Norwegian School of Economics
Bergen, Spring 2021

The Effect from Taxes on the Location of Patents

A quantitative research on affiliates within European multinational enterprises

Anker Albert, Major in Business Analysis and Performance Management

Are Kjetså Hole, Major in Business Analysis and Performance Management

Supervisors: Mohammed Mardan and Steffen Juranek

Master Thesis

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

In this thesis, we examine how multinational enterprises strategically allocate their patents in order to reduce the consolidated tax burdens. It is crucial to acknowledge the importance of patents in profit shifting, because it concerns a considerable proportion of lost revenues for European countries. These types of profit shifting strategies have been studied by several researchers previously, but many of them have lost their topicality. Patent box regimes and changes in statutory income tax rates have changed the tax regulatory environment in Europe substantially. However, the effect of these recent changes has received little attention by academics. This thesis aims to fill this academic gap by providing empirical results from a dataset that has a high degree of recency, which thus includes relevant tax deductions from implemented patent boxes. In order to investigate how patents are being used in profit shifting activities, we have adopted the empirical approach from Karkinsky & Riedel (2012). Furthermore, to provide a basis of empirical evidence of profit shifting, we have used a model based on the methodological approach from Böhm, Karkinsky, Knoll, & Riedel (2015). This is a logistic model that estimates the probability of the patent inventor and the patent applicant being geographically separated. By doing so, we provide empirical results that will contribute to strengthening the validity of our main analysis. In the last part of this thesis, we investigate whether high- or low-quality patents are predominantly used in profit shifting activities. Hence, this thesis aims to help tax authorities identifying which patents are more likely to be used in profit shifting activities. Finally, the associated semi-elasticities will be calculated in order for the results to be comparable to previous literature.

Acknowledgements

We would like to thank our supervisors, Mohammed Mardan and Steffen Juranek, for great engagement and invaluable feedback during the entirety of our master thesis. Their knowledge is unmatched in this field and has been of great inspiration while writing this thesis. Furthermore, we would like to show our sincerest gratitude to the Norwegian Tax Authority for entrusting our master thesis and giving us a grant. Their professional recognition has been highly appreciated while writing in a field we previously did not have much knowledge in. Finally, we want to thank our friends and family for their continuous support throughout the writing process. This has been a tough semester characterized by home office and corona, so your support, humour and input has been essential to both our master and well-being.

Most of this thesis has been written within the four walls of Are's 10 square meter dormitory, and we are happy to say that we are still the best of friends.

Anker Albert

Are Kjetså Hole

Table of Contents

Table of Tables

1 Introduction

International differences in statutory income tax rates enables multinational enterprises (hereafter MNEs) to develop favourable tax planning strategies and cause a yearly loss of tax revenues around 650 billion dollars (Crivelli, De Mooij, & Keen, 2016). MNEs can exploit international tax variations by using different mechanisms by shifting their profits to countries with favourable corporate income tax rates. MNEs may engage in profit shifting activities through e.g., transfer price manipulation, intra-company debt, or strategic location of intangible assets. Tax planning activities among MNEs have been greatly debated, and several studies on this topic highlight how severe the economic consequences are. The discrepancy emerges because governments lose a substantial proportion of their tax revenues, whilst many MNEs consider these activities to be both legal and necessary in order to maintain competitive.

For this thesis, we investigate if, and to what extent, patents are being used in profit shifting activities. Previous studies have given evidence of the extent of which patents are being used as instruments to minimize the consolidated tax burdens. Many acclaimed companies such as Microsoft[1], Apple[2] and Starbucks Corporation[3] have been under accusation of using patent-shifting mechanisms in order to avoid taxes. Significant corporate income tax revenues are lost because MNEs chose to apply for their patents in countries where the tax rates are low. By doing so, affiliates can exaggerate the transfer price on licensing the usage of the patents to other affiliates, and thus reduce the profits of the subsidiaries located in high tax countries. Basing the thesis on the empirical approach proposed by Karkinsky and Riedel (2012) and Böhm et al. (2015), we provide empirical evidence that MNEs are still using patents as instruments in profit shifting activities. Furthermore, this thesis elaborates on whether high or low-quality patents are primarily being used in tax planning activities and will provide the associated semi-elasticities for the different quality patents.

---

[1] See (Hickey, 2013), available at https://www.businessinsider.com/apple-microsoft-avoids-taxes-loopholes-irs-2013-1?r=US&IR=T
[2] See (Gleckman, 2013), available at https://www.forbes.com/sites/beltway/2013/05/21/the-real-story-about-apples-tax-avoidance-how-ordinary-it-is/
[3] See (The Economist, 2012), available at https://www.economist.com/business/2012/12/15/wake-up-and-smell-the-coffee

An overarching approach in this thesis has been to produce results that are valid and insightful in the economic and tax regulatory environment in Europe today. In recent years, several European countries have introduced patent box regimes, which incentivizes patent applications. To account for this and provide an analysis with a high degree of topicality, the recency of the time period has been particularly accentuated. A combination between availability of data, and an overall aim to obtain a high degree of topicality, has resulted in a thesis that includes observations from 2011 to 2017.

The data sample consists of companies from the EU-27[4], in addition to Norway, Switzerland and the United Kingdom. The most imperative reason for choosing these countries comes from the availability of data concerning European intangible assets. Professor Juranek at NHH provided us with the data basis, which has been further complemented with data from the European Patent Office and the Organization for Economic Co-operation and Development (hereafter EPO and OECD). Even though our thesis excludes non-European countries, the remaining still represents a high number compared to previous literature. If there is adequate affiliate specific data available from a country, we see no reason why they should not be included.

During the early 2000s, governments raised concerns regarding the increasing relocation of valuable intangible property to low-tax economies (Hejazi, 2006, p. 399). As a result, policymakers implemented different strategies to limit the magnitude of profit shifting, e.g., through the introduction of strict transfer pricing regulations, controlled foreign corporation rules (CFC), and thin capitalization rules. The most notable of these that are mentioned in previous literature is the CFC-rules. Our thesis does not account for this as they are abolished by the EU. Instead, we include the intellectual property box regimes that some argue is a direct consequence from the abolishment of CFC rules (Bräutigam, Spengel, & Streif, 2015, p. 3).

The average statutory corporate income tax rates (hereafter CIT rates) have steadily been declining. According to the OECD, the European CIT rates have been falling from 48.5% in 1985 to 24.18% in 2017 (Alstadsæter, Barrios, Nicodeme, Skonieczna, & Vezzani, 2018, p. 136). The general decrease in CIT rates ultimately results in smaller tax differences between European

[4] There were not adequate data from Lithuania to perform the desired analysis, which is why this country has been removed. Only 26 of the 27 of the EU countries are therefore included.

countries. This in turn means that interconnected tax planning prospects might not be as profitable as they previously were. However, because of the introduction of multiple patent box regimes, the effective tax differences on income generated by patents in Europe has endured. There is moderate empirical evidence on the significance of patent box regimes on research and development (hereafter R&D) and strategic patent location. Several studies have given evidence of a negative connection between the corporate income tax rates and affiliates' amount of intangible assets (see e.g., Dischinger and Riedel (2011), Ernst and Spengel (2011), Karkinsky and Riedel (2012), Böhm et al. (2014), Ernst et al. (2014), or Griffith et al. (2014)), but few include the impact of patent box regimes. This is partly due to the somewhat outdated data used in previous studies, where only a limited number of countries had actually implemented patent boxes.

In recent years, patent box regimes have been implemented in several European countries, which substantially increases the differences in taxes applicable to income generated by patent royalties. In order for our thesis to reflect these differences, it is crucial to include patent boxes and their associated tax deductions. The regimes have been implemented to stimulate and attract R&D investments and will potentially have great impact on location of patents. There are no European regulations that determine how tax deductions from patent boxes are calculated (EY, 2020). Some deductions are a percentage of the statutory corporate income tax, others have a flat tax on all income received from patents. The difference between CIT rates and tax deductions from patent box regimes vary substantially. The effective reduction in taxes differ from 35% in Malta, to 4.5% in Hungary[5]. We suspect that the introduction of patent boxes has considerably changed the way MNEs carries out their tax planning activities.

Several studies point out that the arm's length price of intra-firm transfers of intangibles is challenging to observe and determine (Choi, Ishikawa, & Okoshi, 2020). As a result, MNEs have an incentive to shift profits from subsidiaries in high-tax economies to intangible-holding-affiliates in low-tax economies by exaggerating the actual arm's length prices of royalties and licenses. Furthermore, there are no viable source where we can observe relocations of patents within multinational enterprises after the application process. Hence, some of the methods of unveiling possible tax planning activities are not accessible. However, we can observe a strong suggestive

[5] See appendix, table D for overview of patent box countries and their associated tax deductions form patent boxes.

indicator of profit shifting if the inventor of a patent is located in a different location than where the MNE carries out the patent application. The inventor of a patent does not necessarily have to be its legal owner, and thus the entirety of the application process can be done by an affiliate located in a different country. This in turn enables affiliates that are part of an MNE to strategically locate the patent in a country with favourable tax deductions, or where the CIT rate is lower compared to the inventor country. Böhm et al. (2015) claims that this is one of the most common patent related strategies MNEs engage in to shift profits. For this reason, their methodology will be used as a point of departure for giving empirical evidence of profit shifting in our data sample.

In order to add valuable results to existing literature, we have added an extension of our model by separating high- and low-quality patents. The first patent applications at the EPO dates back to 1978, and since then there have been a wide array of suggestions for determining the quality of a patent. It is not straight forward to determine whether a patent is high- or low-quality, and different fields of studies recognizes contrasting characteristics. For engineers, a high-quality patent is likely to be a patent with a clearly described content that secures a major invention, instead of an incremental advance in technology. On the other hand, economists might argue that a patent is recognized as high-quality if it achieves the key objectives of the patent system. This can for instance be to incentivize or reward, while also facilitating further technological development, and thus economic growth. Legal scholars conversely often value a patent's quality by its capability to endure a legal test without being discredited. Due to the nature of patents and their ability to cover a variety of fields, a general quality indicator must therefore cover a multitude of aspects.

In order to determine a patent's quality, we have adopted a quality indicator that has been comprised by Squicciarini, Dernis and Criscuolo (2013) from the department of science, technology and industry at OECD (hereafter STI). Choosing the indicators that have been developed by STI is applicable for several reasons. The calculations of the quality indicators are built on extensive literature, it relies on information from the relevant patent application form and are calculated on patent cohort.[6] The cohorts are based on a combination of the year of filing and the technology field. By doing so, the calculation of the quality indicator will account for potential technology- and time-related shocks. After deciding a suitable quality indicator, it is important to

[6] For further discussion about patent quality, see Squicciarini, Dernis and Criscuolo (2021).

determine a threshold where a patent can be characterized as a high-quality patent. The quality indicator provided by STI only provides a number, and we have to decide which percentile that adequately represents a high-quality patent. The threshold might be debatable, which is why we have set up three different thresholds in order to analyse the elasticities at three different percentiles[7].

We will analyse profit shifting mechanisms in the same manner that has been done by previous studies. In order to make the results viable in the economic and tax regulatory environment in Europe today, the degree of recency in the time sample is high. Furthermore, we will take the analysis a step further by separating low- and high-quality patents and provide their respective elasticities. Thus, the research question for this thesis is:

Do multinational enterprises strategically locate patents in order to shift profits and reduce the consolidated tax burdens, and are high- or low-quality patents predominantly used in these strategies?

This thesis provides further insights and contributes to previous literature in multiple ways. Firstly, the current published articles concerning patents and profit shifting have somewhat lost their topicality, due to large changes in tax policies in recent times (see e.g., Dischinger and Riedel (2011), Ernst and Spengel (2011), Karkinsky and Riedel (2012), Böhm et al. (2014), Ernst et al. (2014), or Griffith et al. (2014)). Some of the largest changes in corporate income tax rates have occurred in recent times. Simultaneously, the initiation of patent box regimes in several countries in Europe has sparked a new method for MNEs to strategically engage in tax planning activities. To our knowledge, the only literature that estimates the effects of relevant patent box regimes has been conducted by Alstadsæter et al. (2018). We compliment this literature by utilizing a time sample from 2011 – 2017, whereas theirs is from 2000 – 2012. This thesis thus comprehends newly introduced patent box regimes that have been implemented post 2012.

Furthermore, we include a more comprehensive number of European countries than previous studies (see e.g., Ernst and Spengel (2011), Karkinsky and Riedel (2012), Böhm et al. (2014), or

[7] For further explanation about quality indicator thresholds, see section 4.

Griffith et al. (2014))[8]. Excluding countries with beneficial tax regimes, and thus a high likelihood of being used for tax avoidance activities, might be a source of disruption to the results. Moreover, by including more countries, our dataset also provides a larger number of affiliates. The inclusion of these affiliates increases the probability of capturing important profit shifting activities that are being done in Europe.

Previous literature has primarily focused on intangible assets in general, whereas this thesis will study what type of patents that are predominantly used for tax planning activities. As formerly stated, we will investigate whether high- or low-quality patents are being used as a mean to avoid taxes. By doing so, this thesis will provide an understanding to whether a large number of low-quality patents, or a small number of high-quality are most frequently used in profit shifting activities. The analysis we provide thereby further relates to Alstadsæter et al. (2018), who also separate patents by their quality.

To prove that patents are being used for profit shifting, previous studies have mainly aimed attention to the number of patent applications per affiliate, and how sensitive the number of patent applications are to differences in European taxes. Karkinsky and Riedel (2012) use the number of patent applications as their dependent variable throughout their studies, and similar research has not introduced significant varieties to the dependent variable (see e.g., Griffith et al. 2014, Dudar & Voget, (2015)). By doing so, the results will primarily be indicative, and not necessarily give more than anecdotal evidence of profit shifting. Countries with handsome tax deductions on income generated from patents will naturally attract R&D investors, and thus it is expected to see a growth in patent applications. This evidently means that there are complications when ascertaining the results as empirical evidence of profit shifting.

In order to cope with these complications, we will implement a similar model to the one proposed by Böhm et al. (2014, p.12). In order to evidence profit shifting in European countries, they examine how the location of the patent applicant and patent inventor is geographically separated. Specifically, the model studies the probability of a patent inventor being in a different country than where the patent is applied for. However, their empirical approach differs from ours as they do not

[8] Ernst and Spengel (2011) include 20 countries, Karkinsky and Riedel (2012) include 18 countries, Böhm et al. (2014) include 22 countries and Griffith et al. (2014) include 15 countries.

include the statutory income tax rate in the inventor country as an independent variable. Their independent variable of interest is the applicant country CIT rate, whereas we consider the inventor country CIT rate to be equally important. When MNEs decide where to apply for a patent, both the applicant country and inventor country CIT rates are decisive. Therefore, we will have two main regressors in our analysis. Thus, we are able to analyse how tax differences between inventor country and applicant country determines where the MNE will conduct the patent application.

There are three different models in this thesis, which can be summarized as follows: The first model aims to give empirical evidence of profit shifting activities. The model estimates the probability of patent applicant and patent inventor to be geographically separated. The second model focuses on number of patent applications per affiliate, and how sensitive they are to changes in European tax rates. Finally, the third model is an extension of the second model, which investigates whether low- or high-quality patents are predominantly used in profit shifting activities. For simplicity reasons, these models will henceforth be called the inventor model, main model and quality model.

This thesis is structured in eight parts and proceeds as follows: Section 2 will shortly review the existing literature that have been done on this topic, and how it relates to our thesis. Section 3 will introduce theoretical considerations and predictions of the models that are going to be used. Section 4 will continue with the relevant data description, followed by section 5 which demonstrates our empirical strategy. Thereafter, section 6 will present and analyse the empirical results from our three models. In order to strengthen our results, various samples and specification choices of our results will be examined by performing robustness tests in section 7. Finally, section 8 consists of concluding statements.

2 Literature review

In order to delineate the academic climate on this topic, this section will review previous literature and their findings. As our thesis is built upon the research of Karkinsky and Riedel (2012) and Böhm et al. (2015), their findings are valuable knowledge to our analysis. Further studies that are examining this field will be outlined to establish an academic basis to compare our results.

