magnitude has changed to a negative value. For vertical spillovers through backward linkages, there are no significant results to be found for neither domestic firms, nor the whole sample. The relatively low R^2 is in line with results provided by Javorcik and Spatareanu (2011) who obtains similar low coefficients, ranging between 0.02 and 0.05.

For Polish firms, horizontal spillovers appear to be negative and significant. This is in line with previous estimations which indicate that the market stealing effect might outweigh possible technological transfers. For the whole sample, negative horizontal effects occur only through MNE_adv. This can be explained by MNE_adv claiming a larger market share, as they are more productive and competitive than their MNE_dev competitors. When only considering domestic firms, there is also a negative and significant horizontal effect occurring through MNE_dev, additionally to the negative effect from MNE_adv. While domestic firms perceive a 0.22 percent decrease in productivity with a one percentage point increase of the presence of MNEs from developing countries, the effect caused by MNEs from advanced countries is more than 3 times as large, namely 0.71 percent. A reason for that is, that even though MNE_dev are not able to take much market share from MNE_adv, they are indeed competitive enough to push domestic firms out of the market. This indicates that there is a competition effect present for both, domestic firms and MNE_adv and also MNE_dev (see Aitken and Harrison (1999)). This is surprising, as the technological gap between domestic firms and MNE_dev is expected to be smaller as the gap between domestic firms and MNE_adv. Moreover, the negative horizontal effect from MNE_adv is larger for only domestic firms as it is for the entire sample, indicating that domestic firms suffer particularly more than other MNEs. Regarding spillovers through backward linkages, there are no significant results present for either estimation. These results are similar to the ones obtained in the Czech Republic. The R^2 is rather low and in line with previously obtained results in the literature (see Javorcik and Spatareanu (2011)). For $Size$, the effects remain similar to previous estimations, indicating that a one percent increase in firm size is associated with a 0.2 percent increase in TFP for all estimations.

In a final step, model 2.33 is extended by implementing the measure for absorptive capacity as previously defined. A new extended model is written as

Table 2.9: *Estimation - Spillovers from Developing Countries*

Depended Variable $ln(TFP_{ijt})$	**Czech Republic** (1) FE	(2) FE	**Poland** (1) FE	(2) FE
$Horizontal\_Dev_{jt-1}$	3.511**	2.923*	−0.539	−0.223*
	(1.707)	(1.759)	(0.371)	(0.124)
$Horizontal\_Adv_{jt-1}$	1.483***	−0.162	−0.465***	−0.713***
	(0.509)	(0.144)	(0.124)	(0.222)
$Backward\_Dev_{jt-1}$	1.245	0.396	−0.210	0.073
	(0.845)	(0.273)	(0.143)	(0.064)
$Backward\_Adv_{jt-1}$	0.938	0.418	−0.309	−0.102
	(0.663)	(0.374)	(0.197)	(0.097)
Control Variables				
$Size_{ijt-1}$	0.288***	0.279***	0.245***	0.238***
	(0.092)	(0.100)	(0.046)	(0.065)
Age_{ijt-1}	0.008***	0.003	0.006	−0.001
	(0.002)	(0.002)	(0.006)	(0.007)
$Herfindahl_{jt-1}$	−0.469*	−0.378	−0.096	−0.103
	(0.261)	(0.214)	(0.126)	(0.106)
R^2	0.06	0.04	0.04	0.03
Sample	*All*	*Domestic*	*All*	*Domestic*
Observations	62,976	54,251	12,694	9,972
Firms	17,281	15,162	6,300	5,098

Notes: This table shows the estimation results of the extended model presented in Equation 2.33 for both the Czech Republic and Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. Column (1) considers the entire sample, while estimation (2) only focuses on domestic firms. Both estimations consider fixed-effects on the firm-level. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable $Horizontal\_Dev$ measures the presence of foreign companies from developing countries in a particular sector. It is calculated by dividing the output of foreign firms from developing countries in an industry by the total industry-output (see Equation 2.29). $Horizontal\_Adv$ is calculated in the same way, however, only considering the output from foreign firms coming from advanced countries (see Equation 2.31). In contrast to that, $Backward\_Dev$ is calculated as the sum of the intermediate supply share to all other industries weighted with the presence of foreign firms from developing countries (see Equation 2.30). $Backward\_Adv$ is calculated in the same way, however only considering the foreign presence of firms coming from advanced countries (see Equation 2.32). The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year. The control variable $Herfindahl$ represents a Herfindahl-Index which measures market concentration. It is defined as the sum of the squared market shares of all companies within a sector (see Equation2.26).
Following the suggestion of Javorcik and Spatareanu (2011) all independent variables are included with a lag of one period.
Robust standard errors are presented in parenthesis.
Each regression includes year fixed-effects.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

$$\begin{aligned} ln(TFP_{ijt}) = &\alpha_0 + \beta_1 Horizontal\_Dev_{jt-1} + \beta_2 Backward\_Dev_{jt-1} \\ &+ \beta_3 Horizontal\_Adv_{jt-1} + \beta_4 Backward\_Adv_{jt-1} \\ &+ \beta_5 Horizontal\_Dev_{jt-1} * ABC_{ijt} + \beta_6 Backward\_Dev_{jt-1} * ABC_{ijt} \\ &+ \beta_7 Horizontal\_Adv_{jt-1} * ABC_{ijt} + \beta_8 Backward\_Adv_{jt-1} * ABC_{ijt} \\ &+ \beta_9 Size_{ijt-1} + \beta_{10} Age_{ijt-1} + \beta_{11} Herfindahl_{jt-1} + \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{2.34}$$

with ABC_{ijt} being defined as the ratio of a firm's own total factor productivity level to the maximum productivity level in its industry (see Equation 2.12).

Tabel 2.10 shows the results of the estimation of Equation 2.34. Again, the positive horizontal spillovers in the Czech Republic remain present for both linkages to MNE_dev and MNE_adv. The interaction terms with the absorptive capacity are positive and statistically significant as well, indicating that a firm's absorptive capacity is an essential factor regarding perceiving benefits from foreign presence. It can further be noted that the effect coming from MNE_adv is larger than the one from MNE_dev. This implies that with a higher absorptive capacity, presence of MNEs from advanced economies is more beneficial as the presence of MNEs from developed countries. For a firm with average productivity a one percentage point increase in the presence of MNEs from advanced countries within its industry is associated with an increase in productivity of 1.2 percent, holding everything else constant.[3] Further, there is now a positive and statistically significant effect occurring through backward linkages, however only to MNE_adv. This means that a one percentage point increase in presence of MNEs from advanced countries in the sourcing sectors is associated with a 0.73 percent increase in TFP for a firm with an average TFP.[4] This effect did not occur in previous estimations and stresses the importance of accounting for absorptive capacity. When only considering domestic firms, there is only an effect present from MNE_dev. Further, it can be seen that domestic firms benefit from vertical spillovers through backward linkages from MNE_dev, not from MNE_adv. A one percentage point increase in presence of MNEs from developing countries in the sourcing sectors is associated with a 0.84 percent increase in TFP for a domestic firm with an average TFP.[5]

It can be seen that even though all firms benefit from backward spillovers, the origin of this effect appears to be different. While for the entire sample these spillovers occur through MNE_adv , this effect does not hold for domestic firms. However, domestic firms perceive productivity gains with backward linkages to MNE_dev . This could be explained by MNE_dev having a lower technological frontier which makes it easier for domestic firms to upgrade their technology. Further, MNE_dev might have different ambitions as MNE_adv and rather tend to integrate domestic firms into their production process as reliable suppliers. The control variables show similar results as in previous estimations presented in Table 2.8.

For Poland, the negative horizontal effect remains present having its origin at the presence of MNE_adv . Further, the interaction term with ABC is positive and statistically significant, showing that firms with less distance to the technological frontier suffer less from the competition effect. For domestic companies, this effect is present

[3]This is calculated in following way: $1.431 + 0.104 * (-2.237) = 1.198$. The mean of TFP for firms in the Czech Republic is -2.237 (see Table 2.1).

[4]Calculated as: $0.862 + 0.059 * (-2.237) = 0.730$

[5]Calculated as: $0.993 + 0.057 * (-2.237) = 0.843$

Table 2.10: *Estimation - Spillovers from Developing Countries incl. Absorptive Capacity*

Depended Variable $ln(TFP_{ijt})$	**Czech Republic** (1) FE	(2) FE	**Poland** (1) FE	(2) FE
$Horizontal\_Dev_{jt-1}$	1.207**	1.114**	−0.404	−0.418***
	(0.583)	(0.498)	(0.293)	(0.114)
$Horizontal\_Adv_{jt-1}$	1.431***	1.403	−0.603***	−0.711***
	(0.380)	(0.880)	(0.188)	(0.282)
$Backward\_Dev_{jt-1}$	0.668	0.993**	0.320	0.286
	(0.417)	(0.501)	(0.293)	(0.198)
$Backward\_Adv_{jt-1}$	0.862**	0.789	0.416	0.336
	(0.420)	(0.532)	(0.309)	(0.273)
$Horizontal\_Dev_{jt-1} * ABC_{ijt}$	0.071***	0.059***	0.017	0.021***
	(0.021)	(0.021)	(0.015)	(0.008)
$Horizontal\_Adv_{jt-1} * ABC_{ijt}$	0.104***	0.117	0.015*	0.024**
	(0.001)	(0.073)	(0.009)	(0.012)
$Backward\_Dev_{jt-1} * ABC_{ijt}$	0.052	0.067***	0.040	0.033
	(0.037)	(0.024)	(0.031)	(0.029)
$Backward\_Adv_{jt-1} * ABC_{ijt}$	0.059***	0.046	0.042	0.039
	(0.020)	(0.032)	(0.036)	(0.034)
Control Variables				
$Size_{ijt-1}$	0.247***	0.201***	0.225***	0.219***
	(0.067)	(0.053)	(0.033)	(0.041)
Age_{ijt-1}	0.004***	0.003***	0.018***	0.007
	(0.001)	(0.001)	(0.005)	0.006
$Herfindahl_{jt-1}$	−0.325***	−0.361***	−0.343*	−0.316
	(0.108)	(0.114)	(0.183)	(0.218)
R^2	0.16	0.11	0.08	0.06
Sample	*All*	*Domestic*	*All*	*Domestic*
Observations	62,976	54,251	12,694	9,972
Firms	17,281	15,162	6,300	5,098

Notes: This table shows the estimation results of the extended model presented in Equation 2.34 for both the Czech Republic and Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. Column (1) and (3) consider the entire sample, while column (2) and (4) only focus on domestic firms. Both estimations consider fixed-effects on the firm-level. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable $Horizontal\_Dev$ measures the presence of foreign companies from developing countries in a particular sector. It is calculated by dividing the output of foreign firms from developing countries in an industry by the total industry-output (see Equation 2.29). $Horizontal\_Adv$ is calculated in the same way, however, only considering the output from foreign firms coming from advanced countries (see Equation 2.31). In contrast to that, $Backward\_Dev$ is calculated as the sum of the intermediate supply share to all other industries weighted with the presence of foreign firms from developing countries (see Equation 2.30). $Backward\_Adv$ is calculated in the same way, however only considering the foreign presence of firms coming from advanced countries (see Equation 2.32). The measure for absorptive capacity ABC is calculated by dividing a firm's own total factor productivity (TFP) by the maximum TFP within its industry in a given year (see Equation 2.12). The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year. The control variable $Herfindahl$ represents a Herfindahl-Index which measures market concentration. It is defined as the sum of the squared market shares of all companies within a sector (see Equation2.26).
Following the suggestion of Javorcik and Spatareanu (2011) all independent variables are included with a lag of one period.
Robust standard errors are presented in parenthesis.
Each regression includes year fixed-effects.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

as well. However, there is also a negative competition effect through $Horizontal\_Dev$ occurring. Its interaction term with ABC is positive and significant, damping the negative main effect for companies with higher absorptive capacity. A domestic firm with average productivity perceives a 0.48 percent decrease in its TFP with a one percentage point increase of the presences of MNEs from developing countries in its own industry. [6] For an increase in the presence of MNEs from advanced economies this effect is more negative, namely 0.78 percent. For backward linkages there are no effects significant showing that firms are neither benefiting nor suffering from interactions with other sectors with a strong foreign presence.

Compared with previous studies, such as Djankov and Hoekman (2000) who finds horizontal spillovers in the Czech Republic, these results are in line with the literature. Further, this study confirms previous findings by Kinoshita (2000) who first fails to find positive spillovers horizontally. After controlling for absorptive capacity using R&D expenditures of a company, she finds positive and significant intra-industry effects, which highlight the importance to account for the capability of a company to adapt new technology.

When analyzing companies operating in Poland, the effect for backward spillovers appears to be insignificant, being in line with previous results in the literature which fails to find evidence for significant productivity externalities through vertical linkages in the Polish economy (see Konings (2001) and Nicolini and Resmini (2010)). Conducting the separation into developing and developed firms and re-defining the spillover proxies shows, that the presence of MNE from developing countries does not have a particular effect which would differ from previous results in the literature, highlighting that spillovers through backward linkages are not occurring in Poland. Further, horizontal spillovers appear to be significant and negative for domestic firms.This is partly in line with results of Konings (2001) who fails to find any significant horizontal spillovers in Poland but highlights that there is a negative tendency to be seen. He identifies as a potential reason that positive technology externalities and the negative competition effect seem to channel each other out. Additionally, this could partially be explained with findings of Rugraff (2008), who suggests that CEECs rather followed the approach of Ireland, which solely focuses on attracting FDI without strengthening indigenous firms by providing strong government support in the first place.

2.6.2 Domestic Multinational Enterprises

To investigate the occurrence of spillovers towards domestic firms in more detail, domestic firms are now separated identifying them as a domestic multinational enterprise or a solely domestic firm. This is done by using ORBIS data on whether a firm has subsidiaries

[6] Calculated as: $0.418 + 0.021 * (-3.017) = -0.481$. The average TFP for a domestic firm is -3.017

or not. ORBIS reports the numbers of subsidiaries a company has which seems to be adequate to use for such an analysis at first glance. However, this report of subsidiary does not exclude domestic subsidiaries. Therefore, a firm could have subsidiaries, however, all of them could be located in the home country of the parent. This would give the appearance of a company being multinational, even though it only operates in one country.

Therefore, a more extended approach is undertaken, by extracting a list of all subsidiaries for each company with their respective country code they are operating in. In a next step, companies are identified as $Domestic\_MNE$ when they have at least one subsidiary operating in another country than the home country. After this exercise, Equation 2.34 is estimated again, only considering $Domestic\_MNE$. Table 2.11 presents the estimation results.

Column (1) and (3) refer to the estimation without controlling for absorptive capacity while column (2) and (4) include the respective measure. For the Czech Republic there is a positive and significant effect for domestic multinational firms present, having their origin in horizontal spillovers from MNE_adv. A one percent increase in foreign presence in a sector is associated with an increase in a domestic MNEs' TFP of 0.17 percent. In comparison, the effect from MNE_dev is insignificant. This can be explained by MNE_dev having a lower level of technology than domestic multinationals, which prevents a potential learning or imitation process through this channel. As MNE from developed countries are considered to have a high technological level, potential technology transfers are more likely to happen from this source. When including ABC in the estimation, there are now positive and significant effects through backward linkages occurring. This is rather surprising, as the origin of different spillovers are differing. It indicates that sourcing intermediate inputs from industries with strong foreign presence from developing countries has a positive effect on productivity for domestic MNE. This means that a one percent increase in presence of MNEs from developing countries in the sourcing sectors is associated with a 1.04 percent increase in TFP for a domestic MNE with an average TFP.

This is rather surprising as the same effect does not hold for industries with strong foreign presence from developed countries. A potential explanation could be that MNE_dev are mainly supplying domestic multinationals, as MNE_adv might have better international nexuses and are able to source intermediate goods internationally to ensure high quality and efficiency. Therefore, only MNE_dev are generating these positive externalities towards domestic MNEs.

For Poland, there are no effects present as long as it is not controlled for absorptive capacity. After including a measure for such in column (2), there is a positive and significant horizontal effect present, with its origin from MNE_adv. It is interesting to see that this effect appears to be positive now, as it has been negative for all previous

Table 2.11: *Estimation - Spillovers from Developing Countries to Domestic MNEs*

Depended Variable $ln(TFP_{ijt})$	**Czech Republic** (1) FE	(2) FE	**Poland** (1) FE	(2) FE
$Horizontal\_Dev_{jt-1}$	0.974	0.879	1.225	1.524
	(0.622)	(0.583)	(0.889)	(1.367)
$Horizontal\_Adv_{jt-1}$	1.690*	1.513**	0.650	1.318*
	(1.002)	(0.732)	(0.574)	(0.754)
$Backward\_Dev_{jt-1}$	1.438	1.270**	−1.563	1.782
	(1.216)	(0.596)	(15.916)	(6.061)
$Backward\_Adv_{jt-1}$	1.183	1.006	0.936	1.592
	(1.164)	(0.709)	(3.412)	(3.451)
$Horizontal\_Dev_{jt-1} * ABC_{ijt}$		0.312		1.184
		(0.285)		(1.212)
$Horizontal\_Adv_{jt-1} * ABC_{ijt}$		0.085***		0.051
		(0.030)		(0.033)
$Backward\_Dev_{jt-1} * ABC_{ijt}$		0.099***		0.084
		(0.021)		(0.082)
$Backward\_Adv_{jt-1} * ABC_{ijt}$		0.082		0.058
		(0.059)		(0.050)
Control Variables				
$Size\,(lag1)$	0.547***	0.524***	0.614***	0.589***
	(0.065)	(0.131)	(0.093)	(0.070)
$Age\,(lag1)$	0.005	0.012	0.021	0.001
	(0.016)	(0.014)	(0.059)	(0.056)
$Herfindahl\,(lag1)$	−0.948	−0.428***	−1.928	−0.380
	(0.671)	(0.063)	(2.145)	(1.290)
R^2	0.05	0.14	0.09	0.16
Sample	*DomesticMNE*	*DomesticMNE*	*DomesticMNE*	*DomesticMNE*
Observations	1,912	1,912	161	161
Firms	440	440	81	81

Notes: This table shows the estimation results only considering $DomesticMNE$ in the sample for both the Czech Republic and Poland. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2014. While column (1) and (3) follow the model presented in Equation 2.33 and do not consider absorptive capacity, (2) and (4) follow the approach shown in Equation 2.34 and account for absorptive capacity (ABC). Both estimations consider fixed-effects on the firm-level. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable $Horizontal\_Dev$ measures the presence of foreign companies from developing countries in a particular sector. It is calculated by dividing the output of foreign firms from developing countries in an industry by the total industry-output (see Equation 2.29). $Horizontal\_Adv$ is calculated in the same way, however, only considering the output from foreign firms coming from advanced countries (see Equation 2.31). In contrast to that, $Backward\_Dev$ is calculated as the sum of the intermediate supply share to all other industries weighted with the presence of foreign firms from developing countries (see Equation 2.30). $Backward\_Adv$ is calculated in the same way, however only considering the foreign presence of firms coming from advanced countries (see Equation 2.32). The measure for absorptive capacity ABC is calculated by dividing a firm's own total factor productivity (TFP) by the maximum TFP within its industry in a given year (see Equation 2.12). The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year. The control variable $Herfindahl$ represents a Herfindahl-Index which measures market concentration. It is defined as the sum of the squared market shares of all companies within a sector (see Equation2.26).
Following the suggestion of Javorcik and Spatareanu (2011) all independent variables are included with a lag of one period.
Robust standard errors are presented in parenthesis.
Each regression includes year fixed-effects.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

estimations. However, it is important to point out that this effect is only significant at a 10 percent level and the sample size when only considering Polish domestic MNEs is rather small, only covering 81 observations. Therefore, results here should only be interpreted with caution. The age of a domestic MNE appears to be insignificant, while the size

of it shows to be significant and positive for all estimations. Considering estimation (2) and (4), a one percent increase in a domestic MNE's total assets is associated with an increase of its TFP of 0.52 percent in the Czech Republic and 0.59 percent in Poland, holding everything else constant.

2.7 Conclusion

This paper analyzes spillover effects occurring in the Czech Republic and in Poland using ORBIS data from 2009-2014. As ORBIS data is not particularly suited for econometric analyses, this study undergoes an extensive data cleaning and data treatment. After deflating all nominal values, input variables for estimating total factor productivity are defined and adjusted. Having these adjusted values, total factor productivity is estimated using the approach of Levinsohn and Petrin (2003) as a first step. These estimated values are used as a dependent variable. In a next step, spillover proxies are defined following Javorcik (2004) and a simple baseline model is defined to gain first results

After estimating this model, the estimation approach is extended by controlling for absorptive capacity. It highlights the importance of doing so, as horizontal spillovers in the Czech Republic become more statistically significant and positive. Further, negative spillovers occurring in Poland to domestic firms are confirmed to be significant.

To fill a gap in the literature, MNEs are now identified as either coming from a developed or developing country using International Monetray Fund (2009) classifications. A more advanced model is now defined following the approach of Javorcik and Spatareanu (2011), using spillover proxies considering the origin of a multinational firm. While in the first approach there are no positive externalities through backward linkages to be seen, there are positive spillovers present once it is accounted for absorptive capacity. This is a novel insight into the occurrence of spillovers coming from FDI which has not been discovered and researched yet.

The findings of these study emphasize the importance of the absorptive capacity, providing more evidence that simply attracting FDI does not necessarily lead to positive externalities. More importantly, it is essential that firms are already endowed with a certain level of technology in order to be able to adopt new knowledge and technological progress. This is in line with previous studies, such as Rugraff (2008) who compared two different FDI strategies, the Irish model and the TKC model. As companies coming from developing countries are likely to have a lower technological level compared to their counterparts coming from developed countries, domestic firms show a higher potential to benefit from their presence. This is based on the idea that the technology gap is smaller, making it easier for domestic firms to adopt new technology, which increases the likelihood for spillovers to occur. While effects coming from interactions with suppliers

cannot be found in Poland, the results show positive effects through backward linkages in the Czech Republic.

These findings stress that there is further research required focusing on the origin of a foreign investor. Multiple factors play a significant role, such as new technology brought to a host country, the technological levels of domestic firms, the intentions of a foreign investor, or the competition within an industry. As all these factors are vastly considered in numerous studies, there is clearly a lack to be seen when it comes to considering the origin of FDI. Therefore, more research would be desirable and necessary in order to find more evidence if such effects stemming from MNEs from developing economies remain present in other countries and whether this is an effect that remains present for several datasets. When comparing spillovers coming from MNE_Dev and MNE_Adv, Czech companies perceive a stronger positive effect from interactions with sectors with a strong presence of multinational firms coming from developing countries. This supports the theory that a smaller technological gap facilitates spillovers.

Chapter 3

Multinationality in Times of Financial Pressure

3.1 Introduction

The impact and magnitude of the global financial crisis occurring in the late 2000s can be described as notably severe and extraordinary. Besides having a rigorous impact on economies worldwide, it further transformed into a sovereign debt crisis in the euro area (Acharya et al., 2014; Alter and Schüler, 2012). Having its origin in Greece it progressively spread to other European economies, such as Ireland and Portugal, which consequently had to resort to bailout schemes set up by the IMF, the EU and the ECB. This resulted in a rise of financial pressure in Europe which remained at high levels until 2012 (see Benito (2017)) suggesting the financial crisis being the trigger and the subsequent sovereign debt crisis reflecting higher expenses regarding interests rates.

The proposed research aims to investigate how productivity on the firm level responds to financial pressure during the sovereign debt crisis, focusing on countries in the euro area. It follows the approach of Nickell and Nicolitsas (1999) and later further employed by Fernandes et al. (2014) who research how financial pressure impacts employment in periphery countries in the euro zone.

With the capital exercise by the European Banking Authority (EBA) occurring in 2011, bank lending got significantly limited as banks were required to reach tier 1 capital ratio at a level of 9 percent by not later than June 2012. Therefore, this external shock led to a surprising and unexpected reduction of access to capital. When facing a higher level of financial pressure, companies might end up with adjusting their operations on a large scale, which could mean a reduction of employment or general reorganization.

This study intents to research the effect of financial pressure on productivity levels of both domestic and multinational firms. It intends to separate firms by their ownership status in order to investigate whether foreign ownership plays a significant role when

it comes to dealing with financial pressure. The focus is on firms being located in a selection of countries which are part of the euro zone and therefore strongly affected by the EBA decision. Further, a distinction is made by classifying firms into being located in periphery or non-periphery countries.[1] The results suggest that indeed the level of ownership matters when it comes to the perception of financial pressure. The motivation behind this distinction is the assumption that generally multinational firms are equipped with different ways of sourcing new capital and financing themselves than solely domestic firms are able to. Therefore, limited access to bank loans might not be as sever for a multinational organization as it would be for a national domestic firm which relies largely on the banking sector to finance itself.

Firm-level data comprising both financial and ownership data is obtained from the ORBIS database and a dataset is constructed following the procedure of Kalemli-Ozcan et al. (2015) comprising more than 4 million observations of 660,000 firms operating in 6 countries of the euro zone.[2] The results provide novel insight and show that effects can occur in both, positive and negative ways, suggesting there might be both winners and losers resulting from an external banking shock.

3.2 Literature Review

This literature review is split into three sections. The first section provides a general overview on the literature on financial pressure and its impact on firm performance. The second part gives a more specific insight to the EBA capital exercise performed in 2011, its impact on bank lending and how a weakened banking sector impacts companies and the real economy. The third section then provides the novelty of this study and outlines how it intends to extend the existing literature by analysing financial pressure on firms distinguished by their ownership levels considering the EBA capital enhancement exercise.

3.2.1 General Review on Financial Pressure

One of the pioneers researching the relationship between investment and financial constrains are Fazzari et al. (1987). Using firm-level data on 421 U.S. manufacturing firms for the time period from 1968 to 1984, they highlight that financial constrains such as the cost of external finance and its availability to companies have an effect on corporate financial decisions. Accounting for both fixed firm and year effects in their estimation strategy, it is further shown that this effect can be different depending on the

[1] An overview of which countries got defined as periphery and non-periphery can be seen in Section 3.4.5.

[2] The countries included in the final dataset are: Austria, Belgium, Finland, France, Germany, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain. Due to the data cleaning process, not all member countries of the euro zone can be included.

observable characteristics, which is used by the lender in order to determine a company's financial state and further then its creditworthiness.

Nickell and Nicolitsas (1997) investigate how restrictive practices in a firm impacts productivity, employment, and pay. They examine 66 manufacturing firms operating in Great Britain over the period 1979 to 1986 with a total of 225 observations. Applying a first-difference approach and accounting for both industry- and time-fixed effects. Even though the focus of this study is not predominantly on financial pressure, it highlights the importance of financial pressure in the nexus of restrictive practices. It is stressed that when perceiving financial pressure a firm most likely negotiates lower wages and reduction in their level of restrictive practice. Considering this link, it can be seen that financial pressure can be a determinant regarding pay raise and employment.

In a following paper, Nickell and Nicolitsas (1999) extend their research and now raising the question how company behaviour is impacted by increased financial pressure. Using firm level data on around 670 manufacturing companies in the United Kingdom from EXSTAT covering the time from 1972 to 1986 they particularly raise the question how financial pressure has an effect on employment, wages and further firm productivity. In order to define a measure for financial pressure, they use the ratio between interest payments and cash flow which they call the borrowing ratio. They highlight that such a definition implies two main problems, even when lagging the variable one period. The first bias they identify as negative in case the error contains favourable shocks towards a company resulting in an increase of employment and a reduction in the borrowing ratio. They compare it to a missing variable problem as their included variables cannot account for and capture all important shocks. A second bias can arise in a positive way as a firm might employ too many workers for a short time period because of an adjustment cost shock. This would lead to an increase in the borrowing ratio as their financial position worsens. In order to overcome these endogeneity problems they use deep lags on employment, output, capital stock, and wages.

Their results show that an increase in financial pressure has a large and negative effect on employment, a rather smaller negative effect on pay increase and a minuscule positive effect on productivity. For employment, they find a 3 percent reduction resulting from a 5 to 8 percent increase in interest rates in the short-run. In the long run, the results indicate even a larger effect, reaching almost 7 percent. They stress how monetary policy is an important and significant channel impacting employment. Further, a small but statistically significant effect on total factor productivity is present. As a potential reason they see that firms might have an incentive to improve their efficiency under financial pressure.

Nucci et al. (2005) extend the literature by focusing on how a firm's financial structure is related to productivity. They are focusing on more than 40,000 Italian manufacturing firms and respective 177,000 observations for the time from 1982 to 1998. In order

to estimate firm-level productivity, they are following the approach of Olley and Pakes (1992) which reverts to using investment as a proxy for unobservable shocks. Applying several tax components as instruments in their analysis, their results support the thesis that companies, which are less reliant on financing through debt, tend to have more immaterial assets and, therefore, are able to undertake more innovative activities. These innovative activities are then ultimately resulting in higher total factor productivity. This indicates that firms who are less reliant on bank financing might have an additional advantage on productivity, as they are less affected by financial pressure.

Gatti and Love (2008) raise the question how access to credit impacts and might even improve productivity. Using cross-section data on over 540 Bulgarian firms for the year 2003, they estimate how productivity is affected by different levels of access to credits. They further point out that this can also be seen as a channel, which ultimately results in economic growth. As their data does not include information on investment, they follow the approach by Levinsohn and Petrin (2003) in order to estimate total factor productivity in a first step. Instead of using data on investment, their approach rather uses intermediate inputs as a proxy. In a second step, they create a pseudo-panel dataset and conduct a 2SLS regression using past growth rates in sales as an instrument for access to credit. The results indicate that access to credit has a strong and positive effect on productivity across firms. These results remain significant, even when different measures for access or estimations of TFP are applied.

The impact of financial constraints and pressure on growth and firm survival is researched by Musso and Schiavo (2008). Their study comprises 16,500 French manufacturing companies from 1996-2004 with over 75,000 observations. Applying a 'synthetic index' based on a large number of variables, they extend the literature by proposing a new methodology on how to measure and account for financial constraints. Their results suggest that firm survival is strongly related to financial constraints. Additionally, a higher level of access to external funds affects firm growth positively. For productivity, they find a positive and significant effect on productivity in the short-run. This is in line with previous results by Nickell and Nicolitsas (1999) who find firm-productivity responding in a positive way with increasing financial pressure. They conclude that this effect might be due to the fact that a constrained firm is forced to cut costs in order to generate new resources which they cannot raise on financial markets anymore. As a final suggestion they stress that further research is necessary to investigate how this effect might be in the long-run and if the effect on long-term efficiency might be a different one.

Millard and Nicolae (2014) undertake a general equilibrium approach in order to research the effect of the financial crisis on total factor productivity growth. Using a macroeconomic approach, they apply a simple endogenous growth model in which a financial shock is the trigger of a rise in the spread between the rate of interest which is

paid by companies and the risk-free rate. As a crucial channel they identify that firms are in need to borrow in order to finance their research and development spending. If there is a rise in the spread occurring, this results in declining R&D spending. As this directly impacts innovation, it further reduces total factor productivity growth as well. They conclude, that a permanent reduction of labour productivity and in the levels of output can be seen as a final result.

Byoun and Xu (2016) find evidence that firms, which rely stronger on external finance, were hit by the financial crisis in 2008 more severely and became more vulnerable. Their dataset consists of around 2,700 U.S. firms for six quarters from Q3-2007 to Q4-2008. Applying a difference-in-differences approach they examine both external- and internal finance dependent firms (EFD and IFD). While EFD firms perceive a reduction in their capital during the time of the financial crisis and a decline in their investments as a consequence, IFD firms expand their investment activities by raising external capital. This results in IFD firms being able to even gain in market share during times of financial pressure. They conclude that the behavior of IFD firms is neither driven by normal investment opportunities nor by available cash. They argue that the results suggest rather predatorial actions and behavior regarding IFD firms, which take advantage of their competitors when they are financially weakened.

The impacts of monetary policy on labor productivity and labor demand is discussed by Benito (2017). He reflects several pros and cons and highlights that "monetary policy actions supported economic activity, labor demand and employment during the 2008 global financial crisis." Regarding productivity performance it is stressed that the ECB supported higher level of employment by easing financial pressure on businesses. This occurs by cutting interest rates or applying additional non-standard policy measures such as the quantitative easing programs. This alleviation of financial pressure which is predominantly intended to promote the alleviation of financial pressure might also impacted labor productivity growth via reduced reallocation in a negative way. He further highlights, that the empirical evidence on the impact of financial pressure on firm-productivity during the great recession is rather scarce.

Bucă and Vermeulen (2017) examine how bank credit tightening affected firm investment during the time of the 2008 financial crisis. Deriving several several credit tightening indexes and combine it with balance sheet data for six countries of the euro zone, they create a novel dataset comprising the years 2004 to 2014 and over 3,400 observations. Controlling for unobserved segment fixed effect and time-fixed effects, their results show that firms which are rather bank-dependent reduce their investment to a larger extent compared to their counterparts when facing credit tightening. This is in line with previous results of Byoun and Xu (2016) suggesting firms which rather rely on external financing are impacted more severely by restricted access to credit.

3.2.2 Review on the EBA Capital Exercise and Bank Lending

This second part of the literature review gives insight into two things. First, it outlines a brief summary and the history of the 2011 EBA capital enhancement exercise. It then extends providing an overview of the relevant literature researching how this exercise impacts on bank lending and further impacts on firms as a consequence.

The EBA Capital Enhancement Exercise

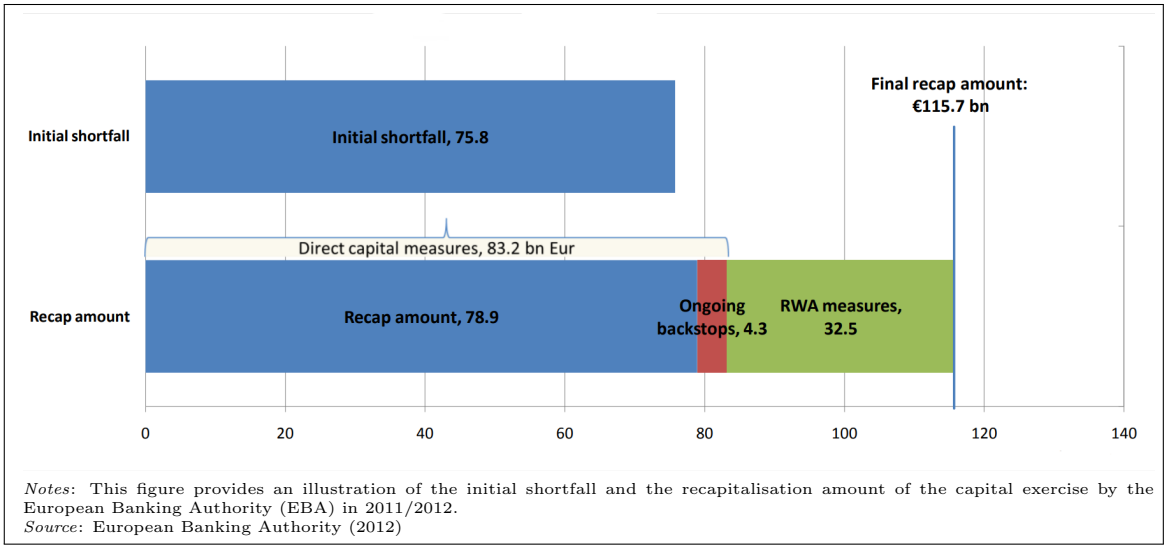
As a response to the sovereign debt crisis the European Banking Authority (EBA), a regulatory agency of the European Union with the purpose to harmonize and regulate banking supervision within the EU, announced a rather surprising and unexpected measure in October 2011 (European Banking Authority, 2011*a*; Jenkins and Atkins, 2011). A Special Capital Enhancement Exercise was introduced with the aim to force banks with a significant amount of overvalued sovereign debt exposures to enhance their capital ratios by not later than June 2012. This intervention was applicable to only the largest banks in each country, having a cut-off level that was determined by the EBA. It was decided that only banks will be affected which jointly hold at least 50 percent or more of the national banking sector using the end of 2010 as a reference time. This exercise struck rather surprising and unexpected as banks already had to undergo numerous stress tests by the EBA earlier that year, in June 2011. An article published in the Financial Times on 11 October 2011 refers to the EBA requirements as "well beyond the current expectations of banks and analysts" (Jenkins and Atkins, 2011).

Selected European banks were required to reach and sustain a core tier 1 (CT1) capital ratio at a 9 percent level by June 2012. This represents an economically significant increase regarding the capital requirements, compared to the previous level of only 5 percent. The EBA adopted a country-specific measure of selection which included banks "in descending order of their market shares by total assets in each Member State" to an extend which would cover "50 % of the national banking sectors in each EU Member State" (European Banking Authority, 2011*b*). However, the size of the national banking sector in Europe appears to be substantially different in total size. Therefore, the selection threshold assigned specifically for each country yielded an extensive overlap regarding the size of banks being selected and the ones not selected for the exposure of that exercise.

In their final report released in October 2012, the EBA illustrates and highlights the execution and results of their unexpected measure (European Banking Authority, 2012). 27 banks in the euro area were identified having a shortfall of 76 billion euros which had to be tackled and lifted-up by increasing the highest quality capital elements along with a set of actions targeting the reduction of risk weighted assets (RWAs). This had to be achieved without significantly impacting lending into the real economy. In order to achieve the extensive requirements by end of June 2012, banks subsequently implemented

comprehensive measures. Capital plans were then submitted to the National Supervisory Authorities (NSAs) while coordinating with the EBA as well. In their assessment the EBA concludes that "the vast majority of banks are compliant with the EBA Recommendation as of end of June. For the remaining banks, backstops approved before the end of June are being implemented, with the explicit support formally endorsed by governments."

Figure 3.1: *Final Recap Amount against the Initial Shortfall*



Notes: This figure provides an illustration of the initial shortfall and the recapitalisation amount of the capital exercise by the European Banking Authority (EBA) in 2011/2012.
Source: European Banking Authority (2012)

The 27 banks which initially had a shortfall of more than 76 billion euros reached a level of recapitalisation of 115.7 billion euros. 24 of the 27 chosen banks were able to report a CT1 higher than 9 percent after the sovereign buffer was accounted for. For the 3 banks which were not able to crack the 9 percent ceiling, backstops were implemented after receiving approval by their respective governments. With the implemented backstops all 27 banks were able to reach and sustain a CT1 above 9 percent. Figure 3.1 shows the comparison of the initial shortfall and the recap amount. The recapitalisation amount of 115.7 billion euros was not only obtained by implementing direct capital measures which enhanced and bolstered the bank's capital level but also thought RWA measures, which were leading to a decrease in the banks' capital requirements.

The recapitalization can be broken down into an increase in direct capital measures to 83.2 billion euros, representing 72 percent of the full recapitalization amount and reaching 108.5 percent over the initial shortfall. Besides that, 28 percent of the recapitalization amount was achieved through RWA measures, which were rising to 32.2 billion euros. The RWA measures even result in a surplus of 39.9 billion euros, outreaching the 9 percent CT1 after sovereign buffer.

As these measures occurred rather unexpected and surprising for most banks, they had to responds rather quickly to fulfill the impost targets. Particularly bank lending can shift into focus. Therefore, the effects of the EBA exercise were not only impacting

banks directly but get transmitted through their own lending behavior towards firms and potentially impact the economy through different channels as a consequence. Therefore, the next part of this review outlines an overview of the literature examining the effects of the imposed EBA restrictions from an angle not focusing on the direct effect on banks but rather on the effect it had on entities operating in an economy that might rely on banks as one form of raising capital in order to execute investment decisions. This could be, for instance, private firms which require a bank loan to finance their operations.

Literature Review on Bank Lending

The real effects caused by financial pressure are examined by Fernandes et al. (2014) who investigate how the financial crisis impacted employment in Europe. They identify a variable "interest burden" following the approach of Nickell and Nicolitsas (1999) in order to measure to what extend a firm might be exposed to financial pressure. Particularly the effect of higher financial pressure on employment is the center point of the study. Their rich panel data set on the firm-level covers more than 150.000 companies in the euro area for the years 2003 to 2011 resulting in more than a million observations. They define a dummy variable indicating the years 2007 to 2009, the time frame in which the financial crisis predominantly took place. They further distinguish between center and periphery economies such as Italy, Ireland, Portugal and Spain. This provides novel insight on how different regions are systematically different affected by the financial crisis and the resulting financial constrains and limited access to credit.

Applying a System-GMM estimatior, their results show that a company's interest burden has a negative and highly significant effect on its employment. With an increase of the interest burden by 10 percent, the level of employment reduces by 0.35 percent ceteris paribus. Their results are in line with the interpretations and findings of Benito and Hernando (2008) who provide evidence for financial constraints being a significant factor affecting labor demand. When controlling for the time frame when the financial crisis takes place the coefficient for interest burden appears to be negative and statistically significant as well. However, this is only for the defined crisis time 2007 to 2009, while there is no significant effect to be seen for the time before and after. This implies that the importance of financial pressure is more distinct during times of crisis. With the interest burden changing by 10 percent employment is affected by 0.08 percent during tranquil times. In contrast to that, the same change in the interest burden would cause a much larger change in employment during troublesome times, which is 0.32 percent.

The analysis is further extended by separating companies operating in countries which are considered to be the periphery of the euro area from companies which are located in non-periphery countries. Their findings provide insight how employment is affected differently depending on the area operating in. Indeed, the results for firms being in

the periphery during crisis period differ significantly from the results for firms which are located in non-periphery countries. When interacting interest burden with the dummy variable controlling for periphery, the effect is significant for the crisis period. In contrast to that, there is no significant effect to be seen for the time period outside the defined time frame of the crisis-dummy. This provides a novel insight, indicating that firms in periphery countries are responding differently during cyclical fluctuations when they are facing higher debt servicing cost.

Another distinction is made by considering firm size. Following the definition of the European Commission, firms are now separated by identifying them as either SME or non-SME. They find evidence for SME responding negatively in their employment decisions during the crisis time. In contrast to that, no statistically significant effect for their larger counterparts can be found. This indicates that smaller firms are indeed more responsive to debt servicing costs altering their employment when comparing them to larger firms. When taking into account the geographical area, it can be seen that SMEs in periphery regions are also responding to higher interest burdens with a decrease in employment during crisis time. For larger firms, the allocation does not appear to play an essential role. The results show no significant impact of the interest burden on employment, neither in periphery areas nor in non-periphery countries. These results remain significant, even after the conduction of multiple robustness checks with respect to the time frame used to define the years of the crisis and also the measurement of interest burden. They conclude that financial constrains can be seen as a crucial component that determined firm-employment in the aftermath of the financial crisis in 2008. Firm size and also the region a firm operates in turns out to be of importance as well, as different effects could be found by separating the outskirts from the center economies, providing novel insight.

In their study Gropp et al. (2018) research how the balance sheets of banks are impacted by higher capital requirements and how these are transmitted into the real economy. Their framework is based on an approach of a quasi-natural experiment by taking advantage of the EBA capital exercise occurring in late 2011. This quasi-experiment can be exploited to overcome the issue of finding exogenous variation in capital requirements. Further, they stress the importance and challenge to distinguish between credit supply and credit demand. The observation of lower outstanding consumer loans does not necessarily imply that credit supplied by banks, which were affected by the capital exercise, diminished. It could also be the result of firms simply borrowing less from banks that were exposed to this exercise and frequenting different banks instead. The data set used in the study comprises all 61 banks being subject to the bank exercise and all 494 'non-exercised' banks which are included in the SNL Financial Company database for a time period from 2009 to 2013. Further, data on

several components of credit risk-weighted assets are hand-collected using the Pillar 3 disclosure reports published by each bank.

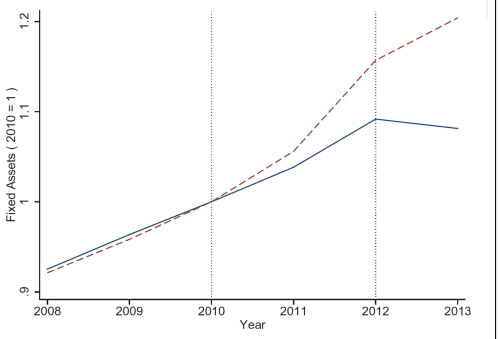
In order to link their data on banks to the firm-level and see potential effects on companies, they include firm-level data of almost 2,000 firms obtained from the AMADEUS database and create a measure on how much a firm tends to borrow from a capital exercised bank. This is seen as a crucial step as a reduction in supplied credit by banks, which are affected by the capital exercise might not necessarily lead to significant effects on the firm-level. Other banks might be able to compensate this effect by making up the reduction of loans provided and increase their lending behavior (Gropp et al., 2018). This way, firms might be able to compensate for that by simply changing their credit supplier and selecting specific banks which are not targeted by the capital exercise. In order to account for this, firms are split into two groups. The first group are firms which are highly dependent on capital exercise banks. The second group are firms which predominantly obtain their loans from banks which are not exposed to this exercise. Considering these groups, the differences in the changes of multiple characteristics such as fixed assets, total assets and sales are estimated. They further create a subsample of their data set identifying companies which are not listed. Not being listed implies a stronger dependency on banks. This is because they have the disadvantage of having less opportunities to raise new funds as they do not have any stocks traded on exchanges where new potential investors can invest. Further, listed companies have the potential to increase their capital by undertaking a seasoned equity offering. When these types of financing are not available and the possibilities to acquire new funds is rather limited, it appears quite intuitive that banks loans might be a preferred way of raising new capital.

In their results, Gropp et al. (2018) find a clear tendency for the effect of limited access to bank loans for companies. A negative effect for assets-, investments- and also sales growth can be identified when firms depend on banks which are exposed to the capital exercise. On average they find that 'capital exercised bank' (CEB) -dependent companies grow over 4 percentage points less than their competitors which are not as much reliant on loans from capital exercised banks. Regarding investments, they even show a discrepancy by 6 percentage points in growth when comparing to firms which are less CEB-dependent. Further, their sales growth appears to be 5 percentage points smaller. Their analysis is further extended by now distinguishing listed and unlisted firms. The evidence suggests that these negative effects are predominantly driven by firm which are not listed as they suffer from less alternatives of sources of funding. This is in line with the general assumption that unlisted firms are more bank dependent as listed ones are. Unlisted CEB-dependent firms grow 6 percentage points less in their total assets and had 9 percentage points less investment growth than other unlisted firms which do not rely on CEBs.

Further, Figure 3.2 provides an insight of how the means of fixed assets and sales develops over time for both groups, CEB-dependent and non-CEB-dependent firms. The former group is illustrated with the solid blue line while the latter group is represented by the dashed red line. Gropp et al. (2018) normalize the data to a value of 1 for the year 2010. The two dashed vertical lines highlight the years 2010 and 2012, which are the years directly before and after the announcement of the capital exercise by the EBA.

