The Impact of Corporate Taxes on R&D and Patent Holdings[1]

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Abstract: This paper complements a small but growing literature on the effect of corporate taxes on R&D investment and patent holdings. We provide evidence that patenting strategies are exploited as a device to transfer income to low-tax jurisdictions. Using data on the population of corporate patent applications to the European Patent Office, we show that the location of R&D investment and patent ownership is geographically separated in a non-negligible number of cases. Moreover, our results suggest that this geographical split is partly motivated by tax considerations. We find that countries which levy low patent income taxes attract ownership of foreign-invented patents, especially those patents that have a high earnings potential. Analogously, inventor countries with high patent income tax rates observe ownership relocations of high-quality patents from their borders. Moreover, our results suggest that the probability for a patent to be owned by a party in a tax haven country significantly decreases if the inventor country has implemented controlled foreign company laws.

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1 Introduction

Intellectual property (IP) and other intangible assets are key drivers for corporate success in the modern economy. The income derived from intangible assets is at the same time internationally highly mobile as intellectual property has no trade costs and can thus be held at locations other than the inventor country or the country where the IP is used. Anecdotal evidence suggests that multinational companies exploit this mobility and strategically locate ownership of their intangible property at tax-haven affiliates, with the intention of minimizing their corporate tax burden (Wall Street Journal, 2005, The Guardian, 2009, Business Week, 2010).

Governments and tax authorities have raised increasing concerns about these relocation schemes and the associated revenue losses. Recently, several countries even responded by lowering their tax rates on income from patents and licenses, presumably to stop IP relocations and attract patent income from abroad. Examples are the Netherlands, Belgium and Luxembourg which implemented special patent tax provisions in 2007 and 2008. Most recently, the UK announced to significantly reduce its tax rate on patent income from 2013 onwards.

Empirical studies which assess the link between corporate taxation, R&D investment and intangible asset holdings are, however, still scarce at best. Moreover, existing papers assume that the R&D input and output, i.e. the R&D unit and the resulting patent holdings, are located at one and the same affiliate within a multinational entity (MNE). Contrary to this assumption, practitioners argue that the most attractive patent income relocation schemes involve a geographical split between the R&D unit and the resulting patents[1] as this allows MNEs to reap the benefits from attractive R&D locations in countries with well developed labor markets for high-skilled workers and good infrastructure provisions without facing the downside of high taxes on the R&D output.

The aim of our paper is to quantify the importance and determinants of this income shifting channel. To do so, we employ information on corporate patent applications to the European Patent Office (EPO) between 1990 and 2007, distinguishing between the host countries of the patent applicant and inventor of the technology. Our data indicates that the location of patent applicant and patent inventor is geographically split for around 8 percent of all patent applications. Descriptive statistics moreover

[1] Technically, such a split may for example be implemented through contract research agreements where an R&D unit undertakes research for a group affiliate in a tax-haven country which finances the project and bears its risk. While the R&D unit earns a small fixed profit margin on its costs, the residual income accrues with the contracting entity in the low-tax country.

point to the importance of tax considerations in driving this decision. Precisely, we find that a large fraction of patents held in low-tax economies was invented in a foreign country. In small tax havens, this ratio is often well above 80%, but even in large and economically important low-tax countries like Ireland and Switzerland foreign-invented patents account for around 35% and 45% percent of all patent holdings. Most other European high-technology countries, in contrast, observe much smaller foreign invented patent holdings, commonly well below 10%.

The paper further aims to identify the determinants of the geographical relocation of patent ownership. In doing so, we account for the perspective of both, the inventor country as well as the potential host locations for patent ownership. From a taxation point of view, we expect that a high tax rate on patent income in the inventor country increases the probability that the patent is relocated to a foreign economy. Following the same reasoning, a low patent income tax at potential host locations is expected to attract patent ownership. Moreover, this tax-induced relocation incentive is plausibly larger the higher the expected earnings potential of the patent. Since the literature has provided evidence that the distribution of patent value is highly dispersed (see e.g. Harhoff et al., 1999), we explicitly account for this type of heterogeneity in our analysis. Precisely, to proxy for the earnings potential of the patents in our data, we follow previous studies and exploit information on the family size of the patent (i.e. the number of countries in which the firm files for patent protection), the number of forward citations and the number of industry classes.