According to Dischinger and Riedel (2011, p. 691), affiliates within an MNE had little to no fees for using patents or trademarks until the early 1990s. However, as intangible assets have become critical factors in product innovation and marketing, owners of intellectual property started charging affiliates, resulting in intra-firm trade of immaterial goods. Furthermore, the authors point to anecdotal evidence that MNEs transfer their intellectual property to low-tax jurisdictions. For instance, Pfizer and Microsoft have relocated much of their R&D holdings and patents in Ireland. Some companies have even founded intangible-holding companies in tax havens that own and administer their brands and licenses. Shell, for instance, has located their brand management at a Swiss affiliate where they charge royalties to operating affiliates worldwide (Dischinger and Riedel, 2011, p 691). In addition, several financial consultancies promote global tax planning strategies by relocating intellectual property to low-tax affiliates.

Profit shifting by locating intellectual property in low-tax economies is a relatively new field of study. Dischinger and Riedel (2011) were among the first to study empirically whether there is a systematic behaviour amid MNEs to shift profits by relocating their intangible assets to low-tax countries. Using panel data consisting of 23 EU countries for ten years, Dischinger and Riedel (2011, p. 692) analyse *"whether corporate taxes distort the location of intangible assets within a corporate group"*. Their results suggest that subsidiaries with the lowest relative corporate tax rate within the multinational group hold a higher level of intangible assets. Furthermore, as MNEs are increasingly aware that intellectual property is an essential factor in contributing to the overall profit and marketing, their results suggest that multinationals distort these assets' location to minimize their overall tax liabilities. The semi-elasticity of their study is -1.7, expressing that a one percentage point decrease in the average tax difference to all affiliates in the MNE raises the number of intangible assets in an affiliate by around 1.7% on average (p. 700).

In the works of Karkinsky and Riedel (2012), they narrow their scope of research by excluding intangible assets such as trademarks and copyrights, focusing on patents only within multinationals and whether their location is affected by corporate taxation. Using a unique dataset that combines company accounting data with information on patent applications provided by the EPO, they find that a subsidiary's number of patent applications are substantially and negatively affected by corporate taxation. Their results prevail when controlling for affiliate size, firm-fixed effects, and time-varying country characteristics. Furthermore, the results withhold when they account for CFC legislation and the role of withholding taxes on royalty payments. Unlike the study of Dischinger and Riedel (2011), Karkinsky and Riedel (2012) include two regressors of interest, the tax rate differential to other group affiliates and corporate tax rates. Both variables exert a significantly negative effect on the number of patent applications. According to their estimates, the semi-elasticity of their results is around -3.5. This suggests that a one percentage point decrease in corporate tax rates will, in general, increase the number of patent applications in an affiliate by 3.5%.

The research by Griffith et al., (2014) conforms to the findings of Dischinger, Karkinsky and Riedel. Using an even large time sample (1985-2005), they also find that reforms with preferential tax treatments on patent income, such as patent boxes, have a substantial effect on where MNEs choose to locate their intellectual property.

Böhm et al. (2015, p. 4) discuss the main reasons why patents are considered attractive instruments for shifting income. First, R&D activities typically generate higher-than-average returns (see e.g., Hall, Mairesse, & Mohnen, 2009)), and many patents have significant industrial value. Multinationals are thereby enticed to place their patents in low-tax affiliates in order to lower their corporate tax burden. With higher earnings potential, the incentive becomes even stronger. Second, protected intellectual property is often used as a common input factor for many operating affiliates within an MNE. They are obliged to pay a royalty on this use to the patent owner. Thus, placing patents in a low-tax subsidiary may encourage more profit shifting since a low-tax subsidiary can overstate the royalty prices they charge other affiliates in high-tax jurisdictions. As a result, the tax burden of the MNE is reduced. Third, trading costs for patent-protected intellectual property are extremely low, allowing them to be isolated from operating affiliates in high-tax countries at a low cost.

There are different methods MNEs can relocate patents to affiliates in low-tax jurisdictions. The most common way this is done implies that the inventor of a patent and the one applying for it are located in different countries (Böhm et al., 2015, p. 1). Their results suggest the probability of relocating a patent is positively correlated with an increase in the applicant country CIT rate.

Juranek, Schindler, and Schneider (2018) analyse another concern regarding profit shifting; MNEs that are relocating intellectual property from high-tax jurisdictions to countries that have implemented patent box regimes. As previously mentioned, governments are increasingly concerned about such relocation of intangible assets as it decreases the corporate tax base. Their research adds to the studies on patent location and tax incentives by accounting for patent box regimes and how the relating challenges can be handled. According to the authors, a patent box regime offers preferential tax rates for intellectual property revenues. In addition, there is no requirement that royalty income should be linked to the domestic economic operation that a business engages in to produce the underlying intellectual property. As a result, patent box regimes can be used to attract corporate profits through tax competition. Due to this, the tax base of the inventor country will be reduced.

Another study on patent boxes is conducted by Alstadsæter et al. (2018). They analyse the different types of patent boxes, and how they affect patent position and local inventorship (p. 135). The authors have a dataset providing information on world corporate R&D investors' patent applications to the EPO from 39 home countries in 33 different host countries from 2000 to 2012. Their research is focused on the top 2,000 global corporate R&D investors. According to their results, patent box regimes have a significant impact on attracting foreign patents. High-quality patents, i.e., patents with high earnings potential, are particularly influenced by patent boxes in their location choices (p. 135). The findings of Alstadsæter et al. argue that patent box regimes struggle to incentivize industries to establish local research, despite the purpose of patent box regimes being to promote innovation. Thus, the effects of patent boxes appear to be mainly of a tax nature.

3 Patents and profit shifting in theory

3.1 Theoretical considerations

In this section, we discuss the impact foreign corporate tax structures have on patent ownership within multinational corporations.

A patent yields the owner an exclusive right to utilize an invention. In other words, it grants an interim monopolistic right to benefit from the technology within the geographic region to which it has been granted. The patent owner can charge other parties outside the multinational group a royalty fee if they want to exploit the technology as well. However, MNEs often wish to keep the invention from third parties. Hence, they tend to sell patents to affiliates within the multinational group only. The receiving affiliate are further on required to pay a royalty to the selling firm. Our dataset provides important insight in the location of patents, and often, the inventor firm and holding firm are geographically separated.

As mentioned in section 2, MNEs are increasingly aware that intellectual property is an essential factor in contributing to their overall profit and marketing. To many MNEs, patents are even considered as some of their most valuable assets. With this in mind, it is palpable to assume that MNEs wish to decrease their overall tax burden as much as possible by locating their patents in affiliated companies in low tax-jurisdictions. Thus, choosing the patent location within a multinational group is influenced by different tax-considerations (Karkinsky & Riedel, 2012, p. 177). This is especially true for patents, as the newly created knowledge often accounts for a large portion of the company's profits, while at the same time, the manufacturing affiliates typically generate relatively low profits (Dischinger & Riedel, 2011, p. 693).

Due to the intangible nature of patents, locating them at low-tax affiliates is beneficial. Many affiliate companies in an MNE are reliant on different intangible inputs in their production. As users of intellectual property are forced to pay a royalty fee to the selling affiliate, it enables the MNE to shift profits from all manufacturing affiliates to the patent holding affiliate. As mentioned, since manufacturing firms' profits are relatively small, they are able to shift what little income they generate to affiliates in low-tax jurisdictions by overrating the actual intra-firm transfer price, resulting in a significant reduction in the company's overall tax base. Thus, affiliates in low-tax countries may act as a profit shifting link to all other high-tax affiliates. This would not be the case if the patent was located in a high-tax affiliate as other high-tax affiliates would lack shifting opportunities. This in turn is another incentive for MNEs to locate their intellectual property at low-tax affiliates.

According to Karkinsky and Riedel (2012, p. 178), not all new inventions are patented, but rather kept in secrecy. It is difficult for fiscal authorities to observe internal firm knowledge. Once this knowledge is patented, however, it attracts taxable income. This is because the technology is manifested, and the various consumers of the technology in the production chain must fund the intellectual property. In comparison, revenue attributable to intellectual property accrues to the operating affiliates while knowledge is used informally within an MNE, such as by higher premiums paid to final consumers. Patenting new technology attracts revenue from high-tax operating affiliates. It is thus an appealing tactic to patent in low-tax affiliates, in addition that it lowers the MNEs' total tax burden as well.

Another consideration is the fact that royalty paying countries often charge a withholding tax rate on royalties that are paid across borders (Karkinsky & Riedel, 2012, p. 178). The affiliates that receive the income stream from selling a patent to an associated affiliate often apply for a tax credit on the withholding taxes that they have already paid. This is usually done before the income stream is valued at their local statutory tax rate. That way, the patent selling affiliate is able to avoid international double taxation. Thus, it is the relation between the size of the corporate income tax at the country that sells the intellectual property and the withholding tax placed by the country that purchase the intellectual property, that determines the effective tax burden. For instance, if the country that receives the royalty payment has a higher corporate tax rate than the withholding tax that is originally paid, they will receive a credit for the tax that have already been paid. As a result, the effective tax on the royalty income equals the receiving country's corporate tax rate. Moreover, this means that the withholding tax rate does not affect an MNE's decision on where they should place their patent. Conversely, when the receiving country has a lower tax rate than the withholding rate, the royalty payment is taxed at the withholding tax rate. This in turn incentivizes MNEs to place their intellectual properties in areas that have benign bilateral tax treaties as they are able to ensure low withholding tax payments on their income (Karkinsky & Riedel, 2012, p. 178).

In summary, the aforementioned considerations suggest that MNEs have an incentive to place their patents at affiliates in countries with low corporate tax rates in relation to other affiliates in the group. There are numerous strategies to achieve this. Firstly, MNEs can place their entire R&D units in affiliates facing low corporate income taxes. However, this may include substantial costs. Hence, it is often assumed that a more common strategy includes locating the head R&D unit at a low-tax affiliate and subcontract other research with other R&D units. In addition, another strategy for MNEs is to engage in cost-sharing arrangements. The risks and benefits of creating a new technology would thus be shared by the different affiliates within the group. These cost-sharing arrangements, if properly managed, enable MNEs to delegate an over-proportional sum of income to low-tax affiliates.

From the aforementioned theoretical considerations, we suspect several outcomes from our thesis. Firstly, we assume that an increase of tax rates in the inventor country is likely to incentivize MNEs to locate their patents in affiliates facing lower taxes. Conversely, an increase in associated affiliates' tax rates is likely to retain MNEs from locating their patents in a different country than the inventor country. Secondly, affiliates with lower tax rates than other associated affiliates in the same group is likely to hold more patent applications. Thus, we assume that increases in tax rates will reduce the number of patent applications. Moreover, based on previous literature (see Alstadsæter et al., 2018), we suspect that high-quality patents will be more sensitive to changes in taxes as they often generate higher returns than low-quality patents. As mentioned in section 2, the higher the earnings potential, the incentive to locate patents at low-tax affiliates increase.

4 Data and descriptive statistics

4.1 Data sources and sample restrictions

In order to create sample data that includes all necessary dimensions, data have been gathered from several different sources[9]. In the following sections, we are going to unfold the data processing step-by-step.

4.1.1 Affiliate dataset

To research the extent of which taxes determine the number of patent applications, the most pivotal information is number of applications filed by the respective affiliate. The data basis for this thesis therefore builds on a dataset provided by Steffen Juranek, which contains merged information on patent application ID, with corresponding company BVDID, application date and ownership share. BVDID is a unique identification number provided by Bureau van Dijk in the Amadeus database. The affiliates' BVDID is valuable information, because it enables extraction of company specific financial, ownership and geographical data from the Amadeus database. To get the associated application dates for each patent, the aforementioned dataset has been merged with data gathered from EPO's Worldwide Patent Statistical Database (hereafter PATSTAT). This database contains information on all patent applications dating back to 1978, and their associated patent application date. The most recent application date in this merged dataset is August 2018. Because of the missing observations from this year, all observations post 2017 have been removed. This has been done in order to avoid unbalanced exposure across the year, which could ultimately bias our results.

After the patent application has been filed to the EPO office, companies can still choose to re-locate these patents to other locations, and thus use them as instruments for profit shifting. The re-allocations and the correlated transfer prices are unobservable, so we are not able to include that in our dataset. However, sales of intangible assets are rare in practice, and are not considered to be

[9] For a full overview of the different sources of data, see the appendix, table A.

an important strategy for profit shifting (Karkinsky & Riedel, 2012). Therefore, we do not consider this problem as something that will decrease the validity of our analysis.

In order for MNEs to use patents as an instrument for tax avoidance, they have to be in control of the relevant affiliate. Therefore, only affiliates that are majority owned by a global ultimate owner will be in our main analysis. Furthermore, in order for an affiliate to be included in our dataset, the company must have applied for at least one patent during the sample period. Hence, some patent-holding affiliates will be excluded from our sample data. This being said, the current inclusion of affiliates reflects previous studies (Karkinsky & Riedel, 2012, p. 179) and thus adequately represents the most important patent-holding affiliates in Europe. Further data trimming procedures have been done by excluding solely domestic firms as they can't utilize differences in European tax rates.

After these data trimming procedures have been done, we created a new dataset, aggregating the number of patent applications for each affiliate. The non-aggregated dataset will be used for our inventor model, while the aggregated dataset will be used for the main model.

Some of the affiliates in our dataset have a very high number of applications, with a peak at 1,645 patents. Further trimming of the data have therefore been performed by excluding observations with more than 100 patent applications[10]. By doing so, the analysis will drop the extreme values of patent applications and avoid results steered by outliers in the dataset.

[10] See section 7 on robustness tests where we exclude observations with more than 20 patent applications.

Data trimming procedures

	Number of affiliates	Percentage	Number of patent applications	percentage
(1) All patent applications from 1978 with corresponding affiliate BVDID	225,413	100.00%	3,106,175	100.00%
(2) Remove observations where ownership share is more than 1	209,457	209,457	2,795,650	90.00%
(3) Removing countries that are not included in our dataset	119,037	52.81%	1,275,839	41.07%
(4) Limiting that dataset to only include patent applications between 2011-2017	43,487	19.29%	320,043	10.30%
(5) Remove the observations where affiliates are not majority owned	39,365	17.46%	278,457	8.96%
(6) Removing purely domestic affiliates	34,291	15.21%	238,098	7.67%
(7) Removing observations with over 100 patent applications in a single year	33,361	14.80%	168,153	5.41%
Final sample	33,361	14.80%	168,153	5.41%

Table 1: Data trimming procedures

After conducting several data trimming procedures, we end up with a sample data that consists of 33,361 different affiliates, with a total of 168,153 patent applications. The step-by-step approach can be observed in table 1. In order to obtain our final sample, we first removed observations where the patent had more than one owner. We further excluded all the non-relevant countries from our base dataset, before limiting the sample data to the selected time sample. After this, we proceeded with some affiliate specific trimming procedures. Firstly, we removed all the observations where the affiliates were not majority owned. Second, we removed purely domestic firms. Finally, we removed all observations that have more than 100 patent applications in a single year in order to avoid over dispersion.

Another vital data management aspect that has been done in this thesis is to include observations where the affiliate did not apply for a patent. All the years that an affiliate did not apply for a patent are valuable information to our analysis. From table 1 it can be observed that there are 33,361 affiliates, that has applied for a total of 168,153 patents, yet the total number of observations in our main data sample is 233,319. The remaining observations comes from including all the years where the relevant affiliate did not apply for a patent[11].

4.1.2 Inventor and applicant country dataset

As previously mentioned, the inventor dataset has not been aggregated, since we are not interested in affiliate information when investigating a general tendency of allocations of patents. Therefore, an observation in this dataset equals one patent and its associated characteristics. Inventor specific information has been retrieved from the OECD database (2021), which includes information about the inventor(s) of the patent, and where they currently live.

Patents can have multiple inventors, which can also be located in different countries and even in different MNEs. This provides some challenges. Therefore, we decided that the inventor country differs from the applicant country if 50% or more of the patent inventors are located outside the applying country.

The number of patent applications are higher in our inventor model sample data, as some of the data trimming procedures that are suitable for the aggregated data sample is not necessarily fit for this data sample. Therefore, the inventor model will have a total of 317,775 patent applications, compared to the main model with 168,153 applications.