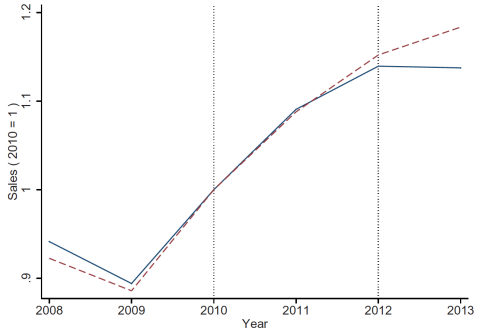
Figure 3.2: *Firm Level Outcomes - Results of Gropp et al. (2018)*

(a) *Firm fixed assets over time*



Notes: This figure illustrates the development of fixed assets of firms during the time of the EBA capital exercise. While the solid blue line refers to CEB-depended firms, the dashed red line refers to non-CEB-depended firms.
Source: Gropp et al. (2018)

(b) *Firm sales over time*



Notes: This figure illustrates the development of sales of firms during the time of the EBA capital exercise. While the solid blue line refers to CEB-depended firms, the dashed red line refers to non-CEB-depended firms.
Source: Gropp et al. (2018)

When observing the development of both assets and sales one can see that the evolvement of dependent and non-dependent firms are rather similar and following the same trend, indicating similar corporate policies are applied. However, once reaching the year 2011, dependent firms can be identified to have lower growth in sales and assets, when comparing them to their non-dependent competitors.

Their obtained results strongly suggest that the EBA capital exercise did not only affect banks directly but also got transfers into the real economy affecting firms in their performance, investment decisions and growth. These results become particularly interesting, when putting them into perspective and comparing them with the final report of the EBA (European Banking Authority, 2012). The report concludes that the effects of the capital exercise "have not led directly to a significant reduction of lending into the real economy". This contradicts the findings of Gropp et al. (2018) who indeed find evidence for a reduction of credit supply and a negative and significant effect in the real economy. Their results also suggest, that firms are not able to fully substitute the diminished credit supply by approaching other banks which are not exposed by the capital exercise. Therefore, firms are left with less credit as they might require and are impacted by a reduction in growth. These insights are particularly novel as they provide

evidence how not only the banks but also the real economy is affected by this external shock.

Focusing on Portuguese banks and companies, Blattner et al. (2019) investigate the development of productivity growth in the wake of the sovereign debt crisis in Europe. Conducting a natural experiment using quarterly data on loan balances on the firm-bank level comprising over 140,000 non-financial firms and 45 banks for a time period from 2009 to 2015 with a total of more than 380,000 lending relationships, they find two main results. Firstly, banks affected by the EBA exercise cut back on bank lending, being in line with the findings of Gropp et al. (2018). Secondly, an effect can be identified revealing that banks undertake a process of reallocating credit to companies in financial distress. Predominantly a tendency of underreported loan loss provisioning in the past can be identified with these firms. In order to distinguish firms with underreported loans losses from others, they develop an algorithm to detect the level of underreporting for all firm-bank pairs they have in their dataset on a monthly basis. They argue that exposing underreported loan losses can be seen as a powerful tool when it comes to identifying lending behaviour that is predominantly driven by distorted incentives.

Two types of distorted lending incentives are predominantly identified and expected to be highly correlated with the underreporting of loan losses, namely a delay in recognizing losses and also risk-shifting. In order to improve their regulatory capital position, banks and their shareholders often refrain from raising new capital and rather prefer improving their regulatory capital positions in other ways. One way can be the approach of simply rolling over loans to firms which have previously been underreported, even if these loans show a negative net present value. This is because if a bank decides to cut lending to an underreported firm entirely, it runs the risk of pushing the firm into insolvency. This would then have the consequence, that the entire unreported loss has to be recognized. In contrast to that, the risk of being required to mark down the inflated value of the loan can be rather easily avoided by rolling over the loans. Regarding risk-shifting, Blattner et al. (2019) claim that bank shareholders become more willing to take a risk and "gamble", once they are severely undercapitalized and run the risk of defaulting in some states of the world. Bearing this in mind, it contributes to the lending behavior to distressed firms which are allocated in the same state, in which also the bank itself would go under. With limited liability, losses for bank shareholders can be limited in these states. Therefore, shareholders are more interested in states in which firms show the potential of recovering and likely coincide with the bank and as a result stay liquid. Such risk-shifting leads to investments with negative net present values. Further, the incentive arises to reduce the loan losses which have to be reported, in order to avoid potential monitoring of these loans by the financial regulators.

Merging proprietary administrative data provided by the Portuguese central bank with financial data from an annual firm census, a firm-bank level data set is obtained.

Conducting an extensive analysis, multiple effects regarding firm-productivity are found. Their results show that Portuguese companies are exposed to a declining productivity growth in the years leading up to the sovereign debt crisis. This is particularly predominant in the service sector which represents roughly 75 percent of Portugal's employment and value added. The cause of this negative increase in productivity is identified being driven by a misallocation of inputs across firms, particularly capital. These results are in line with previous findings by Gopinath et al. (2017) who find evidence for a slow productivity growth for companies operating in manufacturing in South European countries being predominantly driven by a growing misallocation of capital.

In addition to that, Blattner et al. (2019) also undertake an examination of the effects the EBA intervention has on aggregated productivity. A productivity decomposition is applied in order to identify how much of its decline can contributed to the EBA capital exercise. This decomposition exposes two linkages through which the EBA intervention can have an effect on productivity. The first way occurs through a direct impact of credit shocks on firm-level TFP. The second way can happen in a way that credit shocks might lead to inputs being reallocated across firms. This happens when an undercapitalized bank would, for instance, reallocate credit from solvent firms which are not under distress towards distressed and underreported companies. Then capital which is held by underreported firms is prevented from being reallocated to firms where the capital would show higher potential of earning a greater return. Simultaneously, with underreported firms taking up credit the supplied credit keeps declining, leaving out companies which would potentially have a higher factor return. This would force them to discard inputs.

While not finding significant effects for a direct impact of the EBA exercise, the focus of the analysis shifts on the effect of factor misallocations. Their results show that the decline in productivity growth in the year 2012, one year after the announcement and implementation of the EBA intervention, can be accounted for by this intervention with about 50 percent. Further, the results indicate that more than 70 percent of the increase in capital misallocations can be explained by the capital exercise of 2011. Their study provides a novel insight into the different channels of how an external shock like the 2011's EBA capital exercise can not only impact banks directly but get further transmitted into the real economy having negative effects on firms. The main channel they identify for Portuguese banks and firms, is the misallocation of credit leading to a misallocation of production factors and inputs. They stress that this effect might be particularly sever in economies which heavily rely on financing through banks and are rather bank dependent.

Farinha et al. (2019) provide another insight on how bank shocks can impact firm performance in Portugal. However, instead of productivity their focus lies rather on corporate failures and firm survival. Being in line with findings of Blattner et al. (2019),

they provide evidence of negative effects for both banks and firms which can be attributed to a bank shock using firm-bank matched data for the time period 2005 to 2014. This rich dataset comprises almost 1.6 million observations on the bank-firm level and over 335,000 observations on the firm level. In a first step, they assess how banks which are exposed to a funding shock respond in terms of supplied credit to companies. Further, crumbling credit conditions and their consequences are put into focus and examined in order to find evidence on how they can be determinants for firms' survival prospects. They stress that heterogeneity regarding firms and their balance sheets plays an important role and that not all firms are affected proportionally.

The basic premises for their study are tremendous loan disruptions in Portugal being created and caused by the sovereign debt crisis in Europe. Exploiting a rich dataset on the bank-firm level they are able to estimate credit supply growth. This way, the variation in credit growth from different banks, which are affected by the funding shock to different degrees, to the same firm can be evaluated. Further, credit supply and demand are separated by applying the approach of Khwaja and Mian (2008) using firm fixed effects. Their results show strong and statistically significant support of the theory that credit growth declines severely following a funding outflow. Firms which predominantly borrow from banks that are affected by the funding outflow are exposed to a reduced credit supply in particular. They find that the average firm suffers from a reduction in credit by almost 6 percent being translated into a total drop in available credit of 4.7 billion euros. Similar results are found by De Jonghe et al. (2020) for Belgium after the bankruptcy of Lehman Brothers.

In a next step, the effect on firm survival is examined. They find positive and significant effects of the funding shock on the chances for a firm to fail. Particularly firms, which borrow from banks which are affected by the funding shock, are facing a higher probability to exit the market and not survive. In more detail, when borrowing from a bank which experienced a 3.9 percent outflow, the likelihood of firm failure increases by 1.72 percentage points for the average firm in the sample used in the analysis. This supports the hypothesis that a negative bank shock would have a negative impact on firm survival and worsens a firms chance to stay competitive in a market. Farinha et al. (2019) conclude that firms borrowing from banks which are subject to a funding outflow are more likely to exit the market and run into bankruptcy. This can be understood as an important policy implication. As access to credit appears to be an essential factor regarding firm survival and an important source of financial stability for firms to finance themselves, the results indicate that there is an incentive for policy makers to shift their agenda towards a provision of easily available and low-cost loans. This way firms can substitute their lack of capital they intended to obtain by taking a loan and are more likely to survive and to prevent their bankruptcy.

3.2.3 Novelty of this Study

This study intends to extend the literature on financial pressure and its impact on the real economy by focusing on companies from a different angle. It is purpose is to answer the question whether multinationality plays a role on how financial pressure impacts firm productivity, focusing on firms operating in the euro zone for the time period from 2009 to 2018. Instead of considering only the size of a company by its number of employees, it rather focuses on the ownership characteristics of a company. The intention behind this is to gain insight into the question, whether financial pressure created by the capital enhancement exercise by the EBA in 2011 impacts a MNE differently as it would impact a purely domestic firm.[3] One intuitive idea taken into consideration to motivate this question is that a company which had undertaken the step of becoming multinational has more opportunities of gaining access to capital as a domestic company which is not listed on the stock market would have (Erel et al., 2020). Therefore, this raises the question whether MNEs are differently affected by a bank shock and limited access to capital and suffer less from it, and the main impact of such external shock falls onto domestic firms which potentially rely more on bank loans. One hypothesis might be that multinationality can play a key role regarding the perception of financial pressure and a bank shock. However, this is not necessarily given, as there is also a cultural component. Some countries and regions generally rely more on bank loans and are more linked and connected to local banks, for instance Germany. The main focus of the literature falls mostly on the impact of financial pressure on employment. This study undertakes a different approach and takes a view from a different angle, researching the impact on firm-productivity.

To investigate this hypothesis in more detail and in order to answer the question whether multinationality plays a significant role in how a company perceives financial pressure regarding its productivity, this Chapter follows the approach of two studies. The measurement regarding financial pressure follows the approach of Nickell and Nicolitsas (1999), which is also applied by Fernandes et al. (2014). However, their focus predominantly lies on the impact of financial pressure on employment and wages. In contrast to that, Gatti and Love (2008) investigates the impact of access to loans on TFP for companies operating in Bulgaria. However, Gatti and Love (2008) only focuses on one country and considers solely cross-sectional data from the year 2003. In contrast to that, this study can revert to data covering the years 2009 to 2018 for all countries being in the eurozone.

[3]As the EBA capital enhancement exercise took place in 2011 in the wake of the sovereign debt crisis in the euro area, the selection of countries in the final dataset comprises only countries which have the euro as a currency. Due to an extensive data cleaning process (see Section 3.3.1) not all countries having the euro as a currency are included: Austria, Belgium, Finland, France, Germany, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain.

3.3 Data

The firm-level data used in this study is gathered from the ORBIS database which covers information on more than 280 million companies worldwide of which 99 percent are private. It is not only limited to financial data but also contains information on ownership structure and the global ultimate owner of each individual company. To make use of this rich database, all available companies operating in all sectors for each country which is having the euro as its currency is obtained. As the data quality and provision of ORBIS is not necessarily designed for economic research Kalemli-Ozcan et al. (2015) suggest an extensive data cleaning procedure and highlight the flaws of using this particular data. These data cleaning procedures is presented in this section. The initial raw data consists of 34,097,063 observations of 2,099,733 companies operating in the euro zone. [4]

3.3.1 General Cleaning

This study investigates the effects of financial pressure on TFP of firms. Therefore, the first focus is put on the variables used to conduct the estimation for TPF following the approach of Levinsohn and Petrin (2003). In order to conduct this approach, the key variables are identified as *Added Value*, *Capital Stock*, *Costs of Employees* and *Material Costs*. However, ORBIS has limitations regarding reporting and data availability which can make it more difficult to conduct this first step.

Levinsohn and Petrin (2003) explain that TFP can be estimated using either *Output* or *Added Value* as the depended variable and highlight that using Added Value is the superior approach. However, this can be cumbersome using ORBIS data, as the coverage of Added Value often appears to be poor. To extend the data coverage and avoid extreme loss of data, additional imputations are executed in order to extend the coverage.

As already applied in Chapter 2 Section 2.4.3, this study follows the same approach suggested by Gonnard and Ragoussis (2013) in order to proxy value added. For illustration purposes, the procedure is again outlined in this Chapter in order to provide a better understanding.

In order to extend the data coverage and avoid extreme loss of data, additional imputations can be executed in order to extend the coverage. As this study applies *Value Added* as a depended variable for estimating total factor productivity (TFP), sufficient reporting and availability of this financial figure is crucial in the dataset. Gonnard and Ragoussis (2013) suggest that the best way to substitute *Value Added* is to exploit its definition based on factor incomes. This required to add up factor incomes going to both

[4]The raw data contains observations of firms operating in countries which have the euro as a currency. The initial dataset includes following countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovenia, Slovakia, Spain.

employees and capital owners. For the former this is expressed as the wage bill wL with w being the average labour cost and L the number of employees. For the latter rK is representing the profits, the rate of return r times the capital stock K. With this at hand, Value Added AV can be defined as

$$VA = wL + rK \tag{3.1}$$

Obtaining data from ORBIS, the empirical counterparts in the dataset are *Costs of Employees* and *EBITDA* (Earning Before Interest Taxes Depreciation and Amortisation). Making use of these variables and the definition of *Value Added* VA in (3.1), *Value Added* can be computed by applying

$$VA_{csit}^{InternallyImputed} = CostofEmployees_{csit} + EBITDA_{csit} \tag{3.2}$$

where c denotes the country, s the sector, i the firm and t the time. Gonnard and Ragoussis (2013) point out that this way of computing VA is applicable as it shows strong correlation with the real VA for companies that had this figure reported. According to Gal (2013), who estimates TFP for several OECD countries, these internally imputed values show indeed high correlation on the log-level, 0.98 for an average country and year.

Regarding labour input, ORBIS does not provide a detailed reporting on numbers of hours worked. Only the number of employees is reported, while it is not possible to distinguish between low skilled and high skilled or white-collar and blue-collar jobs. This makes it impossible to obtain information on the characteristics of the employees or the type of employment. Gal (2013) suggests that this obstacle could principally be circumvented by using *Costs of Employees*. However, this can mislead as it is directly affected by changes in the regulatory environment (minimum wages, social security contributions etc.). In order to account for these changes, labour costs are deflated with a labour cost index provided by Eurostat (2019*b*). This index "measures the cost pressure arising from the production factor 'labour'", considering wage and salary components and also social contributions by the employer. In this way, the problems mentioned by Gal (2013) can be accounted for. As this index is only available with 2012 as a base year, it gets adjusted before its application, having its base year as 2010. This is important in order to ensure that all financial data is deflated to the same year as other deflators applied for other variables are reported with this year as their base.

In order to calculate the capital stock, the same procedure outlined in Chapter 2 is conducted, with the level of real capital stock K_{it} in firm i in year t being defined as

$$K_{it} = K_{i,t-1}(1 - \delta_{it}) + I_{it} \tag{3.3}$$

where I_{it} represents real investments. It is defined as

$$I_{it} = \frac{(K_{it}^{BV} - K_{i,t-t}^{BV} + DEPR_{it}^{BV})}{PI_t} \tag{3.4}$$

I_{it} is calculated with the difference between the current (K_{it}^{BV}) and the lagged book value ($K_{i,t-t}^{BV}$) of the tangible fixed assets adding depreciation ($DEPR_{it}^{BV}$). Both variables are reported in the ORBIS database which facilitates the application of the PI Method to a large extent. It gets then deflated by a country and industry specific investment deflator PI_t which is obtained by the OECD STAN-Database (OECD, 2019). The depreciation rate in (3.3) is defined as

$$\delta_{it} = \frac{DEPR_{it}^{BV}}{K_{i,t-t}^{BV}} \tag{3.5}$$

The book value of depreciation $DEPR_{it}^{BV}$ is divided by the book value of the tangible fixed assets $K_{i,t-t}^{BV}$. For the first observed year, there is no definition for $K_{i,t-1}$ in (3.3). Therefore, the real capital stock K_{i0} gets defined as the net capital stock (tangible fixed assets K_{i0}^{BV}) and deflated by the investment price index PI_0

$$K_{i0} = \frac{K_{i0}^{BV}}{PI_0} \tag{3.6}$$

Following the same procedures outlined in Chapter 2, this study as well follows the approach of Gal (2013) who suggests a procedure to approach outliers. Before estimating TFP on the firm-level, extreme cases regarding certain ratios can be identified, such a as *Capital/Labour* or *Material/Output*. With these observations with extreme ratios being identified, they can then be dropped in a later stage once the estimation of TFP is completed and the results are obtained.

This paper follows this procedure with considering the ratios *Material/Output* , *Capital/Labour* and *Capital/Output*. After obtaining estimates for TFP, the top and bottom one percent of these ratios are then dropped and excluded from the final dataset and analysis. Further, only unconsolidated financial data is kept in the dataset, excluding consolidated data in order to avoid double accounting (see Gal (2013)). After conducting such cleaning the dataset results in 6,026,498 observations of 1,442,683 companies .

Further, an indicator variable for a firm's ownership situation is constructed, identifying it by its 'Global Ultimate Owner' (GUO). A dummy variable is created with the value of 1 if the GUO is located in another country than the one the firm is operating in. In order to distinguish domestic and foreign firms, the variable 'Global Ultimate Owner' (GUO) will be used. This follows the procedure suggested by Kalemli-Ozcan et al. (2015). It is used to distinguish the effects of financial pressure on TFP based on the type of ownership a company is exposed to.

3.3.2 Industrial Producer Price Indices

As ORBIS data is reported in nominal values, it is essential to adjust it to real values. Data is reported for each year and company, however, is not adjusted to current values. This means that the values in the database stay fixed and are not updated or adjusted to current USD automatically. Therefore, this step has to be done manually.

All financial variables are reported in thousands of USD by default. The market exchange rate of a company's host-country's currency is used for each individual year in order to convert values from the local currency into USD (Gonnard and Ragoussis, 2013). To compare financial data over time, it is necessary to adjust the reported value for price changes. However, as most firm-level datasets, there are no specific firm-level price indices included. To overcome this issue, Gal (2013) suggest a best practice method of using external data retrieved from the OECD STAN database. This database provides 2-digit industry deflators for all member countries of the OECD. It has the advantage that not only deflators are provided for each industry, but also individually for several values, such as output, added value, investment, and intermediate inputs. This allows to deflate each variable with its respective index using 2010 as a base year. Gal (2013) further points out, that these price indices are referring to national currencies of each particular country. Therefore, as best practice, all values should be retrieved in national currency and then deflated them before using the values in USD. As all firms used in this study are located in the euro area, this issue remains to be minor as all countries use the same common currency. ORBIS provides exchange rates from local currencies to USD and euros, therefore no additional data needs to be retrieved to conduct this manipulation.

3.3.3 Ownership

Another fundamental component of this study is the distinction between firms by their ownership status. In order to do that, data on global ultimate ownership is used. This is directly provided as a two-digit country code and can therefore be obtained easily. As an important cleaning process, all country codes get examined. The European Commission (2019*b*) states that BvD reports unknown individuals as "WW" or "YY" for unknown entities. Futher, "ZZ" indicates entities which do not have a specific identifier in the database. Therefore, these observations are dropped from the dataset, as the ultimate owner is not uniquely identified. After this step the dataset consists of 5,238,441 observations of 1,244,217 companies.

In contrast to that procedure, missing values in ownership are not immediately dropped. If such value is missing, information on direct ownership is examined. If this variable appears not to be reported either, the ID of the ultimate owner can be

examined. As these ownership IDs also begin with the country code of its respective owner, the country of global ultimate ownership can be easily obtained.

Based on global ultimate ownership, companies get classified into four different categories

- *Domestic Firm* – Purely domestic firm which does not have any foreign linkages
- *Domestic MNE* – A domestic firm which is itself a multinational enterprise
- *Euro MNE* – A company which is owned by a global ultimate owner from another country within the euro zone (foreign owned but by an owner who is based in a country which has the euro as a currency
- *Foreign MNE* – A company whose ultimate owner lies in another country which is not part of the euro zone

Figure B.1 provides an overview of the composition and the firm distribution for each country included in the dataset individually. One can see that most countries are mainly composed of domestic firms. Interestingly, Germany and Austria show a larger proportion of domestic MNEs when comparing to only purely domestic. This is not surprising and reflects the fact that both countries are home to rather large multinational enterprises which are widely known and operation worldwide. Further, it can be seen that Luxembourg is home to only a few solely domestic companies. More than 68 percent of the companies in Luxembourg included in the dataset are MNEs, both foreign or domestic. This is in line with the perception of Luxembourg being a tax haven which makes it very attractive for MNE to invest and shift their operations into this particular country.

3.3.4 Firm Size

In order to get an inside into the composition of firm sizes, the database provides information on how a firm is categorized in respect to its size. Kalemli-Ozcan et al. (2015) highlight that the threshold and definitions of how companies are classified is not exactly transparent, however, it is based on factors such as employment, sales and operating revenue. Therefore, this classification appears to be suitable for being used in an analysis. ORBIS groups firms into four categories, namely very large, large, medium, and small firms.

Figure B.2 provides an overview for each country on the size of the firms it hosts. When observing France, Italy and Spain, and Finland, one can see that the companies operating these countries are vastly small or medium sized companies. This is in line with the observation, that in these countries also the proportion of domestic firms is relatively high (between 70 and 80 percent, see Figure B.1). This indicates that in these

countries mainly operate domestic firms which are relatively small. For countries such as Luxembourg, Germany or Austria, it appears to be a different scenario, showing a large proportion of very large and large corporations. Being in the center of Europe, it indicates that firms might have it easier to grow and establish themselves in the world market, when comparing them to firms operating in countries which are considered to be in the periphery of the euro zone.

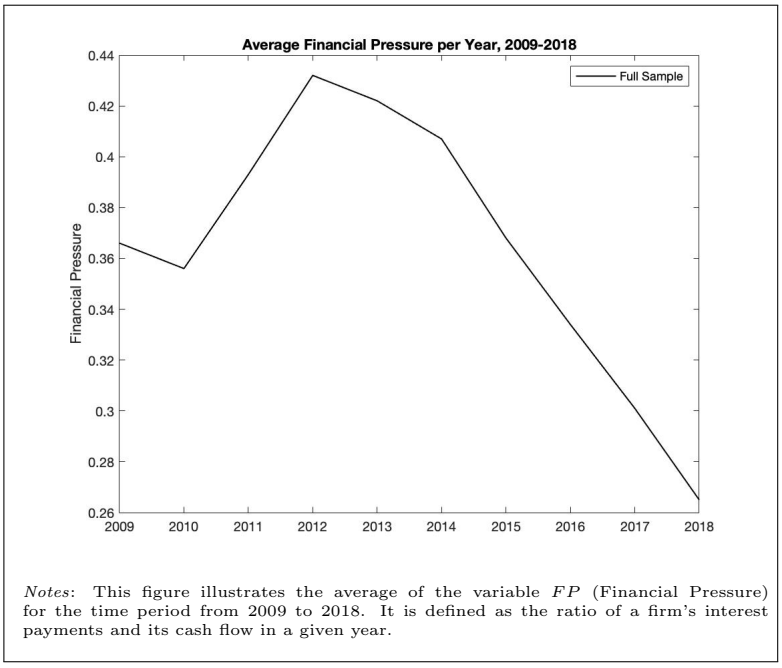
3.3.5 Measuring Financial Pressure

The econometric analysis in Section 3.4 intends to demonstrate how firm-productivity is affected by financial pressure. Therefore, it is important to find an appropriate measure for this. Hence, the variable FP_{it} is calculated representing financial pressure. This variable is defined by following the literature adopting the approach of Nickell and Nicolitsas (1999) and Benito and Hernando (2008) who use the ratio of interest payments to cash flow.

$$FP_{it} = \frac{InterestPayments_{it}}{CashFlow_{it}} \tag{3.7}$$

Therefore, financial pressure FP_{it} of company i in year t can be calculated by dividing its reported $InterestPayments_{it}$ by its reported $CashFlow_{it}$. Figure 3.3 shows the average financial pressure for each year from 2009 to 2018.

Figure 3.3: *Average Financial Pressure from 2009 to 2018*



Notes: This figure illustrates the average of the variable FP (Financial Pressure) for the time period from 2009 to 2018. It is defined as the ratio of a firm's interest payments and its cash flow in a given year.

One can observe a clear spike in 2012 and 2013, after starting to increase rapidly in 2011. This provides evidence that the EBA exercise in 2011 indeed caused a stronger burden on firms in the euro zone and increased the financial pressure. Further, it can be seen that pressure declines significantly after the year 2013. This supports the assumption which is used to create the EBA dummy variable considering 2012 and 2013 to be the years where pressure would manifest itself the most, as they are the two years after the announcement of the EBA exercise in late 2011.

In a next step, the top and bottom one percentile with respect to major key variables such as FP (see Equation 3.7) and TFP (see Section 2.5.1) are excluded to account for outliers. Further, firms which do not fulfill the condition of having at least three consecutive years are dropped, following the approach of Fernandes et al. (2014). This results in a dataset which consists of 663,042 firms comprising 4,004,061 observations for the years 2009 to 2018.

3.3.6 Final Dataset

The final dataset consists of 663,042 firms comprising 4,004,061 observations for the years 2009 to 2018 covering a selection of 12 countries within the euro zone.[5] An overview of the descriptive statistics for all variables used in the data analysis is provided in Table B.6 in the Appendix.

Table 3.1 provides a general overview of how many observations per firm are how often appearing in the dataset.[6] It can be seen that there are no companies included that do not have at least 3 consecutive observations, therefore the minimum number of observations per firm is 3. Further, more than 56 percent of observations in the dataset belong to firms, which show their financial data reported consistently for at least 7 years. Therefore, the panel dataset can be seen of acceptable quality with a high number of observations per firm.

Table B.2 builts up on this and shows how many companies per country are represented how many times in the dataset (see Appendix). It can be observed, that firms are evenly represented for the respective number of observations. Only companies which are appearing for 10 years and therefore cover the entire time span are underrepresented. Further, 114,644 companies out of the total 663,042 are represented in 8 years which accounts for more than 17 percent of all firms.

[5] In the data cleaning process a number of countries are excluded entirely. The countries included in the final dataset are: Austria, Belgium, Finland, France, Germany, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain.

[6] Lags of variables which are used in the data analysis are not yet considered at this stage. As the data analysis uses a lag of one period of the variable FP, the number of observations considered in the regression is smaller. The data structure for this smaller sample excluding missing values for FP_{ijt-1} can be found in Table B.4 and Table B.5 in the Appendix.

Table 3.1: *Structure of the Unbalanced Panel Data Set*

Number of Observation per Firm	Frequency	Percent	Cumulative Percentage
3	256,125	6.40	6.40
4	382,972	9.56	15.96
5	488,690	12.20	28.17
6	567,672	14.18	42.34
7	651,791	16.28	58.62
8	917,152	22.91	81.53
9	706,599	17.65	99.17
10	33,060	0.83	100.00
Total	**4,004,061**	**100.00**	**100.00**

Notes: This table presents the structure of the unbalanced final dataset including all firms of all countries for the time period from 2009 to 2018. Firms which do not have data reported for at least 3 consecutive periods are dropped. Therefore, the minimum number of observations per firm is 3.

In addition to that, Table B.3 (see Appendix) provides an overview of how many companies for each country in each year are included in the data. It can be seen that the selection of countries is rather limited, only 12 countries of the 19 countries which are comprised by the eurozone are included. The major reason for this is the extensive data cleaning procedure. In particular, the variable *Material Costs* plays a significant role. Generally, *Material Costs* of a firm is very poorly reported in ORBIS and leads to huge data loss. On top of that, reporting standards and regulations differ from country to country. Therefore, countries such as Greece or Ireland almost drop out entirely, when excluding firms that have no data reported for their material expenses. As this is a crucial element of estimating total factor productivity, the inclusion of this variable is vital. Even though countries such as Greece or Ireland might appear to be of particular interest for this analysis, they are excluded for the reason of poor data quality.

Moreover, it can be seen that Italy and Spain show a significantly higher number of firms, when comparing them to the rest of the countries included in the dataset. Also here, different regulations and requirements of reporting play a role. Therefore, companies operating in Spain or Italy suffer way less from data loss and are stronger represented in this panel.

3.4 Econometric Framework

This section presents the main econometric framework and illustrates how the model is set up. First, a simple baseline model to illustrate the main idea is presented. It then further introduces more variables and specifications making it less general and focusing

on specifications to separate effects between different classifications of companies during different stages in time.

3.4.1 Estimating Total Factor Productivity

This Chapter follows the same estimation procedure outlined in Section 2.5.1. In order to avoid repetition of previously undertaken procedures, it is refrained to repeat the already outlined approach again here in this section.

3.4.2 Baseline Model

A simple model is defined following a similar approach as Fernandes et al. (2014) who investigate the effect of financial pressure on employment.

$$ln(TFP_{it}) = \beta_0 + \beta_1 Foreign_i + \beta_2 FP_{it-1} + \beta_3 Size_{it} + \beta_4 Age_{it} + \alpha_i + \theta_t + \epsilon_{it} \tag{3.8}$$

The independent variable TFP_{it} is defined as total factor productivity being obtained by using the estimation method suggested by Levinsohn and Petrin (2003). Further, common control variables such as $Size_{it}$ (measured in total assets) and Age_{it} (using the difference of the incorporation-year and the year in which the financial data is reported in) of a company are used. In addition, a dummy variable $Foreign_i$ is defined as having the value of 1, if a firm is foreign owned. In order to account for financial pressure, the previously defined measure FP_{it} is implemented, which is the ratio of a firms interest payments to its cash flow in year t (see Equation 3.7). Lastly, α_i accounts for fixed-effects on the firm level and θ_t for time fixed-effects.

The variable $Foreign_i$ is expected to be positive and significant. This is based on the stylized fact that foreign multinationals are considered to be more productive than domestic firms. For FP_{it} a negative coefficient is expected, implying that with higher financial pressure a firm is not able to operate at its most productive level (see Blattner et al. (2019)). Control variables $Size_{it}$ and Age_{it} are expected to be positive, based on the assumption that larger and older (and therefore more experienced) firms are able to operate at a more productive level than small and less experienced companies do.

3.4.3 The Effect of the Capital Enhancement Exercise

As the aim of this paper is to investigate, whether there are significant differences between the times of pre- , post- , and ongoing- capital enhancement exercise, a dummy variable called EBA_t is introduced which takes the value one for the years 2012 and 2013, the two years after its announcement in October 2011. This appears to be a reasonable

justification, as banks had the requirement to adjust their capital ratios by mid 2012 dragging on their changed behaviour in lending into the year 2013. Further, with less access to bank loans some firms might have been forced to not undertake certain projects or adjustments in their technological level, which they might have done otherwise. As a result, this is then reflected in the future upcoming year.

$$\begin{aligned} ln(TFP_{it}) = &\beta_0 + \beta_1 Foreign_i + \beta_2 FP_{it-1} * EBA_t + \beta_3 FP_{it-1} * (1 - EBA_t) \\ &+ \beta_4 Size_{it} + \beta_5 Age_{it} + \alpha_i + \theta_t + \epsilon_{it} \end{aligned} \tag{3.9}$$

Equation 3.9 extends the baseline model in Equation 3.8 by implementing a dummy EBA_t indicating the time of the capital enhancement exercise and $(1 - EBA_t$ to indicate years which are not considered to be times of crisis. Both dummy variables are interacted with FP_{it-1} which is the measure for financial pressure. Control variables remain unchanged and are defined as in Equation 3.8.

For the interaction term $FP_{it-1} * EBA_t$ a negative coefficient is expected. However, for $FP_{it-1} * (1 - EBA_t$ an even larger and negative effect can be expected. While in both cases financial pressure is perceived to have a negative effect on a firms total factor productivity, it can be expected that this effect increases substantially in times of limited access to credit (see Fernandes et al. (2014)).

In the presence of a structural change in lending behaviour of banks to companies, it raises the question whether the effect of financial pressure on a firm's productivity is significantly affected. Tf this holds to be true, then the effect of financial pressure during the time of the adaptation of the capital enhancement exercise (β_2) should be significantly different than the effect of financial pressure during times with regular bank lending behaviour (β_3).

3.4.4 Domestic and Multinational Firms

In the next step, the extended baseline model presented on Equation 3.9 gets more specified by distinguishing between different types of companies. A categorical variable $f_type_i$is introduced.[7] This variable is a categorical variable identifying a firm based on its ownership status, following the approach presented in Section 3.3.3. Applying these three-way interactions in the estimation allows to separate the effect of financial pressure not only during crisis and tranquil times, but also between MNEs and domestic firms.

[7]Firms are grouped into 4 categories. *Domestic Firms* are firms which purely operate in the local market and do not have foreign subsidiaries. *Domestic MNEs* are domestic firms which are MNEs themselves and have foreign subsidiaries. *Euro MNEs* are foreign MNEs with a GUO from a country which is part of the euro zone. *Foreign MNEs* are MNEs which have their GUO in another country which is not part of the euro zone.

With this model at hand, the effect of financial pressure can now be estimated on different categories of firms. This is of particular interest, as domestic firms might be more likely to rely on bank loans than MNEs, as MNEs might find easier alternative methods of accessing and obtaining new capital. Therefore, the effects could potentially differ substantially.

$$\begin{aligned} ln(TFP_{it}) = \beta_0 &+ \beta_1 FP_{it-1} * EBA_t * f\_type_i + \beta_2 FP_{it-1} * (1 - EBA_t) * f\_type_i \\ &+ \beta_3 FP_{it-1} * EBA_t * (1 - f\_type_i) + \beta_4 FB_{it-1} * (1 - EBA_t) \\ &* (1 - f\_type_i) + \beta_5 Size_{it} + \beta_6 Age_{it} + \alpha_i + \theta_t + \epsilon_{it} \end{aligned} \tag{3.10}$$

The setup of this model presented in Equation 3.10 is the same as in Equation 3.9, however, extending it with three-way interactions accounting for all potential combinations of EBA_t and f_type_i.

Regarding the different firm types represented by f_type_i it can be expected that MNEs in general are suffering less from financial pressure than domestic firms do.[8] For this reason, larger and negative effect of FB_{it-1} on $ln(TFP_{it})$ can be expected for domestic firms when comparing them to their multinational competitors. Further *Euro MNEs* are expected to perceive a larger negative effect from FP_{it-1} on $ln(TFP_{it})$ than *Foreign MNEs*. This is based on the fact that *Foreign MNEs* are having a parent company outside of the euro area. For this reason, they might be able to access capital outside of the euro area more easily.

3.4.5 Periphery and Non-Periphery

Another aspect taken into account by Fernandes et al. (2014) is to distinguish countries between periphery and non-periphery of the euro zone. This gets of particular interest when investigating financial pressure in more detail and separating its yearly average between these two regions.

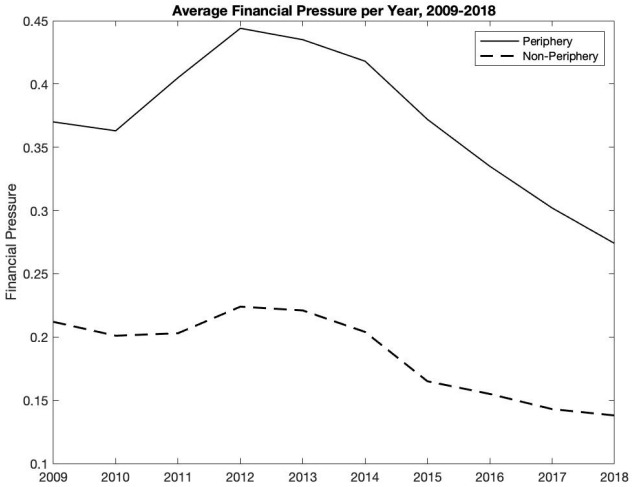
This study follows the classifications of Del Río-Casasola (2021) who provides an extensive analysis on how to categorized the EU-20 countries into center- and periphery-countries (a graphical illustration can be seen in Figure B.3 in the Appendix). As Latvia is not considered in the classification of Del Río-Casasola (2021), this study categorizes it to be part of the periphery, considering that its two neighbor countries Lithuania and Estonia are categorized in this way. The countries which are included in the dataset are categorized in following way:

[8]This is based on the more complex financial structure of MNEs. Being conected to multiple entities worldwide allows potentially for more flexibility regarding accessing capital in various ways. For this reason, MNEs can be assumed to be less reliant on bank loans than domestic firms (see Erel et al. (2020)).

- *Center Countries (Core Countries)*: Austria, Belgium, Finland, France, Germany, Luxembourg.
- *Periphery Countries*: Italy, Latvia, Portugal, Slovakia, Slovenia, Spain.

Figure 3.4 shows the average financial pressure per year separated by periphery and non-periphery countries. Even though the trend for both appears to develop in a similar way, the magnitude differs substantially. Firms in non-periphery countries appear to perceive only about half the pressure as their periphery counterparts. Also the peak around 2012 and 2013 is way less pronounced as it is for the periphery countries. This phenomenon is in line with the literature. Fernandes et al. (2014) find a similar pattern, with firms in the periphery of the euro zone perceiving more financial pressure than firms in core countries. Therefore, the estimation separating companies based on their ownership is further examined, and re-estimated for both regions individually. Considering Figure 3.4 it can be expected that firms in periphery countries are more negatively affected than firms operating in core countries.

Figure 3.4: *Average Financial Pressure - Periphery and Non-Periphery from 2009 to 2018*



Notes: This figure illustrates the average of the variable FP (Financial Pressure) for 12 european countries for the time period from 2009 to 2018 using ORBIS data. It is defined as the ratio of a firm's interest payments and its cash flow in a given year. A distinction between periphery and non-periphery countries of the euro zone is done following Del Río-Casasola (2021). While the solid line represents the former, the latter is illustrated by the dashed line.
Periphery countries: Austria, Belgium, Finland, France, Germany, Luxembourg.
Non-Periphery countries: Italy, Latvia, Portugal, Slovakia, Slovenia, Spain.

3.4.6 Estimation Strategy

In order to control for firm-specific, time-invariant effects, all estimations are conducted accounting for fixed-effects in order to overcome an endogeneity problem. A potential problem occurring is that there might be an advantage for more productive firms regarding the ability of obtaining credit from banks (which would result in a positive bias towards the coefficient of FP_{it}, implying a more productive firm might suffer less from financial pressure as a less productive one. On the contrary, more productive firms might be in a position where they rely less on financing through banks and taking loans but rather on equity financing and retaining their earnings. In this case, a negative bias would be present.

The issue of endogeneity and omitted unobservables is addressed by Gatti and Love (2008) who research the effect of access to credit on firm productivity for companies in Bulgaria. They overcome this issue by implementing a 2SLS estimation approach. As a measure for financial pressure, they make use of data on each company's credit line, indicating less financial pressure with a higher credit line and high pressure with a lower one. As such data cannot be obtained from the ORBIS database, this study uses the previously mentioned approach by Nickell and Nicolitsas (1999). Therefore, a 2SLS approach appears to be troublesome as identifying a suitable instrument for FP_{it} appears to be rather problematic.

For this reason, this study applies a fixed-effects estimation approach in order to control for firm-specific and time-invariant effects.

3.5 Empirical Results

Table 3.2 represents the empirical results obtained by estimating the baseline model and the model considering the EBA time. They are first estimated with OLS, then OLS taking country and time effects into account, and further accounting for firm-fixed effects.

For all results obtained in the baseline model, it can be seen that firm size has a positive and significant effect. However, it is worth nothing that this effect is rather marginal. A one percent increase in firm size (total assets) is associated with a 0.2 percent increase in firm productivity when considering firm fixed-effects in the estimation (see column (3))This is in line with the literature and presumption that large firms tend to be more productive as smaller ones, being able to benefit from economies of scale (Leung et al., 2008). Similar effects can be observed for the age of a firm, which appears to be highly significant but very close to 0. When observing the effect of foreign ownership, it can be seen that the coefficient is positive and statistically significant. Also this result is in line with the theory that being multinational has a positive effect on a firm's productivity, and that foreign owned firms are generally more productive as their domestic counterparts

(see Caves (1974)). Considering fixed effects on the country level (column (2)), a firm is 22 percent more productive when it is considered to be a MNE. Financial pressure appears to have a negative and significant effect on productivity, however, it does not appear to be substantially large when considering the entire time period and not taking into account the separation of the EBA time in the estimation. The results in column (3) suggest that a 10 percent increase in financial pressure is associated with a 0.05 percent decline in productivity, holding everything else constant. This result is in line with previous findings by Benito and Hernando (2008) who stresses that not much evidence on the impact of financial pressure on firm-productivity.

Table 3.2: *Estimation - Baseline Model and EBA*

Depended Variable	(1)	(2)	(3)	(4)	(5)	(6)
$ln(TFP_{it})$	Baseline	Baseline	Baseline	EBA	EBA	EBA
$Foreign_{it}$	0.262***	0.223***	–	0.263***	0.223***	–
	(0.002)	(0.001)		(0.001)	(0.002)	
FP_{it-1}	−0.030***	−0.042	−0.005***	–	–	–
	(0.000)	(0.000)	(0.001)			
$FP_{it-1} * EBA_t$	–	–	–	−0.034***	−0.048***	−0.010***
				(0.002)	(0.002)	(0.001)
$FP_{it-1} * (1 - EBA_t)$	–	–	–	−0.029***	−0.026***	0.004
				(0.001)	(0.003)	(0.004)
$Constant$	1.078***	1.511***	1.041***	1.078***	1.513	1.043***
	(0.002)	(0.004)	(0.003)	(0.001)	(0.004)	(0.003)
Control Variables						
$Size_{it}$	0.001***	0.002***	0.002***	0.001***	0.001***	0.001***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Age_{it}	−0.001***	0.000**	0.002***	−0.001***	0.000**	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$CountryDummies$	*no*	*yes*	–	*no*	*yes*	–
$TimeDummies$	*no*	*yes*	*yes*	*no*	*yes*	*yes*
$FixedEffects$	*no*	*no*	*yes*	*no*	*no*	*yes*
R^2	0.04	0.41	0.02	0.03	0.43	0.02
$Observations$	3,080,374	3,080,374	3,080,374	3,080,374	3,080,374	3,080,374
$Firms$	663,042	663,042	663,042	663,042	663,042	663,042

Notes: This table presents the estimation results of the baseline model presented in Equation 3.8 and the model considering the time of the EBA exercise presented in Equation 3.9. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2018. The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable $Foreign$ is a dummy variable taking the value 1 if a firm's global ultimate owner (GUO) can be identified as being from another country than the host country of a firm. The variable FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). It is considered with a lag of one period (one year). Therefore, the data structure and number of observations in Table B.4 and Table B.5 apply. The variable EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year.
Following countries are included: Austria, Belgium, Finland, France, Germany, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

In a next step, the dummy variable EBA is introduced (see Equation 3.9) in order to account for the time period 2012 and 2013, in which financial pressure is considered to have its peak (see Figure 3.3). The results are presented in the second half of Table 3.2, which is shown in column (4) to column (6). It can be seen that firm size remains positive and significant. Further, the coefficients for financial pressure appears to remain negative and significant during the times of the EBA exercise for all estimation methods. This suggests that indeed the overall effect of financial pressure during this time had a negative impact of firm level productivity. When considering country dummies and time dummies (see column (5)), a 10 percent increase of financial pressure during the time of the EBA exercise is associated with a 0.48 percent decline in productivity. During tranquil times, it is less and only 2.6 percent, holding everything else constant. When turning to column (6) and considering fixed effects on the firm level, a 10 percent increase in financial pressure is associated with a 0.1 percent decline in firm productivity. When comparing the effect of financial pressure during tranquil times and considering firm-fixed effects, one can observe that the coefficient does not appear to be statistically significant. This provides evidence for firms being able to compensate financial pressure under normal circumstances and that their productivity level remain at an equal level. These effects are rather surprising, as previous literature only finds little evidence or small positive effects from financial pressure on TFP (see Gatti and Love (2008) and Musso and Schiavo (2008)). Therefore, the analysis is extended by conducting a sample split.

In this step, countries get separated into two groups, namely periphery and non-periphery countries. This is based on the assumptions that companies in periphery countries might rely more on bank financing and therefore are more sensitive to external shocks when their access to credit gets limited (see Fernandes et al. (2014). Table 3.3 provides the estimation results considering the entire sample and both sample splits, separating the countries and firms by periphery and non-periphery.

One can observe that predominantly companies operating in periphery countries suffer from negative effects of financial pressure on their productivity levels. For firms operating periphery countries, a 10 percent increase in financial pressure is associated with a 0.17 percent decrease in TFP during the time of the EBA exercise, and with a 0.1 percent decrease in TFP during traquil times, holding everything else constant. In contrast to that, there is a positive and significant effect to be seen for firms located in non-periphery countries. This is intuitively rather surprising, however, in line with results provided by Nickell and Nicolitsas (1999) and Gatti and Love (2008) who find evidence of financial pressure affecting firm productivity in a positive way. The results in column (3) suggest that a 10 percent increase in financial pressure during the time of the EBA exercise affected firms operating in non-periphery countries positively with an increase of 0.03 percent in their TFP, holding everything else constant. While this effect is rather small, it is in line with Nickell and Nicolitsas (1999) who find evidence for only a "minuscule"

Table 3.3: *Estimation - EBA and Periphery*

Depended Variable	(1)	(2)	(3)
$ln(TFP_{it})$	All Sample	Periphery	Non-Periphery
$FP_{it-1} * EBA_t$	-0.010^{***}	-0.017^{***}	0.003^{**}
	(0.001)	(0.001)	(0.001)
$FP_{it-1} * (1 - EBA_t)$	0.004	-0.010^{***}	0.006
	(0.004)	(0.002)	(0.004)
Constant	1.043^{***}	1.071^{***}	0.947^{***}
	(0.003)	(0.003)	(0.005)
Control Variables			
$Size_{it}$	0.001^{***}	0.001^{**}	0.002^{**}
	(0.000)	(0.000)	(0.002)
Age_{it}	0.002^{***}	0.002^{***}	0.002^{***}
	(0.000)	(0.000)	(0.000)
$Fixed - Effects$	*yes*	*yes*	*yes*
$TimeDummies$	*yes*	*yes*	*yes*
R^2	0.02	0.02	0.01
Observations	3,080,374	2,414,050	666,324
Firms	663,042	509,688	153,354

Notes: This table presents the estimation results of the model considering the time of the EBA exercise presented in Equation 3.9. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2018. A sample split is conducted separating countries into the periphery and non-periphery (see Section 3.4.5). The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). The variable EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year.
Periphery countries: Austria, Belgium, Finland, France, Germany, Luxembourg.
Non-Periphery countries: Italy, Latvia, Portugal, Slovakia, Slovenia, Spain.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

positive effect of financial pressure on TFP. Further, the effects of size and age on TFP appear to be positive and significant for all estimations, however, of little magnitude.