In line with these considerations, the results indicate that a high tax rate on patent income increases the probability that the patent applicant is located in a country other than the inventor country. This effect turns out to be larger the higher the value and earnings potential of the patent. From the perspective of the potential host locations, we find that low patent income tax rates are instrumental in attracting foreign patent holdings. Our findings furthermore again indicate that the probability to relocate a patent to a low tax country significantly increases in patent quality. Both results are robust to a large number of model specifications and against controlling for various other country and patent characteristics. Quantitatively, we find that an increase in patent quality by one standard deviation raises the probability of patent location in a foreign tax haven economy by around 10%. This indicates that multinationals distort their patent holdings such that patents with a high expected value and earnings potential tend to be owned in countries with favourable tax legislations. Relocations of patents from the inventor country to a foreign tax haven are in turn found to be less likely if so called controlled foreign company rules are imposed which may make patent income taxable in the parent country.

The design of our empirical baseline analysis implicitly presumes a two-step decision process in which firms first decide whether to relocate the patent to a foreign country and then, conditional on relocation, choose where to locate patent ownership. In sensitivity checks, we show that our results are robust to the adoption of a simultaneous choice framework where firms face the options to retain the patent at the inventor location, relocate it to a foreign tax haven country or to a foreign non-tax haven country. In a further robustness check, we link the patent information to company level data and rerun our baseline models accounting for unobserved heterogeneity across multinational groups. The results support our baseline estimates.

Our paper is related to a small literature that investigates effects of the tax system on the location of R&D activity within multinational companies. Several papers in this literature assess the effects of R&D tax credits and allowances on R&D investments. Early papers by Hall (1993) and Hines (1994) study the responsiveness of corporate R&D to the Research and Experimentation Tax Credit in the US and find significant R&D price elasticities. Similar results are reported by Jaffe and Hines (2001). Bloom et al. (2002) confirm the positive effect of R&D tax credits on the level of R&D expenditures using macro data for OECD countries.

A small number of recent studies moreover stresses the effect of the corporate tax system on the location of the *output* to R&D activities. Grubert and Mutti (2008) show that R&D activities of US parents have become a weak predictor for their received royalty payments but simultaneously strongly determine affiliate earnings in low-tax countries. They interpret their results to reflect tax-avoidance schemes implemented through favorable cost sharing agreements between the parent firm and low-tax subsidiaries. Similar evidence is presented by Dischinger and Riedel (2011) who show that intangible asset holdings are distorted towards low-tax subsidiaries within a multinational group. Griffith et al. (2011) and Karkinsky and Riedel (2012) provide evidence that corporate income tax rates negatively impact on patent holdings of multinational affiliates. Our paper extends their analysis by explicitly focussing on the possibility that multinational groups geographically spilt the location of R&D activities and the resulting patent holdings and by assessing effects related to the selection of patents with different earnings potential across affiliates. In doing so, our paper supports recent theoretical claims that corporate taxation distorts the location of heterogeneous assets (and functions) such that high-value projects are located in countries with a low corporate tax rate and vice versa (see Becker and Fuest (2007) and Haufler and Stähler (2012)).

The paper also contributes to the flourishing empirical literature on tax-motivated international income shifting (see e.g. Huizina and Laeven (2008) for a recent contribution and Devereux and Maffini (2007) for a survey of the literature). While the identification of tax-motivated profit shifting commonly relies on complex empirical identification strategies and a number of non-trivial identification assumptions, our paper offers strongly suggestive descriptive evidence that MNEs relocate income to tax haven economies as we find that tax havens, in contrast to well-developed industrialized countries, host a significant number of foreign invented patents. Since most tax haven countries, especially the small island havens, do not feature institutional or economic characteristics which make them attractive patent holding locations, this descriptive pattern points to distortions in patent ownership for tax saving purposes.

The remainder of the paper is structured as follows: Section 2 presents theoretical considerations to motivate the specification of our estimation model. Sections 3 and 4 describe our data and provide the descriptive statistics. Sections 5 and 6 present the estimation approach and the empirical results. Section 7 concludes.