4.1.3 High versus low quality patents

In order to determine the quality of the patents, the quality index elaborated by the OECD will be implemented. The quality indicator developed by OECD statistical department have been consolidated by 6 different qualifications: Number of forward citations (up to 5 years after publication), patent family size, number of claims, patent generality index, backward citations and grant lag. Since we have a high degree of recency in our dataset, the resulting quality indexes will be partly missing, and thus our data sample will be reduced. The recency is the cause for the reduction of observations because determining the quality of a patent is difficult when the associated characteristics have not yet been applied or tested. We are not too concerned about this inconvenience, as the resulting observations prevail as sufficient compared to relevant literature

[11] See appendix, table C for overview of number of observations by patent applications

(see Alstadsæter et al., 2018). The quality index is a number between 0 and 1, which is calculated by taking the unweighted average mean of the 6 aforementioned components[12].

To determine the semi-elasticities for high- and low-quality patents, we have separated the patents with a quality index threshold of 0.3, 0.35 and 0.4, respectively. 45.7% of all patents are considered high quality when the threshold is 0.3, 25.6% when the threshold is 0.35, and 12.7% when the threshold is 0.4. By separating the patents at different thresholds, the analysis can better pinpoint which patents are likely to be used in profit shifting activities. Formally, our approach can be written as following:

1. $PQI > 0.3 = \; High\ quality_{it},\ PQI < 0.3 = Low\ quality_{it}$
2. $PQI > 0.35 = \; High\ quality_{it},\ PQI < 0.35 = Low\ quality_{it}$
3. $PQI > 0.4 = \; High\ quality_{it},\ PQI < 0.4 = Low\ quality_{it}$

Where PQI stands for the patent quality indicator. Correspondingly to our main dataset, the number of patent applications will be aggregated for each unique affiliate. We thus create three different datasets that contain aggregated patent applications per affiliate for each of the three quality thresholds. In that way, we can observe how many low- and high-quality patents each affiliate has every year, at different quality indicators.

4.2 Dependent variables

For the inventor model, the dependent variable that will be estimated is a binary variable that takes the value of 1 if applicant country is different from inventor country.

In the main model, the dependent variable is number of patent applications. In order to structurally arrange our dataset with affiliates and their corresponding patent application(s), country and ownership share, we aggregate the data by affiliates so that we have the cumulated patent

[12] See Lanjouw & Schankerman (2004) for further discussion about calculating the unweighted mean, and more in-depth discussion concerning the definition of a quality of a patent.

applications for each affiliate in the relevant year. Since each patent application only occur once, aggregating the number of observations each affiliate occur will effectively result in number of patent applications for that specific year and affiliate. The same dependent variable will be used in the quality model.

4.3 Tax variables

Our model consists of three different tax variables, effective tax rate ETR_{it}, statutory income tax rate CIT_{it}, and a patent box dummy D_{it}. Effective tax rate is the applicable tax rate for income generated from licensing patent royalties. The effective tax rate can formally be written as:

$$4. \quad ETR_{it} = D_{it} \begin{cases} 1 & PTR_{it} \\ 0 & CIT_{it} \end{cases}$$

Where ETR_{it} is effective tax rate in country i at time t. D_{it} is a dummy variable that will take the value 1 if there is a patent box tax deduction in country i at time t. If the dummy variable equals 0, the normal statutory tax rate will be used as effective tax rate. If the dummy variable equals 1, the effective tax rate will have patent box tax rates. The CIT rate is the applicable country specific tax rate that will be utilized if the country has not implemented any patent box tax deduction.

Regulatory tax data have primarily been gathered from the Tax Foundation.org (2020). This data provides all applicable statutory tax rates throughout our sample period. The process of implementing the patent box tax deductions is more tedious. As described in section 1, there are no European regulatory tax guidelines that determines an admissible patent tax rate. Therefore, our data accumulation has been from different sources, which has been cross validated to ensure correctness. There are 13 different countries that have implemented patent boxes in our dataset: Great Britain, Ireland, The Netherlands, France, Spain, Portugal, Italy, Hungary, Switzerland, Cyprus, Belgium, Luxembourg and Malta. The patent box tax deductions are gathered primarily from EY's "Worldwide R&D Incentives Reference Guide" (2020). For further data collecting where this guide is inadequate, the article "Patent Boxes Design, Patents Location and Local R&D" (Alstadsæter et al., 2018) have been used.

4.4 Control variables

In addition to our main independent variables, there are other factors that may affect the number of patent applications. Therefore, we chose to include four country specific control variables. These control variables are intellectual property protection (hereafter IP protection), freedom from corruption, the logarithm of gross domestic product (hereafter GDP) and the number of researchers per 1 million inhabitants. The common denominator in all of these control variables is that we wish to account for country specific attractiveness. Furthermore, these variables will naturally attract R&D investors. Another argument for including these control variables is to produce results that are comparable to similar studies in this field (see e.g., Riedel 2012, Griffith et al. 2014). All of the aforementioned control variable data has been gathered from The World Bank (2018, 2019).

4.5 Descriptive statistics

In the following section, we take a deeper look in the main statistics relevant for the thesis. First, we present the country specific information with observations, affiliates, patent applications and corresponding percentages. Thereafter, table 3 presents relative numbers of applications per 100,000 inhabitants and affiliates. Finally, the relevant tax changes in our sample period will be outlined.

The importance of high inclusion of affiliates has previously been emphasized. Country specific data has been provided in table 2. As previously mentioned, this thesis' sample data has only included European countries. The observations cumulate to 33,389 different affiliates across our sample data. Non-surprisingly, the most reoccurring countries are Germany, Italy and Great Britain, with 10,097, 5,392 and 4,998 affiliates respectively. The countries with the lowest number of affiliates are Croatia, Latvia and Hungary, with 13, 17 and 21 affiliates. These countries also make up the highest, and lowest number of observations in our sample data.

	Number of observations	Percentage of observations	Number of affiliates	Percentage of affiliates	Number of applications	Percentage of applications
Austria	8,357	3.58%	1,195	3.58%	7,278	4.33%
Belgium	2,966	1.27%	425	1.27%	3,867	2.30%
Bulgaria	266	0.11%	39	0.12%	52	0.03%
Switzerland	10,881	4.66%	1,558	4.67%	13,077	7.79%
Cyprus	308	0.13%	45	0.13%	85	0.05%
Czech rep.	1,351	0.58%	194	0.58%	370	0.22%
Germany	70,591	30.26%	10,097	30.24%	65,035	38.72%
Denmark	7,195	3.08%	1,029	3.08%	5,007	2.98%
Estonia	553	0.24%	80	0.24%	115	0.07%
Spain	7,280	3.12%	1,041	3.12%	2,741	1.63%
Finland	5,844	2.50%	838	2.51%	3,878	2.31%
France	12,556	5.38%	1,801	5.39%	16,440	9.79%
UK	34,982	14.99%	4,998	14.97%	15,361	9.15%
Greece	154	0.07%	23	0.07%	90	0.05%
Croatia	84	0.04%	13	0.04%	13	0.01%
Hungary	140	0.06%	21	0.06%	74	0.04%
Ireland	3,101	1.33%	444	1.33%	1,746	1.04%
Italy	37,737	16.17%	5,392	16.15%	14,300	8.51%
Luxembourg	1,197	0.51%	172	0.52%	1,044	0.62%
Latvia	112	0.05%	17	0.05%	15	0.01%
Malta	378	0.16%	55	0.16%	312	0.19%
Netherlands	10,162	4.36%	1,456	4.36%	7,176	4.21%
Norway	4,802	2.06%	687	2.06%	1,633	0.97%
Poland	3,003	1.29%	430	1.29%	898	0.53%
Portugal	1,323	0.57%	190	0.57%	299	0.18%
Romania	273	0.12%	40	0.12%	62	0.04%
Sweden	6,428	2.76%	922	2.76%	6,788	3.98%
Slovenia	896	0.38%	129	0.39%	312	0.19%
Slovakia	399	0.17%	58	0.17%	85	0.05%
Total	233,319	100.00%	33,389	100.00%	168,153	100.00%

Table 2: Observations, affiliates and patent applications by country

Germany has the most observations, affiliates and patent applications, with approximately a third of all of the aforementioned factors. This number is twice as high as any other country in the sample period. Germany is renowned for being a technologically advanced country, hence its high number of patent applications. Furthermore, it is also the largest country, surpassing France at second with almost 14 million inhabitants. The high number of applications in Germany, and the consequential impact that potentially can make in the analysis might be substantial. Therefore, Germany will be excluded in the robustness testing in section 7.

Number of applications isolated provides limited information. Therefore, we have provided table 3 that gives number of patent applications per 100,000 inhabitants. By doing so, the descriptive statistics give some valuable insight in which countries that have a relative high number of applications, compared to the number of inhabitants. When calculating this number, we have used the average number of inhabitants in the different countries through the sample period. There are some countries that show a great number of patent applications relative to the number of inhabitants. Especially high is the relative number in both Switzerland and Luxembourg, with 155.32 and 176.75, respectively. This number is quite considerable given the average of 32.15. The high number of patent applications relative to the number of inhabitants might suggest that these countries are being used in profit shifting strategies, which is non-surprising given the relaxed taxation in those countries.

Furthermore, in the same table, we have provided the average number of applications per affiliate. This number provides insight to the general patent activity in the country. With an average number of 5 patent applications per affiliate, the countries with the most patent applying affiliates are France, Belgium and Switzerland, with an average number of applications at 9.1, 9.1 and 8.4, respectively.

	Patent applications per 100,000 inhabitants	Average number of applications per affiliate
Austria	82.96	6.1
Belgium	34.07	9.1
Bulgaria	0.73	1.3
Switzerland	155.32	8.4
Cyprus	9.94	1.9
Czech rep.	3.50	1.9
Germany	78.81	6.4
Denmark	87.10	4.9
Estonia	8.74	1.4
Spain	5.89	2.6
Finland	70.47	4.6
France	24.54	9.1
UK	23.34	3.1
Greece	0.84	3.9
Croatia	0.31	1.0
Hungary	0.76	3.5
Ireland	36.49	3.9
Italy	23.60	2.7
Luxembourg	176.75	6.1
Latvia	0.77	0.9
Malta	67.78	5.7
Netherlands	41.42	4.9
Norway	31.06	2.4
Poland	2.36	2.1
Portugal	2.90	1.6
Romania	0.32	1.6
Sweden	66.91	7.3
Slovenia	15.10	2.4
Slovakia	1.56	1.5
Average	32.15	5.0

Table 3: Relative number of applications

4.5.1 Tax rate statistics

In the following section, we provide statistics on the statutory tax development in Europe during our sample period. The first changes we examine are the effective tax rates and the CIT rate. The effective tax rate is calculated by implementing the relevant patent box tax deductions, which is why a continuous drop in table 4 can be observed during the period. Most notably is Malta, which has an effective tax rate of 0% due to the deduction from their patent box regime. The consistently highest effective tax rate is in Germany, with a rate of 30.175% throughout the sample period[13].

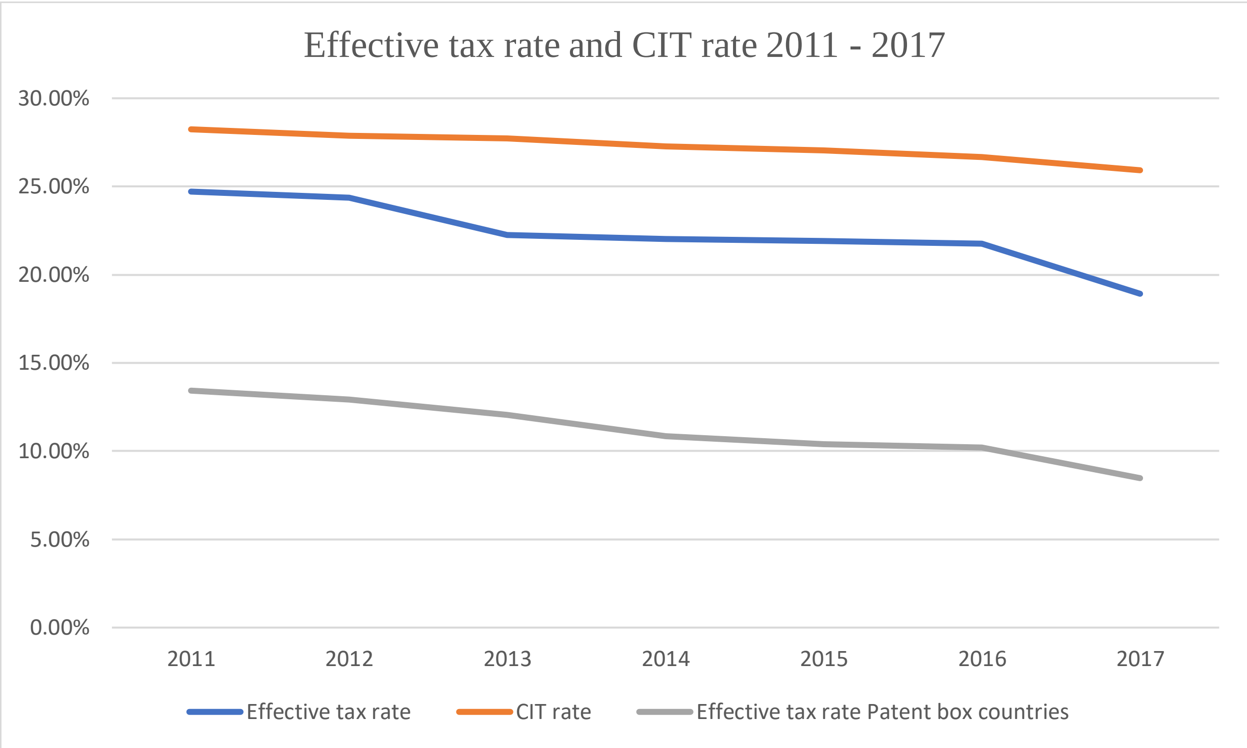

Table 4: Effective tax rate, CIT rate, and effective tax rate on patent box countries

In order to understand how considerable some of the tax deductions are, table 4 also includes a graph depicting the average tax rate for the countries that have implemented patent box regimes. The largest difference caused by the patent box regimes derives from Malta, where the tax reduction represents a change of 35 percentage points. The lowest difference comes from Ireland,

[13] For complete overview of the effective tax rates, and the tax deductions, see tables D and E in appendix.

with a deduction on 6.25 percentage points. This reduction is lower compared to other countries, but Ireland already has an inherently low statutory tax rate of 12.5%[14].

Additionally, table 5 provides an overview of the patent box dummy variable. This table is outlined so that the time of the patent box implementation can be observed for each country. Previously, countries have been pressured from the EU to abolish the patent box regimes, which happened in Ireland in 2010. They have, however, been able to implement a new regime that is still being used[15]. Despite efforts from the EU, this table shows a tendency of more countries choosing to implement a patent box scheme. After the patent box has been implemented, none of the European countries in our sample have removed them. From table 5, we can observe that Italy implemented a patent box regime in 2017. Furthermore, Portugal and Ireland are countries that have recently chosen to include a patent box regime in their regulatory tax systems.

	Patent box dummy 2011 - 2017						
	1 indicates that patent box has been implemented						
	2011	2012	2013	2014	2015	2016	2017
Belgium	1	1	1	1	1	1	1
Switzerland	1	1	1	1	1	1	1
Cyprus	0	1	1	1	1	1	1
Spain	1	1	1	1	1	1	1
France	1	1	1	1	1	1	1
UK	0	0	1	1	1	1	1
Hungary	1	1	1	1	1	1	1
Ireland	0	0	0	0	1	1	1
Italy	0	0	0	0	0	0	1
Luxembourg	1	1	1	1	1	1	1
Malta	1	1	1	1	1	1	1
Netherlands	1	1	1	1	1	1	1
Portugal	0	0	0	1	1	1	1

Table 5: Countries with patent box regimes

[14] See appendix, table D for complete overview of the tax deductions from patent box regimes.

[15] Ireland implemented an alternative called "knowledge development box" in 2015, offering a reduced tax rate of 6.25%.

4.5.2 Summary statistics

Panel A of table 6 shows the summary statistics from both the dependent and independent variables that are being used in the inventor model. This panel reveals that the inventor of a patent is located in a different country than where it is applied for approximately 20% of the time, which is a considerable proportion. This proportion represents 63,555 patent applications that are potentially being used as profit shifting instruments. Panel B of table 8 shows the summary statistics of our main model, where we investigate number of applications conducted by affiliates. The panel shows a yearly average of 0.72 patent applications per affiliate, with a standard deviation of 3.67.