A potential reason for such results might be that firms in non-periphery countries are being less reliant on banks and lending. Further, Figure B.2 (see Appendix) provides another interesting insight regarding firm size. It can be observed that core countries are hosts to a relatively large proportion of very large and large firms, while in periphery countries small and medium size firms are predominant. As larger firms usually require significantly more hierarchical structures and organizational effort, it they can be exposed to losses in efficiency based on bureaucratic and higher managerial efforts. As financial pressure occurs, firms might adapt and adjust small reorganizations to compensate for the limited access to credit, making their processes even more efficient which results in higher levels of productivity (see Musso and Schiavo (2008)). In tranquil times, large enterprises potentially do not perceive the necessity to restructure and organize processes

in a better way. Perceiving this pressure can trigger management decisions to conduct reorganizations, for instance by reducing the number of employees. This is also in line with the literature suggesting that financial pressure impacts employment in a negative way (see Fernandes et al. (2014)). With less employees and less capital, large companies might be more able to restructure and produce on the same level of productivity as they are more likely to be endowed with intangible assets such as patents or a brand.

In a last step, countries are not only separated into periphery and non-periphery but also firms are distinguished by their level of ownership. Table 3.4 shows the estimation results for all four groups of firms presented in Section 3.3.3 during EBA time and non-EBA time estimating for both periphery and non-periphery. When observing the effects on the whole sample, one can see that all types of companies perceive negative effects during non-crisis times. While for the foreign multinational firms this effect appears to be insignificant, it is surprising that the largest magnitude appears for domestic MNEs even surpassing the effect financial pressure has on the productivity of domestic firms. In tranquil times a 10 percent increase in financial pressure is associated with a 0.13 percent decrease in productivity for domestic MNEs, while domestic firms only perceive a 0.06 percent decrease, considering all the sample (see column (1)) and holding everything else constant. One reason for this might be that domestic MNEs require generally more capital as they tend to be vastly larger when operating multiple plants abroad and maintaining their operation in their home country. Therefore, a lack of access to capital might appear more problematic for them resulting in negative effects on productivity. During the time of the EBA exercise, negative effects for both domestic and domestic MNEs can be seen, while European and foreign MNE perceive an increase in productivity. This effect also comes as a surprise and might be related to restructuring and reorganization due to adjustments in employment. This is in line with Nickell and Nicolitsas (1999) who stress the effects of potential restructuring and downsizing as a result of financial pressure to have a positive effect on TFP. Further, an additional effect on the market might arise. With domestic firms struggling more under financial pressure, European and foreign MNEs might face less troubles in coping with limited access to capital and therefore obtain more market share (see Aitken and Harrison (1999)).

When observing periphery countries, the effects appear to be rather similar, however, slightly larger. Particularly during times of the EBA exercise, the negative effects seem to outweigh potential positive effects, even for European MNEs. A 10 percent increase in financial pressure is associated with a 0.13 percent decrease in TFP for european MNEs in periphery countries during the time of the EBA exercise. For foreign MNE the effect remains insignificant. In contrast to that, the firms operating in non-periphery countries appear to suffer less from financial pressure. European MNEs perceive a positive and significant effect for both non-EBA time and EBA time. During the time of the EBA exercise this effect seems to be even larger. A 10 percent increase in financial pressure

Table 3.4: *Estimation - Firm Classification*

	Depended Variable $ln(TFP_{it})$	(1) All Sample	(2) Periphery	(3) Non-Periphery
non EBA time	$FP_{it-1} * (1 - EBA_t) * domestic$	-0.006^{***} (0.001)	-0.007^{***} (0.001)	-0.004^{***} (0.001)
	$FP_{it-1} * (1 - EBA_t) * domesticMNE$	-0.013^{***} (0.000)	-0.014^{***} (0.001)	0.009 (0.006)
	$FP_{it-1} * (1 - EBA_t) * europeanMNE$	-0.001^{**} (0.001)	-0.002^{***} (0.001)	0.001^{***} (0.001)
	$FP_{it-1} * (1 - EBA_t) * foreignMNE$	-0.007 (0.004)	-0.004^{*} (0.002)	0.001 (0.004)
EBA time	$FP_{it-1} * EBA_t * domestic$	-0.007^{***} (0.001)	-0.010^{***} (0.003)	-0.006^{***} (0.002)
	$FP_{it-1} * EBA_t * domesticMNE$	-0.015^{***} (0.004)	-0.020^{***} (0.005)	-0.008 (0.005)
	$FP_{it-1} * EBA_t * europeanMNE$	0.015^{***} (0.004)	-0.013^{***} (0.005)	0.028^{***} (0.005)
	$FP_{it-1} * EBA_t * foreignMNE$	0.104^{***} (0.002)	0.107 (0.071)	0.095^{***} (0.005)
	$Constant$	1.037^{***} (0.005)	1.061^{***} (0.008)	0.889^{***} (0.011)
	Control Variables			
	$Size_{it}$	0.001^{***} (0.000)	0.001^{**} (0.001)	0.002^{**} (0.001)
	Age_{it}	0.002^{***} (0.001)	0.002^{***} (0.000)	0.002^{***} (0.000)
	$Fixed - Effects$	*yes*	*yes*	*yes*
	$TimeDummies$	*yes*	*yes*	*yes*
	R^2	0.03	0.03	0.03
	$Observations$	3,080,374	2,414,050	666,324
	$Firms$	663,042	509,688	153,354

Notes: This table presents the estimation results of the model considering the time of the EBA exercise presented in Equation 3.9. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2018. A sample split is conducted separating countries into the periphery and non-periphery (see Section 3.4.5). The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). The variable EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. The variable *domestic* is a dummy variable taking the value 1 if a firm is purely domestic. $domesticMNE$ refers to domestic firms which are themselves MNE. $europeanMNE$ are firms which are from a foreign country which is part of the euro zone. $foreignMNE$ are firms which are MNE coming from any other country than the euro zone. The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year.
Periphery countries: Austria, Belgium, Finland, France, Germany, Luxembourg.
Non-Periphery countries: Italy, Latvia, Portugal, Slovakia, Slovenia, Spain.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

is associated with a 0.28 percent increase in productivity for european MNE during the time of the EBA exercise. This effect provides evidence that not only ownership seems to impact the perception of financial pressure but also a firm's location. While European MNEs in periphery countries perceive losses, the ones located in the non-periphery gain in productivity. Further, foreign owned MNEs benefit from productivity gains during times of restricted financial access, providing support for the theory that they do not

rely on financing through banks and find other ways of accessing capital. This is in line with results of Nucci et al. (2005) who finds evidence that firms who are less dependent on financing through bank loans are less affected by financial shocks. Further, with many firms struggling on the market they might be able to raise their market share and restructure themselves in a more productive way (see Nickell and Nicolitsas (1999)). The control variables *Age* and *Size* appear to be positive and significant, however, of marginal magnitude.

Generally speaking, one can observe that particularly the periphery suffers the most, with both solely domestic firms and domestic multinationals perceiving the highest negative effects. In contrast to that, the effects for non-periphery countries is rather mixed, showing that financial pressure can result in "winners and losers".

3.5.1 Robustness Checks

In order to test for robustness of the model and estimation results, additional alternations of the sample are conducted. This is further motivated to provide a better way of comparison with previous studies on financial pressure such as Fernandes et al. (2014) and Acharya et al. (2018). Particularly with respect to the definition of periphery and non-periphery countries, this study undertakes a categorization different than in these aforementioned studies and follows the definition of Del Río-Casasola (2021) (see Figure B.3).

Besides this difference of defining periphery and non-periphery, the data structure in Table B.3 shows that Latvia and Luxembourg appear to have only a small number of firms included in the dataset when comparing them to the other countries. For Latvia only 586 firms and 3,443 respective observations are reported, while for Luxembourg only 377 firms and 2,093 observations are included in the dataset.

For this reason, these two countries are excluded from the data analysis, including now following countries: Austria, Belgium, Finland, France, Germany, Italy, Portugal, Slovenia, Slovakia, and Spain. The baseline model presented in Equation 3.8 is estimated with this smaller sample. The results can be seen in Table B.7 in the Appendix.

The results show no significant changes regarding the effects and magnitudes of the respective coefficients, when comparing Table B.7 to Table 3.2. However, the effects appear to be minusculely larger. Observing column (6) it can be seen that now a 10 percent increase in financial pressure during the time of the EBA exercise is associated with a 0.12 percent decrease in productivity, holding everything else constant. Previous results only obtained a 0.1 percent decrease. Even though this negative effect is larger, it is not by a large magnitude.

Further, a slightly larger R^2 can be obtained for all estimations. Again, these larger R^2 are not larger to a substantial degree, only exceeding previously obtained results in Table 3.2 by 1 to 2 percentage points.

In a next step, a separation between periphery and non-periphery following Fernandes et al. (2014) and Acharya et al. (2018) is conducted and Equation 3.9 is re-estimated. The respective results are presented in Table B.8 in the Appendix. The results appear to be of the same significance and similar magnitude as results presented in 3.3. Also here a minuscule increase in R^2 can be observed, however, not exceeding more than one percentage point increase. For firms in periphery countries a 10 percent increase during the time of the EBA exercise is associated with a 0.21 percent decrease in TFP, holding everything else constant. In Table 3.3 this effect appeared to be smaller, having a magnitude of only 0.17 percent. However, the results are in line with Nickell and Nicolitsas (1999) who points out that such effects appear to be rather of a diminutive size.

In a last step, a separation between firm type is conducted. This extends the previous step of separating countries into periphery and non-periphery following Fernandes et al. (2014) and Acharya et al. (2018). The estimation results are presented in Table B.9 in the Appendix. The effects remain unchanged, being of same significance and almost identical magnitude. For the coefficients having a different magnitude, the difference appears to be of almost neglectable magnitude. However, a larger change can be identified for european MNEs in non-periphery countries during tranquil times. For this firm group a 10 percent increase in financial pressure is associated with a 0.02 percent increase in TFP. The results of the initial estimation presented in Table 3.4 shows a magnitude of 0.01, implying that the magnitude doubled. However, it is important to point out that the magnitude is of a diminutive size and rather small.

Further, a small increase in R^2 can be observed. However, this increase does not exceed a magnitude of more than one percentage point, increasing R^2 from 0.03 to 0.04. This is in line with previous robustness checks presented in Table 3.2 and Table B.8 which find a small increase in R^2 as well.

3.6 Conclusion

This study provides evidence on how financial pressure impacts the productivity levels of firms. It extends the existing literature by not only taking another perspective by focusing on productivity but also extends the analysis by not only considering the location a particular firm operates in but also takes into account the ownership status of a particular firm. Obtaining a dataset from the ORBIS database which consists of more than 4,000,000 observations of 663,042 firms covering the years 2009 to 2018 an extensive data cleaning

procedure is undertaken, identifying firms as either being domestic, domestic MNEs, European MNEs, or foreign MNEs.

The main focus of this study is on whether ownership of a firm plays a significant factor when it comes to dealing with financial pressure and keeping productivity intact. The Capital Enhancement Exercise undertaken by the European Banking Authority is used as an external shock and a dummy variable is created taking the value of 1 for the years 2012 and 2013. With this exercise and banks limiting lending towards private firms, it is of interest whether this behaviour affects firms in their efficiency and productivity, running the risk of not having sufficient access to capital.

The empirical analysis provides evidence that the general effect of financial pressure is negative and significant. This effect appears even strong during the time of the EBA exercise, suggesting that in this time period firms suffer stronger in productivity losses based on financial pressure as they do during tranquil times. Further, European and foreign MNEs obtain productivity gains which is rather surprising and an unexpected insight. This might be based on the fact that they tend to be larger with more affiliates and different ways of accessing new capital, when comparing them to their domestic counterparts.

After separating the analysis into countries which are in the periphery of the euro zone and countries which can be classified as core and non-periphery, the results suggest that firms in the periphery suffer from financial pressure to a larger degree and have higher declines in productivity as firms which operate in non-periphery countries. Interestingly, European and foreign MNEs based in the non-peripheries even gain in productivity, which can be attributed to restructuring and a potential crowding out effect on the market. In contrast to that, these effects appear to be negative in the periphery, suggesting that MNEs being located in periphery and non-periphery might differ vastly. There might be different intentions of making the decision to locate oneself in a core-country instead of a periphery country.

The results suggest that multinationality is indeed a significant factor when it comes to sustaining a credit shock and when it comes to finding different ways of accessing capital. Besides the ownership status, also the location and environment of the host country plays a crucial role when it comes to how a firm is able to deal with limited access to bank loans.

Chapter 4

Multinationality, Taxation and Innovation

4.1 Introduction

Tax policies and their implications for firms, governments, people, or simply the demand for "tax-justice" appear to be highly disputed on a global level (Tax Justice Network, 2020). Particularly MNEs are often accused of not paying their "fair share" and of being able to evade taxes too easily (Financial Times, 2019). For instance, the U.S. company Apple received tax benefits worth more than 13 billion euros by the Irish government with a "selective treatment which allowed Apple to pay an effective corporate tax rate of 1 percent on its European profits in 2003 down to 0.005 percent in 2014" (European Commission, 2016*a*). This was later ruled to be illegal by the European Commission which now demands the EU member Ireland to retrieve these tax benefits which were given to Apple unlawfully.

Such an incidence does not appear to be an individual and isolated case. It appears that particularly MNEs have perfected their way of operating in a globalized world, to exploit certain tax treatments in an optimal way (Egger et al., 2010*b*). In order to avoid such considerably unfair scenarios, like the incident with Apple which occurred in Ireland (European Commission, 2016*a*), the EU pursues to implement a Common Consolidated Corporate Tax Base (CCCTB) in order to combat such unjust tax treatment of MNEs by various member countries (European Commission, 2016*b*). However, such a tax base regime is also highly disputed and criticized and the implementation of such is expected to fail after the European Commission announced to withdraw such proposal from the agenda (see European Commission (2019*a*)). This is because it requires the approval of all European member states, of which many are considered to be tax havens seeking to attract MNEs by providing an attractively low corporate tax rate or other favourable tax treatments in other ways (Tax Justice Network, 2020).

Providing tax incentive can have multiple reasons. With firms considering a particular country as a location to invest and establish a subsidiary, multiple effects are expected to occur by policy makers. Not only an increase in employment and additional tax revenue are taken under consideration, but also the inflow of new technology, accompanied by additional development of ideas, products, and innovations (see Andréosso-O'Callaghan (2000), Palazzi (2011), and Hasen (2017)). While the literature on multinational firms and taxation predominantly focuses on tax evasion through profit shifting, transfer pricing, and tax planning, the applied research on taxation on innovation appears to be rather limited.[1] Therefore, this study seeks to examine and understand the mechanisms occurring, which might impact a firm's proclivity for R&D pursuits and involvement in innovation processes. Particularly the EU can be identified as lacking behind significantly for the early 2000s, when it comes to favourable tax treatment regarding innovation (Andréosso-O'Callaghan, 2000).

This study applies a rich data set which comprises financial data on the firm level and a firm's ownership structure. It is merged with data on both statutory corporate tax rate and also tax base for all countries individually. This data is then used to conduct an econometric analysis in order to investigate how tax changes impact innovation on the firm level. The dataset comprises more than 147,251 companies and 1,234,220 observations, including all member states of the European Union from the years 2011 to 2020. [2]Further,this time period appears of particular interest, as various countries have been including favourable tax regimes regarding innovation, which is often referred to as "patent box" (see Zegarowicz et al. (2018)).[3]

This study is structured in the following way. It first provides an extensive overview of the theoretical background on taxation of MNEs. These mechanisms are crucial, in order to understand and identify the channels at play when firms are making investment decisions or intend to conduct operations in a specific location. Being endowed with specific characteristics and capabilities, firms might be able to avoid taxation, regardless of a change in statutory tax rate and therefore unlock more capital which can be used for innovation activities. While such effects are the fundamental basics behind it, Section 4.2.7 emphasizes how taxation can shape innovation and which channels might come into play. The study is then continued with providing an extensive literature review examining both, the literature on taxation of MNE and also on how such taxation and tax policy affects innovation and research activities of firms. It then provides an overview of the data

[1]An overview of this research is provided in Section 4.3.2

[2]Following countries are included in the dataset: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. A detailed overview of all the countries included can be found in Table 4.3

[3]A patent box describes a form of tax policy which taxes business income generated from patents or intellectual property with a rate below the statutory corporate tax rate. The aim of such policy is the promotion of research and development activities.

being used for the analysis undertaken, followed by outlining the econometric framework with providing a overview of the applied models. In the following section, the results are discussed, followed by a final conclusion.

The results suggest that a change in tax policy affects firms in various ways. While there appears no statistically significant effect to be occurring for MNEs, predominantly small and medium-sized enterprises (SMEs) and domestic firms appear to be affected by tax increases. Further, a patent box regime by itself appears to affect innovation in a positive way, however, a tax change under such a regime seems to affect firms even more negatively, which is rather a counter intuitive result. Further, the analysis goes beyond the initial approach and seeks to understand the effect of tax changes on the number of filed patents by firms. It fails to find conclusive and consistent results, finding evidence for a tendency that patents are only a limited instrument to grasp potential innovation of a company. Therefore, this study is not able to find tax incentives provided through a change in the statutory tax rate or the tax base to be a driving factor for MNE to increase their innovation efforts. In contrast to that, a patent box regime appears to provide such an incentive and is reflected in firm's intangible assets, which are used as a proxy for innovation outcomes, in a positive way.

This study extends the literature by analyzing a rich dataset comprising the second decade of the 21st century with including all member states of the European Union. Further, it accounts for tax base changes retrieved from the annual report of the "Taxation Trends in the European Union" report, which has not been used in any econometric analysis. While data on tax base changes appears to be rather cumbersome and not extensively reported, a comprehensive analysis of these reports is undertaken to create dummy variables manually, in order to account for tax base changes. Besides that, not only the effect of tax rate changes on tangible assets is measured, but also how such changes might affect the tendency to file for patents. This provides further insight into measurement techniques of innovation, as a tendency can be identified with firms not necessarily filing for patents when developing new products or technologies. The reason behind this can be intentions of data protection, as filing for patents inevitably requires one to reveal the obtained technology publicly. With most innovations being intangible, policing potential violations of patent rights appears to be rather difficult and remaining the secrecy of innovation through non-disclosure agreements might be a preferable way. Bearing this in mind, an analysis of both patent filed but also of intangible assets appear to be of particular interest as different effects might arise.

4.2 Theoretical Background

This section provides a general overview of theories that link fiscal policies and FDI. It shows how taxes can be perceived as a crucial incentive for MNEs to invest in a particular

country and how and why it can be very attractive for countries to incentivize investments by providing a rather low corporate tax rate to MNEs in general or tailored to specific sectors and industries.

4.2.1 Fiscal Instruments as Tools to Attract FDI

In order to achieve self-set growth and development goals, policy makers can follow different approaches. One particular strategy that can be pursued is designing policies in order to attract FDI. This can be seen particularly in developing countries, motivated by the aspiration of substantial growth opportunities which are associated with such capital flows from highly productive MNEs (Wilson, 1999). Therefore, fiscal incentives are broadly used as a tool to actively promote and incentivize MNEs to establish subsidiaries and invest within the boundaries of a particular country (see Wilson (1999) and Hanson (2001)). This is not only limited to developing countries. Also within the developed world, fiscal incentives are a competitive tool to attract MNEs, providing evidence that this phenomenon is appearing on a global level and is not only limited to a particular region or economic status (see European Union (2017), Tax Foundation (2020), Tax Justice Network (2020), and Tax Justice Network (2021)).

This raises the question why fiscal instruments are perceived as such an effective way by policy makers, when they want to shift towards a more "investment-friendly" environment within their local economy. One reason why the pursuit of attracting FDI through the provision of fiscal incentives is fairly attractive, is that it is a rather visible change and relatively easy to implement (Wilson, 1999). Therefore, such changes regarding a country's fiscal policy are spread to and perceived by multinational in a quick way and the intention to invest into a particular region might be made rather quickly without facing a too extensive and too time consuming due-diligence procedure which can protract the conduction of an investment decision. Another reason which makes fiscal instruments a popular tool for the attraction of FDI is the idea, that deficiencies in the business environment might be compensated for. The advantage of this particular way is that it does not require the direct use of government funds (Hines Jr and Rice, 1994; Wilson, 1999). This has the advantage, that an elected government would be able to intervene and adjust its economy and business environment without increasing its public spending. However, this avoidance of additional public spending would come at the cost of a reduction of tax income. This might result not necessarily in a better outcome, however, it can be argued that such conduct might be perceived more positively by the population and increases the chances for another re-election. A third reason that outlines the popularity of providing fiscal incentives is that it also provides a lot of leeway and flexibility for policy makers. Fiscal incentives do not have to be general and broad when put into legislation (Akcigit and Stantcheva, 2020). They can also be specified

towards particular sectors, regions and certain activities. Therefore, investment can be channelled through specific means providing control on where investment are more attractive. This allows to target certain aspects which can be in line with the current government's political motivations and goals. As an example, fiscal incentives might be provided regarding a preferred treatment of R&D (see Acharya et al. (2018) and Akcigit and Stantcheva (2020)). This would provide a strong incentive to MNEs to shift only this particular department of their operations to the country. Therefore, more technology and research output might occur in this country, which can often be of interest for policy makers who hope to benefit from potential spillover effects.

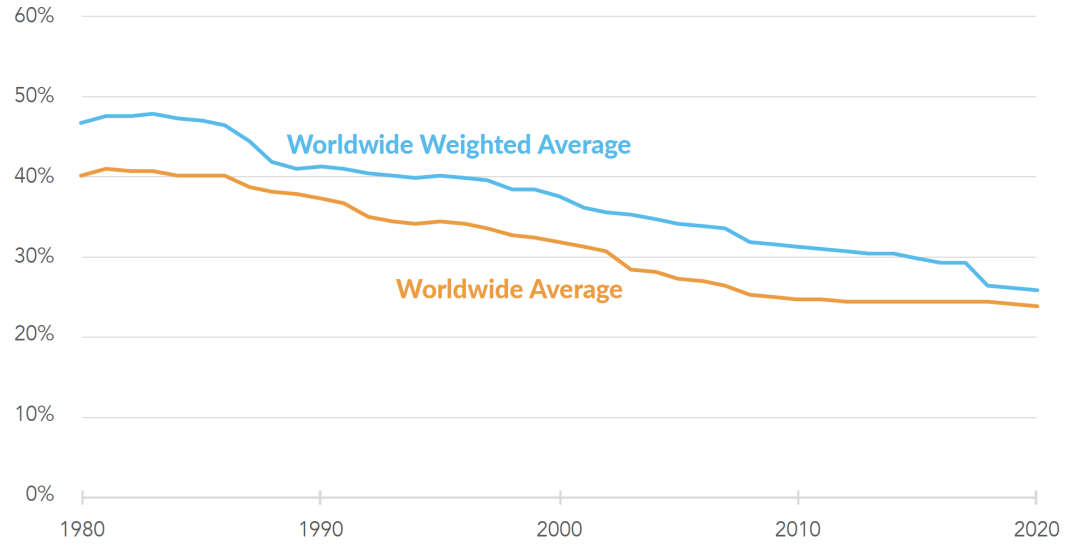
However, this approach comes with its downsides and challenges as well. In order to specifically channel foreign capital towards a desired and targeted allocation, economic fundamentals might have to be changed. This can be rather time consuming and cumbersome for policy makers to achieve. Furthermore, Wilson (1999) points out various problems which can occur when such behavior occurs on a global scale. With tax competition intensifying, as the desire to attract FDI increases among countries, negative effects are likely to occur. Wilson (1999) argues that such a vicious cycle can result in a "race to the bottom". It is pointed out that such a race can occur in various ways and that there are multiple reasons for it. For instance, such a race occurs as well at the cost of the environment and sustainability. When aggressively competing for the attention of mobile firms, an inefficient application of rather loose environmental policies is identified as being used quiet extensively by countries.

4.2.2 Corporate Tax Rate

One of the most intuitive and most applicable way to attract foreign capital occurs through the provision of a competitive and rather low corporate tax rate (Rugraff, 2008). Figure 4.1 gives an overview of the worldwide average corporate tax rate covering the years 1980 to 2020. One can see that there is a declining trend to be seen on a global scale. This holds for both weighted and unweighted average. Tax Foundation (2020) points out that a massive reduction of the average corporate tax rate has taken place over the last 40 years. While the unweighted average in 1980 was at 40.11 percent, the 2020 average statutory tax rate shrunk to 23.85 percent. This represents a 41 percent reduction in less than half a century.

When observing the weighted averages one can see that it remains slightly above the unweighted average, however, follows the same trend. The main reason for this is the U.S. having a relatively high tax rate in comparison to other countries. Besides that, it contributes to the global GDP significantly, resulting in a stronger weight on this rather high statutory corporate tax rate. This hold until 2017, where a large drop can be observed, bringing both weighted and unweighted average closer together. This shift

Figure 4.1: *Statutory Weighted and Unweighted Corporate Tax Rates, 1980-2020*



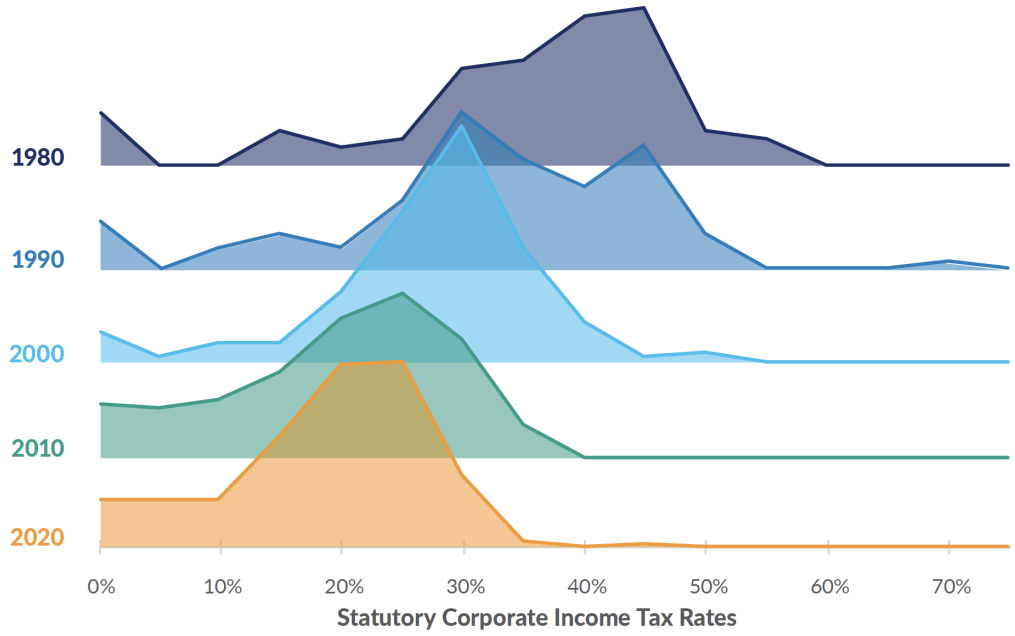
Notes: This figure provides an illustration of the worldwide average tax rate for the time period from 1980 to 2020. It shows two different averages, one weighted and one unweighted. While the weighted average is defined by a countries corporate tax rate weighted with its GDP in ratio to the world GDP in a particular year, the unweighted average does not apply such a measure and weights every country equally.
Source: Tax Foundation (2020)

is based on the U.S. tax reform which took place in 2017. Due to the strong weight, this reform resulted in a massive decline. While the weighted average statutory corporate tax rate was at 46.52 percent in the year 1980, it arrived at 25.85 percent in the year 2020. This represents a reduction of 44 percent over 40 years. This even surpasses the 41 percent decline of the unweighted average indicating that a competitive tax rate is not only an attractive and popular tool for developing economies. Also economies with relatively high output seem to compete with providing tax incentives and lowering their statutory corporate tax rate.

Figure 4.2 shows the distribution of the global statutory corporate tax rate divided into decades. One can see a distinct shift towards tax rates lower than 30 percent. But not only the average of the tax rate is exposed to a substantial reduction. The distribution itself declines significantly as well. The largest shift and most distinct change can be seen when comparing the distribution of the decades 2000 and 2010. While in 2000 only about 42 percent of countries stipulate their statutory corporate tax rate at 30 percent or below, in 2010 more than 78 percent of all countries shift their statutory rate to this level or even below it. Furthermore, it can be seen that the majority of tax rates which are surpassing the 30 percent boundary are not far from it. This shows that even countries which are considered of having comparatively unfavorable tax policies are not really surpassing the average tax rate by a large magnitude.

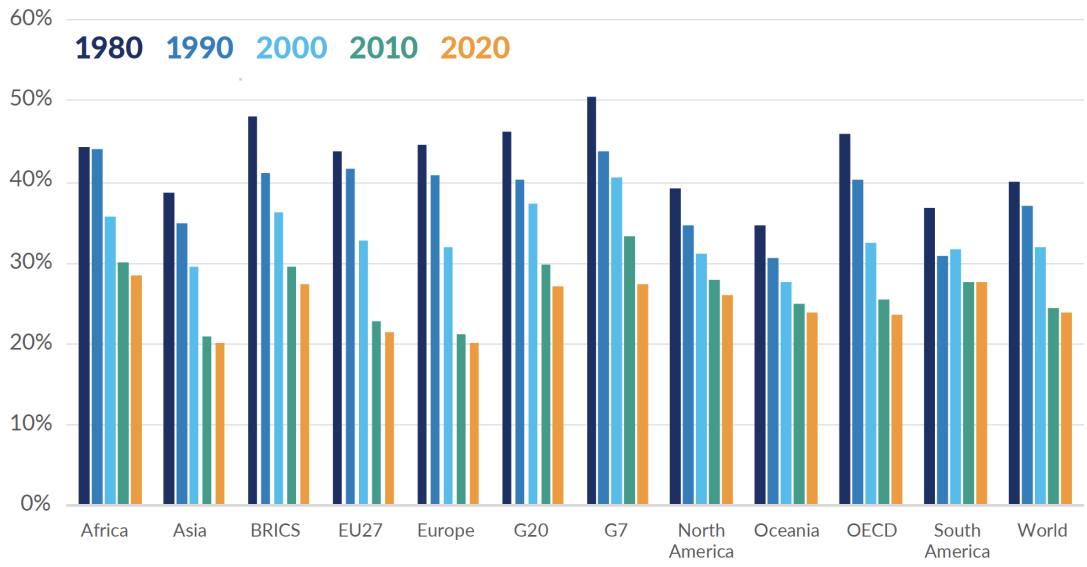
Additionally, Figure 4.3 shows an overview of the average statutory corporate tax rate split into region and decade. One can see that all regions show a significant decline

Figure 4.2: *Distribution of Worldwide Statutory Corporate Tax Rates by Decade, 1980-2020*



Notes: This figure illustrates the distribution of the worldwide statutory corporate tax rate. It is divided by decade and comprises the decades from 1980 to 2020. It shows a significant shift of the average corporate tax rate over these four decades and a diminishing distribution.
Source: Tax Foundation (2020)

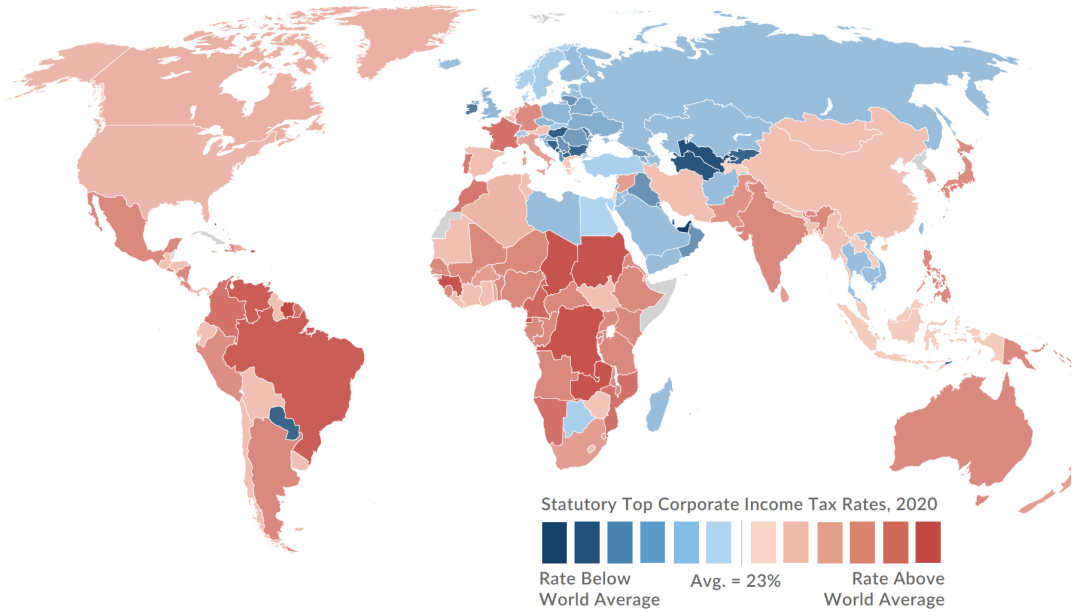
Figure 4.3: *Average Statutory Corporate Tax Rate by Region and Decade*



Notes: This figure shows a representation of the worldwide statutory corporate tax rate by decade and region. It can be seen that for the decades of 1980 to 2020 a declining tendency is present for all considered geographical regions.
Source: Tax Foundation (2020)

in their statutory rates over those four decades. The largest decline can be perceived in Europe. Here, the tax rate diminishes from an average of 44.6 percent in 1980 to merely 19.99 percent in 2020. This represents a reduction of 55 percent. Again, it can be seen that the largest shift takes place during the decades 2000 and 2010. This holds true for most of the regions. However, North America shows a less drastic and more steady decline of its tax rate over the four decades. In contrast to that, South America perceives the smallest decline when comparing it to other regions. In this region, the average statutory corporate tax rate declines by about 25 percent with a tax rate of 36.66 percent in 1980 and 27.54 percent in 2020. For this particular region it is worth pointing out that it perceives a slight increase in its average corporate tax rate between the decades 1990 and 2000. However, this average rises merely at less than one percentage point. When observing the complete time span of 40 years, a clear downward trend is revealing itself.

Figure 4.4: *Statutory Top Corporate Tax Rates, 2020*



Notes: This figure shows the statutory top corporate income tax rates in the world. Countries with a corporate tax rate below the average (23 percent) are highlighted in blue, while countries with a corporate tax rate above the average are indicated in red.
Source: Tax Foundation (2020)

An illustrative overview of how the levels of the corporate tax rates differ around the world can be seen on the world map in Figure 4.4. It can be seen that Europe and Asia show the tendency of providing the highest tax incentives with the majority of their countries having their corporate tax rate below the average of 23 percent. On the other hand, one can observe that Africa and South America have not adopted competitive corporate tax rates yet. For South America, only Paraguay competes with a rate which is below the average, while in Africa such countries can be found in the north, bordering

the Mediterranean Sea. North America and also Oceania appear to be allocated above but still relatively close to the world average statutory corporate tax rate.

Generally, it can be observed that most of the countries settle for a tax rate which is rather close to the average, regardless whether it is above or below. However, some countries compete aggressively with putting a tremendously low tax rate into legislation or even abolish taxation on corporations entirely. Such countries and jurisdictions are referred to as tax havens and are generally perceived in a rather critical way as they enable and incentivize MNEs to underpay their taxes or to avoid them entirely. These tax havens contribute to global corporate tax abuse in a significant way and are therefore the target of policy makers who aim to reduce possibilities for MNEs to avoid tax payments in the respective countries they are operating in. Examples for such tax havens are the British Virgin Islands, the Cayman Islands, Switzerland or Ireland (Tax Justice Network, 2021).

4.2.3 Providing Other Fiscal Incentives

Besides competing by merely lowering its statutory corporate tax rate, a country could make the decision to attract foreign capital by providing certain fiscal incentives. A very common way in which this can occur is the partial or even entire exemption from corporate taxes, import duties, or tariffs. These incentives are usually bound to specific requirements a company is expected to fulfill (see Palazzi (2011) and Akcigit and Stantcheva (2020)). In order to provide transparency about such requirements, they are usually put into legislation establishing the ground rules for all foreign corporations equally. In this case it is known which expectations have to be met and which potential restriction might apply in certain cases. However, these restrictions and requirements can be formulated individually for each country depending on its needs and government policies. These can vary substantially across countries. Nevertheless, such restrictions often apply to specific fields of activities or particular geographic regions within a country. This enables policy makers to channel investment and the expected growth into previously specified areas which are part of their political agenda.

Hanson (2001) points out that such concessions are particularly done for foreign firms excluding domestic firms. Such exemptions are usually limited for a certain time period, very often for less than a decade. This provides an incentive for a rather short-term giving the opportunity to return to previous tax policies yet allowing MNEs enough time to initiate new projects and build new subsidiaries. Further, PwC (2018) provides an overview of such tax concessions in their Tax Summery Report, illustrating that set up and conditions on how corporate taxes vary and are applied for each country. It confirms that most tax exemptions remain limited to certain time periods, usually not exceeding a time frame of 5 or 10 years.

Besides giving tax exemptions, a country could also decide to provide subsidies which can often be directly negotiated with an individual corporation. This can be done on a case-by-case basis allowing policy makers a lot of leeway on how the conditions of such subsidies might occur. Even though such practice appears to be common, it is rather difficult to systematically document and record them. Subsidies play a distinct role within the European Union and are considered to be the most important regional policy instrument. Its importance is highlighted in regards of its effectiveness regarding channelling aid specifically into regions and territories which are lagging behind the most with the union (European Union, 2017). Further, Fuest and Huber (2000) argue that investment subsidies provide more benefits and appear to be more fruitful and successful as alternatives such as employments subsidies. An example for this could be the policies applied in the UK in the late 1990s, when the British government provided subsidies for Samsung and Siemens. It is estimated that subsidies provided exceeded 30.000 dollars per employee as an incentive to attract these companies to the regions of north-east England.

4.2.4 Tax Havens

As already mentioned in the previous section, territories which apply a rather small corporate tax rate generally or even abandoned it entirely are considered to be tax havens. In a rather early work, Hines Jr and Rice (1994) identify 41 countries to be considered as tax havens with regard to U.S. corporations. These havens vary to a large extend in terms of population, size, and GDP. However, they identify Hong Kong, Ireland, Panama, Singapore, and Switzerland to be the most decisive ones, representing about 80 percent of the population of all tax havens and almost 90 percent of its GDP. Even though, these countries can differ substantially from each other, they follow the same system using the "lure of low tax rates" (Hines Jr and Rice, 1994). In order to understand the usefulness of such tax havens to corporations, it is important to understand tax system and the mechanisms which occur. This is illustrated in the following Section 4.2.5 in detail.

There are several devices through which a firm has the possibility to move taxable earnings to tax havens. The three most notable ones can be described as the usage of debt contracts, the conversion of U.S. export income into tax haven income, and the adjustment of transfer prices. Hines Jr and Rice (1994) suggest four characteristics which determine whether a country can be considered a tax haven or not.

1. The corporate tax rate is rather low when comparing it internationally.
2. The legislation is rather lax in respect of transparency and supports and promotes business and banking secrecy.
3. Advanced communication facilities.

4. It is self-promoting and actively offering itself as an offshore tax haven.

The European Union (2021) defines a black list of countries which are considered as tax havens considering certain requirements such as transparency and cooperation. It is updated on a regular basis and currently consists of 12 countries including Panama, the Seychelles, the U.S. Virgin Islands, and Barbados. As these tax havens are recognized as the cause of considerable damage to local economies, the European Union applies several sanctions and advices its member states to enforce them.

4.2.5 The Different Types of Tax Systems

In order to understand the incentives for MNEs to make investment decisions considering fiscal incentives, it is important to be aware of different tax systems and their implications on how they are applied in certain situations. Fundamentally, there are two principle international tax systems which can be identified, namely the tax-exempt system and the tax-credit system (see Tax Foundation (2021*b*) and Tax Foundation (2021*c*)).[4] This section provides an overview of these two systems, explains them in their basic approaches and mechanisms and highlights the differences. This is important as the tax incentives of a host country can be significantly determined and affected by the tax system a particular home country has implemented (Hines Jr and Rice, 1994). This is illustrated with practical examples provided in Figure 4.5 to Figure 4.9.

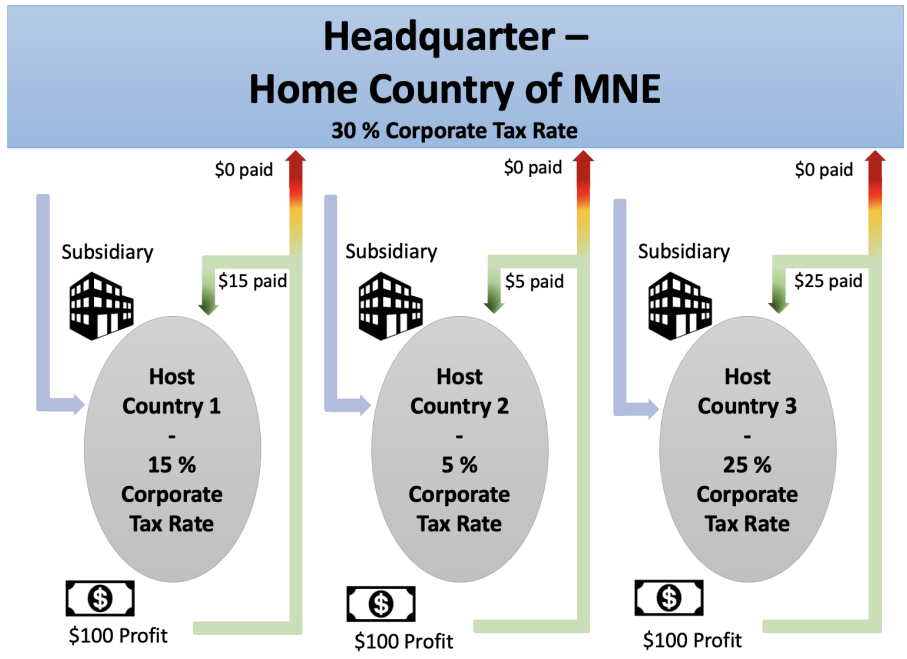
The Tax-Exempt System

The tax-exempt system is also known as the territorial tax system and is vastly applied within most OECD countries such as France, Germany, or the United Kingdom (Tax Foundation, 2021*b*). The fundamental idea of the tax-exempt system is rather straight forward. The income which is earned by a foreign subsidiary in a particular host country is exempt from being taxed in the home country where the mother company is located in. In consequence, the earned profits are only taxed where they are generated, which is the host country in which the operations are done.

Figure 4.5 provides an illustration of these principles. Considering a MNE building a subsidiary in three individual host countries with different corporate tax rates. In this particular example all three host countries provide a lower tax rate as the home country of the MNE offers. In this case, all the profit is taxed within the host country itself and all tax revenue flows to the fiscal authority in the country the operation takes place. In contrast to that, zero taxes are paid within the home country. This bears the implication that all three host countries can specifically target MNE from countries with

[4]The tax-exempt system is also referred to as the 'territorial tax system', while the tax-credit system is referred to as 'worldwide tax system'.

Figure 4.5: *The Tax-Exempt System*



Notes: This figure provides a graphical illustration of the main mechanisms of the tax exempt system. It can be see that tax only has to be paid in the host country and there is no tax paid to the home country.
Source: This illustration follows Hines Jr and Rice (1994) who provides a similar example for U.S. corporations. A broader overview of the tax systems is provided by Tax Foundation (2021*b*) and Tax Foundation (2021*c*).

a tax-exempt system by lowering their own corporate tax rate to a level which is below the level within a particular home country. Under the mechanisms of this system, a MNE might be beckoned by a significantly lower tax rate as it is able to avoid the much higher tax rate, which would have to be paid in their home country, entirely. This is commonly happening particularly in countries which are considered tax-havens, which are partly even offering a zero percent tax rate, luring firms to operate entirely under a tax-free umbrella.

The Tax-Credit System

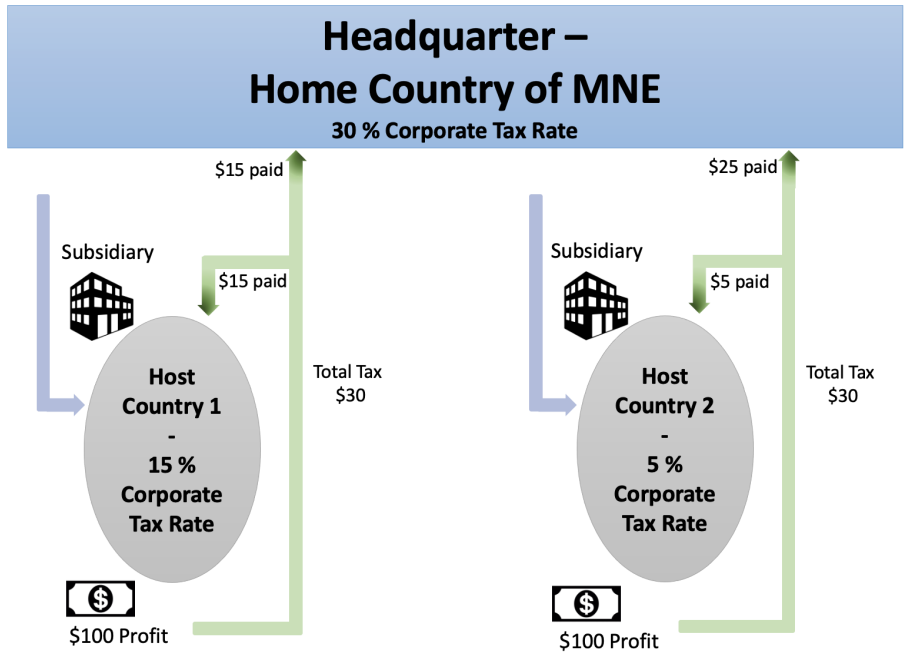
In contrast to the tax-exemption system, the tax-credit system takes a different approach. Under this system, foreign incomes are also taxed entirely within the home country. However, this procedure would result in double taxation and appears rather unfair for an enterprise which operates in multiple countries as their profits would be taxed twice, first in the host country and then again in the home country. In order to avoid this to happen, taxpayers are granted *foreign tax credits* which they can claim for taxes which have already been paid to foreign fiscal authorities. To illustrate the different mechanisms and effects appropriately and clearly, it makes sense to differentiate between

different scenarios and tax constellations in the involved countries.