2 Theoretical Considerations

The purpose of our paper is to empirically investigate whether and to what extent corporations exploit patents to transfer corporate income to tax favorable locations.

From a theoretical point of view, patents are expected to be attractive income shifting devices for three reasons. First, R&D activities tend to earn above average returns (see e.g. Hall et al., 2009) and many patents carry substantial industrial value. Multinationals thus have an incentive to locate their patents at low-tax affiliates in order to reduce their corporate tax burden. This incentive becomes stronger the higher the expected earnings potential of the patent.

Second, locating patents at low-tax affiliates may open up additional profit shifting opportunities as protected intellectual property often serves as a common input factor for several operating affiliates within the multinational group which are forced, by the transfer price system, to pay a royalty to the patent owner. This generates opportunities to distort the royalty payments of group affiliates to the patent-holding affiliate to reduce the MNE's tax burden. Precisely, if the patent is held by a tax-haven entity, the MNE may overstate the associated royalty prices charged to production and sales affiliates in high-tax countries in order to transfer income to the low-tax country.

Third, trade costs for intellectual property protected by patents are essentially zero and their geographical location can thus be separated from operating affiliates (in high-tax countries) at low costs.

In practice, MNEs can exploit various organisational structures to achieve a (re)location of patents to low-tax economies. First, they may obviously shift whole R&D units to low-tax affiliates. As this, however, may involve considerable costs, practitioners claim that one of the most common organisational structures is to engage in subcontracting agreements in which the R&D head office is located in a low-tax country and sets up subcontracting agreements with operating R&D units at other affiliates. The latter earn a fixed margin on their costs while the head office bears the project risk, receives the associated patent rights and earns all residual profits.

The latter strategy implies that the location of patent applicant and patent inventor is geographically separated. The purpose of our paper is the assess the quantitative importance of this type of relocation strategy. We will further identify determinants of the decision to relocate a patent from the inventor country. Following the reasoning above, we expect that a high patent income tax in the inventor country tends to increase the probability of relocation and that this effect is larger the higher the patent's earning potential. Analogously, from the perspective of potential host locations for foreign invented patents, the probability to attract patent ownership is in turn expected to be inversely related to the patent income tax rate, whereas the effect is, again, presumed to be larger the higher the expected value of the patent. The theoretical considerations thus predict a systematic selection of high-quality patents to low-tax entities (see also Haufler and Stähler (2012) for a closely related theoretical argument).

Furthermore note that several (high-tax) countries try to limit income shifting from their borders by so-called 'Controlled Foreign Company' (CFC) rules which aim to prevent companies from avoiding taxes in their residence country by diverting income to subsidiaries in low tax jurisdictions. CFC rules operate by imposing an immediate tax charge at the level of the parent company on income earned in a foreign subsidiary if a set of criteria is fulfilled. The criteria vary across countries but in essence include an ownership threshold (e.g. the parent must hold more than 10% of the equity in the subsidiary), a tax threshold (e.g. the foreign tax paid on the subsidiary income must be less than 60% of the tax that would have been paid had the income been generated at the parent's location), and a threshold which specifies that a certain proportion of the subsidiary's income must arise from 'passive' or 'tainted' sources (e.g. a fraction greater than 5%). In most national CFC laws, royalties are considered to be passive income. If the CFC criteria for a given subsidiary are met, the passive income of that subsidiary effectively becomes taxed at the corporate rate at the parent location, even if the income is not repatriated. Consequently, if CFC rules are in place, we consider the relocation of patents to low-tax countries to be less attractive.

In the following, we will bring these hypotheses to the data.

3 Data

To investigate the questions outlined above, we exploit patent data from the European Patent Office's (EPO) Worldwide Patent Statistical Database (PATSTAT). While these data are available for the period 1978 to 2007, our analysis is restricted to the years from 1990 onwards as we lack concise tax information for earlier years.

EPO's Worldwide Patent Statistical Database (PATSTAT) contains information on all patent applications to the EPO, including information about the patent applicant and the patent inventor, the application date, the technology class of the patent and the patent citations. The data version used in this paper is October 2007 and comprises up to 100,000 patent applications per year (from corporate and non-corporate patent applicants). Firms seeking patent protection in a number of European states may file an application directly at the EPO and designate the relevant national offices (among those covered by the EPO) in which protection is sought.[2] Filing a patent with the EPO offers two main advantages: first, firms can make a single application which is cheaper than filing separately in each national office, and second, firms can delay the decision over which national states to further the application in. Thus, it is especially attractive to file the valuable patents with the EPO which a firm intends to exploit in several European markets.