Panel A and B in table 7 depict the descriptive statistics from the six different patent quality datasets that are being used in our quality model. The panels are split by the three quality thresholds of 0.3, 0.35 and 0.4, respectively. We can observe from the panels that the number of observations has decreased a considerable amount compared to our main dataset. The cumulated observations from both the high-and low-quality patents represents 52,191 observations, compared to the main dataset with 233,319 observations. These reductions have previously been elaborated in section 4.1.3. Since the threshold for high-quality patents increase, the low-quality datasets will have more observations than the high-quality datasets. To further demonstrate the distribution between high- and low-quality patents, panel C in table 7 gives an overview of how many applications there are for each of the three thresholds.

Panel A: Summary statistics for inventor dataset

Variable	Mean	Standard deviation
Different country	0.1923	0.39
Applicant statutory income tax rate	28.19	5.09
Inventor statutory income tax rate	28.87	5.37
Applicant effective tax rate	21.82	9.15
Inventor effective tax rate	22.59	8.81
IP protection applicant country	5.527	0.58
Freedom of corruption applicant country	1.697	0.52
Freedom of corruption inventor country	1.595	0.6
Number of observations	317776	

Panel B: Summary statistics for main dataset

Variable	Mean	Standard deviation
Number of patent applications	0.72	3.67
Effective tax rate	22.27	9.02
Patent box dummy	0.3355	0.47
Statutory income tax rate	27.25	5.03
IP protection	5.294	0.81
Freedom of corruption	1.473	0.72
Researchers	4139.8	1320.85
Log GDP	2.19E+12	1.27E+12
Number of observations	233319	

Table 6: Summary statistics, inventor and main model

Panel A: Summary statistics for high-quality patent datasets

Variable	High-quality patents > 0.3 Mean	Standard deviation	High-quality patents > 0.35 Mean	Standard deviation	High-quality patents > 0.4 Mean	Standard deviation
Number of applications	2.954	9.73	2.532	6.21	2.161	3.97
Effective tax rate	23.12	8.92	22.98	8.95	22.74	9.05
Statutory income tax rate	28.15	4.77	28.18	4.81	28.18	4.83
Patent box dummy	0.3073	0.46	0.3135	0.46	0.3253	0.47
IP protection	5.373	0.72	5.398	0.69	5.416	0.68
Freedom of corruption	1.567	0.64	1.59	0.62	1.607	0.61
Researchers	4210	1153.73	4239.6	1125.37	4271.6	1105
Log GDP	2.30E+12	1.30E+12	2.28E+12	1.31E+12	2.26E+12	1.32E+12
Number of observations	24449		15768		9181	

Panel B: Summary statistics for low-quality patent datasets

Variable	Low-quality patents < 0.3 Mean	Standard deviation	Low-quality patents < 0.35 Mean	Standard deviation	Low-quality patents < 0.4 Mean	Standard deviation
Number of applications	3.014	14.21	3.308	16.35	3.475	17.4
Effective tax rate	23.08	8.88	23.13	8.89	23.14	8.89
Statutory income tax rate	28.05	4.87	28.06	4.83	28.04	4.82
Patent box dummy	0.3102	0.46	0.3076	0.46	0.306	0.46
IP protection	5.324	0.76	5.323	0.76	5.323	0.76
Freedom of corruption	1.515	0.68	1.516	0.68	1.518	0.68
Researchers	4152.1	1199.4	4148.9	1205	4148.3	1203.5
Log GDP	2.28E+12	1.29E+12	2.29E+12	1.29E+12	2.28E+12	1.29E+12
Number of observations	27742		35066		39145	

Panel C: Distribution of patent applications

	0.3 distribution	0.3 percentage	0.35 distribution	0.35 percentage	0.4 distribution	0.4 percentage
High quality	71158	45.7%	39816	25.6%	19747	12.7%
Low quality	83573	54.3%	115915	74.4%	135984	87.3%
Total applications	155731		155731		155731	

Table 7: Summary statistics, quality model

5 Empirical strategy and regression specification

Our thesis considers three different regression specifications. First, we aim to add a dimension that has scarcely been used in previous research; does the tax rate affect the probability of a patent inventor and applicant to be geographically separated? This model is implemented to give empirical evidence that patents are used as instruments for profit-shifting. Further, the main model is applied to determine if, and to what extent, the number of patent applications in an affiliate is affected by different tax measures. The quality model is an extension of the main model, which aims to determine whether high- or low-quality patents are predominantly used in profit shifting activities.

5.1 Inventor model

The theoretical predictions for this model have been outlined in section 3.1. For this model we are estimating a binomial dependent variable, that takes the value of 1 if applicant country and inventor country is different. In this model, we assume that the applicant country tax rate will reduce the likelihood of the dependent variable being 1, contrary to inventor country tax rate, which we assume will increase the probability of the dependent variable being 1. Due to this, the most pertinent model to fit the data is a logistic regression, which gives the following regression specification:

$$5.\ \ P_{it} = \frac{e^{\{\beta_0+\beta_1 ICT_{it}+\beta_2 ACT_{it}+\beta_3 X_{it}+\theta_i+\varrho_t+\epsilon_{it}\}}}{1+e^{\{\beta_0+\beta_1 ICT_{it}+\beta_2 ACT_{it}+\beta_3 X_{it}+\theta_i+\varrho_t+\epsilon_{it}\}}}$$

In this model, the dependent variable P_{it} is a dummy variable that takes the value 1 if the inventor of the patent is in a different country than where the patent has been applied for. At the right hand-side of the model, we have the intercept β_0 and our main independent variables of interest; $\beta_1 ICT_{it}$ and $\beta_2 ACT_{it}$. The first independent variable depicts the CIT rate in the country where the patent i was invented at time t. The second represents the CIT rate in the applicant country where patent i

was applied for, at time t. Further on, X_{it} is a vector that includes several country specific control variables. These include the logarithm of GDP in each country to see whether rich countries are more lucrative for holding patents. We also include two more variables that measures the level of freedom from corruption and the level of IP protection. Finally, we add the number of researchers per 1,000,000 inhabitants. Using data on number of researchers for each country we test whether affiliates in countries with relatively high number of researchers are more attractive locations. As mentioned in the article by Karkinsky and Riedel (2012, p. 182), there may be other reasons why different affiliates are attractive for holding the patents of a multinational group. These are however difficult or impossible to observe. To deal with this, we include a set of affiliate-fixed effects denoted by θ_i. These will help capture time-constant firm differences. We also include year-fixed effects denoted by ϱ_t, which accounts for shocks that occur over time and affect all affiliates.

Contrary to the main model in section 5.2, the inventor model is not affiliate aggregated, and will thus examine a general tendency of profit shifting. This being said, the basis of the two models is the same as all the affiliates and patent applications from the main model are included in the inventor model. The results from the inventor model can thus be directly translated to the analysis of the main model. By doing so, we can establish a strong indication of profit shifting activities in the same data that we are going to use in later regressions.

5.2 Main model

The principal methodology part of our main model follows the model specifications proposed by Karkinsky and Riedel (2012, p. 182). Precisely, we aim to replicate their study with newer data and adjustments we see fit. Thus, our model specification is as follows:

$$6. \quad Y_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 td_{it} + \beta_3 X_{it} + \theta_i + \varrho_t + \epsilon_{it}$$

Our dependent variable, Y_{it}, depicts the number of patent applications in affiliate i in year t. This is estimated based on different tax-measures that is denoted T_{it}. This includes the corporate income tax rates that the affiliates face, in addition to an effective corporate income tax measure. The latter accounts for patent box tax rates for those countries that have implemented this. The next regressor is a dummy variable that we call box-dummy. This takes the value 1 if a country has implemented a patent box regime and is used in combination with the normal statutory corporate income taxes. We assume that all the aforementioned explanatory variables except the dummy will have a negative effect on the dependent variable. In addition, we include a set of country specific control variables, affiliate, year and country-fixed effects. The inclusion of these have been elaborated in the previous section.

In our first set of regressions, we estimate the equation using a fixed effects OLS model. We further estimate our model using negative binomial regressions with fixed effects. Due to the count nature of our dependent variable, the latter model is applicable. Another argument for using a fixed effects negative binomial model is because the data is over-dispersed i.e., the majority of observations has only one or zero patent applications. Furthermore, our main model aims to replicate the results by Karkinsky and Riedel (2012) with newer data. Since the authors use a fixed effects negative binomial model, we also include this in our thesis to produce comparable results.

The model is estimated using panel data consisting of affiliates that are majority owned by European multinationals. MNEs have the ability to set overrated intra-firm transfer prices to shift profits from patent holding affiliates in high-tax jurisdictions to low-tax affiliates. Our data shows the number of patent applications in an affiliate i located in a country at year t. Using different tax-measures as described, we can test how the number of patent applications are affected by changes in tax rates.

Another aspect that is important to address is endogeneity issues and survey the unbiasedness in our model. A possible endogeneity issue that could arise from our sample data concerns all the tax variables. Large MNEs can incite beneficial tax regulations by consistent profit shifting, and thus influence countries to change their regulatory tax policies. Countries that systematically miss out on possible income due to profit shifting, might therefore introduce favourable tax rates. The implementation of various patent box regimes is a potential result of this.

This being said, we have excluded all global ultimate owners, as well as observations with over 100 patent applications. This in turn means that the remaining affiliates in our sample is likely to be too insignificant in the grand scheme of things to provoke changes in statutory income tax rates.

Furthermore, comparable endogeneity issues have been controlled for in a previous study conducted by Huizinga, Laeven, & Nicodeme (2008). When they control for the possible issues, they find that it has little effect to their base results. Due to the aforementioned arguments, it is therefore reasonable to assume that the tax rates are exogenous with respect to the influence of firms.

5.3 Quality model

The model that has been outlined in the aforementioned section will be adjusted in order to investigate what types of patents that are predominantly used as instruments for profit shifting activities. The previously outlined model has been altered to the following:

7. $High\ quality\ patent\ applications_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 td_{it} + \beta_3 X_{it} + \theta_i + \varrho_t + \epsilon_{it}$
8. $Low\ quality\ patent\ applications_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 td_{it} + \beta_3 X_{it} + \theta_i + \varrho_t + \epsilon_{it}$

The patents are characterized as either high- or low-quality depending on three different thresholds. Both of the models above will be estimated three separate times with a patent quality indicator threshold of 0.3, 0.35, and 0.4. This model is an adjustment to the main model, which is why we include the same independent variables. Furthermore, we will examine the semi-elasticities for the different thresholds. When calculating this, we use the logarithm of number of patent applications at affiliate i in time t. The tax semi-elasticities represent a change in the share of patents for a given affiliate caused by a one percentage point change in the tax rate for the affiliate i at time t.

6 Empirical results

This section shows the empirical results from estimating our model on affiliates of European multinational enterprises during the time period 2011-2017. We start by estimating whether different tax measurements have an effect on relocating a patent application from its inventor country to another affiliate in a different country. Further on, we run our main regressions of interest which analyses how the number of patent applications in an affiliate are affected by different tax measurements. Moreover, we split our dataset into high- and low-quality patents and test whether high quality patents are more sensitive to taxes. Finally, we discuss how different control variables affect the regressors of interest.

6.1 Inventor model

In our first regressions, found in table 8, we estimate the inventor model. The estimates are derived from a logit model where the dependent variable is a dummy, i.e., it takes the value one if a patent is located in a different country than its inventor country. Moreover, a logit model provides a probability measure estimating whether the different regressors increase or reduce the probability of the dependent variable being one.

Our results confirm the theoretical predictions from section 3.1. An increase in the corporate income tax rate at the inventor country increases the probability that the patent will be relocated to another affiliate in another country, all else equal. The opposite is true for an increase in the applicant country's tax rate. The main regressors in this estimation are statistically significant at the one percent level. We note that a patent application relocation is more sensitive for a change in the inventor country's tax rate. This regression control for the level of affiliate, year and country-fixed effects. The results indicate that MNEs tend to keep their patents in affiliates, if affiliates in other countries are facing increasing taxes, and vice versa.

Different country: Logit

Dependent Variable:	Different Country			
Model:	(1)	(2)	(3)	(4)
Variables				
Inventor Country CIT	0.1487***	0.1366***	0.1045***	0.0925***
	(0.0067)	(0.0116)	(0.0083)	(0.0114)
Applicant Country CIT	-0.1056***	-0.1001***	-0.0468***	-0.0425***
	(0.0121)	(0.0143)	(0.0180)	(0.0124)
Applicant Country IP Protection (log)		0.2300		-1.334**
		(0.5421)		(0.6440)
Inventor Country Corruption (log)		-2.705***		-3.030***
		(0.3854)		(0.5274)
Applicant Country Corruption (log)		2.630***		2.626***
		(0.3620)		(0.5244)
Fixed-effects				
Year (7)	Yes	Yes	Yes	Yes
Applicant Country	Yes	Yes	Yes	Yes
Affiliate			Yes	Yes
Fit statistics				
Country	29	26	28	24
Affiliate	–	–	3,767	3,574
Observations	317,775	308,740	206,489	198,082
Squared Correlation	0.28203	0.42338	0.37266	0.49068
Pseudo R^2	0.16459	0.24597	0.32399	0.39928
BIC	260,388.8	219,085.8	203,033.1	173,055.0

One-way (year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in these regressions is different country, i.e., if the patent application country is different from the inventor country. Regression (1) shows the results from running a regression on the inventor and applicant country tax rate only, controlled for the level of year and country-fixed effects. Regression (2) include the same main regressor in addition to the country level control variables, including IP protection in the applicant country and the freedom from corruption for both inventor and applicant country. This regression controls for the level of year and country-fixed effects. Regression (3) is equal to (1), but also controls for the level of affiliate-fixed effects. Regression (4) is equal to (2), but also controls for the level of affiliate-fixed effects. All regressions are estimated using a fixed effects logit model. The sample contains information on inventors of patents from around the globe and the patent applicants from the EU27 in addition to Norway, Great Britain and Switzerland. The sample covers the time period 2011-2017.

Table 8: Logit regression, inventor model

Firstly, (1) tests how the corporate income tax rate in both inventor countries and applicant countries affect the probability that a patent will change its ownership from its inventor country. Secondly, (2) includes country level control variables. These are indexes that measure different scores on the attractiveness of innovation in the different countries. In regression (1) and (2), the coefficients of the main variables of interest are practically the same. All main regressors are statistically significant at the one percent level. The next two regressions (3) and (4) are identical to the former two but also control for the level of affiliate-fixed effects. When controlling for this, the coefficients are somewhat reduced. The applicant country CIT rate coefficient is reduced from approximately 0.10 in (1) and (2) to around 0.04 in (3) and (4). Similarly, a reduction can be observed in inventor country CIT rate coefficients. However, we are not too concerned about this reduction, as the coefficients maintain statistically significant.

6.2 Main model

Our main regressors consists of three different tax measures. First, we analyse the effect of the effective tax variable. In contrast to the standard corporate income tax that shows the normal rates at which companies would be taxed for their income, the effective tax rate variable incorporates the actual rates it will be facing from income derived from patents. Thus, the variable includes the patent box rates for the countries that have implemented this, while it contains the corporate income tax rates of those countries without such a regime. Our next variables of interest are used in combination with one another, that is, the corporate income tax rate with the box-dummy variable that take the value one if a country has implemented a patent box regime, zero otherwise. We have used both a fixed effects within model and a fixed effects negative binomial model to estimate our model. All estimations include affiliate, year and country-fixed effects.