Tax Rates in Host Countries are Lower

Figure 4.6 illustrates a simple example how this system is applied. Assuming a company has a subsidiary in two different countries. Both countries have a lower tax rate than the home country in which the headquarter is located in. In both countries the generated profit is taxed with the corporate tax rate which is applied by the current legislation. If this tax rate is smaller than the one in the home country, the difference of the tax which would have to be paid in the home country and the already paid tax in the host country is charged by the tax authority of the home country.

Figure 4.6: *The Tax-Credit System – Example One*



Notes: This figure provides a graphical illustration of the main mechanisms of the tax-credit system. In this example, the tax rate in the host countries are smaller than the one in the home country. It can be see that while tax has to be paid to the host country, also the home country receives tax payments. The total tax payment is equal to the corporate tax rate applied in the home country.
Source: This illustration follows Hines Jr and Rice (1994) who provides a similar example for U.S. corporations. A broader overview of the tax systems is provided by Tax Foundation (2021*b*) and Tax Foundation (2021*c*).

As a consequence, a firm does not have any fiscal incentives or tax reductions, as foreign profit is taxed with the same tax rate as if the profit was generated in the home country. In this example, host country 1 receives $15 dollars in taxes on a $100 profit. As the tax rate in the home country is 30 percent, an additional $15 tax has to be paid to the home country, resulting in a total tax payment of $30 which is equal to a 30 percent tax rate. Under such system, fiscal incentives do not have any effect on the tax rate a MNE is paying, indicating that host countries are not able to attract investment from

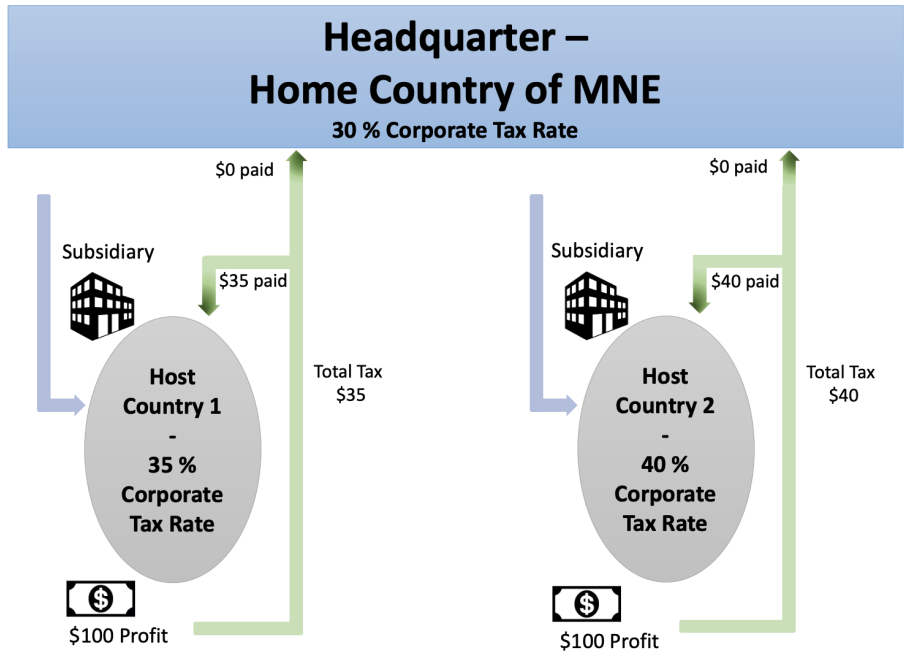
countries which have the *tax credit system* applied in their legislation. As a result, a decrease of the tax rate in the host country would result with the treasury of the home country benefiting from that and even receive higher tax payments.

Considering this, it can be seen that the total tax which has to be paid does not change for the MNE, regardless how much a host country implements a potential decrease in its corporate tax system. Therefore, such a scenario under the tax credit system does not provide any incentive to shift activities towards a country which particularly tries to attract firms by providing tax holidays. However, there are two provisions which also have to be taken into account. These are highlighted and explained using two different scenarios.

Tax Rates in Host Countries are Higher

As a different example, it is again assumed that a firm holds two subsidiaries in two different countries. However, now the host countries both apply a tax rate which is higher than the tax rate implemented in the home country of the MNE. This is illustrated in Figure 4.7.

Figure 4.7: *The Tax-Credit System – Example Two*



Notes: This figure provides a graphical illustration of the main mechanisms of the tax-credit system. In this example, the tax rate in the host countries are larger than the one in the home country. It can be see that while tax has to be paid to the host country, no tax payments have to be made to the home country. However, the total tax payments in the host countries are larger when comparing them to the tax rate applied in the home country.
Source: This illustration follows Hines Jr and Rice (1994) who provides a similar example for U.S. corporations. A broader overview of the tax systems is provided by Tax Foundation (2021*b*) and Tax Foundation (2021*c*).

Now this higher tax rate is applied on the profit, while no tax is paid to the home country. The subsidiary in host country 1 is paying $40 dollars in taxes, while it would only pay $30 dollars if the profit was generated in the home country. If such scenario occurs, that means when the paid taxes in a foreign country exceed the tax liability a company would face in their home country, then the company is in an "excess credit" position. Such a position is of a great disadvantage as tax liabilities are much higher.

There might still be other reasons which impact the decision to open a subsidiary in a particular host country, as there are many other aspects besides fiscal incentives. However, a firm would not be able to avoid this higher tax rate as no refunds are provided by the home country. Therefore, MNEs take advantage of the possibility to average their foreign tax liabilities. This is called *cross-crediting* and is illustrated in the next example.

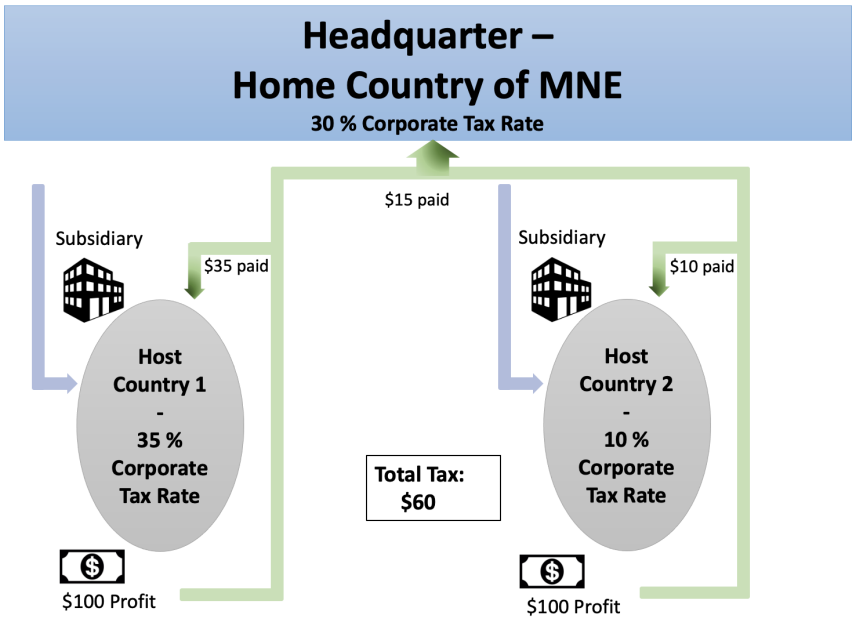
Cross-Crediting

In contrast to the previous assumption, another example can be assumed with a slightly different scenario. This example is shown in Figure 4.8, where not all of the host countries are having a tax rate applied which is lower than the one in the home country. In this case, cross-crediting, also known as worldwide averaging, can be applied which is an attractive tool for a MNE to decrease their tax liabilities when they operate in countries which have a higher tax rate than the home country. In this particular instance, host country 1 has a higher tax rate than the home country, namely 35 percent and not only 30 percent. Host country 2 has a lower tax rate than the home country, merely 10 percent.

Considering this set up, $35 in taxes have to be paid on a $100 profit in host country 1, while in host country 2 the same profit results in only a $10 tax payment. Of a total of $200 dollars profit, total foreign tax liabilities of $45 emerge. However, if the same profit was taxed in the home country, a total tax liability of $60 would have to be paid by the MNE to the tax authorities in their home country. To account for that reduction in tax payments, now $15 taxes have to be paid to the home country, leaving the MNE with their profit being taxed at the regular 30 percent corporate tax rate the home country applies. However, the effective tax paid in the home country is merely one quarter of the whole $60, only $15 dollars.

This mechanism bears interesting implications. Considering the possibility of cross-crediting, low-tax countries still appear to have to potential to attract MNE with fiscal incentives. For instance, it creates a strong incentive for firms, which are in a position of "excess credit" to locate or shift activities into countries with rather low tax rates. This is because a firm can benefit by setting off both tax liabilities against each other when it also operates in another country with a higher tax rate than the

Figure 4.8: *The Tax-Credit System – Cross - Crediting*



Notes: This figure provides a graphical illustration of the main mechanisms of cross-crediting. In this example, the tax rate in the host countries are both larger and also smaller than the one in the home country. It can be see that while tax has to be paid to the host country, also the home country receives tax payments. The total tax payment is equal to the corporate tax rate applied in the home country. This is because the excess tax payments in Country 1 are offset by the lower tax payments in Country 2 (lower and higher in comparison to the home country).
Source: This illustration follows Hines Jr and Rice (1994) who provides a similar example for U.S. corporations. A broader overview of the tax systems is provided by Tax Foundation (2021*b*) and Tax Foundation (2021*c*).

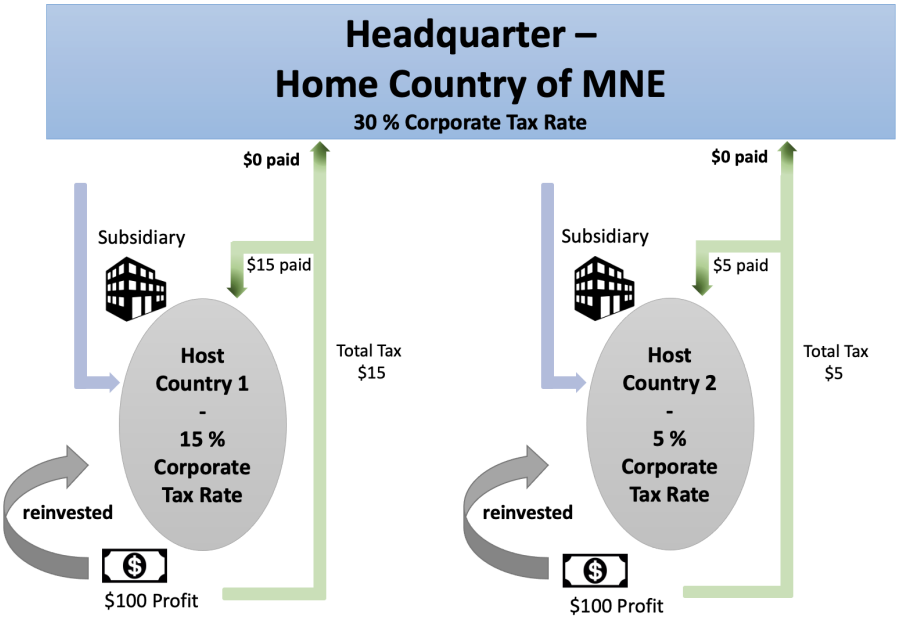
home country. Besides cross-crediting, there is another provision which can be taken advantage of under the tax-credit system.

Deferral

The deferral of taxation is another important mechanism when it comes to foreign earnings. A company has the opportunity to use its profit generated in a foreign country as a reinvestment in their operation undertaken there. Previously provided examples assume that the profits earned abroad return to the parent company (to the home country) giving the local tax authority tax claims. In the example provided in Figure 4.9, however, profits are not shifted back to the home country. Instead, they are reinvested, staying in the respective host countries.

In such case, profit cannot be taxed by the home country and only the tax rate applied by the host country has to be paid. This is because these generated earning are not remitted to the parent and do not appear on the parent's balance sheet as profits. However, this only applies to subsidiaries which incorporated individually in a particular foreign country, and it does not apply to consolidated operations (branches). Therefore,

Figure 4.9: *The Tax-Credit System – Deferral*



Notes: This figure illustrates the mechanism of deferral. In this example, the tax rate in the host countries are smaller than the one in the home country (see example in Figure 4.6). It can be see that while tax has to be paid to the host country, no tax payments have to be made to the home country. This is because taxes in the home country are only charged once profits are repatriated. When profits are reinvested in the subsidiary in the host country, no tax has to be paid to the tax authorities in the home country.
Source: This illustration follows Hines Jr and Rice (1994) who provides a similar example for U.S. corporations. A broader overview of the tax systems is provided by Tax Foundation (2021*b*) and Tax Foundation (2021*c*).

firms have an incentive to delay the repatriation of foreign earnings as in such case they are not exposed to fiscal taxation in their home country.

4.2.6 Tax Avoidance and Tax Evasion

As illustrated in the previous section, the taxation on a multinational level appears to be rather complex. This is due to the different tax systems, various provisions and regulations and a high level of leeway which is granted to the companies. Considering all aspects, international investors are equipped with numerous possibilities and alternatives they can exploit in order to minimize their tax burden. This can already happen in an early stage when it comes to the structure of an investment and the way on how it is intended to be financed. In running operations, transactions can be arranged shifting profits between the related parties which are located in different countries and therefore operate under different tax jurisdiction. It comes to no surprise, that these alternatives and potential options for multinational investors bear an important tax implication. Such conduct is referred to as *tax avoidance*. It is important to point out that these steps are considered to be legal and a company operates within the leeway provided by the law.

Tax Avoidance

Fundamentally, there are two ways how a foreign affiliate can be financed when a MNE decides to expand into another country. The first alternative is financing the newly formed subsidiary via equity (see Egger et al. (2010*a*) and Egger et al. (2010*b*)). This means that the new foreign operation is fully owned by the parent in the home country and that it holds all the equity and ownership. In such a scenario, all profits have to be taxed in the host country and there are no taxes to be paid to the tax authorities in the home country as long as profits are not repatriated back. In contrast to that, operations can also be financed via debt. This means that the new subsidiary is financed with a loan granted by the parent company, i.e. the foreign firm owes money to the firm in the home country. This bears interesting implications, as now this debt also generates interest which has to be paid. Therefore, the subsidiary has the possibility to deduct such interest which allows it to reduce the taxable income it has to pay in the host country. Besides the reduction of income on the subsidiary-side, there are also effects occurring on the parent side. As now the subsidiary is paying interest to the parent in the home country, this interest payments have to be taxed in the home country, meaning that it shifts the tax burden from the host country towards the home country (Egger et al., 2010*a*).

One can see that these different ways of financing foreign affiliates have different implications, advantages and disadvantages. However, considering all these mechanisms one simple tax strategy can be identified which can be used by a MNE to reduce its tax burden. Financing a new affiliate through equity appears to be more attractive, when the new subsidiary is located in a low-tax country. This is straightforward, as generated profits can be taxed with a lower tax rate in the host country, given income is not repatriated to the home country. Debt financing appears to provide more benefits when deciding to opening a plant in a high-tax country. As foreign profits are taxed at a higher rate as they would be in the home country, interest payments can be used to decrease profits and therefore pay less taxes in the host country. These interest payments are then taxed at a comparatively lower rate in the home country as a consequence, because the tax deduction undertaken by the foreign affiliate becomes an interest income for the parent. However, it is important to point out that such strategies have their boundaries, as thin-capitalization rules are applicable and most tax regimes limit the extent to which tax deductions based on interest payments on debt can be undertaken.

There is considerable evidence indicating that tax considerations play a significant role when it comes to choosing the location of a multinational firm. Hubbard and Hines (2008) provide evidence that MNE are able to effectively minimize their tax burden in the U.S. . Using subsidiary-level tax information for 1984 they examine the dividend pay-out behaviour of multinational firms based in the U.S. and find evidence

that parent companies are effectively able to use intrafirm financial transactions in their advantage, primarily through debt shifting. Grubert (1998*b*) expands this research, not only focusing on dividends paid but also consider royalties and license fees. Grubert (2003) links the choice of location with intangible income, intercompany transaction and also income shifting. He provides strong evidence that income shifting is mostly based on intangible assets linked to R&D when investigating parent companies which are based in the U.S. . In contrast to that, Egger et al. (2010*b*) focus on how foreign plant ownership can potentially be used to save taxes considering firms located in Europe. Their findings suggest that debt shifting occurs, but is not the driving factor for profit shifting. However, profit shifting though transfer pricing or license payments and royalties appear to be of higher significance and importance.

Tax Evasion

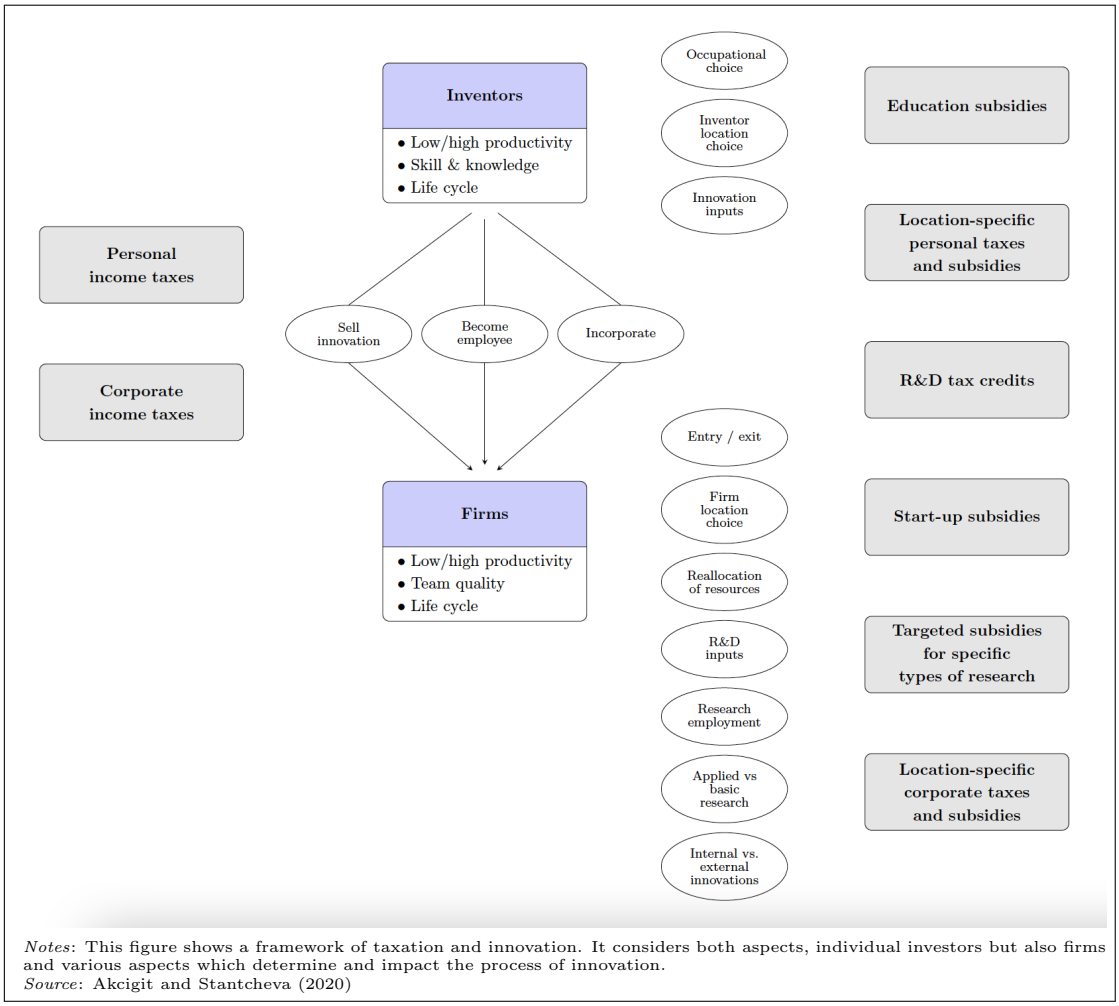
It is clear to see that there are various possibilities a MNE can use to minimize or optimize its tax burdens depending on which strategy it follows. As profit can be shifted through transfer pricing, this might appear tempting to be manipulated and exploited in an illegal way. These transfer prices are supposed to be paid at market price. However, a firm might be able to gain an illegal advantage by overpricing their sales and transfers. This appears particularly attractive when income is shifted from high-tax countries to low-tax countries (Bartelsman and Beetsma, 2003). In this scenario, the affiliate located in the low tax-country sells goods to the subsidiary in a high tax country and applies vastly exaggerated prices. Then, a lot of income is generated in the low-tax country and a lot of expenses are generated in the high-tax country, decreasing the tax burden tremendously. Such conduct is illegal and sanctioned when discovered by the authorities. Nevertheless, income shifting is a widely established procedure undertaken by MNEs. Pak and Zdanowicz (2002) point out that their findings suggest a fiscal loss of more than $53 billion in the U.S. .

Bartelsman and Beetsma (2003) provide evidence that for OECD countries more than 65 percent of additional tax revenue which can be gained through new reforms and tax increases as most of the lost tax revenue can be explained with income shifting between companies. They suggest while tighter enforcements and regulations of transfer pricing might result in higher tax revenue, it also bears the problem that companies might relocate their activities based on that premise and shift activities to countries with either low-taxes or rather lax enforcement of transfer pricing.

4.2.7 How Taxes Shape Innovation

Various mechanisms and margins through which innovation can be affected by tax policies are examined by Akcigit and Stantcheva (2020) which complements and builds up on previous work (see Akcigit et al. (2018) in Section 4.3.2). Such margins comprise the effects of tax policies on both quality and quantity of innovation, the risk of a diminishing business dynamism, a decline in firm entry and productivity, the geographic mobility of innovation and inventors alike, or the direction in which research is pursued.

Figure 4.10: *Framework of Taxation and Innovation*



Notes: This figure shows a framework of taxation and innovation. It considers both aspects, individual investors but also firms and various aspects which determine and impact the process of innovation.
Source: Akcigit and Stantcheva (2020)

Particularly the direction can be of importance as policy makers have the proclivity to undergird their tax implementations with other political agendas and pursuits such as a transition from dirty towards clean technologies. Therefore, there research is driven by the intend to provide evidence on how policies can be designed effectively and how policy makers can promote and foster the most productive and innovative firms while avoiding to waste public funds on less productive ones. Even though their study is not based on an own econometric analysis and rather outlines the existing evidence and mechanisms

the literature establishes, it is still useful to obtain a comprehensive overview on effects being discovered and discussed in both theoretical and applied works. There are various channels through which taxes and tax policy can impact innovation. Figure 4.10 provides a comprehensive overview of the mechanisms and channels being involved.

Innovation and the Main Actors Involved

Fundamentally, innovation is done by either individual inventors or within a corporate environment by firms. The center pillar represents these key players. It can be seen that two options for inventors exist, namely pursuing their innovations through self-employment or by being employed and working in R&D labs which are part of companies. Further, key characteristics such as productivity level or skills and knowledge of both firms and inventors play a crucial role on how taxes can have an impact on them. For firms not only the general quality of itself plays a vital role but also the compositions and quality of the research teams it sets up. Further, the life-cycle in which a firm is currently in has to be considered, reaching from early start-ups to very mature and established corporations. This same aspect holds for inventors as well, with young inventors in early stages or inventors with a high level of experience and improved and advanced skill-sets through learning over time.

Inputs and Actions

The production of innovation requires input. Regardless of the quality and quantity which is produced as a consequence of such production, the inputs being used can be classified as either tangible or intangible. While tangible inputs are represented by things such as equipment, lab space or material used in the research process, intangible assets describe know-how, skills, or the underlying management procedures which can affect research effort in a positive or negative way. On the right-side of Figure 4.10 bubbles can be seen, representing various margins on which firms or inventors can optimize on and which all might be differently affected by various policies. While innovators face the choices of their geographical location, working for a company or being self-employed, their level of tangible and intangible inputs or even the initial occupational choice of become an inventor in the first place, firms are facing the choices of entering a market, remain in operation, or exiting a market. Regarding their choice of location, firms appear to be more flexible as they are able to operate from different locations simultaneously. Moreover, choices on research employment and R&D inputs have to be made. Another aspect which has to be considered is whether the desired research should be directed in either a basic or rather in an applied innovation. While basic innovation is defined as a specific and systematic pursuit to obtain a deeper and more comprehensive understanding of a subject without having a specific application or implementation into

an existing process in mind, applied research is specifically targeted to meet a recognized and pre-defined need. Further, it can be distinguished whether research effort is directed into internal or external innovations. The former describes improvements of already existing products or technologies, while the latter is defined as the development and creation of new and novel products.

Types of Tax Policies

Regarding tax policies, a distinction can be made between general and specific tax policies. General tax policies can be described as rather broad and not having a specific targeted intention. Such policies comprise personal income taxes, educational subsidies, and corporate income taxes. Specific tax policies can be identified as being rather targeted towards innovation, such as R&D tax credits, research subsidies, start-up subsidies, or explicit incentives designed for inventors or firms to locate at a specific location.

When it comes to general tax policies both inventors and companies can be affected by both income and also corporate taxes. While the post-tax income of inventors is directly affected by the personal income tax, the corporate income tax comes into play as well in case an inventor takes the decision to incorporate. Regarding employed inventors and firms, any surplus-sharing bears the implication that both personal and also corporate taxes are of importance and impact the consequential payoffs. Another key aspect impacting a firms R&D decisions is the level to which research inputs can be expensed. It can be expected that corporate taxes do not have any impact and effect on the decisions of investing in R&D pursuits in the case of full expensing. Further, the personal income tax appears also of interest for firms as it can be a crucial aspect which has to be considered when making employment decisions as compensation differentials might arise when and also where taxes are higher. Different responses to taxes can be expected when distinguishing between corporate and non-corporate inventors. This is because payoffs can be differently affected by taxes and also because of the various reasons and motives which motivate them to engage in innovation and research activity in the first place.

In contrast to that, more targeted policies might affect innovation differently. Turning to R&D tax-credits, several effects for both firms and inventors can occur. The full range of decisions which are made by firms can be altered and guided by such credits. For inventors the relative payoffs can change substantially when making the decision to incorporate and work for a firm. Further, the entry into a market can be promoted by specifically targeted subsidies. Such subsidies can even be targeted to specific types of research, meaning basic and applied research can be promoted and encouraged to a different degree. These subsidies can be limited to specific locations as well, indicating that certain places can be promoted for both firms and inventors to settle and undertake

their operations there.

Responses to Tax Policies

Considering this, the question of how the elasticities to such mentioned tax policies manifest themselves arises. Akcigit and Stantcheva (2020) argue that both behavioral elasticities and technological elasticities are the driving factors for this and the response can simply be seen as a composition of both. Fundamentally, behavioral elasticities comprise both firms and individual inventors and their adjustment to all their available margins of action. On the other hand, technological elasticities are rather describing the sensitivity of the innovation outputs to each of these actions, considering both quantity and quality. A rather exaggerated but illustrative example in the realm of technological elasticities can be made. Akcigit and Stantcheva (2020) describe an entire inelastic occurrence of innovation with the example of "Newton is sitting under a tree and an apple falls." Another extreme example for the opposite end would be a solely mechanical innovation process in which an increase of inputs would directly translate into more output. As an example, one could imagine testing a large variety of several chemical combinations. This results in a scaled-up probability to discover new compounds or materials, fundamentally a new innovation.

Turning to behavioral elasticities, similar reflections of both extremes can be made. On the one hand a "mad genius" can be imagined, who is involved into science and innovation production solely because of his or her intrinsic motivation and love to science. On the other hand, one can imagine a purely profit-driven entrepreneur who is only involved in the pursuit of finding new innovations for money reasons.

The Dynamics

In its core, innovation can be described as investment-type activity which is mainly founded on forward-looking behavior. This is because cost which have to be paid upfront today have the potential to lead to streams of benefits and advantages in the future. For this reason, both firms and inventors are required to shape expectations, at least to some degree, about the net present value of those expected returns resulting from the up-front paid investment. These expectations are strongly impacted and shaped by the aforementioned policies and also their potential changes which might occur over a following time period. As an example, the net present value of the payoffs generated from innovation would decrease if corporate taxes are expected to increase in the near-future, while an anticipated decrease of the corporate tax rate results in the opposite, namely an increase of the net present value. However, it is important to point out that predictions regarding tax policies are difficult to make and therefore expectation formation appears

to be a primer issue for agents who are facing the decision of whether and to what extend they should engage in innovation processes. While these effects are rather directed into a forward-looking way, there is also the possibility of innovations responding with lags to changes done by policy makers. This is because of the rather long time period which is needed to produce innovations and the time span of the creation of an innovation. Such lags can occur in a different magnitude depending on what type of policy is changed.

Perspective - Micro and Macro

When it comes to measuring the response to tax policies, it is also important to consider the level of analysis. Different responses can occur, depending on whether the measurement is taken on an individual level or whether an economy-wide response is of interest in the analysis. When turning to the individual level, all the described response margins could potentially respond. When moving towards a macro-level perspective, which could be states in the U.S. or countries in the world for instance, additional effects occur which complement the micro-level effects and layer up on them. As an example, factors might be shifting between places resulting in a reallocation with the potential of adding value overall. Akcigit and Stantcheva (2020) illustrate this by looking at states in the U.S. and stress that the response on the macro state-level can partly be explained though cross-state spillovers or simple business-stealing effects, not being accompanied by increased innovation on a federal level. Further, research infrastructure and amenities can be identified as additional factors which potentially amplify or dampen tax effects on the macro level. Therefore, it can be a crucial factor to consider the level of resolution one takes when turning to empirical literature.

4.3 Literature Review

This section provides an overview of relevant and key literature. It is divided into two parts. The first part illustrates how the statutory tax rate can impact firms in a more broader sense. It is shown how the effective tax rate is affected and how firms might find possibilities to avoid taxation. This highlights which channels and mechanisms the empirical literature finds to be predominantly at play when it comes to tax avoidance or evasion. The second part focuses on innovation, its driving factors and how companies respond to certain incentives.

4.3.1 Taxation and its Effect on FDI and Multinational Firms

An empirical approach is provided by Mutti (1981) examining how tax laws in both the U.S. and also foreign countries influence repatriation practices of U.S. MNEs. He points

out that not only the total funds repatriated but also the way on how these funds might be divided among, dividends, interest payments, and also royalties, appears to be of importance. Several repatriation strategies for U.S. multinational firms are highlighted. These approaches can be seen in the previous section which illustrates the framework of the tax-credit systems and its mechanisms (see Section 4.2.5). The position of being in excess credit appears to be an important incentive regarding repatriation. The data he uses in his analysis is derived from tax forms filed by U.S. controlled foreign subsidiaries in the year 1972. It consists of 4,446 controlled foreign operations which operate in 11 countries. As these reported data are rather limited and incomprehensive, the analysis is not as extensive and deep as desired, however, provides an interesting insight.

While controlling for fixed-effects on the industry level, his results suggest that a decrease in the statutory tax rate is accompanied by an increase of dividend repatriation. It can be observed that more than 50 percent of repatriations are accounted for by dividend payments. This provides an explanation why previous research rather focused on only this aspect. Further, interest payments appear to be rather insignificant and unimportant regarding the way of how funds are brought back to the parent and do not appear to be responsive to tax incentives. However, a statistically significant rank correlation can be identified when attending to royalties and tax incentives originating from withholding rates relative to foreign effective income tax rates. He concludes that even though a comprehensive treatment of all factors which might determine dividends, interest payments, and royalties is not possible due to poor data availability, there are still useful policy implications which can be drawn. It is highlighted that the estimated coefficient enables policy makers to assess the pay-out practice of U.S. subsidiaries during a time of significant corporate tax changes in both the United Kingdom and Germany. With the corporate tax rate being reduced in the U.S. in 1978, similar projections can be made regarding an increased amount of U.S. dividend repatriations.

Hartman (1985) examines the 'residence approach' regarding the taxation of foreign income and its implications in the U.S. using survey data from the U.S. Commerce Department from the year 1980. He argues that corporate taxation of foreign source income can be rather perceived as a tax on the transfer of funds. This is because not the earning of profits but rather the repatriation of profits becomes the actual source of tax liability under deferral. Therefore, this tax has the potential to cause different effects than the ones caused by the tax on domestic income. A distinction between new foreign investments and already 'mature' foreign operations appears to be important when investigating tax implications, as the latter do not require substantial funding from their parent anymore. As firm data is not available, he has to revert to aggregate data in order to discern mature and immature firms and their representation of U.S. foreign direct investment. The data indicates a substantial change in the previous decade. It can be seen that reinvested earnings account for more than three-quarters of the total

earnings, while in previous years such earnings from reinvestments played only a rather minor role. This is also in line with the 'maturing' of foreign U.S. operations which is highlighted in previous works and can be explained by more mature firms being at a more developed stage, being more established and also having more financial possibilities at their disposal.

Developing a simple theoretical model, Hartman (1985) investigates the potential impact of taxes on foreign operations, both mature and immature ones. Novel findings provide new insight and do not leave "any of the conventional wisdom regarding optimal foreign investment decisions unscathed". For the majority of the U.S. firms which are invested abroad, he finds that the tax burden on their foreign income in the U.S. should not have any effect and be irrelevant for further investment decisions. Further, decisions on repatriating income back to the home country seem not to be affected by the tax treatment of foreign source income of the home tax authority. In contrast to that, if a subsidiary is not able to finance itself (e.g. it might be still immature) and relies on funds being transferred from the parent company, then the parent company would respond with a decrease in investments abroad when it faces a tax increase on foreign sourced income in the home country. He argues that this is the case because immature subsidiaries should, unlike mature firms, respond to tax changes with an alteration in their investment decisions This is because taxes are not yet 'unavoidable fixed cost' for them, while for more mature firms such perception can be taken.

Another striking insight is provided regarding the effects occurring when the general system of capital income taxation is changed in the home country. Even though the same tax rate might be applicable to both income generated domestically and income sourced from abroad, a change of the tax rate affects predominantly domestic investment incentives. For this reason, a tax increase which at first glance applies equally on both foreign or and domestic income yet increases the attractiveness of foreign investment more relative to domestic investment. These results, however, depend on the assumption of continued deferral of home country taxes.

In their joint research Grubert and Mutti (1991) analyze three aspects of multinational firm activity which they perceive as interrelated focusing on U.S. companies. These three interrelated aspects are the ability of profit shifting from countries with a high tax rate to other countries with rather low tax rates, host country taxes and tariffs and their resulting impact on real capital distribution, and the way in which such policies affect and influence international trade patterns of the U.S. and host countries. They approach this by using data from 1982 which covers a cross-section of 33 countries and seek to extend the existing literature in multiple ways. While previous studies rather focus on providing evidence for income shifting by investigating the relationship between parent repatriation and tax rates in a host country, their approach in this study intends to find evidence for income shifting to low-tax countries by investigating the relationship between

profit margins and tax rates. Further, an assessment of the relationship between foreign operations controlled by U.S. parents and U.S. imports and exports is conducted.

Their results indicate that taxes and tariffs indeed are influencing MNE operations significantly and have a strong impact on them. The three relationships between trade patterns, foreign investing, and the effect of taxes on income shifting occur to support each other. Incoming shifting into low-tax countries in a disproportionate magnitude also indicates and explains the allocation of FDI in the manufacturing industry in such countries. While income shifting incentives are also applicable for explaining an increase in export by U.S. parents to their affiliates in foreign low-tax countries, the responsiveness of exports as a whole to these countries appears to be much smaller to tax incentives. The results suggest that the net exports of the U.S. might even decline as exports diminish and imports increase. Further, they find the statutory tax rate to be a superior determinant with regards to income shifting than the effective tax rate. When comparing tariffs to low taxes, it can be seen that the former shows the largest impact on promoting sales in a local market while the latter shows a tendency to boost exports to third markets. For future research, they suggest that studies on the industry level might be able to provide additional support and increase confidence in their approach.

Gruber et al. (1993) pursue to find explanations for the rather low taxable income of foreign-controlled firms in the United States. They point out that such occurrence even let to congressional concerns in the early 1990. As an example, they provide aggregated data showing that when comparing the ratio of taxable income to assets of foreign-controlled companies with domestically controlled companies, it can be seen that the numbers substantially differ. These differences even persist when distinguishing between industries or calculating the ratio using sales instead of assets. Various factors can explain such a phenomenon, such as start-up costs, transfer price manipulations, facing higher debt costs than their counterparts in the U.S. , or fluctuations in the exchange rates. To find empirical evidence for this difference, they revert to data collected from the IRS Form 1120, which is the corporate tax form. This data is processed by the Internal Revenue Service and then provided to the Treasury Department, covering all companies which reported assets for more than 50 million dollars. Additionally, information on the ownership structure is provided, allowing to identify a firm as either foreign owned or U.S. owned. Their final sample consists of approximately 4,600 companies, of which 600 appear to be foreign-controlled, and cover the years 1980 to 1987.

Applying several regressions, their results provide insight into the composition of the "foreign-domestic differential". They find that about 50 percent of the difference in taxable income can be attributed to special characteristics which foreign-owned firms have in comparison to their domestic counterparts and not to transfer pricing. They present three major factors. First, a distortion of the taxable income to asset ratio can occur. This distortion is driven by book values of assets being revaluated, particularly in the

aftermath of the acquisition process. Second, a maturation process can be identified with foreign-controlled companies in the manufacturing industry increasing their profitability to a larger degree as domestically owned firms are able to. For this reason, foreign investors might be more willing to accept initial returns being rather low, as they expect the profits in the long-run to be substantially higher. Third, their results suggest that the taxable income of foreign owned firms in the wholesale industry rises more than the one of domestic firms, as the real value of the dollar increases. They stress that returns are depressed when it comes to investments in wholesaling and explain this with a significant drop in the dollar which starts in 1985.

They only find little explanatory power for other commonly suggested explanations. Debt and earnings stripping do not appear to be driving factors for low taxable income on the side of foreign-controlled companies. Further, there is no evidence to support the hypothesis that foreign firms have the proclivity to acquire rather unprofitable firms. However, there is significant evidence indicating that the rather low rate of return of foreign owned companies can be attributed partially to income shifting. The effect of transfer price distortions can be identified. However, it appears to be only of small magnitude.

Altshuler et al. (1995) shed light on the significance of repatriation taxes and intend to answer the question whether and how these taxes affect the decision of a MNE to repatriate profits or rather reinvest abroad. They contrast previous theoretical models which suggest repatriation taxes should not have an effect on dividend remittance with rather recent empirical studies which find that dividend payments appear to be sensitive to repatriation taxes. They dispute previous assumptions by Hartman (1985) who suggests that taxes on dividends are constant over time. This is now extended with the assumption that such taxes may vary over time. This is a key point, as such variability might impact a company's decision to repatriate more profit when tax costs are relatively lower than usual, and retain more profit in the case of unusually high tax costs. At least two different ways can be identified which may lead to a variation of the repatriation tax. First, tax base definitions of the home country might be different than the one in the host country of the foreign subsidiary. Second, a movement of the parent company from an "excess credit" position to an "excess limitation" position. In the former case, the repatriation of foreign income does not generate any additional tax cost. In contrast to that, the latter case may result in a positive or negative tax burden when income is repatriated, depending on the average foreign tax rate the subsidiary is facing. Therefore, the distinction between permanent and transitory tax price effects appears to be a significant procedure.

The dataset used in their analysis consists of information retrieved from three tax and information forms, consisting of roughly 7,100 observations comprising for the years 1980, 1982, 1984, and 1986. Their results find the difference between the permanent

and transitory tax price effects to be statistically significant and positive. This not only indicates that the permanent component is different from the transitory one, but also that its impact on dividend repatriation is rather small as the coefficient appears to be positive. Further estimations show the permanent tax price effect not to be statistically significant at all. This supports the theoretical work of Hartman (1985) and provides support for the theory that the incentive to repatriate dividends is impacted by transitory but not permanent changes in the tax prices. Such results bear important policy implications. For instance, lowering withholding taxes is a popular tool by capital-importing countries to attract new investments through equity. Such behavior might worry other countries with higher withholding taxes, as the risk of multinational equity flowing outward might increase substantially. However, the empirical results indicate that such fear is unfounded as long as such a tax reduction is perceived as permanent.

In another study Grubert (1998*a*) builds on the previous work of Gruber et al. (1993) using data covering the years from 1987 to 1993. As the year 1993 includes more data, for instance more details on foreign ownership structure, this particular year is also analyzed as a cross-section. resulting in a total of about 5,800 companies. He follows the previous attempt of Gruber et al. (1993) retrieving the data from the Form 1120 and identifying a firm as foreign when more than 50 percent of its equity is held by non-residents. As the reports for 1993 include additional ownership data, he sheds light on the taxable income for companies which are only 25 to 50 percent foreign owned. Further, with recent data he is able to update findings from the previous study and is able to answer the question whether certain effects and characteristics found in this study hold and remain over time.

While the previous study suggests that about 25 percent of the difference between the profitability of foreign companies and domestic companies can be explained purely with cross-sectional variables, his findings in this following study suggest this effect to be much higher, more than 50 or even reaching to 75 percent. The importance of dividends becomes focus, as they account for more than 30 percent of the net income generated in the manufacturing industry by U.S.-controlled firms. Further, the importance of depreciation and interest expenses is highlighted, as these appear to be greater with foreign-controlled firms. There is strong evidence to be found that most of the differential can be explained by systematic differences between U.S.-controlled firms and foreign-controlled ones. This is reinforced by the findings when investigating firms with foreign ownership between 25 and 50 percent. As their counterparts which are 100 percent foreign owned, they also show a similar and low profitability. Additionally, there is more evidence for a maturation process to be found when investigating foreign-controlled firms in the manufacturing industry, confirming findings from the previous study. However, the magnitude of such effect appears to be debatable as it diminishes substantially when observations are weighted by size.

Grubert (1998*b*) builds on these findings now pursuing to answer the questions on how operating incoming of foreign companies is divided among interest, royalties, dividends, and retained earnings. His findings reveal that taxes have a strong effect on the composition of payments. It extends the literature as previous work almost exclusively focuses on the behavior of MNEs regarding dividend repatriation. He stresses the importance of such an approach, as 22 percent of total direct investment income which MNEs receive from their subsidiaries abroad, consists of royalties and license fees. As a source of data various tax forms are used, such as tax Form 1120, 1118 and 5471 for the year 1990 which is compiled and provided by the Statistics of Income Division of the Internal Revenue Service. The analysis focuses solely on parent firms operating in goods production, with mining and petroleum manufacturing included, as it is found that almost all U.S. R&D and therefore also the resulting royalties are located in this field. His data collection results in a sample comprising about 3,500 controlled foreign subsidiaries.

His findings provide strong evidence that particularly the own tax price on dividends, royalties and interest appear to be deterring payments from controlled foreign companies. Further, royalties and interest payments appear to be highly substitutable. Even though dividend distribution is strongly determined by the negative effect of high dividend tax prices, this does not provide proof that repatriations in total are affected by repatriation taxes, but rather that it affects the composition of it. This is a crucial point. It demonstrates effectively that it is essential to incorporate the individual components of the taxes prices when constructing them. He provides novel insight that not only the tax prices themselves matter but also the way they originate, and concludes that this is an important aspect to consider when it comes to predicting the behavior of MNEs.

The tax-paying behavior of U.S. firms with strong foreign links is researched by Kinney and Lawrence (2000) and compared to the behavior of other U.S. firms which are less or not at all influenced by foreign-domiciled companies. Other than most previous studies, they do not rely on Internal Revenue Service data but make use of public financial statements gathered from Compustat, resulting in a dataset with 70 firms within a time period of 1975 to 1989. They point out that due to a lack of data availability they focus on firms which are exposed to "significant", however, not 100 percent foreign ownership. This is because information on fully foreign owned firms appears to be poorly reported. As previous research indicates that U.S. operations undertaken by foreign firms appear to pay less taxes when comparing them to other U.S. enterprises, the suspicion of transfer pricing manipulation, differences in operating costs, maturity level of the firm, operating costs, and ownership concentration arises. Unlike previous research, they extend the literature by exploiting public financial statements and not Internal Revenue Service data, which is a rather widely used source of data for such analysis. Their analysis is rooted in an event-time method, which means that that year 1 (the event year) is defined

as the one when acquisition takes place. The previous year to this is defined as base year (or year 0). With this approach, it can be tested whether a difference in the tax burden is present when comparing both domestic-owned and foreign-owned firms for both prior to and subsequent to the conducted investments.

Their findings show strong evidence of a negative and statistically significant relationship between foreign ownership and tax burden, implying that firms with a higher share of foreign ownership pay less taxes than firms which are domestically owned or only exposed to foreign ownership to a small degree. When investigating the reasons for this difference, they fail to find evidence that such result occurs due to ownership concentration effects, greenfield start-up effects, or agency costs which are related to management. Further, their results indicate that the explanation of such reduction in the tax burden being founded in income manipulation appears to be implausible and unsubstantiated. Instead, the obtained results provide evidence indicating that foreign-owned firms undergo a real decrease in their profitability when comparing them to a benchmark sample. As such diminishing profitability is associated with a reduced market return on equity, it is concluded that profit reduction is not artificially constructed and a mere façade but indeed is real. This can be explained by domestic U.S. firms being more informed and rooted in the local market and being more able to identify and exploit opportunities than foreign-owned firms do.

A meta study is undertaken by De Mooij and Ederveen (2003) who review and compare 25 empirical studies. They stress the difficulty of doing so as various specifications, methodologies and sources of data vary vastly across those studies. Even though such obstacles have to be addressed and accounted for, the importance and appeal of such a meta-analysis is emphasized. This is because such analysis has the proclivity to be more rigorous than an ordinary and rather simple examination of the existing literature as it is rooted in a multivariate character. While these studies at hand address various issues and outline fundamental theoretical arguments, the approach of conducting a meta-regression allows to examine their significance ex-post based on existing study results. In order to overcome the mentioned difficulties occurring and to make the outcomes and results of the reviewed studies comparable, a transformation of the coefficients of each individual study is done, converting them into a uniformly defined elasticity, which is the semi-elasticity or also called tax rate elasticity. The interpretation of such elasticity is held rather straight forward, as it measures the change of FDI in percentage which occurs by an alternation in the tax rate of 1 percentage-point. When exploiting information and results of all 25 studies, a meta sample of 371 semi-elasticities can be obtained.