Each patent application comprises detailed information on the patent inventor and the patent applicant, including information on their respective host country. The host country of the patent inventor indicates the location of the R&D unit that created the patented technology or innovation, while the patent applicant is the legal owner of the patent who is consequently subject to taxation (see e.g. Quick and Day (2006)). We restrict our focus to corporate patent applications which were granted by the EPO and where the main inventor (i.e. the first inventor listed on the patent application) is located in an EU 25 or OECD country. In total, our data comprises $530,805$ patent applications. As described above, the focus of our analysis are patent applications where

[2]The EPO is not a body of the European Union and as a result the states which form part of the European Patent Convention (the legal basis for the EPO) are distinct from those in the European Union. See: http://www.epo.org/about-us/epo/member-states.html.

patent inventor and patent applicant are located in different countries.[3] This is the case for $41,961$ patent applications in our sample, i.e. around 8% of all patent applications. Note moreover that, as we only observe information on patent applications, our data does not capture any patent relocation after the application process. However, as outright sales of intangible assets are rare in practice, we consider our analysis to reflect the most important strategies to transfer patent ownership to low-tax economies (see e.g. OECD, 2009).

On top of this baseline information, our analysis requires the construction of indicators for the earnings potential of each patent.[4] In doing so, we follow the previous literature and rely on standard quality indicators for each patent as constructed by Hall et al. (2007). Our preferred measure is the patent's family size, i.e. the number of countries in which the firm seeks patent protection for a particular technology. Since patent applications are associated with significant filing costs (comprising e.g. costs for patent attorneys, filing fees at tax offices and costs for the translation of documents), the number of markets in which patent protection is sought is expected to increase in the value of the patent. The construction of the family size for each patent accounts for equivalent patent applications filed outside of the EPO at an earlier time (priority applications) as well as all applications that report the considered EPO application as a priority. After removing any double counting, the sum of the two measures constitute the size of the patent family.

Following previous studies, we furthermore use the patent's number of forward citations as a proxy for its industrial value. A high number of forward citations indicates that the technology which is protected by the patent has served as a basis for several future inventions. To the extent that the level of technical innovation is positively correlated with a patent's industrial value, the variable is suited as a proxy for the patent's earnings potential. The construction of the variable used in our data accounts for citations within a five year period from the publication date (see Hall et al., 2007).[5]

[3]We employ a strict and a lax definition of a foreign patent. According to the strict definition a patent is defined as foreign if all applicants named on the patent are located in a different country than all inventors named on the patent. According to the lax definition a patent is defined as foreign if the first applicant named on the patent is located in a different country than all inventors named on the patent.

[4]It has been demonstrated by previous research that the distribution of patent value is highly dispersed and skewed (see e.g. Harhoff et al., 1999). While some patents have little or no industrial application and therefore low economic value, others are of substantial value to the assignee.

[5]These citations have an important legal function in the sense that they limit the scope of property

Finally, our analysis also accounts for the number of technological classes that has been shown to be an indicator of technological quality similar to the number of citations (see Lerner, 1994). To guarantee a reasonable level of precision, the construction of our third quality measure accounts for an eight-digit IPC classification reported in the patent document.

We also combine the information contained in these three quality indicators into one quality index variable using factor analysis. Precisely, assuming that the variation in the indicators consists of a quality related component and an idiosyncratic component, the estimation of the factor model exploits that variation in patent quality induces variation common to all indicators and thus yields estimates for patent quality conditional on the indicators (see Hall et al. (2007) and Lanjouw and Schankerman (2004) for details). In our empirical analysis to come, we will use the composite quality variable derived from the factor model. Moreover, we account for the patent's family size which we consider to be the best indicator for the quality of the patent in the earnings dimension.