Fixed Effects, Within Model

Dependent Variable:	Number of Patent Applications			
Model:	(1)	(2)	(3)	(4)
Variables				
Effective Tax Rate	-0.0148***		-0.0111***	
	(0.0011)		(0.0013)	
Corporate Income Tax Rate		-0.0031		-0.0029
		(0.0058)		(0.0060)
Patent Box Regime (dummy)		0.2233***		0.1685***
		(0.0246)		(0.0248)
GDP (log)			-0.0550	-0.2855
			(0.1844)	(0.1876)
Researchers			-4.67×10^{-5}	-4.48×10^{-5}
			(3.34×10^{-5})	(3.52×10^{-5})
Corruption			0.0737	0.1010
			(0.0655)	(0.0637)
IP Protection			0.1434***	0.1321**
			(0.0526)	(0.0528)
Fixed-effects				
Affililate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	33,361	33,361	32,383	32,383
Country	29	29	27	27
Observations	233,319	233,319	226,492	226,492
R^2	0.75223	0.75223	0.75528	0.75529
Within R^2	0.00070	0.00072	0.00081	0.00082

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Main model within The dependent variable in the regressions is the number of patent applications. Regression (1) shows the results from running a regression on the effective tax rate only. Regression (2) shows the results from running a regression on the statutory corporate income tax rate and the patent box regime dummy variable only. Regressions (4) and (5) shows the results from running the same regressions while controlling for country level control variables. These include the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects OLS model, and controls for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 9: Within regressions, main model

The results from table 9 are estimated using a within model and show that both the effective tax rate and the patent box dummy are statistically significant at the one percent level, while the corporate statutory tax rate is insignificant in both regressions. This corresponds with our theoretical predictions, and the results are similar to the findings by Karkinsky and Riedel (2012, p. 183). However, the authors did not use a dummy variable in combination with the CIT rate. Thus, their corporate tax rate is significant and negatively correlated with the dependent variable. Regression (1) suggests that a one percentage point increase in the effective tax rate at the country where an affiliate is located, reduces the number of patent applications by 0.0148. Secondly, the CIT rate is statistically insignificant. The patent box regime dummy, on the other hand, suggests that if affiliates located in a country which have implemented a patent box, its number of patent applications will increase by 0.2233.

Regressions (3) and (4) include country level control variables. In (3), the main variable of interest is the effective tax rate, while the statutory income tax rate and the patent box regime dummy are the main regressors in (4). The estimators for both regressions have been somewhat reduced but remain statistically significant at the one percent level. Similar to (1) and (2), the CIT rate remains statistically insignificant. Regression (3) still suggests a reduction in the number of patent applications, though by 0.011. Additionally, regression (4) suggests that affiliates in countries with patent boxes increase their number of applications by 0.169.

We also ran regressions on our main data using a fixed effects negative binomial model. The results can be found in table 10 and include the same dependent and independent variables as the within regressions.

FE Negative binomial

Dependent Variable:	Number of Patent Applications			
Model:	(1)	(2)	(3)	(4)
Variables				
Effective Tax Rate	-0.0121***		-0.0118***	
	(0.0019)		(0.0021)	
Corporate Income Tax Rate		0.0151***		0.0181***
		(0.0055)		(0.0063)
Patent Box Regime (dummy)		0.2252***		0.2522***
		(0.0321)		(0.0371)
GDP (log)			-1.039***	-1.364***
			(0.2809)	(0.2894)
Researchers			0.0001***	6.66×10^{-5}**
			(3.04×10^{-5})	(3.18×10^{-5})
Corruption			0.1649**	0.2201***
			(0.0758)	(0.0761)
IP Protection			0.0300	0.0003
			(0.0527)	(0.0534)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	27,897	27,897	27,076	27,076
Country	29	29	27	27
Observations	195,081	195,081	189,353	189,353
Squared Correlation	0.79940	0.80058	0.79963	0.80031
Pseudo R^2	0.27115	0.27117	0.27087	0.27091
BIC	639,631.3	639,636.3	619,188.4	619,183.1
Over-dispersion	2.8892	2.8918	2.9320	2.9337

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regression (1) shows the results from running a regression on the effective tax rate only. Regression (2) shows the results from running a regression on the statutory corporate income tax rate and the patent box regime dummy variable only. Regressions (4) and (5) shows the results from running the same regressions while controlling for country level control variables. These include the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects negative binomial model, and controls for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 10: Fixed effects negative binomial, main model

In accordance with the within model in table 9, all regressions in table 10 control for the level of affiliate, year and country-fixed effects. The different models provide the same outcome, though with some differences in the coefficients of the main regressors. Starting with (1), the coefficient suggests that the number of patent applications will reduce by 0.0121 from a one percentage point increase in the effective tax rate. The results are statistically significant at the one percent level. This is fairly similar to both the within model and the findings of Karkinsky and Riedel (2012, p. 183). Further on, regression (2) suggests that a patent box regime will increase the number of patent applications by 0.2252. Conversely to the within regressions, the CIT rate variable is now positive and statistically significant. This can be explained by the patent box dummy variable. As the CIT rate is the inapplicable tax rate for countries that have implemented patent box regimes, the corresponding results must be interpreted with caution. Some countries may still observe a high number of patent applications despite having a high CIT rate. A country with a patent box regime will have favourable taxes on patent generated income, thus attracting more patent applications. However, this effect will not be captured by the CIT rate regressor. The UK for instance, have a relatively high CIT rate average of 22%, yet they have the second largest number of patent applications. This is eminently due to the implementation of a patent box regime where patent related income tax rate is only 10%.

Regressions (3) and (4) include country level control variables and prove to have little influence on the main independent variables. A one percentage point increase in the effective tax suggests that the number of patent applications will decrease by 0.0118. Similarly, a country with a patent box regime suggests that the number of patent applications will increase by 0.2522, all else equal. Additionally, a one percentage point increase in the corporate tax rate indicates that the number of patent applications will increase by 0.0181. The former paragraph elaborates on this circumstance.

The results are somewhat comparable to the findings of Alstadsæter et al. (2018, pp. 153, 155). However, they split their patents in different fields, including the pharmaceutical industry, information and communications technology (ICT) and the car industry. They then regress how these different industries' patent registrations are affected by tax measures. Using a negative binomial model, their effective tax rate estimators are negative and significant at the one percent level for all industries but the ICT. As we test the effects on patents of all industries, our estimates for the effective tax rate are smaller than that of the authors but show the same pattern, i.e., that the effective tax rate exerts a negative effect on the number of patent applications.

Alstadsæter et al. (2018, p. 155) also regress their model on the effects from a patent box regime. Unlike us, they use the tax advantage from a patent box and not a dummy variable. However, the overarching results in their article exhibits the same indicative results as our thesis, i.e., that patent box regimes have a substantial effect on the number of patent applications.

In the following, we discuss the contributions and implications of adding control variables to the main regressors. Both models add country level control variables that affect the main estimates to some degree. Starting with the fixed effects within model in table 9, we find that only the level of IP protection is statistically significant when testing for both the effective tax rate, and the CIT rate and patent box dummy. The coefficient in both regressions is positive and similar, indicating that countries with a high level of IP protection will attract more patent applications. Contrastingly, all control variables but the IP protection is statistically significant in the fixed effects negative binomial model in table 10. The number of researchers per 1,000,000 inhabitants is extremely low, having almost no effect on the dependent variable. The GDP is negatively correlated with the number of patent applications which might be explained by the fact that rich economies have higher taxes on corporate income. The freedom from corruption on the other hand, is positively correlated with the number of patent applications. In general, the control variables reduce the estimators of the main regressors, though not by much. This indicates that the added country level control variables capture some of the effects from the different tax measures.

6.3 Quality model

To further contribute to the studies on the location of intellectual property, we added another dimension to our research, i.e., whether high- or low-quality patents are more prone to be used in profit shifting activities. Our estimates are calculated by a fixed effects within model. The results are somewhat unexpected given previous research. All our regressions indicate that low-quality patents are more sensitive to tax changes, suggesting that MNEs are mainly using low-quality patents to shift profits.

As described in section 4.1.3, we split our main dataset by different thresholds of our quality indicators, e.g., the first column in the regressions is labelled “High 0.3”, indicating that the regression is run on a dataset with patents that have a quality index of more than 0.3. We start by isolating the effective tax rate and its effect on the different patents. All estimates but the threshold of 0.4 are statistically significant. In regression (1), the number of patent applications for patents with a quality score of more than 0.3 is reduced by 0.088 from a one percentage point increase in the effective tax rate. For patents that score 0.35 or higher, the effect decreases and indicate that the number of patents will be reduced by 0.056. All regressions account for the level of affiliate, year and country-fixed effects.

In contrast, the low-quality patents indicate an increasing sensitivity to changes in the effective tax rate. Starting at the threshold of 0.3, a one percentage point increase in the effective tax rate indicates a reduction of patent applications by 0.099. Regression (5) shows that the number of patent applications is reduced by 0.119, and finally, regression (6) suggests that a one percentage point increase in the effective tax reduces the number of patent applications by 0.128 when the threshold is 0.4. All the aforementioned results are significant at the one percent level.

Fixed Effects, Within Model, High vs. Low Quality Patents

Dependent Variable:	Number of Patent Applications					
Model:	(1) High 0.3	(2) High 0.35	(3) High 0.4	(4) Low 0.3	(5) Low 0.35	(6) Low 0.4
Variables						
Effective Tax Rate	-0.0882***	-0.0565**	-0.0342	-0.0992***	-0.1187***	-0.1284***
	(0.0269)	(0.0229)	(0.0226)	(0.0266)	(0.0274)	(0.0280)
Fixed-effects						
Affiliate	Yes	Yes	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Affiliate	12,894	8,581	5,221	15,618	18,842	20,536
Country	30	30	29	30	30	30
Observations	24,425	15,727	9,138	27,727	35,045	39,134
R^2	0.73711	0.73860	0.71751	0.80476	0.80320	0.79955
Within R^2	0.00090	0.00078	0.00056	0.00072	0.00084	0.00087

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. The effective tax rate is the only independent variable in all regressions. Regressions (1), (2), and (3) shows the results from running regressions on high quality patents with quality indexes of 0.3 or higher, 0.35 or higher, and 0.4 or higher, respectively. Regressions (4), (5), and (6) shows the results from running regressions on low quality patents with quality indexes of 0.3 or lower, 0.35 or lower, and 0.4 or lower, respectively. All regressions are estimated using a fixed effects OLS model, and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017). Moreover, the sample is split in six by different quality thresholds, i.e., 0.3, 0.35, and 0.4.

Table 11: Fixed effects within, quality model with effective tax

When adding our set of country level control variables in table 12, the estimates of our main regressor does not change significantly. The trend is exactly the same for all regressions, but the effective tax rate variable is somewhat reduced. This inclusion of control variables further supports the findings as when estimating the effective tax rate alone, suggesting that low-quality patents are more sensitive to changes in this tax measure. Moreover, this further indicates that low-quality patents are more prone to be used as an instrument to shift profits.

Fixed Effects, Within Model, High vs. Low Quality Patents

Dependent Variable:	Number of Patent Applications					
Model:	(1) High 0.3	(2) High 0.35	(3) High 0.4	(4) Low 0.3	(5) Low 0.35	(6) Low 0.4
Variables						
Effective Tax Rate	-0.0833***	-0.0515**	-0.0211	-0.0953***	-0.1151***	-0.1203***
	(0.0302)	(0.0262)	(0.0265)	(0.0291)	(0.0314)	(0.0321)
GDP (log)	-5.544**	-2.661	-0.3680	-2.830	-5.376***	-6.079***
	(2.269)	(2.097)	(2.709)	(1.958)	(1.917)	(1.951)
Researchers	-0.0001	-0.0002	-0.0005	0.0010	0.0007	0.0006
	(0.0004)	(0.0004)	(0.0003)	(0.0007)	(0.0006)	(0.0006)
Corruption	-0.2876	-0.6033	-0.3086	-2.136*	-1.494	-1.521
	(1.164)	(0.9156)	(0.8886)	(1.107)	(1.212)	(1.242)
IP Protection	1.571***	1.423***	1.131***	1.702***	1.617**	2.022***
	(0.5668)	(0.5021)	(0.4362)	(0.6016)	(0.6390)	(0.6664)
Fixed-effects						
Affiliate	Yes	Yes	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Affiliate	12,515	8,314	5,049	15,145	18,277	19,917
Country	27	27	26	27	27	27
Observations	23,676	15,239	8,840	26,873	33,981	37,941
R^2	0.75687	0.75211	0.72164	0.82906	0.81648	0.81020
Within R^2	0.00214	0.00228	0.00256	0.00212	0.00178	0.00183

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. The main regressor is the effective tax rate. All regressions include country level control variables All regressions include country level control variables, i.e., the logarithm of each countries' GDP, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. Regressions (1), (2), and (3) shows the results from running regressions on high quality patents with quality indexes of 0.3 or higher, 0.35 or higher, and 0.4 or higher, respectively. Regressions (4), (5), and (6) shows the results from running regressions on low quality patents with quality indexes of 0.3 or lower, 0.35 or lower, and 0.4 or lower, respectively. All regressions are estimated using a fixed effects OLS model, and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017). Moreover, the sample is split in six by different quality thresholds, i.e., 0.3, 0.35, and 0.4.

Table 12: Fixed effects within, quality model with effective tax and control variables

Our quality regressions are also estimated by testing for the corporate income tax rate in combination with the patent box dummy, found in table 13. The order of the regressions is the same as in table 11 and 12, and all regressions control for the level of affiliate, year and country-fixed effects. Our findings show the exact same trend as our regressions on the effective tax rate, i.e., the effect of the statutory corporate income tax rate and patent box dummy variable diminishes when the threshold for high quality patents increases. Conversely, the effects are opposite for the low-quality patents when the quality threshold increase. These findings further support the results from our former patent quality regressions, indicating that low-quality patents are more sensitive to changes in the corporate tax rate and patent box regimes.

We start the interpretation of our results from table 13 by considering the corporate tax rate and patent box dummy without any control variables. For all regressions on the high-quality patents, the corporate tax rate is insignificant. Further on, regression (1) shows that if a country has implemented a patent box regime, the number of high-quality patent applications increases by 2.136 when the quality threshold is 0.3. This result is significant at the one percent level. Secondly, regression (2) shows that the number of high-quality patent applications increases with 1.234 when the threshold is increased to 0.35 and the dummy variable is one. The significance level in regression (2) is reduced to the 5 percent level. Thirdly, the patent box dummy is insignificant when testing the high-quality patents on a threshold of 0.4.

When estimating the low-quality patents, we find that the statutory income tax rate is insignificant for all low-quality patents. The patent box dummy is significant at the one percent level and indicate that the number of low-quality patent applications will increase by 2.198 when the threshold is 0.3. Secondly, the patent box dummy for regression (5) is significant at the one percent level, indicating that a patent box regime will increase the number of patent applications by 2.695. Finally, regression (6) suggests that a patent box regime causes the number of patent applications to increase by 2.835 when the threshold for low-quality patents is 0.4. This result is also significant at the one percent level.

Fixed Effects, Within Model, High vs. Low Quality Patents

Dependent Variable:	Number of Patent Applications					
Model:	(1) High 0.3	(2) High 0.35	(3) High 0.4	(4) Low 0.3	(5) Low 0.35	(6) Low 0.4
Variables						
Corporate Income Tax Rate	0.1354	0.0417	-0.0102	0.1414	0.1784	0.1729
	(0.1933)	(0.1339)	(0.0914)	(0.1041)	(0.1369)	(0.1481)
Patent Box Regime (dummy)	2.136***	1.234**	0.5966	2.198***	2.695***	2.835***
	(0.7853)	(0.5401)	(0.3954)	(0.4792)	(0.6411)	(0.6839)
Fixed-effects						
Affiliate	Yes	Yes	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Affililate	12,894	8,581	5,221	15,618	18,842	20,536
Country	30	30	29	30	30	30
Observations	24,425	15,727	9,138	27,727	35,045	39,134
R^2	0.73730	0.73874	0.71758	0.80483	0.80330	0.79964
Within R^2	0.00164	0.00134	0.00082	0.00109	0.00132	0.00131

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. The statutory corporate income tax rate and the patent box regime dummy variable are the only independent variables in all regressions. Regressions (1), (2), and (3) shows the results from running regressions on high quality patents with quality indexes of 0.3 or higher, 0.35 or higher, and 0.4 or higher, respectively. Regressions (4), (5), and (6) shows the results from running regressions on low quality patents with quality indexes of 0.3 or lower, 0.35 or lower, and 0.4 or lower, respectively. All regressions are estimated using a fixed effects OLS model, and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017). Moreover, the sample is split in six by different quality thresholds, i.e., 0.3, 0.35, and 0.4.

Table 13: Fixed effects within, quality model with CIT rate and patent box regime

As when testing for the effective tax rate, we add our set of country level control variables to the regressions on statutory tax rate and patent box dummy. Similar to the CIT rate variable in table 13, all are insignificant in table 14 as well. In addition, all patent box coefficients have been somewhat reduced. Another interesting finding that contradicts the results from table 13, is that the patent box estimator is reduced from regression (5) to (6) when the threshold for low-quality patents is increased from 0.35 to 0.4. Moreover, the patent box dummy is insignificant for the high-quality patents when the threshold is 0.35 and 0.4, once more confirming our former results. Thus, only regressions (1), (4), (5) and (6) are relevant to discuss.