The sample reveals that the variation in the mean value of the semi-elasticity is rather large, ranging from -10.9 to +1.3. Also, the number of semi-elasticities which are obtained from each study varies significantly, between 2 and 95. Therefore, De Mooij and Ederveen

(2003) continue to process the sample and eliminate outliers. Their regressions shed light on various aspects being discussed in the studies. In regards to the source of finance, they analyze the responsiveness of retained earnings and transfers to taxes. As not all studies distinguished between these two ways, a large number of studies present the source of finance as unspecified. Considering this, results show that semi-elasticities for retained earnings are much larger than the ones for unspecified data. The coefficient for transfers appears mostly to be negative. This is in line with the findings of Hartman (1985). Nevertheless, none of the obtained coefficients appear to be statistically significant. It is pointed out that the conclusion of retained earnings being more sensitive to taxes when comparing them with transfers cannot be drawn easily.

When it comes to the number of foreign locations, their results suggest that the semi-elasticity for such is smaller when comparing it with foreign total capital. In the majority of the cases the estimated coefficient appears to be negative and statistically significant. This implies a negative correlation of both the number of foreign location and also the sum of foreign capital per location with the tax rate. Further, for plants the semi-elasticity appears to be higher than the one for mergers and acquisitions. It is highlighted that various studies debate about which types of tax rates would be the most suitable ones to measure and capture the tax effect on FDI. The meta-regressions reveals that the average tax rates and also the effective tax rates are impacting foreign direct investment to a much larger extent than the individual statutory tax rate of a country does. Moreover, it is tested whether capital becomes more mobile in the 1980s by investigating the correlation of the semi-elasticity with the median sample year in the respective study. Their obtained results reveal that studies which rely on more recent data show the tendency to yield higher elasticities. While the coefficient for the median year appears to have a positive effect on the semi-elasticity, it is pointed out that in the majority of the cases it does not appear to be statistically significant. They conclude that after analyzing the respective 25 paper a median tax rate elasticity of foreign capital of -3.3 manifests itself. It is pointed out that the substantial variation of the studies can predominantly be explained by their individual characteristics.

The behaviour of multinational firms regarding their price setting is researched by Bernard et al. (2006), stressing that large variation can be identified when comparing arm's-length and related customers. This can be explained with multinational firms having both financial and also managerial motives leading them to set prices at significantly different levels for arm's-length and related party transactions. On the managerial side, this can occur as a firm intends to avoid "double marginalization" when being in a position of strong market power and incentivizes disparate divisions, which are part of a decentralized firm, appropriately. They take advantage of data from the 1990s which tracks U.S. export and links individual trade transactions to firms in the United States which allows them to create a dataset with more than 3.5 million

observations. These data are in line with previous assumptions and models, showing a large and positive discrepancy between internal and external prices set by firms. Further, it can be seen that a high concentration of exports among only a small number of firms appears. While the top one percent of exporting firms in the U.S. represents only 0.03 percent of the total number of firms, their representation in export is tremendous, as they represent more than 80 percent of the total value of exports.

Their results provide strong evidence that exporting U.S. firms burden their arm's-length customers with significantly higher prices as they do related-parties. Particularly differentiated goods appear to have a higher price wedge, averaging around 67 percent, while the one for commodities is smaller. Further, a positive relationship between the price difference and the firm size and also firm export share can be identified. Particularly the interest of transfer pricing and its relationship to firm-behavior and to taxes and tariffs is emphasized. Indeed, the obtained results provide insight into such behavior, suggesting price wedges to be significantly different for the same product when comparing countries which differ in their tax rates and tariffs. Larger gaps between arm's-length and related-party prices arise when the corporate tax rate is rather small and tariffs are high. They conclude by stressing the importance of considering the gap in prices when researching performance advantages for both multinational firms operating in their home country and abroad. As the magnitude of this gap appears to be rather sizable, it might play an important and significant role and is yet mostly unobserved and not considered in studies.

The discrepancy of tax payments between foreign owned companies and domestic firms is researched by Egger et al. (2010*b*) covering more than 500,000 observations of manufacturing firms in Europe. The data used in their study is retrieved from the AMADEUS database, which is a sub-version of the ORBIS database, provided by Bureau von Dijk. With firm-level data for the time period from 1999 to 2006, they create a cross-section using the average values for each firm over the entire time period. Their intention is to determine the causal effects of foreign ownership on profit tax savings and comparing them with the effects on domestically owned firms. Besides the tax savings through foreign ownership, they identify particular channels through which these savings can occur. They particularly highlight two channels which appear to be of importance. The first channel appears through "direct" profit shifting from high-tax countries to low-tax countries. This can be done by transfer pricing, license fee payments or in other similar ways. The second channel occurs in an "indirect" way by shifting the tax base through a shifting of debt to a high-tax country.

Their results show that tax payments differ to a great extent when comparing the average foreign-owned subsidiary with a domestically-owned competitor in Europe. There are significant and substantial profit tax savings occurring for foreign owned firms which are located in high-tax countries. There is strong evidence that profit shifting is a driving

factor for this, which is generally more pronounced in Europe when comparing it to debt shifting. It can be seen that in low-tax countries, foreign owned firms earn significantly higher profits when comparing them to domestic firms. In contrast to that, they find multinational firms in high-tax countries to pay substantially less taxes as their domestic competitors. This concludes in the final result with profit tax payments of foreign-owned multinational firms to be lower than the payments of domestic firms in high-tax countries, however, higher in low-tax countries. These results provide policy implications regarding unitary taxation on a pan-European level and show support of a common consolidated tax base as a measure to prevent tax-avoidance on a large scale.

Another meta-study is conducted by De Mooij (2011) pursuing to shed light on how taxes are impacting corporate financial structures, considering that past studies rigorously examine the debt bias of taxation. As these studies differ in methodologies, specifications and size of the effect, he stresses the importance and usefulness of a meta-analysis. One of the key questions being addressed is whether taxes actually are a driving factor for corporate debt policy and to what extent they might impact it. This is based on evidence suggesting that corporate tax systems show a bias towards debt, allowing interest payments to be deducted but not capital gains or dividends. Assuming the response only to be weak bears the implication that reforms regarding the corporate tax rate would only bring small welfare gains. However, an elimination of the debt bias would contribute to the social benefits substantially, given the behavioral response is rather large. Therefore, a meta sample is constructed, considering 19 different studies. As a consequence, 267 tax elasticities are obtained which are used in more than seven meta regressions investigating several aspects and impacts of specific characteristics.

The results of such extensive examination suggest an average tax elasticity to be located somewhere between 0.5 and 0.7. This corresponds to the debt-asset ratio, which is the most common indicator being estimated in empirical studies, being affected by a tax impact of 0.17 when narrow measures of debt are applied. When only a broad measure of financial leverage is applied, it appears to be 0.28. Further, another trend and tendency can be identified. When comparing them to their older counterparts, studies which rely on much more recent data appear to obtain systematically larger elasticities. The results show that when using 2011 data, it can be expected that one obtains an impact which is much larger than the average the literature finds, reaching up to 1.5 times of it. They conclude that most of the variation in the results of the examined papers is rooted in the type of debt variable being chosen. Besides that, the importance of the adopted measurement for taxes is highlighted. The results appear to differ to a large degree when comparing the studies which apply the average tax rate to the ones which use the statutory tax rate in their analysis. Moreover, non-linearities regarding the effect of taxes on debt can be identified, suggesting firms having the tendency of responding stronger when tax rates are on a high level.

How taxable profits differ between MNE and domestic firms in the United Kingdom is investigated by Bilicka (2019). Her main focus lies on systematic differences in the ratio of profits to total assets which she refers to as "profit ratio gap". Having access to data of confidential unconsolidated corporation tax returns in the United Kingdom for a time period from 2000 to 2014 provided by HMRC she matches this data with firm-level data from FAME, a database provided by Bureau van Dijk resulting in a final dataset consisting of 460,000 observations. Using the ownership information provided by FAME, firms are separated by identifying them of being subsidiaries of multinational enterprises which have their headquarters located outside the United Kingdom and domestic firms which are solely operating in the UK.

Applying a propensity score matching approach, she controls for the differences between those two determined groups regarding the variations in industry and size, leaving a remainder of 12 percentage points of the difference. This suggests that subsidiaries which are foreign owned have a higher proclivity to shift taxable profit out of the UK. Her findings provide evidence that taxable profits of foreign multinational firms are underreported by 50 percent when comparing them to domestic entities. Even though these estimates appear to be large, she suggests that they are still most likely rather conservative and might be much higher.

Regarding the size of the profit ratio gap, she finds a variation between 30 and 70 percent considering the yearly matching estimates. The majority of this gap can be associated with foreign multinationals which largely report zero taxable profit. She suggests that by equalizing the tax payments for both MNEs and domestic firms the potential gain in revenue varies between 3 billion pounds at the beginning of the sample up to 25 billion pounds in the year 2014. When putting this in relative terms, this implies a 10 percent revenue gain for the year 2000 and a 62 percent revenue increase in 2014, ceteris paribus and without behavioral changes.

Egger et al. (2020) attempt to find evidence to support the theory that not only profit shifting is a driving reason regarding lower tax payments by foreign owned enterprises. They further suggest that also bargain power plays a significant role, which is believed to be much higher for MNEs. This is based on the believe that multinational firms, which are larger and more profitable on average when comparing them to national firms, are perceived as more valuable by the tax authorities. The reason for this is that MNEs represent a higher level of employment and also tax revenue. Therefore, a certain level of bargain power on the side of foreign owned firms can be identified, as they have the option of threatening to move their operations from a particular host country to another jurisdiction. This might enable them to negotiate greater tax deductions as a comparable domestic firm would be able to negotiate.

In their analysis they revert to firm-level data on companies which are based in France using the ORBIS database provided by Bureau van Dijk for the years 2007 to 2012

comprising 2,300 companies and respective 4,600 observations. Firms are distinguished into three groups. The first group consists of foreign multinational enterprises which are having their ultimate owner in another country than France. As a second group, companies get assigned to when they are French domestic firms operating in France without having any entities abroad. Lastly, the third group comprises all domestic firms which are also having entities abroad, identifying them as French MNEs. Applying both approaches suggested by Levinsohn and Petrin (2003) and Olley and Pakes (1992) they are able to also consider a firm's productivity level.

Their results suggest that indeed MNEs are having a better bargaining position when facing tax authorities and when it comes to negotiating with policy makers. This can be mainly attributed to their larger size and also to lower relocation costs when comparing to pure domestic firms. Their model suggests that firms with large pre-tax profits and also low fix-costs of relocating are endowed with a higher bargaining position. This results in a lower ETR which has to be paid by them. Further, their stylized model implies a regressive ETR schedule based on the increased negotiation advantage of firms that are more profitable. Empirical analysis suggests that MNEs, regardless whether they are French or foreign owned, pay a 3.42 percentage points lower ETR than a domestic French firm.

To reflect these findings onto a political perspective, the European commission did indeed increase their efforts and investigations regarding "selective, unfair competitive advantages" regard tax rulings of a member state (Bloomberg Tax, 2018). This approach would limit the sovereign ability of each country to determine and regulate their own tax policy. However, the implementation of such limits and regulations appears to be cumbersome as governments tend to be not particularly in favour of constraining their freedom of negotiating deal on a local level.

4.3.2 Taxation and its Effect on Innovation

The effects of tax policies on innovation and R&D appears to shift more and more into focus, however, has been widely neglected by the literature. While research on innovation, its driving factors and consequential benefits have been investigated thoroughly, the implications connected to tax policies have only been considered and taken into focus to a rather small degree. This section provides an overview about the recent literature undertaking the examination of taxes and its potential effects and implications on innovation. As the literature on innovation in general is very extensive, broad and ranges over a wide field of related topics, it is important to point out that this review is held short and solely focuses on research conducted in the context of tax implications and tax policies.

The importance of tax policy and its implications on innovation and innovative behavior in the European Union is addressed by Andréosso-O'Callaghan (2000). Particularly the significance of the high-tech sector is highlighted as in its realm most of the innovation processes are to be expected. She finds that different EU countries which are scientifically and technologically advanced to a similar degree or which are endowed with equal scientific and technological capabilities yet appear to be differently attractive regarding innovation, depending on their regulatory and fiscal regime. Besides allowing to treat R&D costs as current expenditures or offering tax credits to domestic R&D activities, policy makers also have the option to minimize or adjust corporation taxes which high innovative firms are facing. Besides that, tax incentives might also have the effect to attract foreign direct investment which is endowed with high-tech, having the potential to cause spillovers to domestic firms.

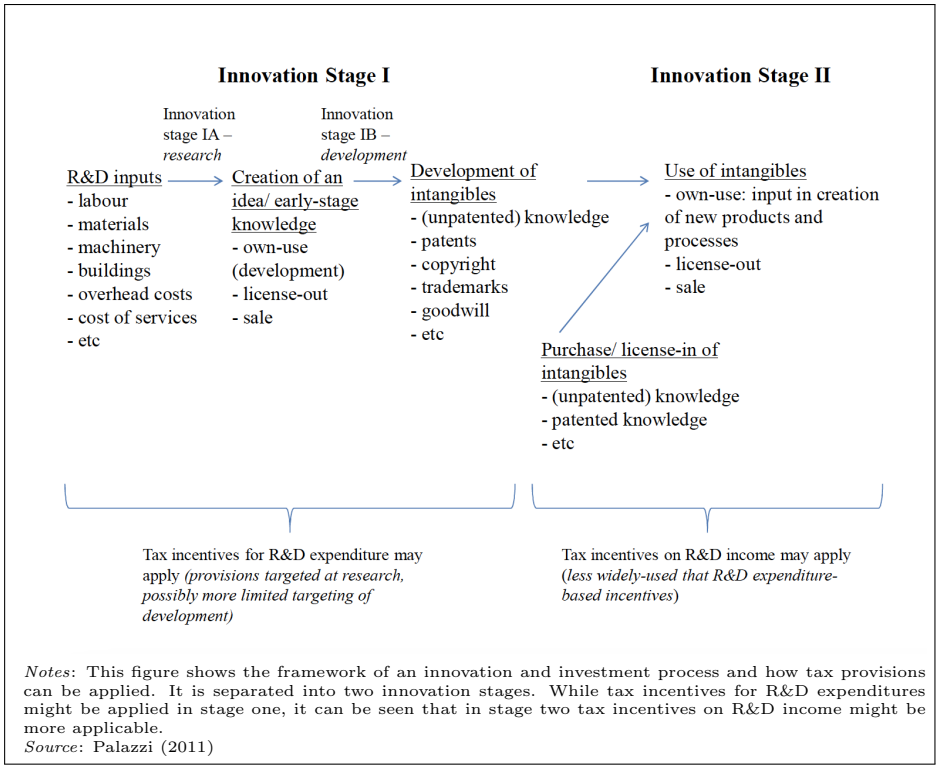
It is emphasized that, with the exception of the United States, most of the developed world has been lagging behind when it comes to tax treatments regarding technology. A main concern regarding the EU is raised, as innovative firms are facing multiple disadvantages when operating in this location. These disadvantages can be separated and grouped into two distinct areas of taxation: indirect taxation and direct taxation. Regarding indirect taxation, a problem arises from different treatments of services which are electronically or non-electronically provided with respect to VAT rules. Unequal treatment appears, as digitally delivered services from EU countries to non-EU countries are subject to VAT, while the supply of non-electronic services is not. This puts EU service providers at a significant disadvantage when comparing them to service providers who are located outside of the EU.

Turning to direct taxation, the personal income tax appears to be of essential importance. A key problem is identified, addressing the unfavorable tax treatment of stock option schemes in the EU. While stock options are perceived as an important way to attract researchers, they are also an essential way of financing research activities in SMEs. Because of their size they are not having much flexibility and capabilities to attract researchers by offering high salaries. The author reflects the EU to the U.S. and sees a lot of improvement to be done for the EU tax regimes to become more competitive regarding the tax treatment of innovation. Even though this study dates back quite far, it still provides an insight of how innovation and the importance of attracting innovation or treating innovative processes in a favorable way is perceived by EU policy makers in the years around the millennium. It can be seen that it is not much of a priority in the EU, particularly when comparing it with the perception of U.S. policy makers and raises therefore the questions if such a lag results in further consequences for firms and the EU as a business location.

An extensive analysis and presentation of the relationship between innovation and taxation is shown in a comprehensive study by Palazzi (2011). She emphasizes the

importance of intangible assets which are in many cases the natural outcome produced by an undertaken R&D activity. This can be seen particularly in industries such as the pharmaceutical, banking, or insurance. Intellectual properties are vital aspects and parts in the value-added chain. From a financial perspective, the value originates from the expected additional profits which are generated from exploiting the intangible in comparison to the absence of it. For this reason, R&D investments contribute to an increase in profits and result in economic growth as a consequence. In order to illustrate this, a basic setup can be seen in Figure 4.11, which describes how R&D tax provisions can have an effect on the decision of firms to invest and conduct innovative processes.

Figure 4.11: *R&D Tax Provisions in the Innovation and Investment Process*



Notes: This figure shows the framework of an innovation and investment process and how tax provisions can be applied. It is separated into two innovation stages. While tax incentives for R&D expenditures might be applied in stage one, it can be seen that in stage two tax incentives on R&D income might be more applicable.
Source: Palazzi (2011)

Fundamentally, an innovation process can be divided into two stages. In the first stage, a decision has to be made about the labour, material, and machinery which should be used in the innovation process or a general budget which can be set initially. The different sub-stages can be best illustrated with an example of the automotive industry. Assuming a car manufacturer has a theoretical idea and concept for a new airbag which is potentially safer and increases the chance of surviving a car accident. This would be described by stage 1A. In the process of further development, which can be improvements of previously developed airbags or the creation of new prototypes, might result in a fully developed and functional product which can then be officially patented in a final stage. This airbag, which is intangible R&D capital, can then be used to build into cars within

the own company in their product line of car models or potentially be sold or licensed to other firms or competitors. This would refer to stage 2 of the innovation process. It is important to emphasize that the inclusion and consideration of stage 2 in the process should not be underestimated, as the true value of a patent is determined by the increased future profits which are generated through licensing, patenting or implementing the new developed idea into own and already existing products.

Regarding tax treatments of the input costs, one can identify substantial differences regarding stage 1A and 1B. While tax incentives for current capital costs might be applicable to research expenditures to a full degree, they might only have a limited application in the stage of development. This is because not all countries which have already implemented R&D tax incentive programmes are recognizing development expenditures in a comprehensive way. However, it can be identified that boosting innovation by encouraging R&D is generally a shared goal of policy makers who intend to boost innovation in their country. Turning to tax rates, a potential strategy can be seen in lowering effective tax rates on income which is the result from intangibles, particularly income which can be attributed to intellectual property. An additional effect can occur with attracting MNEs or firms which hold intellectual property when providing incentives on the income side. As an example, Ireland can be named as a country which is favorable as a location for intellectual property. This is because patent income can be exempted from corporate taxation. Further, other countries offer similar strategies by providing at least a partial exemption or reduction in respect of the tax rate applied on royalty income, such as Hungary, Belgium or Switzerland. Interestingly, it can be observed that most of the countries which provide such royalty tax incentives are also having a rather low corporate income tax in general. It is stressed that a low basic corporate tax rate can be seen as essential when it comes to providing incentives to firms to engage in innovative activities or when it comes to the exploitation of patents.

A sectoral approach is taken by Hasen (2017) who examines the adaptation of tax rules which are designed to promote innovation. As a main justification for such rules, he identifies the reduction and eradication of chronic market failures which might be present in the innovation sector. Using data on risk-return estimates compiled over the period from 1973 to 2015, he finds that policy makers should not design taxes in a way that is furthering innovation but should rather take an approach of removing pre-existing tax distortions, particularly in sectors which are lagging behind in innovation to a large degree, which he defines being relatively measured to the tax distortions occurring in the non-innovation sectors. He finds three fundamental principles to undergird the idea of specifically designed tax rules targeted to promote innovation being undesirable and suboptimal.

Firstly, he points out that the argument of achieving fairness in the taxation of innovation activity cannot be identified as a predominant focus when it comes to reforms

which are sector-oriented. He points out that indeed a number of propositions and models are considering and weighting efficiency, fairness and other aspects with the intention to craft and design a suitable tax regime for innovation. However, he argues that fairness is in its core a property of a system as a whole and not of any particular sector on its own and most certainly not of an economic sector which is arbitrarily defined and chosen.

Secondly, he emphasizes that the correction of an externality not necessarily results in an improvement. This is the case when the ways of corrections require the implementations of distortions into other parts of the system at hand. Therefore, when proposing to reduce a set of distortions which also leads to an increase of another set of distortion, a closer look is needed, examining how the general welfare is affected.

As the third principle, a consequence or corollary which comes out of the second one is identified. He argues that a structural handicap arises from tax rules designed to stimulate innovation when comparing to other possible regimes. This is for the simple reason that special tax rules do not target the actual basic circumstances which are the cause for the market failure for innovation arising in the first place. As an example, one could presume that a market failure in a high-tech sector arises from spillover effects of innovation. Then a solution to such an existing problem can be found in letting the beneficiary parties bear the marginal costs of the benefits they receive, and not in merely incentivizing a stimulation in investments with resources from other parties.

Barry (2017) sheds light on the connection between taxation and innovation using a sharing economy as a case study. The focus in this study is on the U.S. federal income tax system and its challenges and opportunities it might bear regarding new technologies and innovation. Two major findings can be extracted from his analysis. He finds the tax system to be a suboptimal tool for promoting innovation. He argues that tight limits for tax incentive provisions have to be implemented by policy makers, as tax payers might use such provisions in an unexpected manner. This limits the net benefits of such incentive provisions to the taxpayers substantially, in the worst case these benefits might not even have any intended effects at all. Further, data indicates that start-ups or rather small companies can be identified as key drivers of innovation, and evidence suggests that they only show little responsiveness to tax incentives. Secondly, innovation can also be perceived as a tool which can lead to an improvement and optimization of the current tax system. This is because innovation and new technology might bring more opportunity to identify malfunctions and inefficiencies in a tax system, but also to measure and find evidence whether some intended outcomes are achieved.

The effect of both personal and corporate taxes on innovation over the 20th century is researched by Akcigit et al. (2018) for companies located and operating in the United States. Taking advantage of three novel datasets, they are able to consider inventors and patents, information on employment, geographical location and patents a firm filed, and historical corporate tax data on the state level. With this extensive and rich data

comprising over 2.9 million inventors and over 5 millions patents filed, both micro and macro analysis are conducted. While the former focuses on inventors and firms, the latter focuses on states over time. It is highlighted that the question on how tax policies can impact innovation becomes more important and of interest for policy makers. This is because a significant magnitude of spillovers can be expected as a consequence of high innovation activity. Various numbers of OLS regressions are conducted, controlling for fixed effects on the state level, years, and on the inventors themselves. Their results show significant effects indicating negative effects occurring on patents when the personal tax rate is increased. A one percentage point increase in the personal tax rate is associated with a 1.1 percent reduction in the number of patents. Further, the probability for corporate patents is affected negatively, revealing an effect even larger than the one on patents overall. Regarding corporate taxes, the effect is consistently negative for all estimation approaches. However, this effect appears to be only statistically significant regarding the likelihood of having a patent and the magnitude of it appears to be generally much smaller when comparing it with the estimated coefficients obtained for the effect of a change of the personal income tax.

These results indicate that inventors appear to be more sensitive to changes in the personal income tax than to changes in the corporate tax rate. Akcigit et al. (2018) consider this to be intuitive and comprehensible as the personal income affects inventors in a more direct way as corporate taxes do. Therefore, a more thorough analysis is conducted by distinguishing regular inventors from corporate inventors. A corporate inventor is defined as an inventor who created or filed at least one patent through a company. The idea of doing so is to capture the potential effects of not only personal income tax on innovation but also the one originating from corporate taxation. Corporate inventors are very likely to fall under the realm of the corporation tax, therefore a distinction allows to isolate such affect more accurately. The results reveal that corporate inventors are much more sensitive to taxes on both personal and corporate level. Surprisingly, a mildly positive effect for non-corporate inventors manifests itself, however, remains mostly insignificant.

Furthermore, the analysis is conducted on the individual firm level. It can be seen that the number of patents filed by each firm for a given year and also the number of employees who are associated with research activity is significantly affected by the corporate tax rate. For instance, a one percentage point decrease in the corporate tax rate is associated with a decline in patents filed by 4 percent. This effect is confirmed by IV results, which indicate an even larger magnitude. A negative effect can also be identified when attending to the coefficient of the personal income tax. The results show that this effect appears in a non-linear way and is smaller than the one which is caused by the corporate tax rate. They conclude that further research would be "fruitful to compare the U.S. experience to other countries".

4.3.3 Novelty of this Study

This study intends to shed light on how changes in the statutory corporate tax rates in European countries affects innovation activities of individual firms. A comprehensive dataset covering 28 European countries is put together, including both financial and ownership data.[5] It is of particular interest whether companies are responsive to changes in the corporate tax rate, and if so, to what extent. Further, MNEs might have more opportunities to avoid taxes by shifting profits or repatriating them. Therefore, the ownership information can be seen as key, as it allows to identify firms as domestic, foreign MNE, or being a domestic MNE. With being more flexible in avoiding taxes, more capabilities can be identified to unlock capital which can then be used for research activities and obtaining innovations.

While the main analysis focuses on effects of tax changes on intangible assets of firms, it goes beyond this step implementing a novel set of patent data being matched to the firm-level data of Amadeus. This data allows to identify how many patents are filed by which company in which particular year. Therefore, considering the literature discussed in this section, it can be seen that innovation and the mechanisms on how taxes can impact them are well established, however, not extensively researched in an empirical way. Further, the literature primarily focuses on data from the U.S. and tries to identify potential effects in this territory. For this reason, a 'European Perspective' allows a novel comparison and sheds light on how European companies respond to tax changes, and whether there are any potential differences to be seen.

4.4 Data

This section outlines the data on which this study is founded. First, it illustrates the origin of the firm-level financial and ownership data and then continues to highlight the procedures undertaken to find an appropriate measure for innovation. Further, it shows the procedure and basis on how both datasets are united into one and presents the final dataset which is subsequently used for the econometric analysis.

For the firm-level financial and ownership data, very similar procedures are undertaken which are also applied in Chapter 2 and in Chapter 3. Therefore, this part is outlined in a rather short way, as most procedures are already explained and discussed in detail previously. However, an overview is provided to understand which process the dataset went through and how it is cleaned and prepared.

[5]Following countries are included in the dataset: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. A detailed overview of all the countries included can be found in Table 4.3

4.4.1 Financial Data

The firm-level data on which this study is based on is retrieved from the AMADEUS database provided by Bureau van Dijk (BvD). Similar to ORBIS, the data source used in the previous chapters, it contains both financial and ownership data on both public and private companies. However, AMADEUS only contains such data for European countries, while ORBIS offers a more comprehensive collection of data providing information for the entire world (Kalemli-Ozcan et al., 2015). The data quality of the individual countries varies tremendously, as certain variables and financial information can be reported very well in some countries, while other countries show the opposite. This is a well-known problem and addressed in the literature working with BvD-data. Kalemli-Ozcan et al. (2015) provide a comprehensive guide on how to construct nationally representative firm level data using ORBIS or AMADEUS. One of the key differences between both datasets, besides their scope of countries they include, is the "survivorship bias". This is addressed by Kalemli-Ozcan et al. (2015) who explain this bias with differences in the time periods the databases keep companies stored after they stopped reporting financial data. The two databases follow different rules and standards when it comes to including company data for respective years. While AMADEUS deletes a company entirely from its list if there was no report done in the past 5 years, ORBIS still keeps this company. Therefore, using data from the ORBIS database has the advantage that company data, which is not available in the AMADEUS database anymore, can be found. For instance, if a company stopped reporting 5 years ago, the entire data for the past 10 years would be vanished in the AMADEUS database. When using ORBIS, the reported data from the time period before 5 years can still be accessed. Even though ORBIS appears to be the superior way to access firm-level data, institutional access appears to be rather difficult as it is rather cost intensive. Therefore, this study reverts to data retrieved from the AMADEUS database, as it limits its focus solely on firms operating in Europe. Besides the addressed "survivorship bias" (see Kalemli-Ozcan et al. (2015)) the scope and quality compared to ORBIS data is expected to be quite similar.

As this study comprises all reported European countries and does not focus on only one country, the data-quality for each country can differ substantially. The initial raw data consists of 21,309,880 observations of 2,130,988 firms operating in 39 countries in Central and Eastern Europe.

As this study investigates taxation and innovation of manufacturing firms operating in the EU, all countries which are not part of the EU are dropped. Further, all firms which operate in an EU country but not in a manufacturing industry are excluded as well. This leaves 2,363,410 observations of 236,341 firms for 28 countries.

A first cleaning process is done, dropping observations which have missing values and also values reported as zero in total assets and fixed assets. Further, only unconsolidated

financial data is used (see Egger et al. (2020)). Dropping all these unreported values results in a dataset consisting of 1,530,788 observations of 212,846 firms for 28 countries.

As a next step, all financial data is deflated with a GDP deflater retrieved from the IMF (2021). As this study analysis 28 European countries, industrial deflators cannot be applied due to a lack of data availability. Therefore, other than in previous chapters, data is deflated with the country specific GDP deflater applied to all companies, regardless of the industry in which they are operating with the year 2015 being defined as the base year.

4.4.2 Statutory Corporate Tax Rates

In order to investigate how the effects of changes in the corporate tax rates might impact a firm's innovation capabilities, a comprehensive set of data on a country's statutory corporate tax rate for each individual year is necessary. This data is retrieved from the OECD tax database, which provides a comprehensive dataset on various tax rates for all OECD countries (OECD, 2021). However, this tax data only covers the years up to 2018. Further, not all countries reported in the AMADEUS dataset are member of the OECD, which means that not all companies can be assigned a corporate tax rate as a consequence. Therefore, additional data from the KPMG Corporate Tax Rate Table is used (KPMG, 2021). This is another comprehensive collection of corporate tax rates, comprising a large number of geographic regions and countries. It further includes data until the year 2021 and includes missing countries which are not reported in the data retrieved from the OECD. With both sources combined, each company can be assigned with a statutory corporate tax rate based on the country it is operating in and the respective year. The statutory corporate tax rates can be seen in Figure C.1 in the appendix, which provides an overview of each individual country.

As the statutory corporate tax rate is applied to the profit before taxes, all observations which do not have data reported for such are dropped from the dataset (Egger et al., 2020). Further, observations which do not have data reported on the taxes paid in a particular year are excluded as well. This results in a dataset consisting of 1,513,725 observations of 211,737 firms for 28 countries.

4.4.3 Tax Base Measurements

The tax which is supposed to be paid by an entity is not only determined by the statutory tax rate itself. Besides the tax rate applied, also the tax base can be identified as a crucial factor. The tax liability can be described in a very simple way (see Tax Foundation (2021*a*)).

$$Tax\ Liability = Statutory\ Tax\ Rate * Tax\ Base \tag{4.1}$$

It can be seen that not only changes in the $Statutory\,Tax\,Rate$ can have a significant effect on the tax liability but also a change in the $Tax\,Base$, which can have many forms such as income, property, or assets. In order to account for such changes in the model used in this study, additional data is needed which goes beyond merely the tax rate itself. Unfortunately, such data is not easily available and there is not a main source which provides comprehensive and complete data on tax base changes. Amaglobeli et al. (2018) collect data from various sources creating the "Tax Policy Reform Database" which provides an extensive collection of both tax rate changes and also tax base changes for 23 advanced and emerging market economies. However, it does not include a substantial number of European countries and EU member countries, which makes this database suboptimal for implementing it into the analysis. Further, the dataset only reaching to 2014 and does not include any tax reforms which are announced afterwards. Therefore, another strategy has to be undertaken in order to obtain data on tax base changes which comprises mainly European countries and provides a longer time span.

Therefore, this study takes a different approach by taking advantage of the "Taxation Trends in the European Union" in order to identify tax base changes within the European Union. It is a report which is released by the European Commission on an annual basis and provides an overview of the recent development of taxation within the EU (see European Commission (2021*b*)) . Besides a general overview, a more detailed report for each individual country is provided as well which highlights specific tax rate and tax base changes for various different types of taxes, including the corporate income tax. This report provides a detailed description of the tax base changes, and in some cases even the specific date of the announcement and also the implementation date. This study refers to the year in which a tax base change is in force, meaning that if a tax base change is announced in December 2016 but in force from January 2017 for instance, the tax base change is considered to happen in 2017.

Unfortunately, this detailed report is only provided starting from the 2015 version. The versions for the previous years do not include detailed description on tax base changes and how they are implemented. Therefore, additional data is retrieved, exploiting the "Tax Reforms in EU Member States" report, published between 2008 and 2014 (see European Commission (2021*a*)). It provides a less detailed overview of tax base changes as comprehensive tables are not provided and describes tax reforms in a written text. This appears to be more cumbersome but follows the same structure and set- up as the "Taxation Trends in the European Union" report, which allows to combine both sources of data. Therefore, two dummy variables can be created indicating whether an increase of the tax base occurred in a particular year or a decrease.

4.4.4 Ownership Data

Regarding the ownership data, a similar approach is undertaken as outlined in Chapter Two. Information about the Global Ultimate Owner (GUO) is used in order to identify the origin of a firm. This allows to categorize firms into several groups, which can provide a deeper analysis on how different types of firms can be affected by changes in the corporate tax rate in a different way. Further, firms which show a missing value for their GUO are assumed to be domestic, and are assigned the country in which they are operating in. This follows the method suggested by Kalemli-Ozcan et al. (2015). Following the European Commission (2019*b*), "WW" or "YY" are indicators for unknown entities. Futher, "ZZ" indicates entities which do not have a specific identifier in the database. As such indicators make it impossible to identify a firms GUO, such observations are dropped from the dataset. After this step the dataset consists of 1,400,565 observations of 195,553 companies in 28 countries.

Following categories of firms are defined:

- *Domestic Firm* - Purely domestic firm that does not have any foreign linkages.
- *Domestic MNE* – A domestic firm which is a multinational enterprise.
- *Foreign MNE* – A company whose ultimate owner is located in another country.

Figure C.2 provides an overview of how the three defined firm types are occurring for all 28 countries. It can be observed that predominantly domestic firms occur for most of the countries. However, it can be seen that this does not hold true for every country. For instance, almost 80 percent of Irish firms included in the dataset are reported to be foreign MNEs. Moreover, about half of the firms reported for Luxembourg and the Netherlands are classified as being foreign. As these countries are predominantly perceived and also used as tax havens by MNEs, the data reflects this quite clearly as well and is in line with this theory. This is further backed with data from the Tax Justice Network (2021) which provides a yearly ranking of tax haven countries. In the 2021 report, all three countries are ranked in the Top 10. This explains the high representation of foreign firms, using these particular countries as a location in order to avoid high taxation.

4.4.5 Measuring Innovation

This study intends to examine the effect of taxation on innovation. Therefore, a suitable measurement for innovation capacity needs to be implemented. This appears rather cumbersome as there is no precise way to measure such thing. A rather intuitive approach appears when considering R&D expenditures on the firm-level, which would allow to measure how much each company invested in research in each year. With a higher

proclivity to focus on further development, a firm also increases its capabilities to produce new innovation as a consequence. Unfortunately, data on R&D expenditures is poorly reported in Amadeus, and varies tremendously across countries. Therefore, such approach cannot be applied, due to data limitations. However, using a company's intangible assets appears to be a suitable alternative for an econometric analysis. With the 21st century being dominated by technology, new innovation shifted significantly towards being intangible (see Palazzi (2011)). However, this study is not limited to this only measurement of innovation but seeks to implement another way by implementing data on patents.

Jalles (2010) suggests that economic growth is fundamentally drive by the production of innovation and new ideas. Therefore, an appropriate technique of measuring innovation can be seen as vital and a significant step in economic literature. By comparing different measurement techniques and conducting various estimation techniques, Jalles (2010) provides an insight on what can be a suitable proxy for innovation. Two proxies are targeted, namely patents per 100,000 inhabitants and the Property Rights Index, following Ginarte and Park (1997). His results suggest that there is a strong positive effect of ideas and innovation on income per capita growth rate. Both, patents per capita and IPR index show positive and significant effects for all estimation techniques, with patents per capita outreaching the magnitude of IPR index. This provides evidence that patent application can be a key measurement and proxy for innovation.

Carvalho et al. (2015) provide an insight on how to measure innovation in the European Union. They claim this to be a vital procedure as it can assist and be used when defining public policies which are targeted at the stimulation of more innovation within the Union. Further, they do not only identify the potential policy implications as a main factor for the importance of measuring innovation but acknowledge the significance for the support of innovation theories and theoretical analysis as well. Also, the usefulness for developing business strategies on a corporate level is stressed. However, measuring innovation can be appear rather problematic, as it is pointed out by Paas and Poltimäe (2010). They suggest that most applied approaches revert to using R&D expenditures or number of patents filed. They appraise that these aspects "reflect only partial aspects of the complex phenomenon of innovation and could not provide a comprehensive view". This is because such measurable indicators are not capturing the results of innovation entirely. High expenditures in R&D or a large number of filed patents do not reflect the output potential innovations produce and are describing a rather complex phenomenon in a limited and partial degree. To overcome and account for this potential issue, Carvalho et al. (2015) suggest that composite indicators of innovation are essential when measuring and evaluating the complexity of innovation. Therefore, Faber and Hesen (2004) do not only include the patents a company filed in a particular year but also the ratio of new or *substantially improved products* to total sales.

Unfortunately, the AMADEUS database does not provide such information. Hence, this measurement cannot be included. However, patent data is freely accessible through the services of the European Patent Office (2021*b*). Using their *EspaceNet* patent search database allows one to access over 120 million patent documents and provides an extensive insight into both processes, patent filing and also patent granting. Even though using the number of patents as a proxy for innovation has its limitations and does not grasp all aspects of this complex phenomenon, it is still a widely used measurement and appears a significant and driving factor. Particularly when analyzing innovation on the firm-level, data limitation does not allow much leeway. Therefore, the usage of filed patents as a proxy for innovation appears to be a suitable and valid approach following a procedure frequently applied in the literature.

4.4.6 Matching Firm-Level Data and Patents

While patent data is easily accessible and freely available, the effort of matching existing patents to the constructed firm-level dataset appears to be immense. All companies are identified with a unique Bureau van Dijk ID-number which is not applicable in the *EspaceNet* search. Matching patents using the company name bears further potential problems. A company might have re-named itself after some years. Further, patents are often filed in the name of the inventor (i.e. the person's name, not the company's). Therefore, a direct search through the internet data services provided by the European Patent Office (2021*b*) appears to be too cumbersome.

However, Bureau van Dijk provides access to patent data which is retrieved and sourced from the European Patent Office. Besides providing detailed information on title, ownership, and publication number for each patent, this database connects each granted patent to the BvD ID number of its corresponding company. Further, each patent observation can be linked to multiple BvD ID numbers, which allows to identify patents which are the result of joint research efforts. Therefore, some patents are not only linked to one firm, but can have links to multiple companies.

The database shows more than 50 million patents which are linked to their respective company. However, in order to make such information suitable and processable for econometric analysis, an extensive cleaning process has to be undertaken. Only information on the publication date is provided, but not on the filing date. This is not ideal in so far, as the publication date is mostly between one to two years after the patent is filed. Therefore, it is unclear when exactly the patent is filed when only considering the publication date. As a consequence, further investigation is necessary in order to find out when a patent is filed.

A suitable procedure appears when examining the patent application numbers, which are also included in the dataset provided by BvD. According to the guidelines of the World

Intellectual Property Organization (2015) and the European Patent Office (2021*a*), patent application numbers follow a predetermined structure and consist of different components. Starting with a country code, it follows by the year in which the patent application was filed. When investigating this structure in the patent application numbers provided by BvD, one can observe that each application number ends with a suffix which can be identified as a date format "YYYY-MM-DD". This information can be used to clearly identify not only the year but the precise day on which a patent was filed and then further processed by the respective patent office or institute. When having a second look at the data, one can also observe that the date when a patent is granted is approximately 18-24 months after its filing date. This is in line with the guideline of the European Patent Office, which suggests that "European patent applications are generally published 18 months after the date of filing". This evidence further supports the hypothesis, that this date format in the application number constitutes the filing date. Therefore, the year of this suffix is used to identify the year in which a company applied for the respective patent and filed their papers.

Each company appearing in the firm-level dataset is identified by its unique BvD ID which is then used to search for patent-company links. As previously mentioned, multiple patent-company links can occur and are the result of joint research enterprises (this can be observed particularly within the automotive industry). With the filing year at hand, the number of patents filed in a respective year is summed up for each company and year individually. This results in a new variable providing the number of patent applications filed in a year.

Table 4.1: *Descriptive Statistics*

Variable	Observations	Mean	Std. Dev.	Min	Max
STR	1,234,220	0.26	0.07	0.10	0.38
PIT	1,234,220	0.42	0.13	0.10	0.573
TaxBase_Decr	1,234,220	0.50	0.50	0.00	1.00
TaxBase_Incr	1,234,220	0.33	0.47	0.00	1.00
STR_Incr	1,234,220	0.02	0.16	0.00	1.00
Intang_Assets	1,234,220	1,042.50	38,962.33	0.00	1.25E+07
Total_Assets	1,234,220	25,522.21	337,485.70	-1,617.27	7.44E+07
Size	1,234,220	8.25	1.61	-0.10	18.12
Patents_Filed	1,231,582	0.13	3.52	0.00	1083.00

Notes: This table presents the descriptive statistics for all relevant variables used in the econometric analysis. the data is retrieved from the AMADEUS data base and comprises 28 countries for the time period from 2011 to 2020 (see Table 4.3). STR is the statutory corporate tax rate (see Section 4.4.2), PIT the personal income tax rate (OECD, 2021), TaxBase_Decr and Taxbase_Incr dummy variables indicating a decrease or an increase of the tax base (see Section 4.4.3), and STR_Inc a dummy variable taking the value 1 if a change of the STR is an increase. Intangible Assets and Total Assets are retrieved from the AMADEUS database deflated with GDP deflators from the IMF (2021) with 2015 as a base year. Size presents the natural logarithm of Total Assets. The number of patents provided by the European Patent Office (2021*b*) is matched into the AMADEUS database based on a companies unique company identifier.

Table 4.1 presents the summary statistics of the relevant variables used in the data analysis. As the analysis focuses on the effects of STR on a firm's innovation measured in

intangible assets, all observations with negative values for latter are excluded and dropped from the dataset, resulting in firm-year observations which have only positive values or zero for the intangibles. Further, only firms which have at least 5 consecutive years are considered. After these adjustments, the dataset results in 1,234,220 observations for 146,251 firms of 28 countries for the years 2011 to 2020.

4.4.7 Final Dataset

The final dataset consists of a total of 146,251 companies operating in the European Union resulting in 1,234,220 observations comprising 28 countries for the years 2011 to 2020.[6] The dataset is adjusted only considering companies which have at least 5 consecutive observations. The structure of observations is illustrated in Table 4.2. It can be seen that over 80 percent of observations in the dataset have either 8 or 9 consecutive years, indicating a strong panel dataset with many observations covering almost the entire time period with only minor lags.

Table 4.2: *Structure of the Unbalanced Panel Data Set*

Number of Observation per Firm	Frequency	Percent	Cumulative Percentage
5	34,905	2.83	2.83
6	45,618	3.70	6.52
7	74,116	6.01	12.53
8	139,360	11.29	23.82
9	867,321	70.27	94.09
10	72,900	5.91	100.00
Total	**1,234,220**	**100.00**	**100.00**

Notes: This table presents the structure of the unbalanced final dataset obtained from AMADEUS including all firms of all 28 countries for the time period from 2011 to 2020 (see Table 4.3). Firms which do not have data reported for at least 5 consecutive periods are dropped. Therefore, the minimum number of observations per firm is 5.

Further, Table 4.3 provides an overview of the data structure, showing how many firms are represented in each of the individual years considered in the dataset. It can be seen that the number of companies varies substantially. This is due to different levels of data quality and reporting requirements based on a country's respective legislation. It can be seen that this study still includes and considers the United Kingdom as a EU member state. However, it is important to stress that the United Kingdom left the EU effectively in February 2020 and is no longer a part of it anymore. Nevertheless, it is

[6]Following countries are included in the dataset: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

included as it can be identified as being a (transitioning) member state in each of the years which is considered in the dataset. A more detailed illustration of the structure showig number of observations per firm by country can be seen in Table C.1.

Table 4.3: *Number of Companies per Country and Year*

Country	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Austria	636	651	681	702	748	631	638	629	601	61	759
Belgium	1,669	1,825	1,926	1,976	2,058	1,984	1,916	1,864	1,831	358	2,077
Bulgaria	4,325	4,567	4,783	4,990	5,217	5,202	5,201	5,176	5,153	16	5,218
Croatia	1,790	1,907	1,977	2,054	2,148	2,147	2,149	2,137	2,109	32	2,151
Cyprus	8	21	28	30	31	31	30	27	3	0	31
Czech Republic	6,035	6,173	6,383	6,566	6,777	6,483	6,513	6,271	5,685	521	6,795
Denmark	0	0	0	0	58	227	227	227	227	169	227
Estonia	154	183	195	221	247	241	234	227	213	36	251
Finland	806	863	912	957	1,036	949	923	895	869	436	1,086
France	10,759	11,091	11,386	11,599	12,031	10,678	10,487	10,166	9,573	1,659	12,084
Germany	2,105	2,212	2,311	2,368	2,517	2,355	2,248	2,180	1,986	60	2,525
Greece	2,009	2,057	2,120	2,265	2,356	2,311	2,327	2,297	1,980	22	2,356
Hungary	3,677	4,180	4,448	4,691	4,909	4,805	4,784	4,722	4,556	247	4,928
Ireland	150	165	176	196	214	214	208	194	168	13	218
Italy	45,757	47,555	49,539	51,510	53,655	53,475	53,461	53,147	52,383	3,303	53,774
Latvia	720	771	801	818	820	674	700	533	512	275	836
Lithuania	530	565	634	715	747	788	770	705	690	534	811
Luxembourg	62	65	67	70	71	56	38	50	41	6	72
Malta	49	52	55	61	62	59	59	45	18	0	62
Netherlands	293	317	331	351	373	334	304	276	253	32	374
Poland	3,522	3,801	4,019	4,295	4,725	4,450	4,350	4,252	3,876	0	4,725
Portugal	5,279	5,495	5,707	5,872	6,082	6,001	5,971	5,883	5,715	42	6,084
Romania	6,503	6,861	7,218	7,521	7,819	7,754	7,767	7,735	7,624	0	7,819
Slovakia	2,145	2,234	2,320	2,424	2,496	2,514	2,514	2,475	2,426	1,367	2,533
Slovenia	868	892	950	1,011	1,105	1,022	998	1,057	976	0	1,105
Spain	15,351	15,819	16,619	17,472	18,497	18,201	18,095	17,760	16,547	108	18,507
Sweden	2,673	2,801	2,901	3,084	3,323	3,266	3,195	3,121	3,017	1,292	3,500
United Kingdom	4,293	4,554	4,784	5,004	5,284	5,084	4,928	4,831	4,581	820	5,343
Total	122,168	127,677	133,271	138,823	145,406	141,936	141,035	138,882	133,613	11,409	**146,251**

Notes: This table presents the number of companies which are included in the final dataset obtained from AMADEUS for each country and each year for the time period from 2009 to 2020. Due to different legal regulations regarding reporting procedures in each country the number of companies per country can vary quite vastly.