Starting with (1), we find that the patent box dummy is significantly reduced. However, it still suggests that a patent box regime will increase the number of patent applications by 1.290. When the threshold for quality is 0.3, the high-quality patent sample will include the patents with a quality index between 0.3 and 0.35. In the threshold of 0.35, these will be excluded and thus the regressions lose its significance. This indicates that patents with a quality score of 0.35 or less are primarily used for profit shifting. Regression (4) shows that a patent box regime will increase the dependent variable by 1.870 at a threshold for low-quality patents of 0.3. When increasing the threshold to 0.35, the effect is increased to 2.241, while it is reduced to 2.212 when the threshold is increased to 0.4. All these results are significant at the one percent level.

Fixed Effects, Within Model, High vs. Low Quality Patents

Dependent Variable:	Number of Patent Applications					
Model:	(1) High 0.3	(2) High 0.35	(3) High 0.4	(4) Low 0.3	(5) Low 0.35	(6) Low 0.4
Variables						
Corporate Income Tax Rate	-0.0366	-0.0972	-0.0570	0.0829	0.0847	0.0548
	(0.0900)	(0.0728)	(0.0639)	(0.1010)	(0.1028)	(0.1018)
Patent Box Regime (dummy)	1.290***	0.5441	0.1704	1.870***	2.241***	2.212***
	(0.3829)	(0.3335)	(0.3712)	(0.4024)	(0.4235)	(0.4191)
GDP (log)	-7.212***	-3.293	-0.5377	-5.190**	-8.220***	-8.822***
	(2.398)	(2.252)	(2.938)	(2.066)	(2.085)	(2.131)
Researchers	-0.0001	-6.18×10^{-5}	-0.0005	0.0008	0.0005	0.0005
	(0.0004)	(0.0004)	(0.0004)	(0.0006)	(0.0006)	(0.0006)
Corruption	-0.1946	-0.7118	-0.4052	-1.811*	-1.119	-1.193
	(1.196)	(0.9474)	(0.9225)	(1.089)	(1.202)	(1.237)
IP Protection	1.457**	1.382***	1.115**	1.526***	1.390**	1.821***
	(0.5744)	(0.5082)	(0.4450)	(0.5833)	(0.6306)	(0.6614)
Fixed-effects						
Affiliate	Yes	Yes	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Affiliate	12,515	8,314	5,049	15,145	18,277	19,917
Country	27	27	26	27	27	27
Observations	23,676	15,239	8,840	26,873	33,981	37,941
R^2	0.75690	0.75218	0.72169	0.82910	0.81652	0.81023
Within R^2	0.00226	0.00257	0.00273	0.00233	0.00200	0.00198

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. The main regressors are the statutory corporate income tax rate and the patent box regime dummy variable. All regressions include country level control variables All regressions include country level control variables, i.e., the logarithm of each countries' GDP, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. Regressions (1), (2), and (3) shows the results from running regressions on high quality patents with quality indexes of 0.3 or higher, 0.35 or higher, and 0.4 or higher, respectively. Regressions (4), (5), and (6) shows the results from running regressions on low quality patents with quality indexes of 0.3 or lower, 0.35 or lower, and 0.4 or lower, respectively. All regressions are estimated using a fixed effects OLS model, and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017). Moreover, the sample is split in six by different quality thresholds, i.e., 0.3, 0.35, and 0.4.

Table 14: Fixed effects within, quality model with CIT rate, patent box regime and control variables

Summarizing, a patent box regime exerts a substantial effect on the number of patent applications for both high- and low-quality patents. However, this effect decreases when the threshold for high quality patents increases. In contrast, this effect increases when the threshold for low-quality patents increases.

6.4 Semi-elasticities

Semi-Elasticities

	Dependent variable: log(Number of Patent Applications)					
	High > 0.3	High > 0.35	High > 0.4	Low < 0.3	Low < 0.35	Low < 0.4
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Effective Tax Rate	-0,0024	-0,0011	-0,0036	-0,0096 ***	-0,0081 ***	-0,0066 ***
	0,24%	0,11%	0,36%	0,96%	0,81%	0,66%
Corporate Income Tax Rate	0,00385	-0,002	-0,0001	0,00856	0,00924	0,00726
	0,38%	0,20%	0,01%	0,86%	0,92%	0,73%
Patent Box Regime (dummy)	0,06159	0,02345	-0,0508	0,18465 ***	0,17152 ***	0,13506 ***
	6,16%	2,34%	5,08%	18,47%	17,15%	13,51%
Note:				*p<0.1; **p<0,05; ***p<0,01		

Table 15: Semi-elasticities, quality model

When testing for the logarithm of our dependent variable, we derive the semi-elasticities, i.e., the percentage change in the number of patent applications from a change in our regressors. As in tables 11, 12, 13 and 14, the low-quality patents are the most sensitive. Additionally, when having a log-linear model, all estimators on the high-quality patents become insignificant. Thus, our data set once again suggests that MNEs tend to use low-quality patents for profit shifting activities.

As only the low-quality patents yield significant results, we exclude the insignificant results in our further discussion. Note that all regressions are tested with the main regressors separately, i.e., they are tested with the effective tax rate variable, and then tested for the corporate income tax and the patent box dummy variable. Our results suggest that a lower threshold for low-quality patents is more sensitive to both changes in the effective tax rate and the dummy variable. Starting with (4), we find that a one percentage point change in the effective tax rate change the number of patent applications by 0.96%. This percentage change in number of patent applications decreases to 0.81% when increasing the threshold to 0.35 (5) and 0.66% when the threshold is 0.4 (6).

As mentioned, the regressions in table 13 and 14 estimate the effects of both the standard corporate income tax rate and the patent box regime dummy. The former is insignificant in all regressions, while the latter is significant only for low-quality patents. In regression (4), a patent box regime will change the number of patent applications by 18.47% when the threshold for low-quality patents is 0.3. Further on, this effect will decrease to 17.15% (5) and finally to 13.51% (6), when the threshold is increased to 0.35 and 0.4, respectively.

In contrast to the findings of Alstadsæter et al. (2018), our results are, as mentioned, somewhat unexpected. Yet, our results remain significant and robust when controlling for time-varying country characteristics. Former research argues that R&D activities often generate higher-than-average returns (Hall, Mairesse, & Mohnen (2009)), and that this is especially the case for patents with a high earnings potential. Thus, a natural intuition would suggest that the number of high-quality patent applications would be more sensitive to changes in tax measures. With their high earnings potential, an MNE would potentially seek to reduce the tax burden of these patents by locating them at low-tax affiliates. However, there might be several reasons why our research suggests the opposite. Firstly, high-quality patents are resource intensive to produce. If the purpose of a patent is to be used in profit shifting activities, and the interconnected transfer price between affiliates is unobservable, MNEs might consider it unnecessary that these patents are of high-quality. The arms-length price that affiliates pay for the royalties of a patent are not necessarily dependent on the quality, but rather motivated by how MNEs can shift the appropriate amount of profit. With freedom to set the desired price for licensing a patent, MNEs might chose the ones that are less costly. Besides, it is natural to assume that not all MNEs have the necessary resources or R&D units that enable them to invent high-quality patents. Finally, our data set use different quality indicators than previous literature which may be decisive to our results[16]. While a patent's value is often measured by the number of forward citations, our quality index is calculated on a set of different indicators, provided by the OECD.

[16] See section 1 where we outlined the difficulties of determining a patent's quality

7 Robustness tests and extensions

In the following section, we revise our results by widening our analysis and include several robustness tests. In order to structurally test our results, we will divide this section in two; first for our inventor model, then for the main model.

In the first regression, found in table 8, we investigated how tax differences affect the probability that the inventor is located in a different country than where the application is being conducted. For robustness tests, we will firstly perform a probit regression analysis. Furthermore, a test will be conducted where we exclude Germany for or sample data. The last test that will be applied for the inventor model is by applying the effective tax rates instead of the CIT rates.

Next, we are going to perform robustness tests on or main model. The first alteration we are going to do is removing Germany from this model as well. Consequently, we are going to further trim the high values in our dataset by excluding observations with over 20 patent applications. Thereafter, we will split the dataset by affiliate size in order to see what types of affiliates that are mostly used for profit shifting. In all the following robustness tests, the results from the main models are included for easy comparison of the robustness results.

7.1 Robustness tests on inventor model

7.1.1 Probit regression analysis

In the inventor model, we used a logit regression in order to estimate the model. For the purpose of testing the robustness of our results, we are going to utilize a probit regression to see if it yields the same findings. The regression includes both country and year-fixed effects in regression (1) and (3), while (2) and (4) include affiliate fixed effects as well. The outcome from the regressions can be seen in Table 16. The results are consistent as all of the independent variables are still strongly significant. The coefficients have become somewhat smaller, but the regressions in table 16 provides the same indicative result as the logit regression.

Different country: Probit

Dependent Variable:	Different Country			
Model:	(1)	(2)	(3)	(4)
	Probit	Probit	Logit	Logit
Variables				
Inventor Country CIT	0.0602***	0.0519***	0.1366***	0.0925***
	(0.0058)	(0.0057)	(0.0116)	(0.0114)
Applicant Country CIT	-0.0376***	-0.0251***	-0.1001***	-0.0425***
	(0.0079)	(0.0065)	(0.0143)	(0.0124)
Applicant Country IP Protection (log)	0.2442	-0.5105	0.2300	-1.334**
	(0.2786)	(0.3505)	(0.5421)	(0.6440)
Inventor Country Corruption (log)	-0.7378***	-0.9863***	-2.705***	-3.030***
	(0.1692)	(0.2351)	(0.3854)	(0.5274)
Applicant Country Corruption (log)	0.6274***	0.7502***	2.630***	2.626***
	(0.1573)	(0.2731)	(0.3620)	(0.5244)
Fixed-effects				
Year (7)	Yes	Yes	Yes	Yes
Applicant Country	Yes	Yes	Yes	Yes
Affiliate (3,574)		Yes		Yes
Fit statistics				
Applicant Country	26	24	26	24
Observations	308,740	198,082	308,740	198,082
Squared Correlation	0.34288	0.44826	0.42338	0.49068
Pseudo R^2	0.20160	0.37929	0.24597	0.39928
BIC	231,948.2	177,348.4	219,085.8	173,055.0

One-way (year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in these regressions is different country, i.e., if the patent application country is different from the inventor country. Regression (1) and (2) are estimated using a fixed effects probit model. Regressions (3) and (4) is obtained from table 8 to compare the results to our main findings. All regressions include country level control variables, i.e., IP protection in the applicant country and the freedom from corruption for both inventor and applicant country. Regressions (1) and (3) control for the level of country and year-fixed effects, while regressions (2) and (4) also controls for the level of affiliate-fixed effects. The sample contains information on inventors of patents from around the globe and the patent applicants from the EU27 in addition to Norway, Great Britain and Switzerland. The sample covers the time period 2011-2017.

Table 16: Probit, inventor model

7.1.2 Excluding Germany

The next robustness test includes removing Germany from our sample data. The reasoning behind doing so is because Germany accounts for 38% of all the patent applications that has been conducted in our time period. Due to the great number of German patent applications, we are concerned that it might make our results biased. Furthermore, Germany has relatively high statutory income tax rates, and are among the few large European countries that has not implemented a patent box regime. The general pattern of the results derived from the logit model excluding Germany does not affect the coefficients notably. Even though the independent variables have somewhat decreased, they are still strongly significant, thus confirming the results we have found in our main inventor model.

Different country: Logit (Excluding Germany)

Dependent Variable:	Different Country			
Model:	(1) Excl. Germany	(2) Excl. Germany	(3) Incl. Germany	(4) Incl. Germany
Variables				
Inventor Country CIT	0.2043***	0.1753***	0.1366***	0.0925***
	(0.0155)	(0.0115)	(0.0116)	(0.0114)
Applicant Country CIT	-0.1520***	-0.0972***	-0.1001***	-0.0425***
	(0.0135)	(0.0106)	(0.0143)	(0.0124)
Applicant Country IP Protection (log)	0.3769	-0.8777	0.2300	-1.334**
	(0.5347)	(0.5449)	(0.5421)	(0.6440)
Inventor Country Corruption (log)	-1.307***	-1.297***	-2.705***	-3.030***
	(0.2657)	(0.2959)	(0.3854)	(0.5274)
Applicant Country Corruption (log)	1.273***	1.091***	2.630***	2.626***
	(0.2557)	(0.2986)	(0.3620)	(0.5244)
Fixed-effects				
Year (7)	Yes	Yes	Yes	Yes
Applicant Country	Yes	Yes	Yes	Yes
Affiliate		Yes		Yes
Fit statistics				
Applicant Country	25	23	26	24
Affiliate	–	2,532	–	3,574
Observations	188,348	113,756	308,740	198,082
Squared Correlation	0.46019	0.53094	0.42338	0.49068
Pseudo R^2	0.28235	0.44270	0.24597	0.39928
BIC	145,609.1	107,398.1	219,085.8	173,055.0

One-way (year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in these regressions is different country, i.e., if the patent application country is different from the inventor country. All regressions are estimated using a fixed effects logit model. Regressions (3) and (4) is obtained from table 8 to compare the results to our main findings. All regressions include country level control variables, i.e., IP protection in the applicant country and the freedom from corruption for both inventor and applicant country. Regressions (1) and (3) control for the level of country and year-fixed effects, while regressions (2) and (4) also controls for the level of affiliate-fixed effects. The sample contains information on inventors of patents from around the globe and the patent applicants from the EU27 excluding Germany, in addition to Norway, Great Britain and Switzerland. The sample covers the time period 2011-2017.

Table 17: Logit model, excluding Germany

7.1.3 Effective tax rate as independent variable

In our inventor model, we used the statutory income tax rate as the main independent variable of interest. Even though selecting this independent variable is suitable in our main inventor analysis, we still want to investigate whether the effective tax rate might produce different results. Corporations that strategically locate their patent application might do so based on both the applicable patent box taxes, and/or the normal statutory income tax rates. Selecting effective tax rate as an independent variable will thus contribute to assisting the validity in our results. From the robustness test regressions, we can observe that the coefficients are lower than the previously produced results. The inventor country effective tax rate coefficient in (1) has a value of 0.0548, whilst applicant country effective tax rate in (2) is -0.0513. While this model produces somewhat smaller coefficients than previously, we have to take into account that inventor country effective tax rate is highly difficult to precisely include. There are 111 different inventor countries in our sample data, and some of the country specific effective tax rates are lacking. This being said, the robustness test yields the same indicative results the findings from the inventor model in section 6.

Different country: Logit, Effective Tax Rate

Dependent Variable:	Different Country			
Model:	(1)	(2)	(3)	(4)
Variables				
Inventor Country Effective Tax Rate	0.0548***	0.0389***	-0.0224***	-0.0271***
	(0.0080)	(0.0088)	(0.0080)	(0.0085)
Applicant Country Effective Tax Rate	-0.0513***	-0.0327***	0.0187***	0.0215**
	(0.0081)	(0.0086)	(0.0072)	(0.0095)
Applicant Country IP Protection (log)		0.2641		-0.5960
		(0.6045)		(0.5711)
Inventor Country Corruption (log)		-2.550***		-2.507***
		(0.2385)		(0.2872)
Applicant Country Corruption (log)		2.511***		2.455***
		(0.2019)		(0.2319)
Fixed-effects				
Year (7)	Yes	Yes	Yes	Yes
Applicant Country	Yes	Yes	Yes	Yes
Affiliate			Yes	Yes
Fit statistics				
Applicant Country	29	25	24	23
Affiliate	–	–	2,914	2,879
Observations	294,577	290,459	170,776	168,969
Squared Correlation	0.20046	0.30447	0.32380	0.41607
Pseudo R^2	0.12934	0.19313	0.31907	0.38134
BIC	197,385.4	179,025.4	146,998.6	134,453.8

One-way (year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in these regressions is different country, i.e., if the patent application country is different from the inventor country. Regression (1) shows the results from running a regression on the inventor and applicant country effective tax rate only, controlled for the level of year and country-fixed effects. Regression (2) include the same main regressors in addition to the country level control variables, including IP protection in the applicant country and the freedom from corruption for both inventor and applicant country. This regression controls for the level of year and country-fixed effects. Regression (3) is equal to (1), but also controls for the level of affiliate-fixed effects. Regression (4) is equal to (2), but also controls for the level of affiliate-fixed effects. All regressions are estimated using a fixed effects logit model. The sample contains information on inventors of patents from around the globe and the patent applicants from the EU27 in addition to Norway, Great Britain and Switzerland. The sample covers the time period 2011-2017.

Table 18: Logit, inventor model with effective tax rate

7.2 Robustness tests on main model

7.2.1 Removing Germany

For further robustness tests, we remove Germany in this model as well. The reasoning is the same as when we performed it above. Since Germany dominates our data sample in the number of patent applications, it naturally accounts for a large proportion of the affiliates. The results remain consistent when we include this modification. In the first regression, the effective tax rate is negative and statistically significant at the one percent level. Compared to the coefficients in our main model, the effect has decreased slightly, but not significantly. We can thus consider the large number of observations from Germany to not bias our main results.

Fixed Effects, Within Model, Excluding Germany

Dependent Variable:	Number of Patent Applications			
Model:	(1) Excl. Germany	(2) Incl. Germany	(3) Excl. Germany	(4) Incl. Germany
Variables				
Effective Tax Rate	-0.0086***	-0.0111***		
	(0.0014)	(0.0013)		
Corporate Income Tax Rate			0.0039	-0.0029
			(0.0061)	(0.0060)
Patent Box Regime (dummy)			0.1523***	0.1685***
			(0.0257)	(0.0248)
GDP (log)	-0.0511	-0.0550	-0.2395	-0.2855
	(0.1868)	(0.1844)	(0.1922)	(0.1876)
Researchers	-4.14×10^{-5}	-4.67×10^{-5}	-4.9×10^{-5}	-4.48×10^{-5}
	(3.68×10^{-5})	(3.34×10^{-5})	(3.87×10^{-5})	(3.52×10^{-5})
Corruption	0.1746***	0.0737	0.2052***	0.1010
	(0.0624)	(0.0655)	(0.0604)	(0.0637)
IP Protection	0.1218**	0.1434***	0.0992*	0.1321**
	(0.0561)	(0.0526)	(0.0556)	(0.0528)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	22,287	32,383	22,287	32,383
Country	26	27	26	27
Observations	155,901	226,492	155,901	226,492
R^2	0.73078	0.75528	0.73079	0.75529
Within R^2	0.00101	0.00081	0.00105	0.00082

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regressions (1) and (2) shows the results from running a regression on the effective tax rate. Regressions (3) and (4) shows the results from running a regression on the statutory corporate income tax rate and the patent box regime dummy variable. Regressions (1) and (3) exclude Germany from the sample, while regressions (2) and (4) are obtained from table 9 to compare our results to our main findings. All regressions include country level control variables, i.e., the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects OLS model and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 19: Fixed effects within, main model excluding Germany

7.2.2 Further excluding high values

In our main model, we have excluded affiliate observations with over 100 patent applications. Even though this number excludes the most extreme values in our dataset, one might still argue that our results are being driven by outliers. After excluding the observations with over 100 patent applications, the majority of affiliate observations have less than 20 patent applications. In this robustness test, we therefore exclude observations with more than 20 applications in a given year.

Following the estimation methodology from our main model, we use a fixed effects within model. From the results in table 20, we can see that the coefficients are consistent with the results found in our main analysis in table 9. Expectedly, the coefficients are lower than what they were before. This is a natural change since we are removing a big proportion that drives the results. For this robustness test, the most important indicator is that the coefficients remain statistically significant, and that the results are not driven by outliers.

Fixed Effects, Within Model, Excluding Patent Applications Above 20

Dependent Variable:	Number of Patent Applications			
Model:	(1) 20 or less	(2) 100 or less	(3) 20 or less	(4) 100 or less
Variables				
Effective Tax Rate	-0.0069***	-0.0111***		
	(0.0008)	(0.0013)		
Corporate Income Tax Rate			-0.0055*	-0.0029
			(0.0030)	(0.0060)
Patent Box Regime (dummy)			0.0891***	0.1685***
			(0.0146)	(0.0248)
GDP (log)	-0.3000***	-0.0550	-0.4358***	-0.2855
	(0.1044)	(0.1844)	(0.1044)	(0.1876)
Researchers	-5.96×10^{-6}	-4.67×10^{-5}	1.99×10^{-6}	-4.48×10^{-5}
	(1.59×10^{-5})	(3.34×10^{-5})	(1.71×10^{-5})	(3.52×10^{-5})
Corruption	0.0736*	0.0737	0.0915**	0.1010
	(0.0385)	(0.0655)	(0.0377)	(0.0637)
IP Protection	0.0629**	0.1434***	0.0630**	0.1321**
	(0.0260)	(0.0526)	(0.0265)	(0.0528)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country (27)	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	32,349	32,383	32,349	32,383
Observations	225,246	226,492	225,246	226,492
R^2	0.62115	0.75528	0.62116	0.75529
Within R^2	0.00098	0.00081	0.00098	0.00082

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regressions (1) and (2) shows the results from running a regression on the effective tax rate. Regressions (3) and (4) shows the results from running a regression on the statutory corporate income tax rate and the patent box regime dummy variable. Regressions (1) and (3) exclude observations with more than 20 patent applications, while regressions (2) and (4) are obtained from table 9 to compare our results to our main findings. All regressions include country level control variables, i.e., the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects OLS model and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 20: Fixed effects within, main model excluding high number of patent applications

7.2.3 Large, medium and small affiliates

In this test, we divide our dataset in three, depending on the size of the affiliates. This is done to investigate whether large, medium or small affiliates react differently to changes in the European tax environment. By doing so, we can disclose potential heterogeneity that emerges between different sized affiliates. In order to divide our sample, we are using the Amadeus database by Bureau van Dijk. The database facilitates four different size specifications: Very large, large, medium and small. For our division, we are going to cumulate the very large and large affiliates. By doing so, we end up with the most equally distributed three datasets.

The company size classification provided by Bureau van Dijk will be summarized in the following. Very large affiliates must match at least one of the following criteria: Operating revenue above 100 million EUR, total assets above 200 million EUR, or have more than 1,000 employees. In order for an affiliate to be characterized as large, it has to either have an operating revenue of at least 10 million EUR, total assets of at least 20 million EUR, or have more than 150 employees. Medium sized affiliates, on the other hand, needs at least 1 million EUR in operating revenues, 2 million EUR or more total assets, or have more than 15 employees. If an affiliate doesn't match any of these prerequisites, it will be characterized as a small affiliate.

In tables 21 to 24 we have used two models – the fixed effects within and fixed effects negative binomial model. The regressors that are included are effective tax rate, statutory income tax rate and the patent box dummy. From both of the regression specifications we can derive the same results – the smallest affiliates are less sensitive to regulatory tax changes.

First, we look at the effective tax independent variable. In our fixed effects within regression in table 21, we can observe that the coefficients are much lower for small sized affiliates than for the large and medium sized affiliates. The biggest change happens between large and medium sized affiliates, where the effect of the coefficients decreases from -0.0235 in (1) to -0.0066 in (2). Both coefficients are significant at the one percent level. The coefficient for the small affiliates is significant at the five percent level, with a small coefficient of -0.0027 in (3). For our fixed effects negative binomial regressions in table 22, the same tendencies can be observed. For small sized companies, the effective tax coefficient (3) is insignificant. For medium and large companies, the coefficients are strongly significant at the one percent level. Contrary to the fixed effects within estimator in table 21, the negative binomial regressions indicate that medium sized affiliates are more sensitive to tax changes.

Next, we investigate the results when we change the independent variable from effective tax rate to statutory tax rate and the box-dummy variable. Considering the results in our latter regression, we expect to see that large and medium affiliates are more sensitive to patent box regimes than small affiliates, which is confirmed from the results in table 23 and 24. The results from the fixed effects negative model in table 22 indicate that medium sized affiliates are more sensitive to changes in the effective tax rates. However, when estimating the model with the CIT rates and the patent box dummy in table 24, the results indicate that large affiliates are the most sensitive. In the fixed effects within regression in table 23, we can observe that the patent box dummy is substantial for large affiliates, with a coefficient of -0.383, significant at the one percent level (1). This coefficient is considerably higher than for medium sized affiliates, which is -0.066 (2). For small sized affiliates, we observe no significant results (3). In our negative binomial regressions, we also observe that the patent box coefficients for large and medium affiliates are significant, while there are no significant results for the small affiliates.

If we look at the results from this robustness test holistically, we can regard our sample data to be somewhat heterogeneous. Large and medium affiliates seem to be more sensitive to changes in the tax regulatory environment in Europe than smaller ones. The results from our main regression should therefore be interpreted with caution, since smaller affiliates are less receptive to tax changes when it comes to number of patent applications.

Fixed Effects, Within Model, Large, Medium & Small Affiliates

Dependent Variable:	Number of Patent Applications			
Model:	(1) Large	(2) Medium	(3) Small	(4) Main
Variables				
Effective Tax Rate	-0.0235***	-0.0066***	-0.0027**	-0.0111***
	(0.0031)	(0.0011)	(0.0013)	(0.0013)
GDP (log)	-0.7571**	0.0375	-0.1983	-0.0550
	(0.3743)	(0.2395)	(0.2961)	(0.1844)
Researchers	-6.21×10^{-5}	-5.56×10^{-5}	-2.96×10^{-5}	-4.67×10^{-5}
	(8.54×10^{-5})	(4.55×10^{-5})	(2.26×10^{-5})	(3.34×10^{-5})
Corruption	-0.1267	0.2034***	0.0184	0.0737
	(0.1444)	(0.0652)	(0.0756)	(0.0655)
IP Protection	0.4569***	-0.0858**	0.0090	0.1434***
	(0.1303)	(0.0379)	(0.0398)	(0.0526)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	13,021	10,310	9,052	32,383
Country	27	26	27	27
Observations	90,987	72,159	63,346	226,492
R^2	0.76393	0.69089	0.68005	0.75528
Within R^2	0.00173	0.00091	0.00019	0.00081

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regressions (1), (2), and (3) are estimated on data samples differing between large, medium, and small affiliates, respectively. Regression (4) is obtained from table 9 to compare the results to our main findings. The main regressor is the effective tax rate. All regressions include country level control variables, i.e., the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects OLS model and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 21: Fixed effects within, main model with large, medium and small affiliates, effective tax rates

Fixed Effects, Within Model, Large, Medium & Small Affiliates

Dependent Variable:	Number of Patent Applications			
Model:	(1) Large	(2) Medium	(3) Small	(4) Main
Variables				
Corporate Income Tax Rate	-0.0055	-0.0109**	-0.0071	-0.0029
	(0.0136)	(0.0045)	(0.0047)	(0.0060)
Patent Box Regime (dummy)	0.3833***	0.0662***	0.0105	0.1685***
	(0.0588)	(0.0205)	(0.0194)	(0.0248)
GDP (log)	-1.221***	-0.1038	-0.2049	-0.2855
	(0.3905)	(0.2500)	(0.2863)	(0.1876)
Researchers	-5.49×10^{-5}	-3.59×10^{-5}	-2.04×10^{-5}	-4.48×10^{-5}
	(9.17×10^{-5})	(4.92×10^{-5})	(2.4×10^{-5})	(3.52×10^{-5})
Corruption	-0.0722	0.2237***	0.0160	0.1010
	(0.1381)	(0.0637)	(0.0753)	(0.0637)
IP Protection	0.4178***	-0.0807**	0.0207	0.1321**
	(0.1308)	(0.0398)	(0.0400)	(0.0528)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	13,021	10,310	9,052	32,383
Country	27	26	27	27
Observations	90,987	72,159	63,346	226,492
R^2	0.76396	0.69090	0.68005	0.75529
Within R^2	0.00183	0.00095	0.00020	0.00082

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regressions (1), (2), and (3) are estimated on data samples differing between large, medium, and small affiliates, respectively. Regression (4) is obtained from table 9 to compare the results to our main findings. The main regressors are the statutory corporate income tax rate and the patent box regime dummy variable. All regressions include country level control variables, i.e., the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects OLS model and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 22: Fixed effects, main model with large, medium and small affiliates, CIT rates and patent box regime

Fixed Effects, Negative Binomial, Large, Medium & Small Affiliates

Dependent Variable:	Number of Patent Applications			
Model:	(1) Large	(2) Medium	(3) Small	(4) Main
Variables				
Effective Tax Rate	-0.0118***	-0.0187***	-0.0024	-0.0118***
	(0.0029)	(0.0041)	(0.0046)	(0.0021)
GDP (log)	-1.749***	-0.1815	-0.8043	-1.039***
	(0.3875)	(0.4817)	(0.5523)	(0.2809)
Researchers	0.0002***	3.58×10^{-5}	2.56×10^{-5}	0.0001***
	(4.23×10^{-5})	(6.11×10^{-5})	(6.07×10^{-5})	(3.04×10^{-5})
Corruption	0.1993**	0.1605	0.0569	0.1649**
	(0.0999)	(0.1461)	(0.1812)	(0.0758)
IP Protection	0.0489	-0.1942*	0.1418	0.0300
	(0.0693)	(0.1084)	(0.1192)	(0.0527)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	11,256	8,469	7,351	27,076
Country	27	26	26	27
Observations	78,642	59,272	51,439	189,353
Squared Correlation	0.80412	0.75018	0.71688	0.79963
Pseudo R^2	0.28032	0.19897	0.18747	0.27087
BIC	286,996.0	167,725.1	135,807.0	619,188.4
Over-dispersion	3.0805	2.7571	2.3145	2.9320

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regressions (1), (2), and (3) are estimated on data samples differing between large, medium, and small affiliates, respectively. Regression (4) is obtained from table 10 to compare the results to our main findings. The main regressor is the effective tax rate. All regressions include country level control variables, i.e., the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects negative binomial model and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 23: Fixed effects negative binomial, main model with large, medium and small affiliates, effective tax rates

Fixed Effects, Negative Binomial, Large, Medium & Small Affiliates

Dependent Variable:	Number of Patent Applications			
Model:	(1) Large	(2) Medium	(3) Small	(4) Main
Variables				
Corporate Income Tax Rate	0.0234***	-0.0059	0.0272*	0.0181***
	(0.0082)	(0.0135)	(0.0148)	(0.0063)
Patent Box Regime (dummy)	0.2819***	0.2722***	0.1129	0.2522***
	(0.0502)	(0.0752)	(0.0805)	(0.0371)
GDP (log)	-2.008***	-0.5671	-1.047*	-1.364***
	(0.3917)	(0.5100)	(0.5826)	(0.2894)
Researchers	0.0001**	4.04×10^{-5}	-9.17×10^{-6}	6.66×10^{-5}**
	(4.42×10^{-5})	(6.45×10^{-5})	(6.32×10^{-5})	(3.18×10^{-5})
Corruption	0.2476**	0.2110	0.1342	0.2201***
	(0.1000)	(0.1456)	(0.1842)	(0.0761)
IP Protection	0.0141	-0.2071*	0.1273	0.0003
	(0.0701)	(0.1109)	(0.1205)	(0.0534)
Fixed-effects				
Affiliate	Yes	Yes	Yes	Yes
Year (7)	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Fit statistics				
Affiliate	11,256	8,469	7,351	27,076
Country	27	26	26	27
Observations	78,642	59,272	51,439	189,353
Squared Correlation	0.80468	0.74959	0.71996	0.80031
Pseudo R^2	0.28041	0.19897	0.18753	0.27091
BIC	286,988.2	167,736.0	135,813.9	619,183.1
Over-dispersion	3.0829	2.7546	2.3122	2.9337

One-way (affiliate) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

The dependent variable in the regressions is the number of patent applications. Regressions (1), (2), and (3) are estimated on data samples differing between large, medium, and small affiliates, respectively. Regression (4) is obtained from table 10 to compare the results to our main findings. The main regressors are the statutory corporate income tax rate and the patent box regime dummy variable. All regressions include country level control variables, i.e., the logarithm of GDP in each country, the number of researchers per 1,000,000 inhabitants, the freedom from corruption and the level of IP protection in each country. All regressions are estimated using a fixed effects negative binomial model and control for the level of affiliate, year and country-fixed effects. The sample contains information on majority owned European affiliates over 7 years (2011-2017).