4.5 Econometric Framework

In order to investigate how a change in the statutory tax rate impacts a firm's decision on innovation, various regressions are conducted in order to identify certain channels and characteristics which might occur. A very simple baseline model is defined

$$IntangibleAssets_{ijt} = \beta_0 + \beta_1 STR_{jt-1} + \beta_2 Size_{ijt} + \alpha_i + \theta_t + \epsilon_{ijt} \tag{4.2}$$

with the $IntangibleAssets_{ijt}$ of firm i operating in country j in year$t$ used as a proxy for innovation and therefore used as the dependent variable. This follows the suggestion of Jalles (2010) and Palazzi (2011) who emphasizes the importance of intangible assets as they are in many cases the final result of an innovation process. As independent variables, a country's statutory corporate tax rate STR_{jt-1} and the $Size_{ijt}$ of a company in terms of its total assets are used. Further, both firm fixed-effects and time-fixed effects are include. For STR_{jt-1} a negative sign is expected, implying that an increase of the statutory corporate tax rate has a negative impact on innovation (see Akcigit et al. (2018) and Akcigit and Stantcheva (2020)). $Size_{ijt}$ can be expected to have a positive on innovation, suggesting that larger companies have more resources and capabilities to create new innovation outcomes. In a next step, the simple model in Equation 4.2 gets extended, now including additional measurements to account for the *Tax Base*. As not only the tax rate itself but also changes in the tax base determine the tax burden of a firm (see Equation 4.1), two dummy variables are included which indicate whether a country undertakes a change in its tax base in a particular year accounting for both a decrease ($TaxBase\_Decr_{jt-1}$) and an increase ($TaxBase\_Incr_{jt-1}$). While the effect of a decrease in the tax base is expected to have a positive effect on innovation, an increase in the tax base is expected to cause a decrease in innovation (see Akcigit et al. (2018)).

$$\begin{aligned} IntangibleAssets_{ijt} = \beta_0 + \beta_1 STR_{jt-1} + \beta_2 Size_{ijt} + \beta_3 TaxBase\_Incr_{jt-1} \\ + \beta_4 TaxBase\_Decr_{jt-1} + \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{4.3}$$

Beside considering only the statutory corporate tax rate, the literature suggests that also the *personal income tax* PIT_{jt-1} can play a significant role when it comes to firms' choices to undergo innovation and development of new products. As previously discussed, a low PIT might be attracting individual inventors who work independently and then make the decision to partner with a company or get hired. Therefore, the previous model shown in Equation 4.3 gets extended with accounting for the personal tax rate as well.[7] PIT_{jt-1} is expected to have a negative effect on innovation. This assumption is based on the framework provided by Akcigit and Stantcheva (2020) who highlights the importance of the personal income tax for individual inventors.

$$\begin{aligned} IntangibleAssets_{ijt} = \beta_0 + \beta_1 STR_{jt-1} + \beta_2 Size_{ijt} + \beta_3 TaxBase\_Incr_{jt-1} \\ + \beta_4 TaxBase\_Decr_{jt-1} + \beta_5 PIT_{jt-1} + \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{4.4}$$

[7]The extended model in Equation 4.4 is estimated twice. In a first step, it only considers STR and PIT and excludes the measures for tax base changes (this can be seen in column (3) in Table 4.4). In a next step it also considers the measures for tax base changes. These results can be seen in column (4) in Table 4.4.

In a next step, it is examined whether there is a symmetry or an asymmetry in the effect of a change in the statutory corporate tax rate. A dummy variable is included and takes the value 1 if a tax rate change is a tax increase STR_Incr_{jt-1}. In this way it can be examined whether a tax increase has a different and asymmetrical effect when comparing it to a tax decrease. Additionally, an interaction term between this dummy and the statutory corporate tax rate STR_{jt-1} is included as well, resulting in

$$\begin{aligned} IntangibleAssets_{ijt} = &\beta_0 + \beta_1 STR_{jt-1} + \beta_2 Size_{ijt} + \beta_3 STR\_Incr_{jt-1} \\ &+ \beta_4 STR_{jt-1} * STR\_Incr_{jt-1} + \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{4.5}$$

As a last step, an additional dummy variable is created and implemented, which measures whether a country is running a particular legislation with incentives to conduct R&D and innovation. This is usually incentivized by granting firms tax cuts or tax holidays regarding specific investments which are undertaken towards the creation of new innovation or intellectual property. This is commonly referred to as the "patent box". The dummy variable $PatentBox_{jt-1}$ is included taking the value 1 if a country is running a "patent box"-incentive in the respective year (see Zegarowicz et al. (2018)).[8] $PatentBox_{jt-1}$ is expected to have a positive effect on innovation, is by definition a patent box regime promotes R&D and innovation processes.

$$\begin{aligned} IntangibleAssets_{ijt} = &\beta_0 + \beta_1 STR_{jt-1} + \beta_2 Size_{ijt} + \beta_3 PatentBox_{jt-1} \\ &+ \beta_4 STR_{ijt-1} * PatentBox_{jt-1} + \alpha_i + \theta_t + \epsilon_{ijt} \end{aligned} \tag{4.6}$$

With these models defined, various analyses are conducted. In order to investigate how potential effects occur, various sample splits are undertaken to isolate certain channels and distinguish between differences of company types. In total, five samples are created, identifying and separating companies by their ownership status and also firm size:

- Panel A : All Firms
- Panel B : Domestic Firms
- Panel C : Domestic MNE
- Panel D : Foreign MNE
- Panel E : SME (less than 250 employees)

[8] A patent box describes a form of tax policy which taxes business income generated from patents or intellectual property with a rate below the statutory corporate tax rate. The aim of such policy is the promotion of research and development activities.

Further, the same models are applied with a different measurement for innovation. This follows the suggestion of Jalles (2010) who emphasizes the importance of intellectual property and patents as outcomes of innovation processes.

$$PatentsFiled_{ijt} = \beta_0 + \beta_1 STR_{jt-1} + \beta_2 Size_{ijt} + \alpha_i + \theta_t + \epsilon_{ijt} \tag{4.7}$$

Equation 4.7 shows the same baseline model presented in Equation 4.2 with $PatentsFiled_{ijt}$ as dependent variable instead of $IntangibleAssets_{ijt}$. Equation 4.3 to Equation 4.6 are set up in the same way with $PatentsFiled_{ijt}$ as a dependent variable.

Using the data on patents filed by a company which is matched with the firm-level data, the econometric analysis is extended with now including a count model executing a Poisson Regression. All other models previously stated are analysed in this way respectively. This can be an interesting aspect to shed light on in order to see to what extend patents are still a usable proxy to measure innovation as the literature tends to highlight the flaws of this (see Jalles (2010)). There is a trend which can be identified with companies developing new innovation in secret laboratories using non-disclosure agreements. This has the advantage of concepts, technologies and newly developed innovations being kept a secret, while filing a patent requires one to reveal such sensitive innovation.

Besides that, various regressions are included accounting for lags and leads of STR in order to test for the model's robustness. Here it can be interesting to see how long it takes for firms to respond to certain tax changes. The models consider one lag as the time for firms to act after the implementation of a new tax policy. However, such change could occur much quicker or could potentially even be anticipated before. Therefore, such checks are undertaken for both parts of the analysis, the one using intangible assets as a dependent variable but also the second part using the count model with patents filed as a dependent variable.

4.6 Empirical Results

This section is separated into two parts. The first subsection discusses the empirical results with intangible assets being used as a proxy for innovation. The second part conducts the same analysis but changes the dependent variable and uses rather the number of patents filed, running a count model with using a Poisson Regression approach.

4.6.1 Innovation – Intangible Assets

Table 4.4 provides an overview of all six estimations and is split into five parts illustrating the results for each of the sub-samples. When considering all firms which operate in the manufacturing industry, a negative and significant effect can be observed, indicating that

a 1 percent increase in the statutory tax rate in the previous year results in a 1.2 percent decrease in intangible assets. Further, the firm size appears to be positive and statistically significant, indicating that larger companies tend to be more intensive in their intangible assets. When accounting for both decrease and increase in the tax base, no statistical significance can be established for the former. However, an increase in the tax base shows a positive coefficient which is significant at the 10 percent level. A one percent increase in the tax base is associated with a 1.8 percent increase in a firm's intangible assets. This is rather surprising, as it is expected to have a negative effect in innovation. With the tax base being increased, the tax burden is expected to increase as well.

A potential reason for this occurrence is that the measure of a tax base increase fails to identify which specific area in the realm of corporate taxation is altered. Tax base policy is often very specific and can be targeted and directed towards certain industries, locations or other defined conditions. Therefore, such measure in the analysis might not be able to account for an actual tax base change which touches the area of innovation. One could argue with the tax base increasing but not affecting the specific basis for the taxation of innovation and new technology, firms might take this as a signal of a liberal and innovation welcoming policy and decide to conduct more innovative activity there. This issue is in line with Akcigit et al. (2018) who find the huge complexity of tax base policies to be cumbersome. for data analysis and point out that tax bases within the U.S. vary significantly across states.

Further, in column (5) an asymmetry can be observed regarding the change of the CIT. While a 1 percentage point change in the STR by itself, holding everything else constant, results in a 1.264 percentage points change of intangible assets, an increase in STR shows a larger (negative) effect. A one percentage point increase in the STR leads to a 1.72 percentage point decrease in intangible assets. Further, column (3) and (4) show that there is no significant effect to be seen for the personal income tax rate, even when accounting for both tax rate and also tax base changes. Therefore, the results fail to find significant effects for the personal income tax to be a key determinant for innovation as it is pointed out by Akcigit and Stantcheva (2020).

In a final step, column (6) accounts for a potential patent box implementation in the tax legislation of a government (see Zegarowicz et al. (2018)) . There is a positive and significant effect to be seen for the coefficient for patent box. Considering the weighted average corporate tax rate of 24 percent (see Tax Foundation (2020)) a firm which is operating in a country with a patent box regime implemented perceives a 9.7 percent higher level in its intangible assets.[9] This is in line with Palazzi (2011) and Zegarowicz et al. (2018) who point out the importance of the patent box as a policy tool. This bears interesting implications for policy makers, indicating that such pro-innovation targeted policy has a significant effect in attracting firms which are intensive in intangible

[9]This is calculated in following way: $0.579 + 0.24 * (-2.010) = 0.097$

Table 4.4: *Estimation - Effect of STR on Intangible Assets*

Depended Variable	(1)	(2)	(3)	(4)	(5)	(6)
$IntangibleAssets_{ijt}$	STR	Tax Base	PIT	Base+PIT	STR_Incr	PatentBox
Panel A - All Firms						
STR_{jt-1}	-1.251^{**}	-1.310^{**}	-1.154^{**}	-1.194^{**}	-1.264^{**}	0.274
	(0.531)	(0.556)	(0.526)	(0.569)	(0.546)	(0.609)
$Size_{ijt}$	0.579^{***}	0.580^{***}	0.579^{***}	0.579^{***}	0.0579^{***}	0.579^{***}
	(0.086)	(0.086)	(0.086)	(0.086)	(0.086)	(0.086)
$TaxBase\_Decr_{jt-1}$		0.008		0.0084		
		(0.013)		(0.014)		
$TaxBase\_Incr_{jt-1}$		0.017^{*}		0.018^{*}		
		(0.009)		(-0.002)		
PIT_{jt-1}			-0.002	-0.002		
			(0.003)	0.002		
STR_Incr_{jt-1}					0.153^{*}	
					(0.076)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					-0.478^{**}	
					(0.230)	
$PatentBox_{jt-1}$						0.551^{***}
						(0.184)
$STR_{jt-1} * PatentBox_{jt-1}$						-2.010^{***}
						(0.618)
R^2	0.82	0.82	0.82	0.82	0.82	0.82
Observations	1,234,220	1,234,220	1,234,220	1,234,220	1,234,220	1,234,220
Firms	146,251	146,251	146,251	146,251	146,251	146,251
Panel B - Domestic Firms						
STR_{jt-1}	-1.054^{**}	-1.099^{**}	-0.989^{**}	-1.018^{*}	-1.056^{**}	0.207
	(0.443)	(0.466)	(0.478)	(0.534)	(0.462)	(0.697)
$Size_{ijt}$	0.527^{***}	0.527^{***}	0.527^{***}	0.526^{***}	0.527^{***}	0.526^{***}
	(0.093)	(0.930)	(0.093)	(0.093)	(0.093)	(0.093)
$TaxBase\_Decr_{jt-1}$		0.007		0.006		
		(0.015)		(0.016)		
$TaxBase\_Incr_{jt-1}$		0.014^{*}		0.0145^{*}		
		(0.007)		(0.007)		
PIT_{jt-1}			-0.001	-0.002		
			(0.002)	0.002		
STR_Incr_{jt-1}					0.185^{**}	
					(0.086)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					-0.634^{**}	
					(0.0.246)	
$PatentBox_{jt-1}$						0.455^{**}
						(0.211)
$STR_{jt-1} * PatentBox_{jt-1}$						-1.692^{**}
						(0.685)
R^2	0.81	0.81	0.81	0.81	0.81	0.81
Observations	975,089	975,089	975,089	975,089	975,089	975,089
Firms	115,917	115,917	115,917	115,917	115,917	115,917
Panel C - Domestic MNE						
STR_{jt-1}	-2.462	-2.854	-2.027	-2.355	-2.511	0.211
	(1.604)	(1.708)	(1.423)	(1.471)	(1.646)	(1.883)
$Size_{ijt}$	0.935^{***}	0.935^{***}	0.933^{***}	0.933^{***}	0.935^{***}	0.932^{***}
	(0.086)	(0.086)	(0.086)	(0.086)	(0.086)	(0.086)
$TaxBase\_Decr_{jt-1}$		0.053^{*}		0.054^{*}		
		(0.030)		(0.30)		
$TaxBase\_Incr_{jt-1}$		0.038		0.043^{*}		
		(0.026)		(0.025)		
PIT_{jt-1}			-0.007	-0.008		
			(0.006)	0.006		
STR_Incr_{jt-1}					0.295	
					(1.173)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					-0.936	
					(0.536)	
$PatentBox_{jt-1}$						0.955
						(0.701)
$STR_{jt-1} * PatentBox_{jt-1}$						-3.720
						(2.302)
R^2	0.82	0.82	0.82	0.82	0.82	0.82
Observations	73,490	73,490	73,490	73,490	73,490	73,490
Firms	8,438	8,438	8,438	8,438	8,438	8,438

Panel D - Foreign MNE						
STR_{jt-1}	−1.796	−1.870	−1.504	−1.575	−1.864	0.593
	(1.382)	(1.362)	(1.238)	(1.215)	(1.385)	(0.786)
$Size_{ijt}$	0.741***	0.741***	0.740	0.741***	0.740***	0.739***
	(0.079)	(0.079)	(0.079)	(0.0793)	(0.079)	(0.081)
$TaxBase\_Decr_{jt-1}$		0.010		0.011		
		(0.009)		(0.009)		
$TaxBase\_Incr_{jt-1}$		0.027		0.027		
		(0.020)		(0.020)		
PIT_{jt-1}			−0.004	−0.004		
			(0.004)	0.004		
STR_Incr_{jt-1}					0.050	
					(0.081)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					0.064	
					(0.229)	
$PatentBox_{jt-1}$						0.802***
						(0.240)
$STR_{jt-1} * PatentBox_{jt-1}$						−2.878***
						(0.865)
R^2	0.82	0.82	0.82	0.82	0.82	0.82
Observations	185,641	185,641	185,641	185,641	185,641	185,641
Firms	21,896	21,896	21,896	21,896	21,896	21,896
Panel E - SME						
STR_{jt-1}	−1.304***	−1.333***	−1.204**	−1.216**	−1.333***	0.282
	(0.444)	(0.477)	(0.480)	(0.541)	(0.453)	(0.0691)
$Size_{ijt}$	0.548***	0.548***	0.548***	0.548***	0.548***	0.548***
	(0.102)	(0.101)	(0.102)	(0.101)	(0.102)	(0.102)
$TaxBase\_Decr_{jt-1}$		0.006		0.006		
		(0.016)		(0.017)		
$TaxBase\_Incr_{jt-1}$		0.012		0.014		
		(0.007)		(0.008)		
PIT_{jt-1}			−0.002	−0.002		
			(0.002)	0.003		
STR_Incr_{jt-1}					0.159*	
					(0.082)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.473*	
					(0.246)	
$PatentBox_{jt-1}$						0.555***
						(0.190)
$STR_{jt-1} * PatentBox_{jt-1}$						−1.987***
						(0.631)
R^2	0.81	0.81	0.81	0.81	0.81	0.81
Observations	1,064,737	1,064,737	1,064,737	1,064,737	1,064,737	1,064,737
Firms	134,622	134,622	134,622	134,622	134,622	134,622

Notes: This table presents the estimation results of Equation 4.2 to Equation 4.6 in consecutive order from column (1) to (6). It is based on data retrieved from the AMADEUS database including 28 EU countries for the time period from 2011 to 2020 (see Table 4.3). The dependent variable is the reported Intangible Assets of a firm in a given year. It is used as a proxy for innovation. The control variable for the firm size is defined as the log of total assets of a firm in a given year. STR is the statutory corporate tax rate of a country in a respective year. TaxBase_Decr indicates whether the Tax Base in a country for a particular year is decreasing. Similarly, TaxBase_Incr indicates an increase of the Tax Base. PIT measures the personal income tax for each country for every year. STR_Incr takes the value of 1 if a statutory corporate tax rate change is an increase. PatentBox indicates whether a country is running a patent box regime in a particular year.
This Table presents 5 panels. Panel A considers the entire dataset including all firms. Panel B only considers domestic firms, which are firms only supplying a local market without having any foreign affiliates. In contrast to that, Panel C considers Domestic MNEs which are domestic firms which have foreign subsidiaries. Panel D considers Foreign MNEs, which are MNEs with a global ultimate owner (GUO) from a different country. Panel E considers small and medium-sized enterprises (SME). This study classifies a firm as SME when it reports to employ less than 250 employees.
All estimations include fixed-effects on the firm-level and time fixed-effects.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

assets. The interaction term with STR appears to be negative and statistically significant, indicating that a tax increase is still perceived negatively by companies and resulting in a decrease of their intangible assets. This effect is even larger than the observed effects for all other regression models, indicating that under a patent box regime a tax increase is perceived even more negatively. This might be the case as firms anticipate further tax changes and the potential of the patent box regime being ended or limited to some degree.

In a next step, the analysis is split into the four firm types discussed in Section 4.5. When observing purely domestic firms, it can be seen that an increase in taxes affects innovation in a negative way. Overall, the effects are consistent with previously obtained results, however, of smaller magnitude. The significant effects for an asymmetry and the positive and significant effect for the presence of a patent box regime remain present. When turning to the domestic MNE, it can be seen that changes in the statutory tax rate has no statistically significant effect at all. The same holds for foreign MNEs as well. This is in line with the literature, highlighting MNE's capabilities to shift operations, revenue, profits, and assets rather effortlessly and without many obstacles (see Grubert (1998*b*), Grubert (2003) and Bartelsman and Beetsma (2003)). Therefore, research activity might still take place in a particular location even though a tax increase occurs.

This could simply be explained with firms doing tax-planning ahead of time and having their assets and activities allocated in an optimal way. Another important factor to consider is that this study fails to include all countries in the world and is only limited to firm-level data for European countries. Overall, the results suggest that even with lowering the corporate income tax rate, European policy makers fail to attract research activity to be increased by both multinational players, the once with their headquarters in Europe and the ones coming from overseas.

Regarding the patent box regime, it can be seen that the effect is only present for foreign MNE. While a patent box regime by itself affects innovation activities of foreign MNE in a positive way, a tax increase under such regime causes a decrease in a firm's intangible assets. Applying an average corporate tax rate of 24 percent (see Tax Foundation (2020)) a foreign MNE operating in a country with a patent box regime installed is associated to have 11 percent more intangible assets. This is a rather interesting and puzzling observation, as under the absence of such regime no negative and significant effect can be established. A potential explanation of such occurrence can be the anticipation of a limitation of the patent box itself, with taxes being increased in advance. The patent box is used to incentivize research activity and development within a country's borders, with the incentive to attract multinational firms. Establishing a patent box regime under which then the tax rate is increased might provide mixed signals, with MNEs perceiving a shift in tax policies, moving to a more restrictive and less lax regime.

When turning to SME, which are defined as firms which are not employing more than 250 employees, similar effects can be observed as the once obtained for domestic firms. This is in line with the theory that domestic and rather smaller firms are endowed with less capabilities to adapt their activities, as they fail to have plants and operations in other countries (see Grubert (1998*b*) and Grubert (2003)). Therefore, the results suggest that tax increases are rather impacting small and domestic firms in their innovation processes, rather than MNEs. The patent box appears to be only a limited incentive as well, given the main purpose and goal of this regime is the attraction of foreign MNEs to settle in a particular country and conduct research activities there. While the implementation of a patent box regime appears to have positive and significant effect for all firm types except domestic MNE, tax changes are still perceived in a negative way.

Table C.2 presents the same estimation strategies, however, also includes an additional fixed effects interaction term for a year and ISIC industry interaction. The obtained results suggest that the same effects remain present and significant, even under these assumptions. Accounting for an additional layer of fixed effects is highlighted by Kawano and Slemrod (2016) and also by Serrato and Zidar (2018) who point out that particularly tax base effects can be accounted for by such a procedure.

4.6.2 Innovation – Patents Filed

Additionally, another analysis is undertaken, now using the filed patents in a particular year as a proxy for innovation. Table 4.5 provides the regression results of the Poisson Regression.

The results are rather surprising, as no significance for a change in the corporate tax rate can be established except for domestic MNE. This effect appears to be particularly highly significant when controlling for patent box. However, such effect appears to be positive which is rather the opposite than what can be expected. Further, even under the patent box regime a positive effect can be identified. These effects are puzzling. A patent box regime is expected to mitigate the effect of the effect of a tax increase. This effect cannot be observed in the analysis. Even when considering additional controls for fixed effects interacting the industry-level with the year, similar tendencies are observed.

Fundamentally, these results might indicate the reasoning behind innovation and the flaws of patents being used as a form of protection of intellectual property in the 21st century (see Jalles (2010)). While patenting new innovations used to be a popular way to protect one's innovation and prevent competitors to steal or copy technology and exploit it in their own production process, it appears that patents alone are not a very reliable indicator for innovative activities. Filing a patent implies that a created technology has to be fully revealed. This also enables competitors to access such technology, which can occur for example through investigating blueprints, set-ups, codes, or chemical compounds

Table 4.5: *Estimation - Effect of STR on Patents Filed*

Depended Variable	(1)	(2)	(3)	(4)	(5)	(6)
Patents Filed	STR	Tax Base	PIT	Base+PIT	STR_Incr	PatentBox
Panel A - All Firms						
STR_{jt-1}	0.353	0.364	1.371	1.280	0.133	3.012*
	(1.546)	(1.614)	(1.415)	(1.522)	(1.558)	(1.541)
$Size_{ijt}$	0.132***	0.135***	0.130***	0.133***	0.133***	0.129***
	(0.048)	(0.046)	(0.050)	(0.004)	(0.048)	(0.049)
$TaxBase\_Decr_{jt-1}$		−0.026		−0.018		
		(0.046)		(0.042)		
$TaxBase\_Incr_{jt-1}$		0.076		0.076		
		(0.063)		(0.062)		
PIT_{jt-1}			−0.016	−0.015		
			(0.014)	0.013		
STR_Incr_{jt-1}					0.141	
					(0.495)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					0.057	
					(1.356)	
$PatentBox_{jt-1}$						0.679**
						(0.317)
$STR_{jt-1} * PatentBox_{jt-1}$						−1.429
						(1.320)
R^2	0.76	0.76	0.76	0.76	0.76	0.76
Observations	106,977	106,977	106,977	106,977	106,977	106,977
Firms	12,531	12,531	12,531	12,531	12,531	12,531
Panel B - Domestic Firms						
STR_{jt-1}	−0.079	−0.172	−0.024	−0.093	−0.328	−2.736
	(1.102)	(1.107)	(1.044)	(1.131)	(1.200)	(1.773)
$Size_{ijt}$	0.286***	0.287***	0.286***	0.287***	0.283***	0.284***
	(0.098)	(0.099)	(0.098)	(0.098)	(0.098)	(0.098)
$TaxBase\_Decr_{jt-1}$		0.002		0.003		
		(0.045)		(0.044)		
$TaxBase\_Incr_{jt-1}$		0.050		0.050		
		(0.040)		(0.039)		
PIT_{jt-1}			−0.001	−0.001		
			(0.009)	0.010		
STR_Incr_{jt-1}					−0.906***	
					(0.289)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					2.985***	
					(0.778)	
$PatentBox_{jt-1}$						−0.726***
						(0.277)
$STR_{jt-1} * PatentBox_{jt-1}$						2.439**
						(1.098)
R^2	0.50	0.50	0.50	0.50	0.50	0.50
Observations	57,036	57,036	57,036	57,036	57,036	57,036
Firms	6,699	6,699	6,699	6,699	6,699	6,699
Panel C - Domestic MNE						
STR_{jt-1}	3.287	3.500	4.269**	4.285**	3.073	6.489***
	(2.231)	(2.184)	(2.098)	(2.115)	(2.398)	(1.610)
$Size_{ijt}$	0.130*	0.129*	0.128*	0.129*	0.134*	0.127*
	(0.070)	(0.071)	(0.070)	(0.070)	(0.070)	(0.069)
$TaxBase\_Decr_{jt-1}$		−0.049		−0.036		
		(0.044)		(0.048)		
$TaxBase\_Incr_{jt-1}$		0.045		0.043		
		(0.064)		(0.063)		
PIT_{jt-1}			−0.022	−0.019		
			(0.016)	0.017		
STR_Incr_{jt-1}					0.685	
					(0.421)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−1.333	
					(1.208)	
$PatentBox_{jt-1}$						1.610***
						(0.563)
$STR_{jt-1} * PatentBox_{jt-1}$						−4.296*
						(2.318)
R^2	0.78	0.78	0.78	0.78	0.78	0.78
Observations	21,595	21,595	21,595	21,595	21,595	21,595
Firms	2,429	2,429	2,429	2,429	2,429	2,429

Panel D - Foreign MNE						
STR_{jt-1}	−0.985	−1.041	0.058	−0.076	−1.107	1.347
	(1.210)	(1.215)	(1.467)	(1.335)	(1.170)	(0.836)
$Size_{ijt}$	0.047	0.053	0.044	0.049	0.049	0.044
	(0.036)	(0.034)	(0.037)	(0.034)	(0.036)	(0.039)
$TaxBase\_Decr_{jt-1}$		−0.026		−0.018		
		(0.045)		(0.038)		
$TaxBase\_Incr_{jt-1}$		0.109		0.109		
		(0.075)		(0.074)		
PIT_{jt-1}			−0.015	−0.014		
			(0.016)	0.014		
STR_Incr_{jt-1}					0.325	
					(0.865)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.610	
					(2.347)	
$PatentBox_{jt-1}$						0.365*
						(0.206)
$STR_{jt-1} * PatentBox_{jt-1}$						−0.215
						(1.059)
R^2	0.80	0.80	0.80	0.80	0.80	0.80
Observations	28,346	28,346	28,346	28,346	28,346	28,346
Firms	3,340	3,340	3,340	3,340	3,340	3,340
Panel E - SME						
STR_{jt-1}	−0.364	−0.374	−0.686	−0.656	−0.439	−2.123
	(1.223)	(1.252)	(1.191)	(1.247)	(1.314)	(1.908)
$Size_{ijt}$	0.195*	0.196*	0.196*	0.196*	0.194*	0.194*
	(0.113)	(0.112)	(0.113)	(0.112)	(0.113)	(0.112)
$TaxBase\_Decr_{jt-1}$		0.011		0.011		
		(0.031)		(0.031)		
$TaxBase\_Incr_{jt-1}$		0.022		0.020		
		(0.040)		(0.041)		
PIT_{jt-1}			0.004	0.003		
			(0.007)	0.007		
STR_Incr_{jt-1}					−0.843	
					(0.544)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					2.900	
					(1.954)	
$PatentBox_{jt-1}$						−0.500*
						(0.300)
$STR_{jt-1} * PatentBox_{jt-1}$						1.820
						(1.161)
R^2	0.39	0.39	0.39	0.39	0.39	0.39
Observations	76,010	76,010	76,010	76,010	76,010	76,010
Firms	9,485	9,485	9,485	9,485	9,485	9,485

Notes: This table presents the estimation results of Equation 4.2 to Equation 4.6 in consecutive order from (1) to (6). It is based on data retrieved from the AMADEUS database including 28 EU countries for the time period from 2011 to 2020 (see Table 4.3). The dependent variable is the number of patents filed of a firm in a given year (see Equation 4.7). It is used as a proxy for innovation. The control variable for the firm size is defined as the log of total assets of a firm in a given year. STR is the statutory corporate tax rate of a country in a respective year. TaxBase_Decr indicates whether the Tax Base in a country for a particular year is decreasing. Similarly, TaxBase_Incr indicates an increase of the Tax Base. PIT measures the personal income tax for each country for every year. STR_Incr takes the value of 1 if a statutory corporate tax rate change is an increase. PatentBox indicates whether a country is running a patent box regime in a particular year.
This Table presents 5 panels. Panel A considers the entire dataset including all firms. Panel B only considers domestic firms, which are firms only supplying a local market without having any foreign affiliates. In contrast to that, Panel C considers Domestic MNEs which are domestic firms which have foreign subsidiaries. Panel D considers Foreign MNEs, which are MNEs with a global ultimate owner (GUO) from a different country. Panel E considers small and medium-sized enterprises (SME). This study classifies a firm as SME when it reports to employ less than 250 employees.
Firms which do not have any patents and reported 0 patents for all the years are dropped from the estimation due to fixed effects. Therefore, the sample sizes in the estimations are significantly smaller than the original size of the dataset presented in Table 4.3.
For this count model a poisson regression is conducted.
All estimations include fixed-effects on the firm-level and time fixed-effects.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

which are filed with the patent application. With this information publicly available, competitors are able to copy a new technology with marginal alternations in order to avoid violating a protected patent. This is in line with Palazzi (2011) who suggests that most outcomes of innovation processes in the 21st century can be described as intangible and seldomly patented.

While the 20th century can be described as being driven by revolutionizing manufacturing processes and tangible goods, the 21st century is significantly determined by technology and intangible goods. However, such goods appear to be more vulnerable in respect of creating copies or alternations. Therefore, firms might have the proclivity to conduct innovative processes in secret research labs using non-disclosure agreements in order to not be forced to reveal this technology publicly. As an example, one might think of Coca-Cola, a company which never patented their secret formula for their popular fizzy drink. Even though, the formula or recipe has never been protected by a patent, the company does not face any major issues regarding an almost identical product being brought to the market, as competitors failed to copy the product and are not able to identify and figure out the recipe in more than a century.

Further, this positive effect of a tax increase on patents filed can only be observed for domestic MNE but not for foreign MNE. This is rather interesting as both firm types are expected to be endowed with similar capabilities to operate globally (see Grubert (2003) and Bartelsman and Beetsma (2003)). However, regardless of a firm's capabilities, other important factors which might play a role can be the management structure, corporate environment and philosophy under which a firm operates. It is possible that there is a systematically and significantly different mind-set and company culture when comparing European MNEs with MNEs which have their headquarter based in a country overseas. Particularly with firms operating in the technology sector, there are rarely any internationally dominant firms which can be identified as European. Therefore, different approaches regarding innovation on the company level might occur, with foreign MNEs having less tendencies to file patents, while European MNEs still do it "by the book".

Besides that, a filed patent does not actually reflect a true value of an innovation at all, as it can be a completely new and ground-breaking technology or merely a slight improvement of a previously developed product, not offering much of value or improvement regarding sales or product quality. Therefore, this study finds confirmation in the criticism of patents being applicable to proxy innovation activity. This is in line with the literature which identifies patents to become less and less useful as a proxy to measure innovation (see Jalles (2010) and Palazzi (2011)). With technology evolving and consumption having a shift towards intangible goods, patents simply cannot grasp and protect new developments fully and leaves a firm rather vulnerable with research outcomes exposed publicly. This bears the risk of new innovations being exploited and replicated by other competing entities.

Table C.3 presents the same regression output including a control for fixed-effects for year and industry interactions and is included in the appendix. It can be seen that the results do not change in a significant way and such additional measure does not account for these puzzling results.

4.6.3 Robustness Checks

To test for the robustness of the model and for endogeneity, additional estimations are conducted accounting for various lags and leads in the model. These are presented in Table C.4 for the estimation with intangible assets as a dependent variable. In contrast to that, Table C.5 shows the estimations with lags and leads for the estimation strategy using the number of filed patents as a dependent variable. This is interesting as it answers the question on how long it takes for a change in tax policy to manifest itself on a firm level and on how sensitive and quickly firms adjust their behavior and react to a newly implemented legislation.

Table C.4 indicates that the estimation for the effect of a change in the STR on a firm's intangible assets does not appear to show any other significant results for any other lags or leads, except for the chose one year lag. This holds true for all panels, except domestic MNE which show a significant effect on the 3rd lead. However, this effect appears to be very marginal and cannot be identified in any other sub-sample or in the estimation comprising the entire sample.

In contrast to that, Table C.5 shows rather surprising and puzzling results for the estimation strategy using patents filed as a dependent variable. While the first lag of STR appears to be significant for the whole sample, mixed results can be observed for the other sample splits which distinguish between the firm types. Particularly a strong and statistically significant effect occurring in the third lag appears through all panels. This indicates that the behavior of filing for patents seems to be affected by the STR, however, that it takes multiple time periods to be effective. This effect hints that planning to file a patent and the process of developing such might be less adaptable. This implies that regardless of tax changes the development and filing procedures are still undertaken. Generally, the realm of patents and their implication for innovation appear to be not dictated by tax policies per-se, as firms might find loopholes to file for patents in other areas or locations they also operate in.

4.7 Conclusion

This study seeks to give a perspective on answering the question how a change in a country's tax policy impacts a firms innovation capability. It applies a rich dataset comprising all 28 countries which are part of the European Union for the years 2011 to

2020 (see Table 4.3). It further considers tax changes not only measured by a change of the statutory corporate tax rate but also includes a measure to control for changes in the tax base. In order to measure innovation within a firm, two different approaches are undertaken. The first one considers intangible assets as a proxy for newly created innovation, while the second considers patents filed by a company in a particular year. Further, the significance of a patent box regime is examined as it is a popular tool applied by various European countries seeking the goal to attract capital and technology intensive MNEs. However, such policies do not only affect MNEs, even if they are expected to be the main target, but also domestic firms. Therefore, this study undertakes a thorough distinction between various company types, in order to examine whether certain categories of firms are affected by tax changes differently than others.

The results indicate a negative and statistically significant effect of a tax increase on the intangible assets of a firm when considering the entire sample overall. While this effect of the statutory tax rate appears to be relevant, it is rather surprising that the tax base changes fail to have a significant effect on the intangible asset allocation of a firm. This could be attributed to the tax base measure not grasping the change precisely enough, as particularly base changes appear to be very specific and targeted for certain areas, industries, or geographic locations.

Comparing the obtained results of all five subsamples, it can be established that negative effects primarily occur for SME and domestic firms. MNEs, both domestic and also foreign, appear to be not affected by an increase of the statutory corporate tax rate. This is in line with the theory and confirms the presumption of MNEs having more capabilities and being able to bypass taxation through tax planning and profit shifting which allows to unlock resources to undertake research activities and create new innovations.

When accounting for a patent box regime, the results are rather surprising and unexpected. It can be seen that while the patent box regime itself provides a positive effect on a firm's intangible assets, a tax increase under such regime appears to have an even larger effect. It raises the question whether tax increases are perceived as mixed signals and a precursor of a future policy shift. However, this effect remains unanswered and provides room for further analysis and discussion in future research.

When implementing filed patents of a company as the dependent variable, the results appear to be non-conclusive. As there are no significant effects to be obtained for all sub-samples except the domestic MNEs, it raises the question of the validity of such measurement as a proxy for innovation itself. Fundamentally, it is highlighted how measuring and capturing innovation can be a rather abstract pursuit and that it can be a rather difficult thing to measure and grasp in a quantitive way. The most intuitive way to measure a company's proclivity to undertake innovative actions would be by its R&D expenses. Unfortunately, data on such expenses is scarce and not often reported.

Due to data limitation, this study fails to include such an important and crucial financial figure, as the AMADEUS database appears to report rather poorly on such.

There are two main criticisms regarding filed patents to be identified. Not all innovative pursuit results in a final product or actually leads to an outcome of high value. Secondly, even if a positive outcome is obtained, it does not mean that firms desire to patent such, as filing a patent inevitably requires one to expose sensitive information on technology. Instead of doing so, a firm might have the preference of keeping new technologies classified but unprotected by patent laws. Therefore, expenditures regarding R&D or intangible assets appear to be a more suitable approach, however, also appear to have their weaknesses.

This study illustrates how changes in the corporate tax rate impacts a firm's intangibles assets, representing a proxy for innovation. It bears interesting implication for policy makers, highlighting that tax cuts do not have significant effects for multinational firms. It shows that such policy changes rather impact domestic and small firms. The importance of a patent box regime is highlighted and it can be seen that such a political agenda appears to have a positive effect on the intangible assets of firms. However, it can be seen that tax changes might be perceived by firms more severely, indicating that the effect of a change in tax policy on innovation might be even amplified, and not mitigate as it would be expected.

Generally, these findings leave room for further research to be done. For this, a richer dataset would definitely facilitate such analysis, as the measurement of innovation can be a cumbersome enterprise. However, the trend of innovation not being fully grasped by the number of filed patents appears to be present and sparks the debate on how innovation is actually undertaken in the 21st century and what types of new technologies are paramount.

Chapter 5

Conclusion

This thesis provides three empirical chapters on the area of foreign direct investment and multinational firms. These studies highlight and examine the role of MNE in the 21st century and how they differ from domestically owned companies in various aspects. This chapter summarizes the key findings and contributions to the existing literature. Moreover, an outlook on further research and future work is provided.

Chapter 2 investigates how productivity spillovers can arise in the presence of MNEs in two central and eastern European countries (CEECs), the Czech Republic and Poland for the years 2009 to 2014. The results suggest that indeed productivity spillovers arise in the Czech Republic, while in Poland a market stealing effect occurs with domestic firms perceiving the presence of MNEs in a negative way and being affected by a decrease in their productivity levels. Further, the obtained results highlight the importance of accounting for the absorptive capacity of a firm, as productivity spillovers appear to be dependent on the technological level and endowment of the respective domestic firm.

The analysis then goes beyond this analysis and distinguishes the origin of a foreign MNE, putting them into two categories. By distinguishing between the home country of a MNE being either a developed or developing country, this study contributes to the existing literature by accounting for the quality of FDI, separating the effects based on where a MNEs is coming from. This appears to be of particular interest as different countries might seek different goals and aspirations to achieve, conducting investments and operations under different intentions and expectations.

Once accounting for such investment origin, a new channel through which spillovers occur manifests itself. When controlling for absorptive capacity (ABC), productivity spillovers through backward linkages appear to be statistically significant and even larger in their magnitude than the ones occurring through horizontal channels when considering domestic firms only. Besides that, the effects on domestic MNEs is examined as well, including an important distinction between two types of domestic firms which is often neglected in data analysis. When turning to these firms, it can be seen that domestic MNE do perceive positive productivity spillover effects through horizontal linkages, an effect

which appears to be negative for purely domestic firms. This emphasizes the importance of distinguishing between different types of domestic firms as well as depending on whether a firm operates on a global landscape or not, they might also be different in their technological abilities and capabilities to compete with new firms entering a market.

Consequently, the results bear the policy implication that solely attracting FDI through tax incentives does not necessarily lead to positive effects for domestic firms and the local economy in general. It can be seen that the circumstances and technological level are vital when it comes to actually benefitting from the presence of MNEs and the respective technologies they are often bringing. With foreign MNE being at a much higher level of technology and productivity when comparing them to their local competitors, local firms run the risk of not being competitive enough and losing in their productivity, sales, and market share. The separation of the origin of the foreign MNEs appears to be of interest and has not been vastly undertaken in previous literature. It provides further potential for future research to investigate, whether attracting MNE from certain locations or areas might be more desirable than others.

Chapter 3 investigates how financial shocks impact firms which are operating in the euro zone. It analyzes a rich panel-data set for a time period from the year 2009 to 2018 comprising 12 countries which have the euro as a currency. Under financial pressure, MNEs might appear to have an advantage compared to pure domestic firms. This is based on the fact, that MNE have various ways to access finance and capital which are denied for domestic firms. With domestic firms heavily relying on bank loans to finance investments, a financial shock has the potential to heavily disrupt such decisions and limit the access to capital substantially.

With the sovereign debt crisis and the EBA conducting a capital enhancement exercise, access to credit and bank loans was restricted for firms in a significant way, leaving firms without necessary financial possibilities. The results suggest that financial pressure is perceived in different ways, depending on whether a firm is multinational or only operates domestically in its home country without having any foreign linkages to subsidiaries abroad or other entities in other countries of which it holds shares and ownership. Obtaining estimates on TFP on the firm-level, the analysis suggests that indeed financial pressure impacts firm productivity in a significant way. Particularly in the time period of the implementation of the capital enhancement exercise this effect appears to be even stronger. In contrast to domestic firms, however, MNEs appear to perceive even a gain in productivity, suggesting that capital restrictions and an external financial shock can result in an increase of productivity and efficiency. A potential explanation for this might be found with MNEs being larger, more rigid and less flexible due to a more complex corporate structure. Therefore, with downsizing a firm in times of crisis, additional gains in productivity might be achieved.

Further, different effects can be established when distinguishing between the periphery and non-periphery countries of the euro area. This indicates that even though firms operate in the same currency union, the location still matters substantially, with companies which are located in the periphery being more affected by financial pressure and the capital enhancement exercise in application. This leaves further room for future analysis, in which way these firm differ and how companies might make their choice of selecting a country appropriately.

Chapter 4 analyses the effects occurring through a change in the corporate tax rate of a country on innovation of a firm. Its focus is on the European Union, examining firm-level data on 28 member countries including the United Kingdom covering a time period from 2011 to 2020. While a company's tax burden is not only determined by the statutory corproate tax rate (STR) but also the tax base, this study contributes to the existing literature considering the tax base referring to reports provided by the European Commission and manually creates indicator variables in the case a tax base change occurs in a particular year. Further, a novel match of BvD firm-level data and patent data is implemented, pursuing to shed light on tax changes and their impact on the filing behavior of companies regarding patents.

While measuring innovation with the level of intangible assets, a negative and statistically significant effect can be established. This effect remains negative and significant for domestic firms and SME, the results suggest no significant effects occurring for both domestic and also foreign MNE. These results are in line with the theory, that tax changes are only a minor tool when it comes to attracting firms or boost innovative activities.

Further, a patent box regime appears to be reflected in a positive way on innovation by itself. However, a change in the STR is perceived negatively and even larger than otherwise, for all sub-samples being analysed with the exception of domestic MNE.

When applying patents filed as a dependent variable in the analysis, this study fails to establish conclusive results. It rather demonstrates that the application of patents as a measure for innovation has its flaws, confirming this criticism highlighted by the literature. This establishes evidence that innovation and new technology might not necessarily be patented, in order to remain confidentiality. This certainly leaves more approaches for future research, investigating how innovation takes place on a corporate level.

All three studies intend to examine a particular field of which the presence of MNE might be perceived in a positive or also negative way. While a clear answer to the question, whether MNEs should be perceived as "Dr. Jekyll or Mr. Hyde" (see Chapter 1) cannot be given, the three analyses provide a clear illustration on how complex the occurrence of MNEs is and in which ways local economies can be impacted by such. Various factors come into consideration, when it comes to making a decision on whether it is desirable to have MNEs operating in a domestic market. Therefore, MNEs can be seen as bearing

aspects of both, a gift and a curse, depending on various conditions. Therefore, the room for potential future work appears to be rather large with numerous possibilities and angles to take, when examining how firms operate in the global economy.

Appendices

Appendix A

Chapter 2

Table A.1: *Number of Companies per Industry – Czech Republic*

Sector	Number of Companies	Percent
Manufacture of food products, beverages and tobacco products	2,542	12.53
Manufacture of textiles, wearing apparel and leather products	509	2.51
Manufacture of wood and of products of wood and cork, except furniture	354	1.74
Manufacture of chemicals and chemical products	147	0.72
Manufacture of basic pharmaceutical products and pharmac. preparations	133	0.66
Manufacture of rubber and plastic products	262	1.29
Manufacture of other non-metallic mineral products	572	2.82
Manufacture of basic metals	39	0.19
Manufacture of fabricated metal products, except machinery and equipment	1,103	5.43
Manufacture of computer, electronic and optical products	534	2.63
Manufacture of electrical equipment	840	4.14
Manufacture of machinery and equipment n.e.c.	1,490	7.34
Manufacture of motor vehicles, trailers and semi-trailers	201	0.99
Manufacture of other transport equipment	1,417	6.98
Manufacture of furniture; other manufacturing	4,377	21.57
Construction	5,775	28.46
Total	**20.295**	**100**

Notes: This table presents the number of companies included in the final dataset obtained from the ORBIS database for the Czech Republic for the time period from 2009 to 2014 distinguished by sector.