Table 24: Fixed effects negative binomial, main model with large, medium and small affiliates, CIT rates and patent box regime

8 Conclusion

It is vital for tax authorities to recognize the degree of strategic profit shifting activities MNEs engage in through location of patents. Previous studies have provided insights to the extent of which patents are being strategically located and given the associated semi-elasticities. In this thesis, we have elaborated further on this topic. By using the model propositions by Karkinsky and Riedel (2012), and Böhm et al. (2015) as a point of departure, we have been able to both replicate previous findings, and provide new insights and further empirical results.

To date, there are few studies that gives empirical evidence on the impacts of patent boxes and patent location. Many of the published studies on patents and their role in profit shifting have an outdated dataset and have thus partially lost their topicality. In this thesis, we have emphasized using a high degree of recent observations. We thereby manage to include the handsome tax deductions from patents boxes, and yield results that reflect the tax regulatory environment in Europe today. The results provided in section 6 shows that the aforementioned patent box regimes are more significant in estimating the location of patents than both effective - and statutory income tax rate.

Further evidence on this matter have been provided by utilizing a unique, merged dataset with the inventor of the different patents. This thesis has analysed how differences and changes in the tax regulatory climate in Europe determines whether an affiliate will choose to apply for a patent in a different country than where it was invented. By using a regression with a binomial dependent variable that depicts a difference in inventor and applicant country, this thesis has given further empirical evidence on patents and their role as instruments for profit shifting. Almost 20% of all patents applied for at the EPO have a foreign inventor, and our thesis suggests that many of these are strategically located for profit shifting purposes.

In our main model, we produced the same empirical results as previous studies, and included the most applicable tax variables caused by the implementation of patent box regimes in recent times. In line with our theoretical predictions, we find that patent boxes exert a substantial effect on attracting patent applications. The introduction of patent boxes has caused a spark of suspicion that they are primarily used for tax avoidance due to their favourable taxes. Our results suggest that these suspicions are viable. In further interpretation of our results, we found the regulatory tax effects are not equal for all affiliates. When we divide the dataset in three, based on the size of the affiliates, the results suggest that only large and medium sized affiliates engage in patent shifting strategies. Therefore, when interpreting the results of our main analysis, one should be attentive that we cannot give decisive results for smaller sized affiliates.

In the extension of the main model, we find that low-quality patents are predominantly used in profit shifting activities. These results were somewhat unanticipated, as it contradicts previous literature. In the final elaboration of our analysis, we found that the semi-elasticities were noticeably high when estimating for the patent box dummy variable.

For further research in this topic, we would suggest approaching the same research question with a larger inclusion of countries. The results provided in our thesis are limited to European countries, whereas an even broader analysis could investigate the importance of other influential countries, such as USA, Japan, China, India and Canada. Furthermore, a portion of our sample affiliates are likely to be engaged with tax havens, such as Cayman Islands, Bermuda or Gibraltar. For further studies, including these countries could provide insightful results. In addition to this, there are, and has been since the invention of patents, highly debated how different patents should be characterized as high or low patents. For further research, one might choose another indicator of patent quality that is also applicable for the same research question. The aforementioned extensions of our analysis have not been used because of time limitation and data availability.

9 References

Alstadsæter, A., Barrios, S., Nicodeme, G., Skonieczna, A. M., & Vezzani, A. (2018, January). *Patent Boxes Design, Patents Location, and Local R&D.* Retrieved from Economic Policy, 33(93), 131-177: https://doi.org/10.1093/epolic/eix021

Asen, E. (2020, December 9). *Corporate Tx Rates Around the World, 2020.* Retrieved from Tax Foundation: https://taxfoundation.org/publications/corporate-tax-rates-around-the-world/

Böhm, T., Karkinsky, T., Knoll, B., & Riedel, N. (2015, January 7). *The Impact of Corporate Taxes on R&D and Patent Holdings.* Retrieved from NHH: https://www.nhh.no/globalassets/departments/business-and-management-science/seminars/2015-spring/190215.pdf

Bräutigam, R., Spengel, C., & Streif, F. (2015, August). *Decline of CFC Rules and Rise of IP Boxes: How the ECJ Affects Tax Competition and Economic Distortions in Europe.* Retrieved from ZEW, Centre for European Economic Research: https://ftp.zew.de/pub/zew-docs/dp/dp15055.pdf

Choi, J. P., Ishikawa, J., & Okoshi, H. (2020, July 27). *Transfer Pricing of Intanglible Assets With the Arm's Length Principle.* Retrieved from The Centre for Economic Policy Research: https://voxeu.org/article/transfer-pricing-intangible-assets-arm-s-length-principle

Crivelli, E., Mooij, R. d., & Keen, M. (2016). *Base Erosion, Profit Shifting and Developing Countries.* Retrieved from Public Finance Analysis, 72(3): https://econpapers.repec.org/article/mhrfinarc/urn_3asici_3a0015-2218(201609)72_3a3_5f268_3abepsad_5f2.0.tx_5f2-s.htm

Dharmapala, D. (2014, September). *What Do We Know about Base Erosion and Profit Shifting? A Review of the Empirical Literature.* Retrieved from Chicago Unbound: 10.1111/j.1475-5890.2014.12037.x

Dischinger, M., & Riedel, N. (2011). *Corporate Taxes and the Location of Intangible Assets Within Multinational Firms.* Retrieved from Journal of Public Economics, 95(7-8): https://doi.org/10.1016/j.jpubeco.2010.12.002

Dudar, O., & Voget, J. (2015). *Corporate Taxation and Location of Intangible Assets: Patents vs. Trademarks.* Hentet fra Centre for European Economic Resesarch, Discussion Paper No. 16-015: https://ftp.zew.de/pub/zew-docs/dp/dp16015.pdf

Ernst, C., & Spengel, C. (2011). *Taxation, R&D Tax Incentives and Patent Application in Europe.* Retrieved from Centre for European Economic Research (ZEW) Discussion Paper, No.11-024.: https://www.econstor.eu/bitstream/10419/44983/1/656487917.pdf

Ernst, C., Richter, K., & Riedel, N. (2014, May 4). *Corporate Taxation and the Quality of Research and Development.* Retrieved from International Tax and Public Finance, 21(4): https://link.springer.com/article/10.1007/s10797-014-9315-2

EY. (2020). *Tax Guides Library Archive.* Retrieved from EY: https://www.ey.com/en_gl/tax-guides/tax-guide-library-archive

Gleckman, H. (2013, May 21). *The Real Story On Apple's Tax Avoidance: How Ordinary It Is.* Retrieved from Forbes: https://www.forbes.com/sites/beltway/2013/05/21/the-real-story-about-apples-tax-avoidance-how-ordinary-it-is/

Griffith, R., Miller, H., & O'Connell, M. (2014, February 6). *Ownership of Intellectual Property and Corporate Taxation.* Retrieved from Journal of Public Economics, 112(C): http://www.sciencedirect.com/science/article/pii/S0047272714000103

Hall, B. H., Mairesse, j., & Mohnen, P. (2009). *Measuring the Returns to R&D.* Retrieved from Handbook of the Economics of Innovation, 2: https://www.sciencedirect.com/science/article/pii/S0169721810020083

Hejazi, J. (2006, October 19). *Assessing the Risks of Intangibles Migration.* Retrieved from Tax Management Transfer Prcing Report, 15(10): https://papers.ssrn.com/sol3/papers.cfm?abstract_id=938730

Hickey, W. (2013, May 21). *It's Not Just Apple: The Ultra-Complicated Tax Measures That Microsoft Uses To Avoid $2.4 Billion In U.S. Taxes.* Retrieved from Business Insider: https://www.businessinsider.com/apple-microsoft-avoids-taxes-loopholes-irs-2013-1?r=US&IR=T

Huizinga, H., Laeven, l., & Nicodeme, G. (2008, April). *Capital Structure and International Debt Shifting.* Retrieved from Journal of Financial Economics, 88(1): https://www.sciencedirect.com/science/article/abs/pii/S0304405X08000123?via%3Dihub

Juranek, S., Schindler, D., & Schneider, A. (2018, September). *Royalty Taxation under Tax Competition and Profit Shifting.* Retrieved from CESifo Working Paper Series: https://www.cesifo.org/DocDL/cesifo1_wp7227.pdf

Karkinsky, T., & Riedel, N. (2012, April 14). *Corporate Taxation and the Choice of Patent Location Within Multinational Firms.* Retrieved from Journal of International Economics 88(1): https://doi.org/10.1016/j.jinteco.2012.04.002

Klemm, A., & Liu, l. (2020, December 20). *The Impact of Profit Shifting on Economic Activity and Tax Competition.* Retrieved from International Monetary Fund: https://www.imf.org/en/Publications/WP/Issues/2019/12/20/The-Impact-of-Profit-Shifting-on-Economic-Activity-and-Tax-Competition-48741

Lanjouw, J. O., & Schankerman, M. (2004, April). *Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators.* Retrieved from The Economic Journal, 14(495): https://www.ipeg.com/wp-content/uploads/2015/02/Lanjouw-Schankerman-PATENT-QUALITY-AND-RESEARCH-PRODUCTIVITY-measuring-innovation-with-multiple-indicators.pdf

OECD. (2021). *Intellectual Property (IP) Statistics and Analysis.* Retrieved from OECD: https://www.oecd.org/sti/inno/intellectual-property-statistics-and-analysis.htm

ORBIS by Bureau van Dijk. (2021). *ORBIS.* Hentet fra ORBIS by Bureau van Dijk: https://www.bvdinfo.com/en-gb/our-products/data/international/orbis

Squicciarini, M., Dernis, H., & Criscuolo, C. (2013, March). *Measuring Patent Quality: Indicators of Technological and Economic Value.* Retrieved from OECD Science, Technology and Industry Working Papers: http://dx.doi.org/10.1787/5k4522wkw1r8-en

The Economist. (2012, December 15). *Wake Up and Smell the Coffee.* Retrieved from The Economist: https://www.economist.com/business/2012/12/15/wake-up-and-smell-the-coffee

The World Bank. (2018). *Researchers in R&D (per Million People).* Retrieved from The World Bank: https://data.worldbank.org/indicator/SP.POP.SCIE.RD.P6?end=2018&start=2009&view=chart

The World Bank. (2019). *GDP.* Retrieved from The World Bank: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD?end=2019&start=2009&view=chart

Table A: Definitions of variables and the associated source of data

Variable	Definition	Source of data
Applicant country statutory income tax rate	The statutory income tax rate in the country where the patent is applied for	Tax Foundation
Inventor country statutory income tax rate	The statutory income tax rate in the country where the patent is invented	Tax Foundation
Applicant country effective tax rate	The applicable effective tax rate in the country where the patent is applied for	EY R&D incentives guide; Alstadsæter et al. OECD database
Inventor country effective tax rate	The applicable effective tax rate in the country where the patent is invented	EY R&D incentives guide; Alstadsæter et al. OECD database
IP protection applicant country	An indicator of IP protection in the country where the patent is applied for	The world bank
Freedom of corruption applicant country	An indicator of corruption in the country where the patent is applied for	The world bank
Freedom of corruption inventor country	An indicator of corruption in the country where the patent is invented	The world bank
Number of patent applications	The number of patents applied for by each affiliate in a year	Juranek
Effective tax rate	The applicable effective tax rate on income generated from patents	EY R&D incentives guide; Alstadsæter et al. OECD database

Variable	Definition	Source of data
Patent box dummy	A dummy variable indicating if a country has implemented a patent box regime	EY R&D incentives guide; Alstadsæter et al. OECD database
Statutory income tax rate	The statutory income tax rate applicable for the affiliate	Tax foundation

Table B: Year-by-year summary statistics

This table depicts year-by-year summary statistics of the changes in the tax variables in our sample.

Variable	Year	Mean	Observations
Effective tax rate	2011	24.71%	33323
Effective tax rate	2012	24.37%	33324
Effective tax rate	2013	22.25%	33325
Effective tax rate	2014	22.01%	33324
Effective tax rate	2015	21.90%	33324
Effective tax rate	2016	21.75%	33340
Effective tax rate	2017	18.92%	33359
Patent box dummy	2011	19.52%	33323
Patent box dummy	2012	19.65%	33324
Patent box dummy	2013	34.65%	33325
Patent box dummy	2014	35.21%	33324
Patent box dummy	2015	36.55%	33324
Patent box dummy	2016	36.55%	33340
Patent box dummy	2017	52.71%	33359
Statutory income tax rate	2011	28.24%	33323
Statutory income tax rate	2012	27.89%	33324
Statutory income tax rate	2013	27.74%	33325
Statutory income tax rate	2014	27.29%	33324
Statutory income tax rate	2015	27.03%	33324
Statutory income tax rate	2016	26.66%	33340
Statutory income tax rate	2017	25.92%	33359

Table C: Distribution of observations, based on number of patents

This table depicts the different number of observations and number of patents by specific intervals of patent applications.

Number of patent applications	Number of observations	Percentage of observations	Number of patents	Percentage of patents
50 - 100 patent applications	327	0.14%	22,446	13.3%
20 - 49 patent applications	1,078	0.46%	32,470	19.3%
10 - 19 patent applications	1,742	0.75%	23,315	13.9%
5 - 9 patent applications	3,570	1.53%	23,078	13.7%
0 - 4 patent applications	226,602	97.12%	66,844	39.8%
Sum	233,319	100.00%	168,153	100.0%

Table D: Differences in tax from patent box regimes

From this table, we can observe the tax deductions caused by the aforementioned patent box regimes.

	Tax deductions from patent box regimes						
	All numbers under are given in percentages						
	2011	2012	2013	2014	2015	2016	2017
Belgium	27.102	27.102	27.102	27.102	27.102	28.8	28.8
Switzerland	12.37444	12.37444	12.34858	12.34858	12.34858	12.34858	12.34858
Cyprus	0	7.5	10	10	10	10	10
Spain	18	18	15	15	13	10	10
France	19.85139	19.85139	21.7512	21.7512	21.7512	18.93	18.93
UK	0	0	13	11	10	10	7
Hungary	9.5	9.5	9.5	9.5	9.5	9.5	4.5
Ireland	0	0	0	0	6.25	6.25	6.25
Italy	0	0	0	0	0	0	13.9064
Luxembourg	22.96	22.96	23.38	23.38	23.38	23.38	21.24
Malta	35	35	35	35	35	35	35
Netherlands	18	18	18	18	18	18	18
Portugal	0	0	0	15.75	13.75	13.75	13.75

Table E: Effective tax rates in Europe

In the following table the different tax rates applicable on patent income has been given. The tax rates are calculated by including the tax deductions from European tax regimes.

				Effective tax rate			
				All numbers under are given in percentages			
Country	2011	2012	2013	2014	2015	2016	2017
Austria	25	25	25	25	25	25	25
Belgium	6.798	6.798	6.798	6.798	6.798	5.1	5.1
Bulgaria	10	10	10	10	10	10	10
Switzerland	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Cyprus	10	2.5	2.5	2.5	2.5	2.5	2.5
Czech Rep.	19	19	19	19	19	19	19
Germany	30.175	30.175	30.175	30.175	30.175	30.175	30.175
Denmark	25	25	25	24.5	23.5	22	22
Estonia	21	21	21	21	20	20	20
Spain	12	12	15	15	15	15	15
Finland	26	24.5	24.5	20	20	20	20
France	16.245	16.245	16.245	16.245	16.245	15.5	15.5
UK	26	24	10	10	10	10	10
Greece	20	20	26	26	26	29	29
Croatia	20	20	20	20	20	20	18
Hungary	9.5	9.5	9.5	9.5	9.5	9.5	4.5
Ireland	12.5	12.5	12.5	12.5	6.25	6.25	6.25
Italy	31.4	31.29275	31.29275	31.29275	31.29275	31.29275	13.9
Luxembourg	5.84	5.84	5.84	5.84	5.84	5.84	5.84
Latvia	15	15	15	15	15	15	15
Malta	0	0	0	0	0	0	0
Netherlands	7	7	7	7	7	7	7
Norway	28	28	28	27	27	25	24
Poland	19	19	19	19	19	19	19
Portugal	28.5	31.5	31.5	15.75	15.75	15.75	15.75
Romania	16	16	16	16	16	16	16
Sweden	26.3	26.3	22	22	22	22	22
Slovenia	20	18	17	17	17	17	19
Slovakia	19	19	23	22	22	22	21