Table A.2: *Number of Companies per Industry – Poland*

Sector	**Number of Companies**	**Percent**
Manufacture of food products, beverages and tobacco products	2,150	14.46
Manufacture of textiles, wearing apparel and leather products	476	3.20
Manufacture of wood and of products of wood and cork, except furniture	226	1.52
Manufacture of chemicals and chemical products	210	1.41
Manufacture of basic pharmaceutical products and pharmac. preparations	144	0.97
Manufacture of rubber and plastic products	249	1.68
Manufacture of other non-metallic mineral products	648	4.36
Manufacture of fabricated metal products, except machinery and equipment	587	3.95
Manufacture of computer, electronic and optical products	361	2.43
Manufacture of electrical equipment	428	2.88
Manufacture of machinery and equipment n.e.c.	760	5.11
Manufacture of motor vehicles, trailers and semi-trailers	187	1.26
Manufacture of other transport equipment	1,288	8.66
Manufacture of furniture; other manufacturing	3,006	20.22
Construction	4,145	27.88
Total	**14.865**	**100**

Notes: This table presents the number of companies included in the final dataset obtained from the ORBIS database for Poland for the time period from 2009 to 2014 distinguished by sector.

Table A.3: *LevPet Estimation of Total Factor Productivity per Industry - Czech Republic*

Industry	*Labour Input*	*Capital Stock*	*Chi2* †
Manufacture of food products, beverages and tobacco products	0.678*** (0.015)	0.225*** (0.025)	10.49***
Manufacture of textiles, wearing apparel and leather products	0.839*** (0.025)	0.081*** (0.014)	12.57***
Manufacture of wood and of products of wood and cork	0.735*** (0.035)	0.117*** (0.037)	6.95**
Manufacture of chemicals and chemical products	0.711*** (0.079)	0.138*** (0.036)	3.74**
Manufacture of basic pharmaceutical products and pharmac. preparations	0.648*** (0.097)	0.259*** (0.050)	12.61***
Manufacture of rubber and plastic products	0.832*** (0.026)	0.061** (0.025)	9.99***
Manufacture of other non-metallic mineral products	0.705*** (0.019)	0.136*** (0.029)	23.19***
Manufacture of basic metals	0.649*** (0.100)	0.270*** (0.096)	0.60
Manufacture of fabricated metal products	0.778*** (0.012)	0.091*** (0.011)	96.06***
Manufacture of computer, electronic and optical products	0.777*** (0.025)	0.079*** (0.020)	22.83***
Manufacture of electrical equipment	0.789*** (0.016)	0.051*** (0.015)	63.97***
Manufacture of machinery and equipment n.e.c.	0.770*** (0.012)	0.087*** (0.011)	96.20***
Manufacture of motor vehicles, trailers and semi-trailers	0.685*** (0.033)	0.131*** (0.027)	32.73***
Manufacture of other transport equipment	0.761*** (0.015)	0.076*** (0.011)	89.28***
Manufacture of furniture and other manufacturing	0.785*** (0.008)	0.074*** (0.006)	223.83***
Construction	0.772*** (0.006)	0.097*** (0.005)	423.53***

Notes: This table presents the estimated coefficients for *Labour Input* and *Capital Stock* following the approach of Levinsohn and Petrin (2003) for estimating total factor productivity (TFP) on the firm-level for the Czech Republic. It is based on data retrieved from the ORBIS database for a time period from 2009 to 2014.
† Wald test on constant returns to scale.
Robust standard errors are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table A.4: *LevPet Estimation of Total Factor Productivity per Industry - Poland*

Industry	*Labour Input*	*Capital Stock*	*Chi2* †
Manufacture of food products, beverages and tobacco products	0.437*** (0.018)	0.184*** (0.059)	40.49***
Manufacture of textiles, wearing apparel and leather products	0.658*** (0.032)	0.258*** (0.070)	1.36
Manufacture of wood and of products of wood and cork	0.588*** (0.042)	0.278*** (0.127)	1.29
Manufacture of chemicals and chemical products	0.672*** (0.051)	0.122* (0.066)	5.18**
Manufacture of basic pharmaceutical products and pharmac. preparations	0.545*** (0.049)	0.266** (0.113)	2.23
Manufacture of rubber and plastic products	0.639*** (0.049)	0.235*** (0.038)	6.00***
Manufacture of other non-metallic mineral products	0.610*** (0.030)	0.304*** (0.058)	2.06
Manufacture of fabricated metal products	0.645*** (0.025)	0.317*** (0.074)	0.22
Manufacture of computer, electronic and optical products	0.709*** (0.028)	0.149*** (0.049)	7.73**
Manufacture of electrical equipment	0.581*** (0.053)	0.258*** (0.041)	16.41***
Manufacture of machinery and equipment n.e.c.	0.569*** (0.034)	0.085* (0.051)	42.82***
Manufacture of motor vehicles, trailers and semi-trailers	0.579*** (0.057)	0.120* (0.073)	11.17***
Manufacture of other transport equipment	0.656*** (0.017)	0.151*** (0.039)	24.08***
Manufacture of furniture and other manufacturing	0.604*** (0.015)	0.197*** (0.026)	48.11***
Construction	0.549*** (0.011)	0.207*** (0.024)	93.11***

Notes: This table presents the estimated coefficients for *Labour Input* and *Capital Stock* following the approach of Levinsohn and Petrin (2003) for estimating total factor productivity (TFP) on the firm-level for Poland. It is based on data retrieved from the ORBIS database for a time period from 2009 to 2014.
†Wald test on constant returns to scale.
Robust standard errors are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table A.5: *Global Ultimate Owner - Czech Republic*

Developed Countries	Number of Companies
Austria	210
Australia	2
Belgium	46
Canada	11
Switzerland	125
Germany	738
Denmark	16
Spain	45
Finland	16
France	89
United Kingdom	74
Greece	1
Ireland	16
Italy	75
Japan	84
Liechtenstein	13
Luxembourg	38
Malta	2
Netherlands	86
Norway	14
New Zealand	2
Portugal	4
Sweden	45
San Marino	1
United States	164
Total	**1,917**
Total Foreign	**1,917**

Developing Countries	Number of Companies
Armenia	1
Azerbaijan	1
Bulgaria	11
Bermuda	2
Belize	4
China	20
Cyprus	33
Czech Republic	17,960
Egypt	1
Guyana	1
Hong Kong	6
Croatia	2
Hungary	5
Israel	4
India	9
Saint Kitts and Nevis	3
North Korea	1
South Korea	19
Cayman Islands	15
Kazakhstan	1
Lebanon	1
Lithuania	2
Latvia	2
Moldova	1
Marshall Islands	2
Mongolia	1
Mexico	4
Malaysia	2
Philippines	1
Poland	35
Romania	15
Russia	19
Seychelles	14
Slovenia	1
Slovakia	129
Turkey	1
Taiwan	9
Ukraine	32
Uzbekistan	1
British Virgin Islands	5
South Africa	2
Total	**18,378**
Total Foreign	**418**

Notes: This table presents all companies included in the final dataset obtained from the ORBIS database for the Czech Republic for the time period form 2009 to 2014. Firms are identified by their global ultimate owner (GUO) and then separated as either coming from a developed or a developing country. This separation is done following the classifications of the "World Economic Situation and Prospects"- Report (see United Nations (2014)) and the definitions and classifications of the IMF in the year 2009 (see International Monetray Fund (2009)).

Table A.6: *Global Ultimate Owner - Poland*

Developed Countries	**Number of Companies**
Austria	65
Australia	4
Belgium	78
Canada	16
Switzerland	64
Germany	549
Denmark	80
Spain	57
Finland	27
France	111
United Kingdom	82
Greece	4
Ireland	26
Italy	122
Japan	46
Liechtenstein	11
Luxembourg	55
Monaco	1
Netherlands	134
Norway	35
New Zealand	1
Portugal	8
Sweden	85
United States	132
Total	**1,793**
Total Foreign	**1,793**

Developing Countries	**Number of Companies**
Bosnia and Herzegovina	1
Bulgaria	1
Bahamas	2
Belarus	2
Chile	1
China	14
Curacao	1
Cyprus	27
Czech Republic	22
Hong Kong	2
Croatia	2
Hungary	4
Israel	7
India	6
South Korea	18
Cayman Islands	15
Lebanon	1
Lithuania	3
Malta	1
Mexico	3
Pakistan	1
Poland	12,921
Serbia	1
Saudi Arabia	2
Singapore	1
Slovenia	2
Syria	1
Thailand	1
Taiwan	5
Ukraine	1
British Virgin Islands	3
Total	**13,072**
Total Foreign	**151**

Notes: This table presents all companies included in the final dataset obtained from the ORBIS database for Poland for the time period form 2009 to 2014. Firms are identified by their global ultimate owner (GUO) and then separated as either coming from a developed or a developing country. This separation is done following the classifications of the "World Economic Situation and Prospects"- Report (see United Nations (2014)) and the definitions and classifications of the IMF in the year 2009 (see International Monetray Fund (2009)).

Appendix B

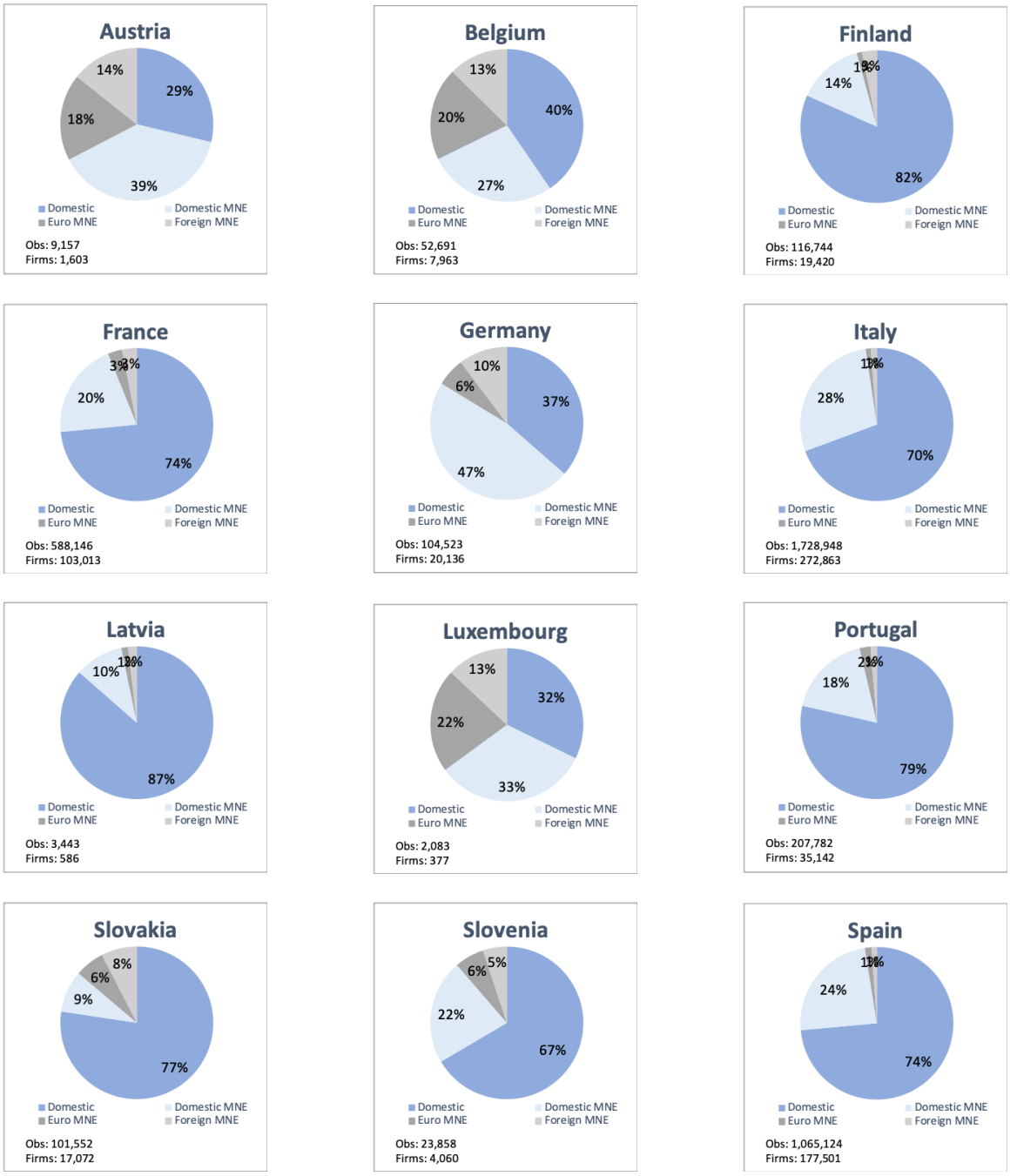
Chapter 3

Table B.1: *LevPet Estimation of Total Factor Productivity - by Country*

Country	*Labour Input*	*Capital Stock*	*Chi2* †
Austria	0.773***	0.109***	130.83***
	(0.004)	(0.010)	
Belgium	0.672***	0.203***	1,348.35***
	(0.001)	(0.004)	
Finland	0.742***	0.122***	3,189.92***
	(0.001)	(0.003)	
France	0.813***	0.133***	9,590.20***
	(0.000)	(0.001)	
Germany	0.696***	0.237***	2,914.27***
	(0.001)	(0.004)	
Italy	0.720***	0.145***	$1.1E+05$***
	(0.000)	(0.001)	
Latvia	0.286***	0.336***	246.44***
	(0.006)	(0.023)	
Luxembourg	0.659***	0.289***	5.91**
	(0.016)	(0.020)	
Portugal	0.759***	0.139***	4,979.02***
	(0.001)	(0.002)	
Slovakia	0.616***	0.172***	7,331.48***
	(0.001)	(0.003)	
Slovenia	0.812***	0.112***	272.60***
	(0.002)	(0.005)	
Spain	0.789***	0.170***	6,186.85***
	(0.000)	(0.001)	

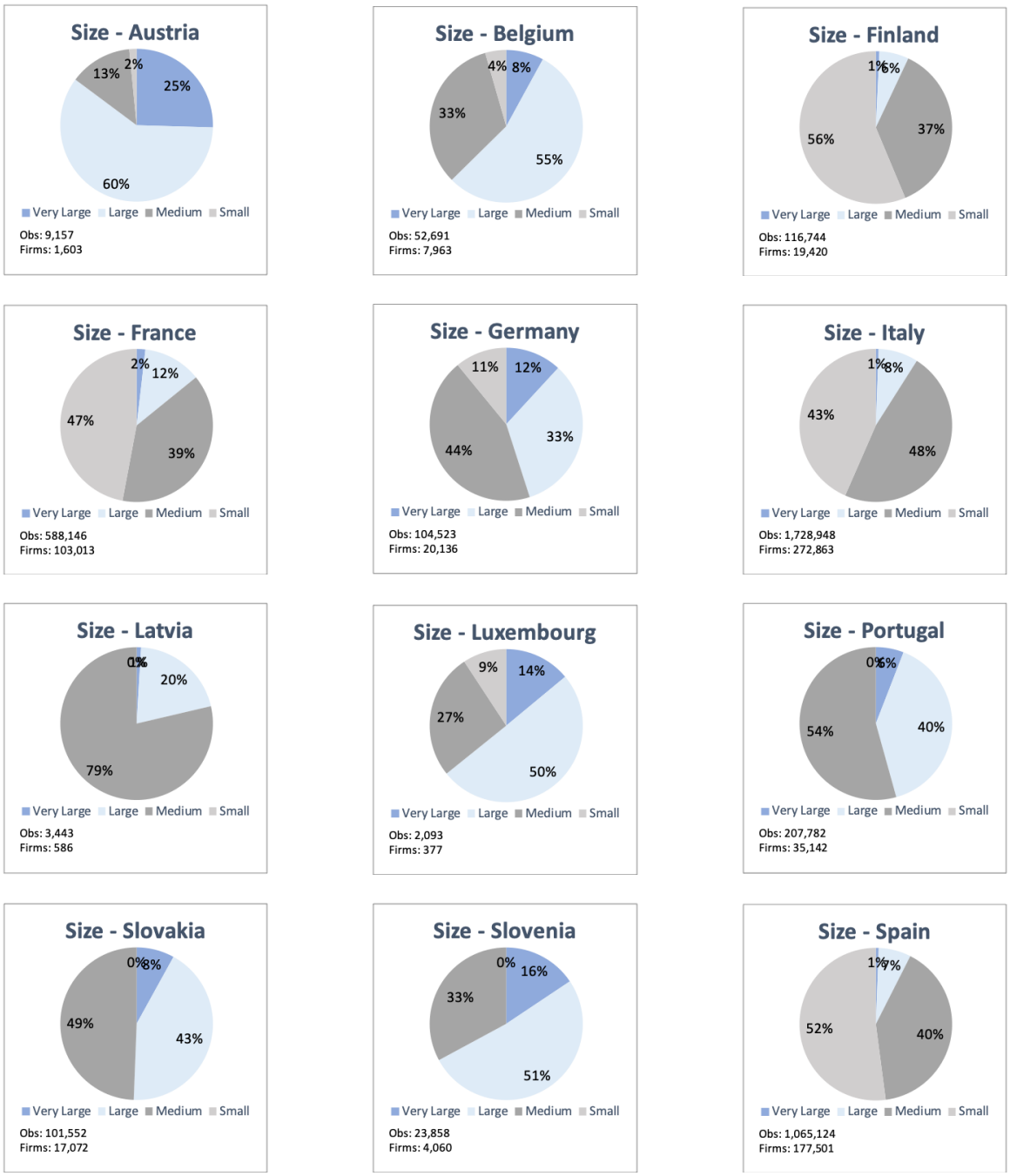
Notes: This table presents the estimated coefficients for *Labour Input* and *Capital Stock* following the approach of Levinsohn and Petrin (2003) for estimating total factor productivity (TFP) on the firm-level for all countries. It is based on data retrieved from the ORBIS database for the time period from 2009 to 2018.
† Wald test on constant returns to scale.
Robust standard errors are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Figure B.1: *Firm Ownership Proportion - by Country*



Notes: This figure illustrates the composition of the firms obtained from the ORBIS database by country for the years 2009 to 2018. A distinction by firm type is made based on the ownership. While domestic firms are firms with a global ultimate owner in the home country, domestic MNEs are firms which have subsidiaries in foreign countries. In contrast to that, Euro MNEs are companies which have a global ultimate owner in another euro-country, while foreign MNEs are companies which have a global ultimate owner in a foreign country which is not part of the euro zone.

Figure B.2: *Firm Size Proportion - by Country*



Notes: This figure illustrates the composition of the firms obtained from the ORBIS database by country for the years 2009 to 2018. A distinction by firm size is made. The firms are classified by the firm-size indicator provided by the ORBIS database.

Table B.2: *Structure of the Unbalanced Panel Data Set - by Country*

Number of Observations per Firm	Austria	Belgium	Finland	France	Germany	Italy	Latvia	Luxembourg	Portugal	Slovakia	Slovenia	Spain	Total
3	234	706	2,579	14,445	4,451	31,733	88	64	4,258	2,811	573	23,433	85,375
4	255	911	2,841	18,780	4,825	34,133	102	67	4,920	2,652	652	25,605	95,743
5	224	1,020	2,952	18,379	3,762	35,680	84	58	5,121	2,532	669	27,257	97,738
6	277	1,105	2,980	17,690	1,665	36,223	79	59	6,078	2,179	611	25,666	94,612
7	301	1,069	2,763	13,253	1,840	38,506	69	56	7,080	1,918	547	25,711	93,113
8	262	1,322	2,623	12,329	2,337	53,825	82	60	5,710	2,019	521	33,554	114,644
9	50	1,830	2,682	8,137	1,256	42,763	82	13	1,975	2,961	487	16,275	78,511
10	0	67	54	702	19	1,647	0	0	24	55	14	724	3,306
Total	1,603	7,963	19,420	103,013	20,136	272,863	586	377	35,142	17,072	4,060	177,501	663,042

Notes: This table presents the structure of the unbalanced final dataset obtained by the ORBIS database for a time period from 2009 to 2018 by country. It shows the number of observations per firm. Due to the selection of variables used in this study only a few companies show data reported for the entire time period. This is based on the fact, that TFP is estimated by using the LevPet approach which requires data on material cost. Information in material cost appears to be very poorly reported in ORBIS which results in many observations dropping out.

Table B.3: *Number of Companies per Country and Year*

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Austria	32	714	821	1,101	1,137	1,210	1,294	1,303	1,230	315	1,603
Belgium	556	5,247	5,768	6,148	6,364	6,557	6,602	6,076	5,489	3,884	8,030
Finland	608	10,597	11,937	12,830	13,073	13,809	14,674	14,849	13,574	10,893	19,474
France	16,759	71,234	79,984	85,126	82,667	75,109	67,627	51,033	42,439	16,168	103,715
Germany	7,803	14,403	17,609	17,485	16,412	9,279	8,418	7,563	5,421	130	20,155
Italy	20,341	166,312	182,895	196,339	200,207	209,879	223,841	221,478	209,313	98,343	274,510
Latvia	0	265	349	388	424	424	421	411	394	367	586
Luxembourg	86	224	250	281	295	278	258	230	176	15	377
Portugal	1,744	25,068	27,127	26,942	25,268	12,492	25,979	25,948	21,055	16,159	35,166
Slovakia	216	8,897	9,826	10,871	11,196	11,839	12,327	13,043	12,229	11,108	17,127
Slovenia	193	2,443	2,733	2,928	2,841	2,822	2,816	2,699	2,463	1,920	4,074
Spain	32,657	115,398	121,654	125,845	126,145	132,879	141,686	134,111	122,903	11,846	178,225
Total	80,995	420,802	460,953	486,284	486,029	476,577	505,943	478,744	436,686	171,148	**663,042**

Notes: This table presents the number of companies which are included in the final dataset obtained from the ORBIS database for each country and each year for the time period from 2009 to 2018. Due to different legal regulations regarding reporting procedures in each country the number of companies per country can vary quite vastly. Unfortunately, several countries which are part of the euro zone could not be included in the analysis due to poor data quality.

Table B.4: *Structure of the Unbalanced Panel Data Set - Data Analysis*

Number of Observation per Firm	Frequency	Percent	Cumulative Percentage
2	251,560	8.17	8.17
3	360,573	11.71	19.87
4	387,112	12.57	32.44
5	438,305	14.23	46.67
6	410,916	13.34	60.01
7	591,962	19.22	79.23
8	610,192	19.81	99.03
9	29,754	0.97	100.00
Total	**3,080,374**	**100.00**	**100.00**

Notes: This table presents the structure of the unbalanced final dataset obtained from the ORBIS database including all firms of all countries for the time period from 2010 to 2018. This table considers the lag of one period for the variable FP (financial pressure) presented in Equation 3.7. Therefore, the number of observations in the regression analysis is smaller than in the initial final data structure presented in Table 3.1. Further, the year 2009 is excluded.

Table B.5: *Number of Companies per Country and Year - Data Analysis*

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Austria	23	541	731	967	999	1,051	1,150	1,140	304	1,603
Belgium	515	4,893	5,379	5,491	5,761	5,883	5,498	5,143	3,626	8,030
Finland	523	9,459	10,633	10,718	11,047	11,743	12,181	12,326	9,722	19,474
France	14,775	66,144	74,110	72,749	65,856	58,660	44,771	36,057	13,641	103,715
Germany	7,204	13,994	16,317	15,211	8,343	7,598	6,920	4,852	107	20,155
Italy	18,199	152,014	166,469	169,696	175,769	187,771	199,621	195,001	91,923	274,510
Latvia	0	239	314	343	371	347	361	363	344	586
Luxembourg	76	188	226	247	243	205	207	163	13	377
Portugal	1,504	22,765	24,260	21,822	10,260	10,684	22,591	19,269	12,032	35,166
Slovakia	185	7,861	8,851	9,030	9,556	10,092	10,674	11,322	10,168	17,127
Slovenia	173	2,204	2,472	2,374	2,311	2,328	2,216	2,159	1,678	4,074
Spain	29,225	102,036	106,363	103,517	108,110	116,885	123,731	113,282	10,915	178,225
Total	72,402	382,338	416,125	412,165	398,626	413,247	429,921	401,077	154,473	**663,042**

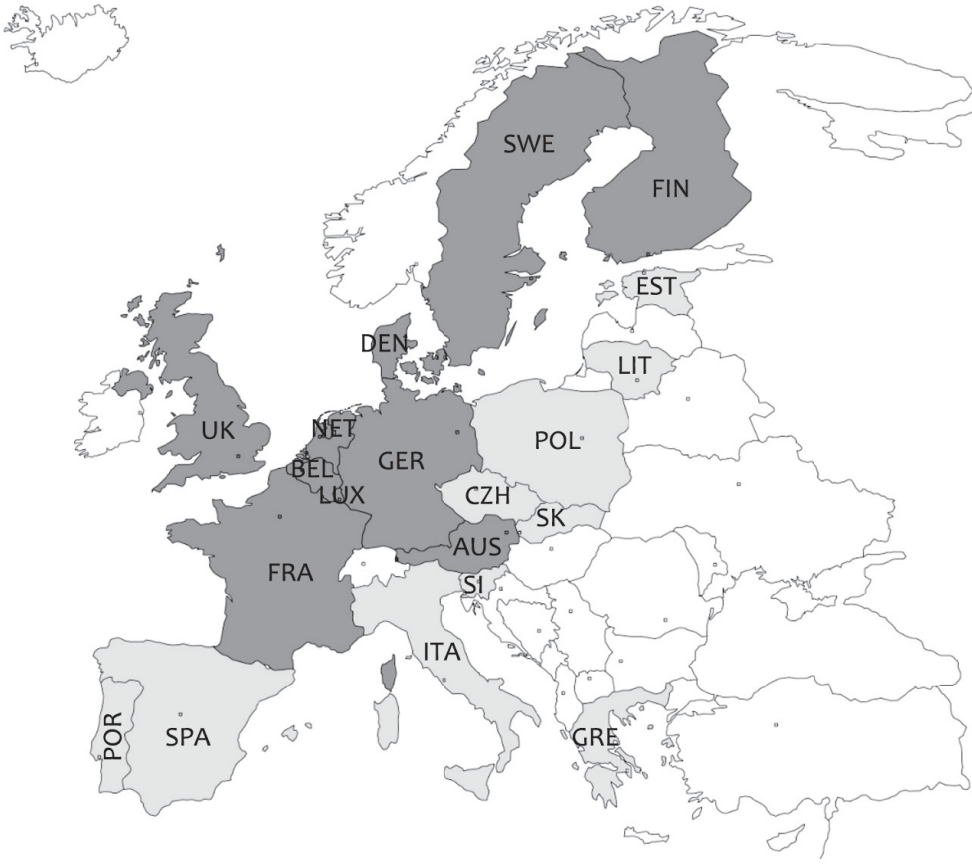
Notes: This table presents the number of companies which are included in the final dataset obtained from the ORBIS database for each country and each year for the time period from 2010 to 2018. Due to different legal regulations regarding reporting procedures in each country the number of companies per country can vary quite vastly. Unfortunately, several countries which are part of the euro zone could not be included in the analysis due to poor data quality. This table considers the lag of one period for the variable FP (financial pressure) presented in Equation 3.7. While the structure of companies per country and year changes, the total sum of companies included in the dataset presented in Table B.3 stays the same.

Table B.6: *Descriptive Statistics*

Variable	Observations	Mean	Std. Dev.	Min	Max
TFP	4,004,061	1.078	0.465	0.152	2.862
Foreign	4,004,061	0.043	0.203	0	1
FP	4,004,061	0.367	0.627	0.002	5.75
EBA	4,004,061	0.242	0.428	0	1
Total Assets	4,004,061	19,7419	1.05E+07	1.015	9.56E+09
Size	4,004,061	7.402	1.862	0.015	22.981
Age	4,004,061	17.641	13.886	1	814

Notes: This table presents the descriptive statistics for all relevant variables obtained from the ORBIS database for the time period from 2009 to 2018. TFP is total factor productivity on the firm level obtained by following the approach of Levinsohn and Petrin (2003). Foreign is a dummy variable taking the value 1 if a firm's global ultimate owner (GUO) can be identified as being from another country than the host country of a firm. FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. Total Assets are the reported total assets of a firm deflated with 2010 as a base year. Size is measured as the natural logarithm of total assets. Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported.

Figure B.3: *Center- and Periphery-Classification in the EU-20*



Notes: This figure provides an overview of how countries in the EU-20 are categorized into center- and periphery countries (Del Río-Casasola, 2021). The countries in the darker shade are considered to be center-countries. The lighter shade highlights countries which are considered to be part of the periphery.
Source: Del Río-Casasola (2021)

Table B.7: *Estimation - Baseline Model and EBA - Robustness Check*

Depended Variable	(1)	(2)	(3)	(4)	(5)	(6)
$ln(TFP_{it})$	Baseline	Baseline	Baseline	EBA	EBA	EBA
$Foreign_{it}$	0.264***	0.224***	–	0.263***	0.224***	–
	(0.003)	(0.001)	(0.002)	(0.001)		
FP_{it-1}	−0.034***	−0.046	−0.007***	–	–	–
	(0.001)	(0.000)	(0.002)			
$FP_{it-1} * EBA_t$	–	–	–	−0.033***	0.049***	−0.012***
				(0.002)	(0.003)	(0.001)
$FP_{it-1} * (1 - EBA_t)$	–	–	–	−0.030***	0.026***	0.006
				(0.001)	(0.003)	(0.004)
$Constant$	1.077***	1.510***	1.040***	1.078***	1.512	1.041***
	(0.002)	(0.003)	(0.004)	(0.001)	(0.004)	(0.004)
Control Variables						
$Size_{it}$	0.003***	0.003***	0.003***	0.002***	0.003***	0.002***
	0.001	0.001	0.000	0.000	0.001	0.000
Age_{it}	−0.001***	0.000**	0.002***	−0.001***	0.000**	0.002***
	0.000	0.000	0.000	0.000	0.000	0.000
$CountryDummies$	*no*	*yes*	–	*no*	*yes*	–
$TimeDummies$	*no*	*yes*	*yes*	*no*	*yes*	*yes*
$FixedEffects$	*no*	*no*	*yes*	*no*	*no*	*yes*
R^2	0.05	0.42	0.04	0.05	0.45	0.04
$Observations$	3,076,124	3,076,124	3,076,124	3,076,124	3,076,124	3,076,124
$Firms$	660,572	660,572	660,572	660,572	660,572	660,572

Notes: This table presents the estimation results of the baseline model presented in Equation 3.8 and the model considering the time of the EBA exercise presented in Equation 3.9. The dependent variable is the log of total factor productivity, computed using the the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable $Foreign$ is a dummy variable taking the value 1 if a firm's global ultimate owner (GUO) can be identified as being from another country than the host country of a firm. The variable FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). It is considered with a lag of one period (one year). Therefore, the data structure and number of observations in Table B.4 and Table B.5 apply. The variable EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year.
In contrast to Table 3.2, this approach excludes Latvia and Luxembourg due to a small sample size.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table B.8: *Estimation - EBA and Periphery - Robustness Check*

Depended Variable $ln(TFP_{it})$	(1) All Sample	(2) Periphery	(3) Non-Periphery
$FP_{it-1} * EBA_t$	-0.015^{***}	-0.021^{***}	0.004^{**}
	(0.002)	(0.001)	(0.002)
$FP_{it-1} * (1 - EBA_t)$	0.004	-0.012^{***}	0.007
	(0.004)	(0.003)	(0.005)
Constant	1.042^{***}	1.074^{***}	0.951^{***}
	(0.003)	(0.003)	(0.005)
Control Variables			
$Size_{it}$	0.001^{**}	0.002^{**}	0.004^{**}
	(0.001)	(0.001)	(0.002)
Age_{it}	0.001^{***}	0.002^{***}	0.001^{***}
	(0.000)	(0.000)	(0.000)
$Fixed - Effects$	*yes*	*yes*	*yes*
$TimeDummies$	*yes*	*yes*	*yes*
R^2	0.03	0.03	0.02
Observations	2,980,470	2,315,714	664,756
Firms	640,878	487,901	152,977

Notes: This table presents the estimation results of the model considering the time of the EBA exercise presented in Equation 3.9. A sample split is conducted separating countries into the periphery and non-periphery (see Section 3.4.5). The dependent variable is the log of total factor productivity, computed using the the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). The variable EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year.
In contrast to Table 3.3, this approach excludes Latvia and Luxembourg due to a small sample size. Further, Slovakia and Slovenia are excluded following the center/ periphery definition of Acharya et al. (2018).
Periphery countries: Austria, Belgium, Finland, France, Germany.
Non-Periphery countries: Italy, Portugal, Spain.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table B.9: *Estimation - Firm Classification - Robustness Check*

	Depended Variable $ln(TFP_{it})$	(1) All Sample	(2) Periphery	(3) Non-Periphery
non EBA time	$FP_{it-1} * (1 - EBA_t) * domestic$	-0.007^{***} (0.002)	-0.009^{***} (0.003)	-0.007^{***} (0.002)
	$FP_{it-1} * (1 - EBA_t) * domesticMNE$	-0.015^{***} (0.001)	-0.015^{***} (0.003)	0.009 (0.006)
	$FP_{it-1} * (1 - EBA_t) * europeanMNE$	-0.003^{**} (0.002)	-0.002^{***} (0.001)	0.002^{***} (0.001)
	$FP_{it-1} * (1 - EBA_t) * foreignMNE$	-0.007 (0.005)	-0.005^{**} (0.002)	0.002 (0.004)
EBA time	$FP_{it-1} * EBA_t * domestic$	-0.009^{***} (0.002)	-0.010^{***} (0.003)	-0.007^{***} (0.002)
	$FP_{it-1} * EBA_t * domesticMNE$	-0.015^{***} (0.003)	-0.021^{***} (0.004)	-0.010 (0.007)
	$FP_{it-1} * EBA_t * europeanMNE$	0.016^{***} (0.004)	-0.014^{***} (0.005)	0.030^{***} (0.006)
	$FP_{it-1} * EBA_t * foreignMNE$	0.104^{***} (0.002)	0.106 (0.071)	0.098^{***} (0.006)
	$Constant$	1.026^{***} (0.008)	1.063^{***} (0.009)	0.883^{***} (0.010)
	Control Variables			
	$Size_{it}$	0.002^{***} (0.000)	0.002^{**} (0.001)	0.003^{**} (0.001)
	Age_{it}	0.002^{***} (0.001)	0.001^{***} (0.000)	0.001^{***} (0.000)
	$Fixed - Effects$	*yes*	*yes*	*yes*
	$TimeDummies$	*yes*	*yes*	*yes*
	R^2	0.04	0.04	0.04
	$Observations$	2,980,470	2,315,714	664,756
	$Firms$	640,878	487,901	152,977

Notes: This table presents the estimation results of the model considering the time of the EBA exercise presented in Equation 3.9. A sample split is conducted separating countries into the periphery and non-periphery (see Section 3.4.5). The dependent variable is the log of total factor productivity, computed using the approach of Levinsohn and Petrin (2003) (see Section 2.5.1). The variable FP is a measure for financial pressure and is defined as the ratio of interest payment to cash flow (see Equation 3.7). The variable EBA takes the value 1 for the years 2012 and 2013, indicating the year in which the capital exercise of the EBA took place and affected the market. The variable $domestic$ is a dummy variable taking the value 1 if a firm is purely domestic. $domesticMNE$ refers to domestic firms which are themselves MNE. $europeanMNE$ are firms which are from a foreign country which is part of the euro zone. $foreignMNE$ are firms which are MNE coming from any other country than the euro zone. The control variable Age is calculated by subtracting the year of incorporation from the respective year in which financial data is reported. The control variable $Size$ is defined as the log of total assets of a firm in a given year.
In contrast to Table 3.4, this approach excludes Latvia and Luxembourg due to a small sample size. Further, Slovakia and Slovenia are excluded following the center/periphery definition of Acharya et al. (2018).
Periphery countries: Austria, Belgium, Finland, France, Germany.
Non-Periphery countries: Italy, Portugal, Spain.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Appendix C

Chapter 4

Table C.1: *Structure of the Unbalanced Panel Data Set - by Country*

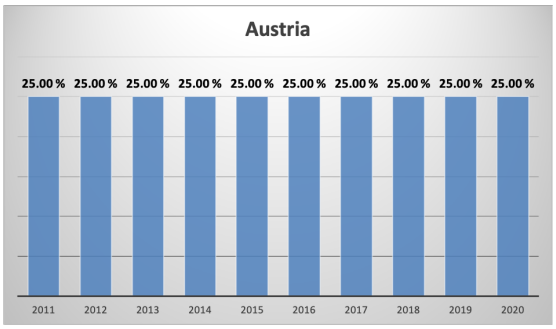
Number of Observations per Firm	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Republic	Denmark	Estonia	Finland	France
5	126	128	207	77	3	217	227	35	90	781
6	46	131	215	78	10	298	0	30	135	841
7	67	161	268	103	11	615	0	27	164	1,244
8	105	291	338	184	6	1,120	0	37	205	2,216
9	387	1,134	4,175	1,686	1	4,181	0	109	322	5,978
10	28	232	15	23	0	364	0	13	170	1,024
Total	759	2,077	5,218	2,151	31	6,795	227	251	1,086	12,084

Number of Observations per Firm	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxem-bourg	Malta	Nether-lands
5	206	99	158	21	2,223	54	60	14	7	41
6	240	121	267	27	2,063	91	71	10	5	52
7	230	169	479	32	2,293	187	127	12	18	54
8	418	381	1,074	41	3,185	160	130	15	19	83
9	1,392	1,568	2,818	91	41,339	221	207	18	13	135
10	39	18	132	6	2,671	123	216	3	0	9
Total	2,525	2,356	4,928	218	53,774	836	811	72	62	374

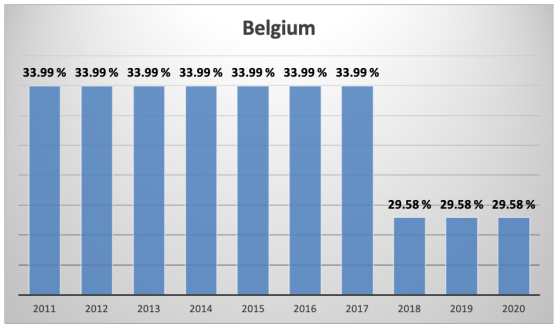
Number of Observations per Firm	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	United Kingdom	Total
5	301	148	258	84	54	812	153	397	6,976
6	464	219	303	95	98	973	297	423	7,597
7	731	344	453	115	144	1,603	497	440	10,581
8	1,177	797	722	164	268	2,797	789	698	17,412
9	2,052	4,551	6,083	942	541	12,246	1,305	2,874	96,360
10	0	25	0	1,133	0	76	459	511	7,280
Total	4,725	6,084	7,819	2,533	1,105	18,507	3,500	5,343	146,251

Notes: This table presents the structure of the unbalanced final dataset obtained from AMADEUS including all firms of all 28 countries for the time period from 2011 to 2020 (see Table 4.3) by country. It shows the number of observations per firm. As firms which do not have at least 5 consecutive observations are dropped, it can be seen that the number of observations per firm is at least 5.

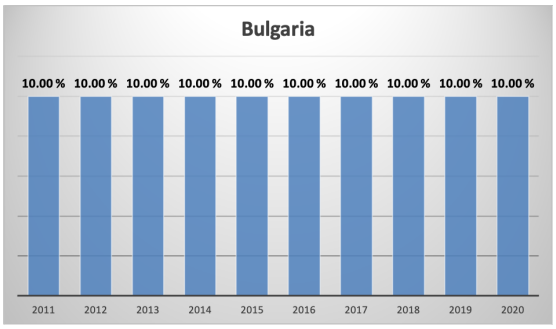
Figure C.1: *Statutory Corporate Tax Rate by Country and Year*



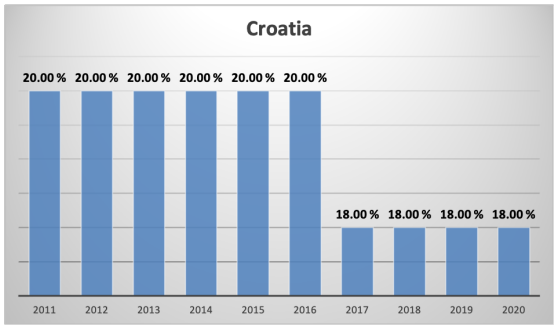
(a) STR - Austria



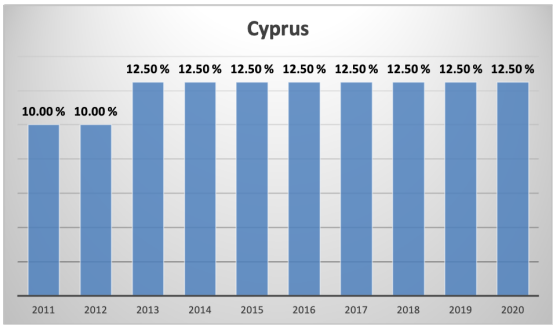
(b) STR - Belgium



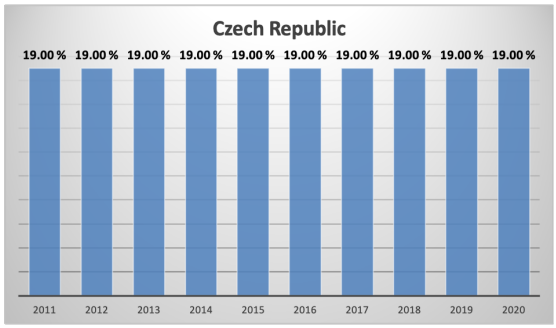
(c) STR - Bulgaria



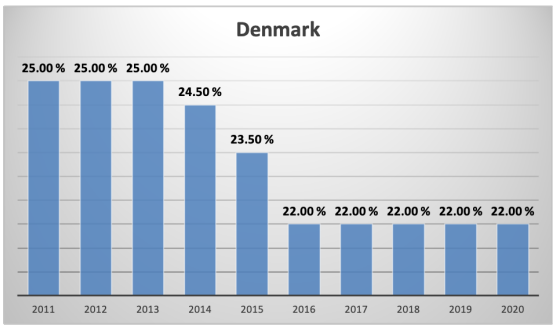
(d) STR - Croatia



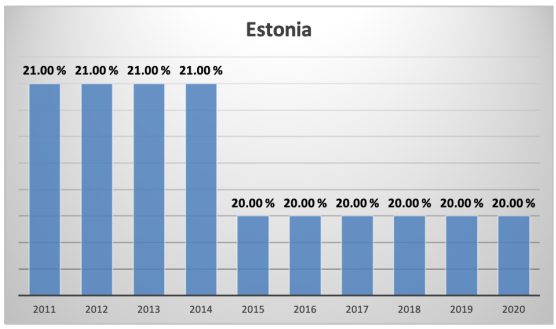
(e) STR - Cyprus



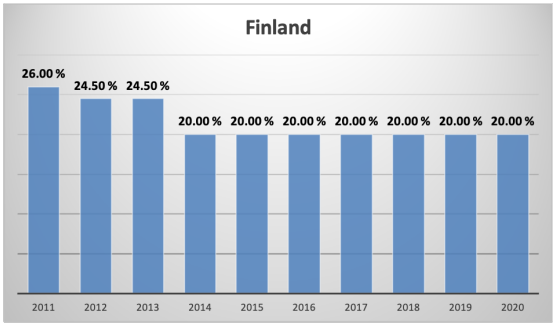
(f) STR - Czech Republic



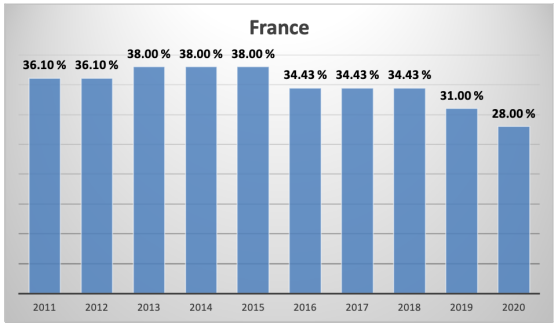
(g) STR - Denmark



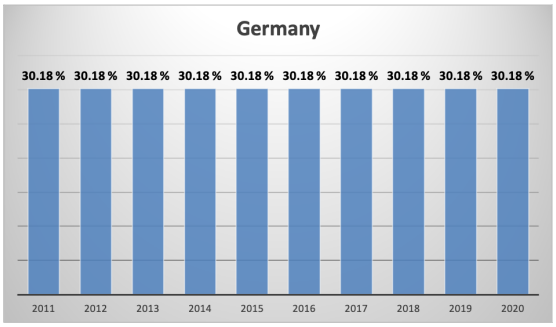
(h) STR - Estonia



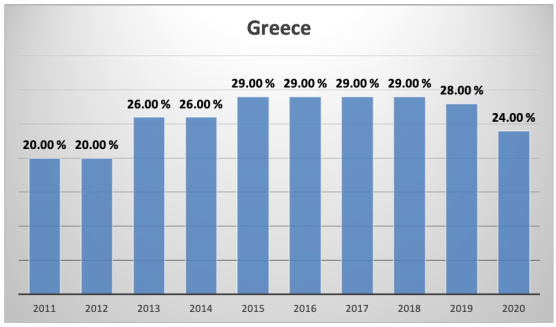
(i) *STR - Finland*



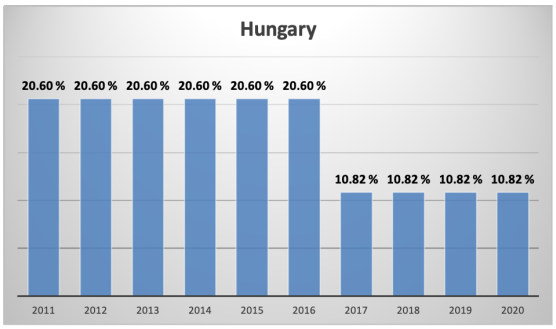
(j) *STR - France*



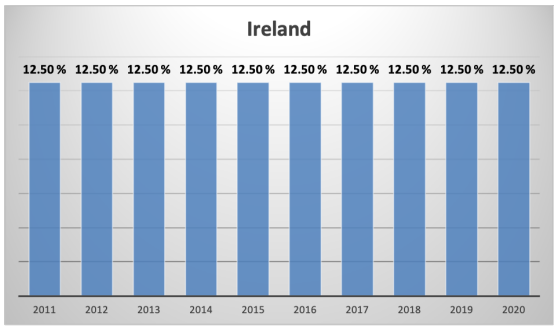
(k) *STR - Germany*



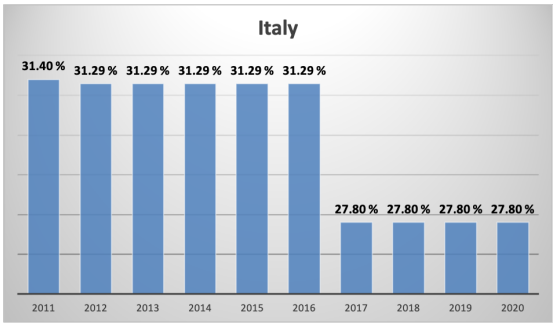
(l) *STR - Greece*



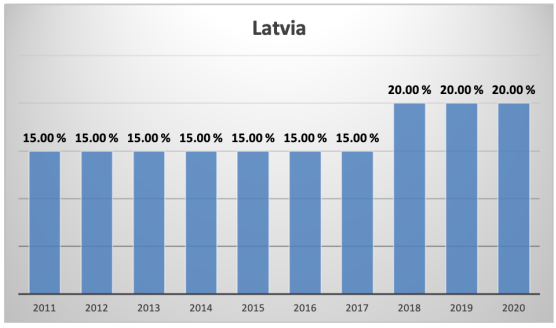
(m) *STR - Hungary*



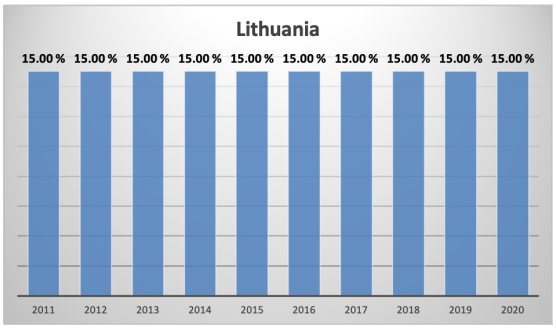
(n) *STR - Ireland*



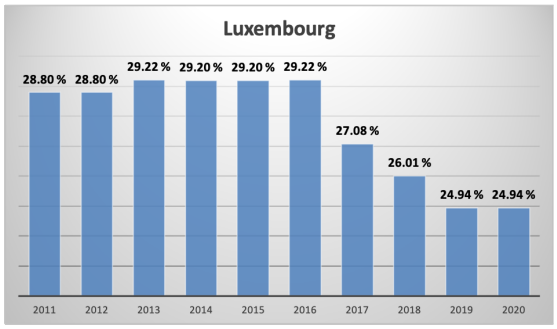
(o) *STR - Italy*



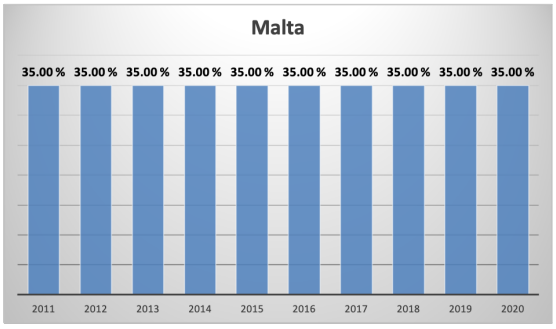
(p) *STR - Latvia*



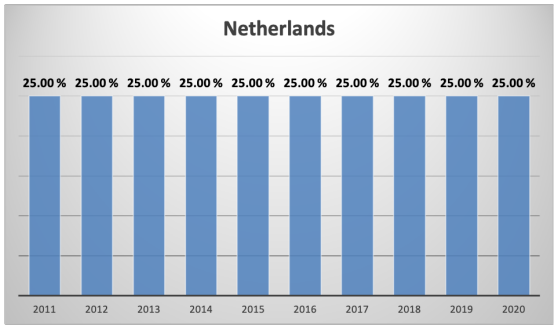
(q) *STR - Lithuania*



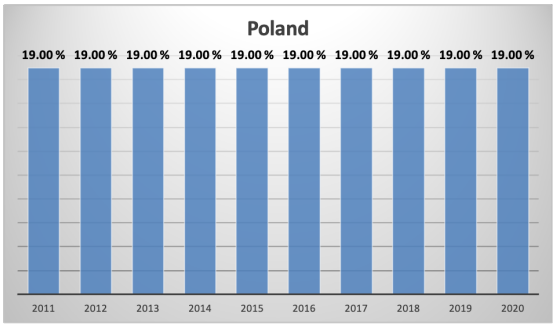
(r) *STR - Luxembourg*



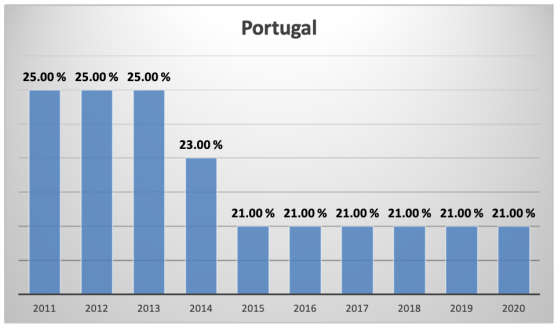
(s) *STR - Malta*



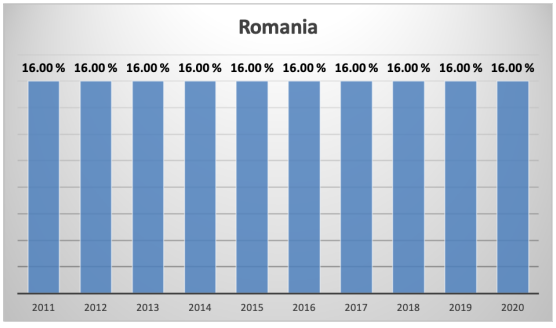
(t) *STR - Netherlands*



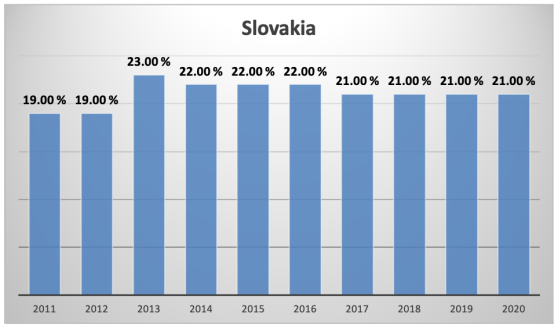
(u) *STR - Poland*



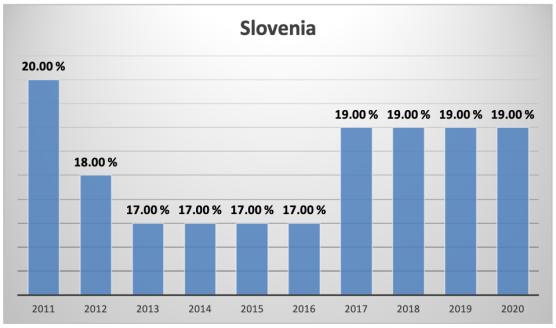
(v) *STR - Portugal*



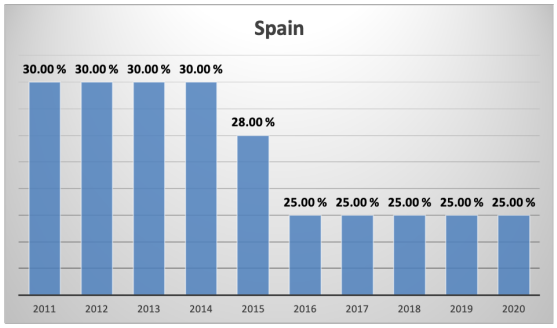
(w) *STR - Romania*



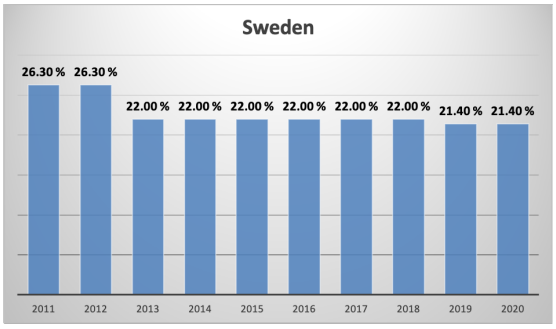
(x) *STR - Slovakia*



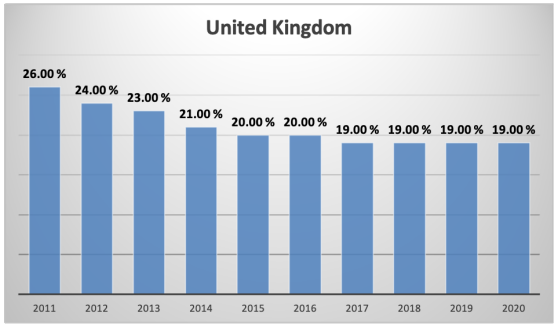
(y) *STR - Slovenia*



(z) *STR - Spain*



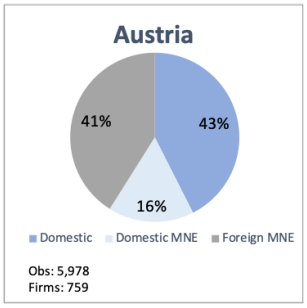
(aa) *STR - Sweden*



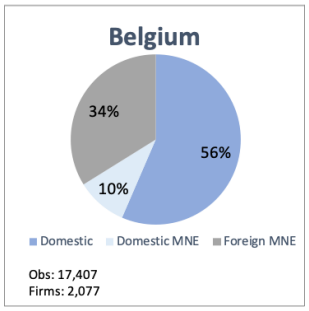
(ab) *STR - United Kingdom*

Notes: This figure provides a representation of the statutory corporate tax rate for all the countries which are included in the dataset obtained from AMADEUS for the time period 2011 to 2020.
Source: OECD (2021), KPMG (2021)

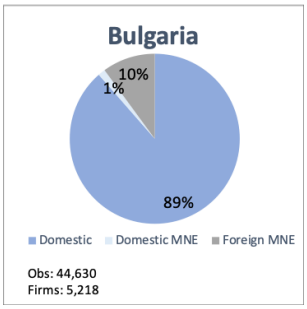
Figure C.2: *Firm Ownership Proportion - by Country*



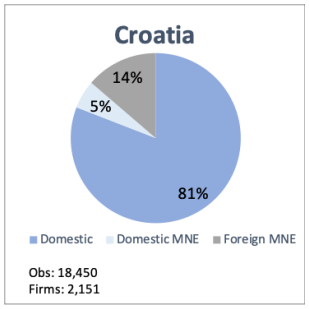
(a) *Firms - Austria*



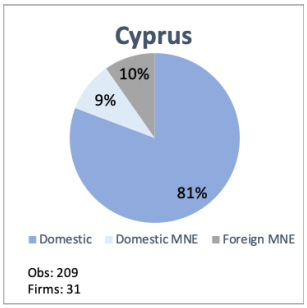
(b) *Firms - Belgium*



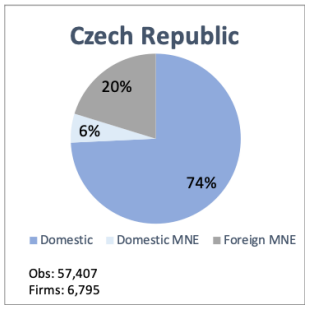
(c) *Firms - Bulgaria*



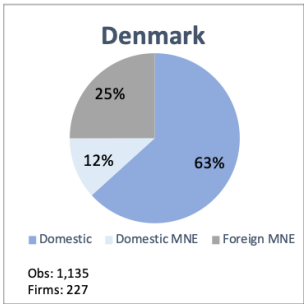
(d) *Firms - Croatia*



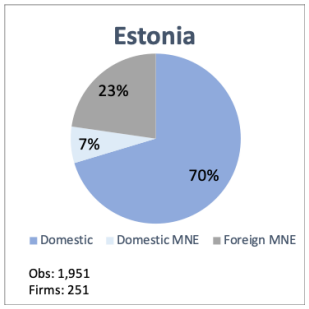
(e) *Firms - Cyprus*



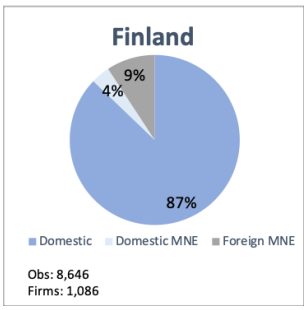
(f) *Firms - Czech Rep.*



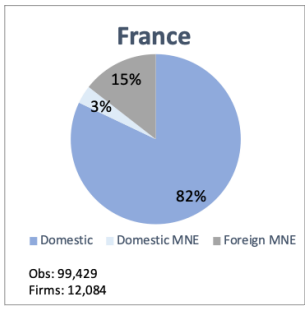
(g) *Firms - Denmark*



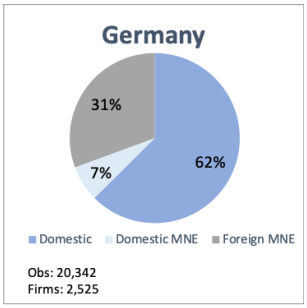
(h) *Firms - Estonia*



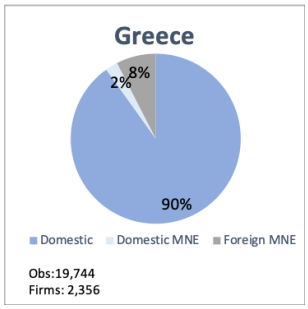
(i) *Firms - Finland*



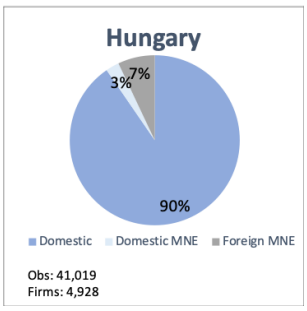
(j) *Firms - France*



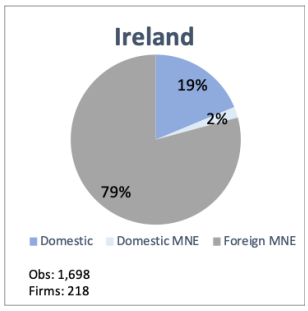
(k) *Firms - Germany*



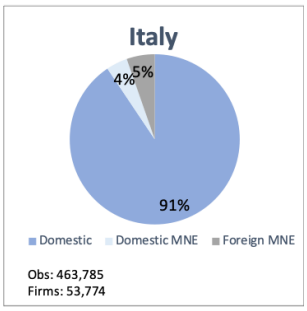
(l) *Firms - Greece*



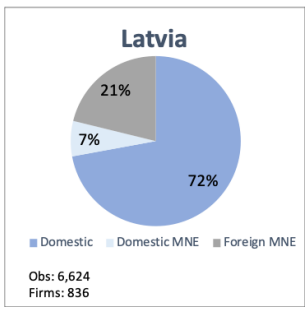
(m) *Firms - Hungary*



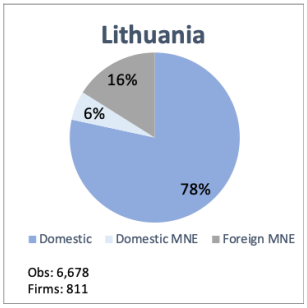
(n) *Firms - Ireland*



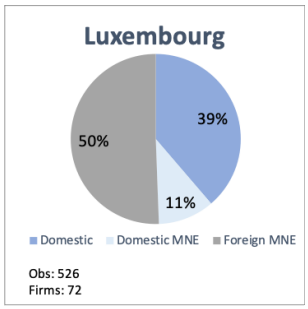
(o) *Firms - Italy*



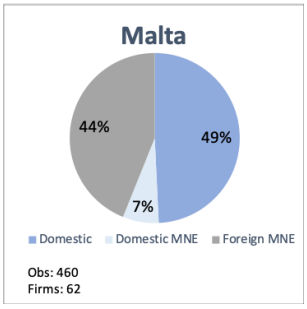
(p) *Firms - Latvia*



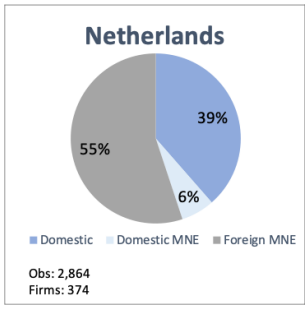
(q) *Firms - Lithuania*



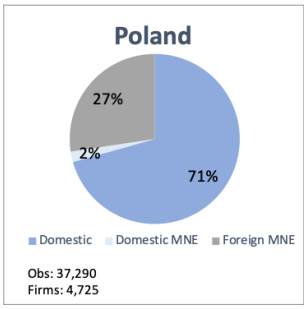
(r) *Firms - Luxembourg*



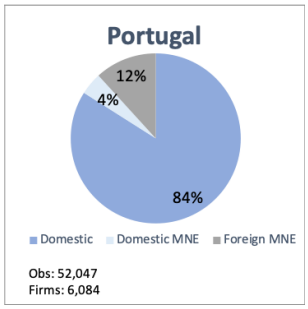
(s) *Firms - Malta*



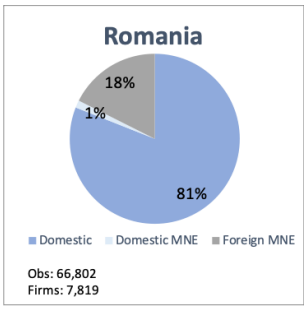
(t) *Firms - Netherlands*



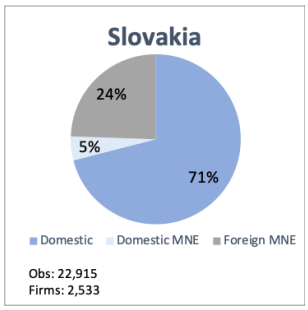
(u) *Firms - Poland*



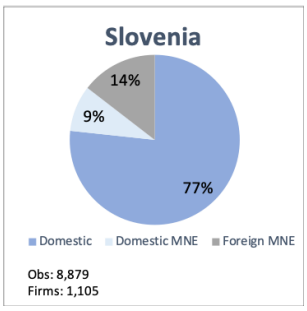
(v) *Firms - Portugal*



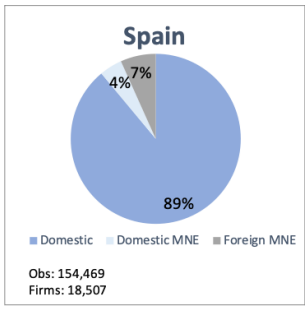
(w) *Firms - Romania*



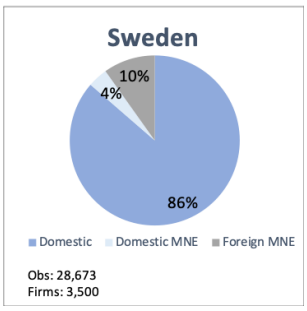
(x) *Firms - Slovakia*



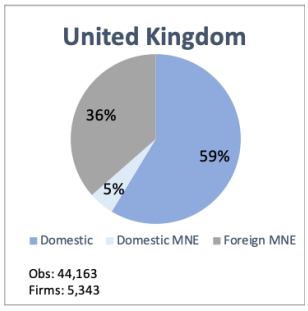
(y) *Firms - Slovenia*



(z) *Firms - Spain*



(aa) *Firms - Sweden*



(ab) *Firms - U.K.*

Notes: This figure provides an overview of the composition of the firms obtained from the AMADEUS database by country for the years 2011 to 2020. A distinction by firm type is made based on the ownership. While domestic firms are firms with a global ultimate owner in the home country, domestic MNEs are firms which have subsidiaries in foreign countries. In contrast to that, foreign MNEs are companies which have a global ultimate owner in a foreign country.

Table C.2: *Estimation - Effect of STR on Intangible Assets + ISIC * Year Interaction*

Depended Variable	(1)	(2)	(3)	(4)	(5)	(6)
Intangible Assets	STR	Tax Base	PIT	Base+PIT	STR_Incr	PatentBox
Panel A - All Firms						
STR_{jt-1}	−1.228**	−1.283**	−1.123**	−1.159*	−1.240**	0.372
	(0.543)	(0.564)	(0.537)	(0.575)	(0.558)	(0.606)
$Size_{ijt}$	0.577***	0.577***	0.577***	0.577***	0.577***	0.576***
	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)
$TaxBase\_Decr_{jt-1}$		0.008		0.007		
		(0.014)		(0.014)		
$TaxBase\_Incr_{jt-1}$		0.018*		0.019*		
		(0.009)		(0.009)		
PIT_{jt-1}			−0.002	−0.002		
			(0.003)	0.003		
STR_Incr_{jt-1}					0.153*	
					(0.078)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.479*	
					(0.230)	
$PatentBox_{jt-1}$						0.579***
						(0.185)
$STR_{jt-1} * PatentBox_{jt-1}$						−2.132***
						(0.6181)
R^2	0.82	0.82	0.82	0.82	0.82	0.82
Observations	1,234,220	1,234,220	1,234,220	1,234,220	1,234,220	1,234,220
Firms	146,251	146,251	146,251	146,251	146,251	146,251
Panel B - Domestic Firms						
STR_{jt-1}	−1.019**	−1.063**	−0.944**	−0.971*	−1.020**	0.329
	(0.460)	(0.476)	(0.492)	(0.540)	(0.480)	(0.700)
$Size_{ijt}$	0.525***	0.524***	0.524***	0.524***	0.525***	0.523***
	(0.094)	(0.093)	(0.094)	(0.093)	(0.094)	(0.094)
$TaxBase\_Decr_{jt-1}$		0.006		0.006		
		(0.016)		(0.016)		
$TaxBase\_Incr_{jt-1}$		0.014**		0.016*		
		(0.007)		(0.007)		
PIT_{jt-1}			0.001	−0.001		
			(0.002)	0.003		
STR_Incr_{jt-1}					0.183**	
					(0.088)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.630**	
					(0.258)	
$PatentBox_{jt-1}$						0.485**
						(0.212)
$STR_{jt-1} * PatentBox_{jt-1}$						−1.828**
						(0.691)
R^2	0.81	0.81	0.81	0.81	0.81	0.81
Observations	975,089	975,089	975,089	975,089	975,089	975,089
Firms	115,917	115,917	115,917	115,917	115,917	115,917
Panel C - Domestic MNE						
STR_{jt-1}	−2.544	−2.923*	−2.099	−2.408	−2.600	0.310
	(1.596)	(1.694)	(1.415)	(1.463)	(1.636)	(1.864)
$Size_{ijt}$	0.932***	0.933***	0.931***	0.931***	0.932***	0.931***
	(0.0877)	(0.087)	(0.088)	(0.088)	(0.088)	(0.088)
$TaxBase\_Decr_{jt-1}$		0.052*		0.054*		
		(0.031)		(0.031)		
$TaxBase\_Incr_{jt-1}$		0.042		0.046*		
		(0.026)		(0.025)		
PIT_{jt-1}			−0.007	0.008		
			(0.006)	0.006		
STR_Incr_{jt-1}					0.314*	
					(0.170)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.962*	
					(0.528)	
$PatentBox_{jt-1}$						1.022
						(0.699)
$STR_{jt-1} * PatentBox_{jt-1}$						−3.969
						(2.309)
R^2	0.82	0.82	0.82	0.82	0.82	0.82
Observations	73,490	73,490	73,490	73,490	73,490	73,490
Firms	8,438	8,438	8,438	8,438	8,438	8,438

Panel D - Foreign MNE						
STR_{jt-1}	−1.830	−1.900	−1.566	−1.633	−1.898	0.595
	(1.371)	(1.350)	(1.226)	(1.202)	(1.373)	(0.781)
$Size_{ijt}$	0.736***	0.737***	0.736***	0.736***	0.736***	0.735***
	(0.079)	(0.078)	(0.079)	(0.078)	(0.079)	(0.080)
$TaxBase\_Decr_{jt-1}$		0.009		0.010		
		(0.008)		(0.009)		
$TaxBase\_Incr_{jt-1}$		0.027		0.027		
		(0.020)		(0.021)		
PIT_{jt-1}			−0.004	−0.004		
			(0.004)	0.004		
STR_Incr_{jt-1}					0.058	
					(0.081)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					0.035	
					(0.231)	
$PatentBox_{jt-1}$						0.816***
						(0.232)
$STR_{jt-1} * PatentBox_{jt-1}$						−2.937***
						(0.833)
R^2	0.82	0.82	0.82	0.82	0.82	0.82
Observations	185,641	185,641	185,641	185,641	185,641	185,641
Firms	21,896	21,896	21,896	21,896	21,896	21,896
Panel E - SME						
STR_{jt-1}	−1.278***	−1.302**	−1.168**	−1.175**	−1.306***	0.386
	(0.460)	(0.486)	(0.492)	(0.547)	(0.469)	(0.684)
$Size_{ijt}$	0.546***	0.546***	0.546***	0.546***	0.546***	0.546***
	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)	(0.102)
$TaxBase\_Decr_{jt-1}$		0.006		0.005		
		(0.016)		(0.017)		
$TaxBase\_Incr_{jt-1}$		0.013*		0.015*		
		(0.007)		(0.008)		
PIT_{jt-1}			−0.002	−0.002		
			(0.002)	0.003		
STR_Incr_{jt-1}					0.159*	
					(0.085)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.472*	
					(0.258)	
$PatentBox_{jt-1}$						0.581***
						(0.190)
$STR_{jt-1} * PatentBox_{jt-1}$						−2.105***
						(0.631)
R^2	0.81	0.81	0.81	0.81	0.81	0.81
Observations	1,064,737	1,064,737	1,064,737	1,064,737	1,064,737	1,064,737
Firms	134,622	134,622	134,622	134,622	134,622	134,622

Notes: This table presents the estimation results of Equation 4.2 to Equation 4.6 in consecutive order from column (1) to (6). It is based on data retrieved from the AMADEUS database including 28 EU countries for the time period from 2011 to 2020 (see Table 4.3). The dependent variable is the reported Intangible Assets of a firm in a given year. It is used as a proxy for innovation. The control variable for the firm size is defined as the log of total assets of a firm in a given year. STR is the statutory corporate tax rate of a country in a respective year. TaxBase_Decr indicates whether the Tax Base in a country for a particular year is decreasing. Similarly, TaxBase_Incr indicates an increase of the Tax Base. PIT measures the personal income tax for each country for every year. STR_Incr takes the value of 1 if a statutory corporate tax rate change is an increase. PatentBox indicates whether a country is running a patent box regime in a particular year.
This Table presents 5 panels. Panel A considers the entire dataset including all firms. Panel B only considers domestic firms, which are firms only supplying a local market without having any foreign affiliates. In contrast to that, Panel C considers Domestic MNEs which are domestic firms which have foreign subsidiaries. Panel D considers Foreign MNEs, which are MNEs with a global ultimate owner (GUO) from a different country. Panel E considers small and medium-sized enterprises (SME). This study classifies a firm as SME when it reports to employ less than 250 employees.
All estimations include an interaction term $industry * year$ which is an interaction term of industry and time fixed-effects. Industries are identified using the ISIC stadard.
All estimations include fixed-effects on the firm-level and time fixed-effects.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table C.3: *Estimation - Effect of STR on Patents Filed + ISIC * Year Interaction*

Depended Variable	(1)	(2)	(3)	(4)	(5)	(6)
Patents Filed	STR	Tax Base	PIT	Base+PIT	STR_Incr	PatentBox
Panel A - All Firms						
STR_{jt-1}	0.584	0.634	1.650	1.617	0.423	3.555**
	(1.647)	(1.711)	(1.606)	(1.693)	(1.671)	(1.738)
$Size_{ijt}$	0.148***	0.149***	0.146***	0.148***	0.148***	0.144***
	(0.047)	(0.045)	(0.048)	(0.046)	(0.047)	(0.047)
$TaxBase\_Decr_{jt-1}$		−0.020		−0.011		
		(0.036)		(0.032)		
$TaxBase\_Incr_{jt-1}$		0.061		0.061		
		(0.050)		(0.049)		
PIT_{jt-1}			−0.016	−0.016		
			(0.014)	0.013		
STR_Incr_{jt-1}					0.040	
					(0.515)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					0.240	
					(0.865)	
$PatentBox_{jt-1}$						0.861**
						(0.338)
$STR_{jt-1} * PatentBox_{jt-1}$						−2.355*
						(1.213)
R^2	0.76	0.76	0.76	0.76	0.76	0.76
Observations	106,977	106,977	106,977	106,977	106,977	106,977
Firms	12,531	12,531	12,531	12,531	12,531	12,531
Panel B - Domestic Firms						
STR_{jt-1}	−0.169	−0.169	−0.476	−0.453	−0.289	−2.555
	(1.414)	(1.323)	(1.175)	(1.132)	(1.466)	(1.872)
$Size_{ijt}$	0.291***	0.291***	0.291***	0.291***	0.289***	0.290***
	(0.091)	(0.091)	(0.090)	(0.090)	(0.090)	(0.091)
$TaxBase\_Decr_{jt-1}$		0.001		−0.001		
		(0.041)		(0.041)		
$TaxBase\_Incr_{jt-1}$		0.028		0.028		
		(0.031)		(0.032)		
PIT_{jt-1}			0.004	0.004		
			(0.008)	0.009		
STR_Incr_{jt-1}					−0.802**	
					(0.311)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					2.550***	
					(0.865)	
$PatentBox_{jt-1}$						−0.620**
						(0.254)
$STR_{jt-1} * PatentBox_{jt-1}$						1.922**
						(0.945)
R^2	0.50	0.50	0.50	0.50	0.50	0.50
Observations	56,994	56,994	56,994	56,994	56,994	56,994
Firms	6,699	6,699	6,699	6,699	6,699	6,699
Panel C - Domestic MNE						
STR_{jt-1}	4.475**	4.647**	5.614***	5.609***	4.327*	8.045***
	(2.194)	(2.248)	(1.947)	(1.990)	(2.272)	(1.748)
$Size_{ijt}$	0.113	0.113	0.112	0.112	0.116	0.109
	(0.081)	(0.082)	(0.081)	(0.081)	(0.081)	(0.082)
$TaxBase\_Decr_{jt-1}$		−0.040		−0.024		
		(0.036)		(0.037)		
$TaxBase\_Incr_{jt-1}$		0.049		0.046		
		(0.054)		(0.055)		
PIT_{jt-1}			−0.026	−0.024		
			(0.017)	0.017		
STR_Incr_{jt-1}					0.336	
					(0.471)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.541	
					(1.326)	
$PatentBox_{jt-1}$						1.787***
						(0.437)
$STR_{jt-1} * PatentBox_{jt-1}$						−5.352***
						(1.588)
R^2	0.79	0.79	0.79	0.79	0.79	0.79
Observations	21,519	21,519	21,519	21,519	21,519	21,519
Firms	2,492	2,492	2,492	2,492	2,492	2,492

Panel D - Foreign MNE						
STR_{jt-1}	−1.334	−1.320	−0.174	−0.222	−1.430	1.165
	(1.273)	(1.306)	(1.558)	(1.558)	(1.248)	(1.309)
$Size_{ijt}$	0.095***	0.097***	0.092**	0.094***	0.096***	0.090**
	(0.037)	(0.035)	(0.038)	(0.036)	(0.037)	(0.040)
$TaxBase\_Decr_{jt-1}$		−0.020		−0.011		
		(0.037)		(0.032)		
$TaxBase\_Incr_{jt-1}$		0.076		0.077		
		(0.064)		(0.064)		
PIT_{jt-1}			−0.017	−0.016		
			(0.015)	0.014		
STR_Incr_{jt-1}					0.267	
					(0.953)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					−0.489	
					(2.576)	
$PatentBox_{jt-1}$						0.489**
						(0.243)
$STR_{jt-1} * PatentBox_{jt-1}$						−0.885
						(0.989)
R^2	0.81	0.81	0.81	0.81	0.81	0.81
Observations	28,300	28,300	28,300	28,300	28,300	28,300
Firms	3,340	3,340	3,340	3,340	3,340	3,340
Panel E - SME						
STR_{jt-1}	−0.204	−0.219	−0.620	−0.593	−0.277	−1.396
	(1.017)	(1.078)	(1.029)	(1.108)	(1.087)	(1.571)
$Size_{ijt}$	0.203*	0.203*	0.203*	0.203*	0.202*	0.202*
	(0.112)	(0.111)	(0.112)	(0.111)	(0.112)	(0.112)
$TaxBase\_Decr_{jt-1}$		0.013		0.013		
		(0.030)		(0.029)		
$TaxBase\_Incr_{jt-1}$		0.024		0.022		
		(0.038)		(0.040)		
PIT_{jt-1}			0.005	0.004		
			(0.007)	0.007		
STR_Incr_{jt-1}					−0.860	
					(0.552)	
$STR_{jt-1} * STR\_Incr_{jt-1}$					2.946**	
					(1.496)	
$PatentBox_{jt-1}$						−0.342
						(0.247)
$STR_{jt-1} * PatentBox_{jt-1}$						1.264
						(0.949)
R^2	0.39	0.39	0.39	0.39	0.39	0.39
Observations	76,010	76,010	76,010	76,010	76,010	76,010
Firms	9,485	9,485	9,485	9,485	9,485	9,485

Notes: This table presents the estimation results of Equation 4.2 to Equation 4.6 in consecutive order from column (1) to (6). It is based on data retrieved from the AMADEUS database including 28 EU countries for the time period from 2011 to 2020 (see Table 4.3). The dependent variable is the number of patents filed of a firm in a given year (see Equation 4.7). It is used as a proxy for innovation. The control variable for the firm size is defined as the log of total assets of a firm in a given year. STR is the statutory corporate tax rate of a country in a respective year. TaxBase_Decr indicates whether the Tax Base in a country for a particular year is decreasing. Similarly, TaxBase_Incr indicates an increase of the Tax Base. PIT measures the personal income tax for each country for every year. STR_Incr takes the value of 1 if a statutory corporate tax rate change is an increase. PatentBox indicates whether a country is running a patent box regime in a particular year.
This Table presents 5 panels. Panel A considers the entire dataset including all firms. Panel B only considers domestic firms, which are firms only supplying a local market without having any foreign affiliates. In contrast to that, Panel C considers Domestic MNEs which are domestic firms which have foreign subsidiaries. Panel D considers Foreign MNEs, which are MNEs with a global ultimate owner (GUO) from a different country. Panel E considers small and medium-sized enterprises (SME). This study classifies a firm as SME when it reports to employ less than 250 employees.
Firms which do not have any patents and reported 0 patents for all the years are dropped from the estimation due to fixed effects. Therefore, the sample sizes in the estimations are significantly smaller than the original size of the dataset presented in Table 4.3.
For this count model a poisson regression is conducted.
All estimations include an interaction term $industry * year$ which is an interaction term of industry and time fixed-effects. Industries are identified using the ISIC stadard.
All estimations include fixed-effects on the firm-level and time fixed-effects.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table C.4: *Robustness - Intangibles Assets - Lags and Leads*

Depended Variable *Intangible Assets*	(1)	(2)	(3)	(4)
Panel A - All Firms				
STR_{jt}	0.049	−0.177		−0.452
	(0.273)	(2.555)		(0.290)
STR_{jt-1} *lag*1	−1.502**	−1.738***	−1.765**	−1.946***
	(0.661)	(0.608)	0.653	(0.684)
STR_{jt-2} *lag*2				0.518
				(0.698)
STR_{jt-3} *lag*3		−0.222	−0.274	−0.518
		0.815	(0.803)	0.802
STR_{jt+1} *lead*1				0.006
				0.005
STR_{jt+2} *lead*2	0.006	0.007		0.004
	0.006	0.004		0.003
STR_{jt+3} *lead*3		−0.000	0.004	0.001
		0.004	0.005	0.004
Size_ijt	0.0557***	0.539***	0.539***	0.539***
	0.084	0.081	0.081	0.081
R^2	0.84	0.85	0.85	0.85
Observations	1,088,156	949,371	949,371	949,371
Firms	146,212	146,198	146,198	146,198
Panel B - Domestic Firms				
STR_{jt}	−0.075	−0.170		−0.408
	(0.324)	(0.332)		(0.293)
STR_{jt-1} *lag*1	−1.128**	−1.507**	−1.543	−1.919***
	(0.454)	(0.571)	0.678	(0.631)
STR_{jt-2} *lag*2				0.913
				(0.624)
STR_{jt-3} *lag*3		0.276	0.234	−0.230
		0.677	(0.660)	0.679
STR_{jt+1} *lead*1				0.005
				0.005
STR_{jt+2} *lead*2	0.004	0.006		0.003
	0.007	0.004		0.002
STR_{jt+3} *lead*3		−0.000	0.003	0.001
		0.004	0.005	0.004
Size_ijt	0.505***	0.487***	0.487***	0.487***
	0.091	0.088	0.088	0.088
R^2	0.82	0.83	0.83	0.83
Observations	860,550	750,708	750,708	750,708
Firms	115,896	115,890	115,890	115,890
Panel C - Domestic MNE				
STR_{jt}	0.437	−0.333		−0.863
	(0.560)	(0.578)		(0.0537)
STR_{jt-1} *lag*1	−3.326	−3.575**	−3.604	−3.458**
	(2.015)	(1.556)	1.506	(1.603)
STR_{jt-2} *lag*2				−0.056
				(1.290)
STR_{jt-3} *lag*3		−1.832	−2.138	−1.809
		2.782	(2.730)	2.295
STR_{jt+1} *lead*1				0.011
				0.007
STR_{jt+2} *lead*2	0.022*	0.025***		0.020***
	0.012	0.008		0.005
STR_{jt+3} *lead*3		−.0.006	0.006	−0.005
		0.007	0.009	−.008
Size_ijt	0.917***	0.893***	0.892***	0.892***
	0.088	0.086	0.086	0.086
R^2	0.83	0.85	0.85	0.85
Observations	64,582	56,434	56,434	56,434
Firms	8,427	8,426	8,426	8,426

Panel D - Foreign MNE				
STR_{jt}	0.462	0.073		−0.110
	(0.424)	(0.392)		(0.407)
STR_{jt-1} *lag*1	−2.622	−1.533*	−1.443**	−0.818
	(1.627)	(0.788)	0.694	(0.883)
STR_{jt-2} *lag*2				−1.570*
				(0.833)
STR_{jt-3} *lag*3		−2.050	−2.083	−1.142
		1.462	(1.455)	0.407
STR_{jt+1} *lead*1				0.005
				0.005
STR_{jt+2} *lead*2	0.009	0.002		0.001
	0.006	0.006		0.005
STR_{jt+3} *lead*3		0.001	0.002	−0.001
		0.005	0.008	0.005
Size_ijt	0.717***	0.704***	0.704***	0.704***
	0.077	0.076	0.076	0.076
R^2	0.83	0.84	0.84	0.84
Observations	163,024	142,229	142,229	142,229
Firms	21,889	21,882	21,882	21,882
Panel E - SME				
STR_{jt}	−0.096	−0.259		−0.469
	(0.276)	(0.291)		(0.305)
STR_{jt-1} *lag*1	−1.492***	−1.769***	−1.850***	−1.988***
	(0.495)	(0.558)	0.644	(0.597)
STR_{jt-2} *lag*2				0.502
				(0.607)
STR_{jt-3} *lag*3		−0.300	−0.329	−0.574
		0.568	(0.566)	0.687
STR_{jt+1} *lead*1				0.005
				0.005
STR_{jt+2} *lead*2	0.009	0.007		0.005*
	0.005	0.005		0.003
STR_{jt+3} *lead*3		0.001	0.005	0.002
		0.004	0.005	0.004
Size_ijt	0.526***	0.510***	0.510***	0.510***
	0.100	0.098	0.098	0.098
R^2	0.82	0.84	0.84	0.84
Observations	941,041	818,176	818,176	818,176
Firms	133,844	132,237	132,237	132,237

Notes: This table presents various robustness checks with various lags and leads of STR. It is based on data retrieved from the AMADEUS database including 28 EU countries for the time period from 2011 to 2020 (see Table 4.3). The dependent variable is the reported intangible assets of a firm in a given year. It is used as a proxy for innovation. STR is the statutory corporate tax rate of a country in a respective year.
This Table presents 5 panels. Panel A considers the entire dataset including all firms. Panel B only considers domestic firms, which are firms only supplying a local market without having any foreign affiliates. In contrast to that, Panel C considers Domestic MNEs which are domestic firms which have foreign subsidiaries. Panel D considers Foreign MNEs, which are MNEs with a global ultimate owner (GUO) from a different country. Panel E considers small and medium-sized enterprises (SME). This study classifies a firm as SME when it reports to employ less than 250 employees.
Due to various lags and leads of STR, the sample sizes in the estimations are smaller than the original sample size presented in Table 4.3.
All estimations include fixed-effects on the firm-level and time fixed-effects.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table C.5: *Robustness - Patents Filed - Lags and Leads*

Depended Variable	(1)	(2)	(3)	(4)
Intangible Assets	R1	R2	R3	R4
Panel A - All Firms				
STR_{jt}	1.634	1.017		1.436
	(1.206)	(0.962)		(0.986)
STR_{jt-1} *lag*1	−0.172	4.978***	5.374***	4.634***
	(1.859)	(1.448)	1.323	(1.559)
STR_{jt-2} *lag*2				1.043
				(2.061)
STR_{jt-3} *lag*3		−5.444**	−5.198**	−6.102***
		2.113	(2.076)	1.980
STR_{jt+1} *lead*1				−0.011**
				0.005
STR_{jt+2} *lead*2	0.014	−0.026*		−0.022
	0.018	0.012		0.014
STR_{jt+3} *lead*3		0.036***	0.023	0.037***
		0.012	0.016	0.013
Size_ijt	0.147***	0.152***	0.150***	0.153***
	0.048	0.044	0.043	0.044
R^2	0.75	0.76	0.76	0.76
Observations	95,087	80,243	80,243	80,243
Firms	12,490	12,046	12,046	12,046
Panel B - Domestic Firms				
STR_{jt}	1.008	1.300		1.441
	(1.057)	(1.008)		(0.855)
STR_{jt-1} *lag*1	−0.756	1.833	2.585**	0.057
	(1.361)	(1.287)	1.192	(1.360)
STR_{jt-2} *lag*2				4.612*
				(2.761)
STR_{jt-3} *lag*3		0.161	0.103	−2.761
		2.555	(2.591)	3.608
STR_{jt+1} *lead*1				−0.007
				0.014
STR_{jt+2} *lead*2	0.019*	−0.011		−0.010
	0.011	0.016		0.013
STR_{jt+3} *lead*3		0.050***	0.045***	0.055***
		0.017	0.017	0.017
Size_ijt	0.281***	0.261***	0.260***	0.263***
	0.092	0.088	0.087	0.087
R^2	0.49	0.49	0.49	0.49
Observations	50,621	42,516	42,516	42,516
Firms	6,670	6,399	6,399	6,399
Panel C - Domestic MNE				
STR_{jt}	1.987	1.382		1.528
	(1.649)	(1.159)		(1.176)
STR_{jt-1} *lag*1	3.423	10.049***	10.863	9.700***
	(2.455)	(1.066)	1.420	(1.286)
STR_{jt-2} *lag*2				1.107
				(2.489)
STR_{jt-3} *lag*3		−9.209***	−9.048***	−9.848***
		2.548	(2.519)	1.986
STR_{jt+1} *lead*1				−0.006
				0.011
STR_{jt+2} *lead*2	0.009	−0.028**		−0.026**
	0.015	0.013		0.0111
STR_{jt+3} *lead*3		0.038***	0.026*	0.040***
		0.012	0.014	0.015
Size_ijt	0.113	0.113	0.110	0.115
	0.084	0.092	0.088	0.093
R^2	0.78	0.79	0.79	0.79
Observations	19,194	16,298	16,298	16,298
Firms	2,485	2,414	2,414	2,414

Panel D - Foreign MNE				
STR_{jt}	1.898	0.811		1.568
	(1.732)	(1.676)		(1.927)
STR_{jt-1} *lag*1	−2.238	2.711	2.853***	2.692
	(1.690)	(1.929)	1.082	(2.198)
STR_{jt-2} *lag*2				0.158
				(2.534)
STR_{jt-3} *lag*3		−4.555**	−4.222**	−4.691**
		1.993	(1.782)	2.005
STR_{jt+1} *lead*1				−0.016*
				0.010
STR_{jt+2} *lead*2	0.013	−0.027		−0.020
	0.023	0.018		0.020
STR_{jt+3} *lead*3		0.031**	0.018	−0.029**
		0.013	0.021	0.015
Size_ijt	0.097***	0.104***	0.102***	0.105***
	0.037	0.030	0.030	0.029
R^2	0.80	0.81	0.81	0.81
Observations	25,245	21,402	21,402	21,402
Firms	3,335	3,233	3,233	3,233
Panel E - SME				
STR_{jt}	0.726	0.320		0.464
	(1.688)	(1.271)		(1.055)
STR_{jt-1} *lag*1	−0.498	3.350***	3.148**	1.585
	(1.592)	(1.290)	1.275	(1.378)
STR_{jt-2} *lag*2				4.266**
				(1.787)
STR_{jt-3} *lag*3		−2.024	−1.635	−4.705
		2.907	(3.057)	3.054
STR_{jt+1} *lead*1				−0.004
				1.055
STR_{jt+2} *lead*2	0.009	−0.027***		−0.026**
	0.017	0.010		0.010
STR_{jt+3} *lead*3		0.049***	0.036*	0.052***
		0.017	0.019	0.019
Size_ijt	0.205**	0.193**	0.193**	0.193**
	0.110	0.094	0.095	0.094
R^2	0.37	0.37	0.37	0.37
Observations	67,615	56,756	56,756	56,756
Firms	9,431	8,992	8,992	8,992

Notes: This table presents various robustness checks with various lags and leads of STR. It is based on data retrieved from the AMADEUS database including 28 EU countries for the time period from 2011 to 2020 (see Table 4.3). The dependent variable is the number of patents filed of a firm in a given year. It is used as a proxy for innovation. STR is the statutory corporate tax rate of a country in a respective year.
This Table presents 5 panels. Panel A considers the entire dataset including all firms. Panel B only considers domestic firms, which are firms only supplying a local market without having any foreign affiliates. In contrast to that, Panel C considers Domestic MNEs which are domestic firms which have foreign subsidiaries. Panel D considers Foreign MNEs, which are MNEs with a global ultimate owner (GUO) from a different country. Panel E considers small and medium-sized enterprises (SME). This study classifies a firm as SME when it reports to employ less than 250 employees.
Firms which do not have any patents and reported 0 patents for all the years are dropped from the estimation due to fixed effects. Further, STR is considered with various lags and leads. Therefore, the sample sizes in the estimations are significantly smaller than the original size of the dataset presented in Table 4.3.
For this count model a poisson regression is conducted.
All estimations include fixed-effects on the firm-level and time fixed-effects.
Clustered standard errors at the country level are presented in parenthesis.
* denotes significance at the 10% level, ** at the 5% level, *** at the 1% level.

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