Since several authors have stressed that the value of patents varies across industries and across time, we follow the existing literature and use quality measures which control for technology and year fixed effects (i.e. are constructed as deviations from the average patent quality in a technology class at a given point in time).[6]

Descriptive statistics for the quality measures in our data are presented in Table 1A. The average value of the composite quality index is 0, varying strongly though between -2.5 and $+7.9$. A similar pattern is found for the family size index. Beyond the quality measures, the data set comprises information on the first industry class which will allow

rights which are awarded to a patent. In the case of EPO patents, inventors are not required to cite prior technology used in the development of their patent and the references are consequently usually added by patent examiners. This implies that not necessarily all innovations which draw on an existing patent in fact acknowledge the reference whereas it has the benefit of a consistent and objective patent citation practice. Note that previous studies have also used backward citations as a measure for patent quality. However, while some scholars have suggested that a large number of backward citations may, for example, reflect a more derivative nature of a patent and a lower degree of innovation (see e.g. Lanjouw and Schankerman, 2004), a large number of citations may also reflect an innovative combination of existing ideas. Consequently, the literature has provided mixed results regarding the correlation between backward citations and patent value (see e.g. Harhoff et al. (1999)). Hence, following this argumentation, our patent quality indicators do not account for information on backward citations.

[6]Note that using quality measures which do not account for this type of normalisation yields similar results to the ones reported in this paper, as our empirical analysis will account for year and technology fixed effects.

us to control for industry fixed effects (related to the patent) in our empirical analysis and information on the year of the patent application. Furthermore, we augment our data by variables which capture various host country characteristics, most importantly information on the host country's tax rate levied on patent income which is obtained from the Corporate Tax Guides of Ernst & Young. While most countries tax patent income at the same rate as other corporate income, a growing number of countries have adopted special low tax rates for patent income in recent years (e.g. Belgium and the Netherlands). Our tax measure accounts for these special low rates for patent income where applicable. Moreover, we define a dummy variable which indicates whether the patent applicant is located in a tax haven country or not where tax havens are defined according to the definition of Dharmapala and Hines (2009). This list comprises all low-tax countries in our data.[7]

Last, we construct a CFC dummy variable which indicates whether CFC legislations are binding for a subsidiary in a given year. The information on CFC legislations is collected from Sandler (1998), Lang et al. (2004) and the International Bureau of Fiscal Documentation (IBFD). As described above, for CFC rules to be binding, they have to be implemented in the subsidiary's parent country and three additional criteria have to be fulfilled: First, the parent firm has to hold a sufficiently large ownership share in the subsidiary. Second, the income derived in the subsidiary has to be mainly passive in nature. Third, the subsidiary's host economy has to be classified as a tax haven by its parent country. In general, royalty income earned on patents is one potential source of passive income in a subsidiary since it often does not relate to other active parts of the business, which suggests that the passive income criterion is fulfilled. Consequently, the construction of our CFC dummy variable will focus on the tax haven criteria which are summarized in Table 1c for the most important parent countries in our sample. As depicted in the table, the tax haven criteria are fulfilled if the subsidiary's host country is on a black list at the parent location or exhibits a corporate tax rate that falls short of a defined threshold. As indicated in the descriptive statistics, most of the patents in our data observe inventor countries which have enacted CFC legislations.

Last, we include information on several host country characteristics like GDP per capita (as a proxy for economic development), the size of the population (as a proxy

[7]In our empirical analysis, we will assess the sensitivity of our results to alternative tax haven definitions. We will for example separately account for the small (island) tax haven economies, excluding Ireland and Switzerland from the definition. Moreover, note that tax havens have proved to be persistent over time. Dharmapala and Hines (2009)'s definition of tax haven countries used in this paper relies on a tax haven list published 15 years earlier in Hines and Rice (1994).

for country size) and governance indicators (to capture the institutional quality in a country) which are obtained from the World Development Indicator Database and the World Bank' governance project respectively.[8] Table 1B presents our basic sample statistics.

4 Descriptive Analysis

Our theoretical considerations in Section 2 suggest that patents are mobile assets within multinational firms whose geographical location can be separated from the inventor country (and other operating affiliates). Consequently, corporations have an incentive to distort their location towards low-tax affiliates in order to reduce their corporate tax burden. Moreover, this incentive is predicted to be higher the larger the expected earnings potential of the patent.

We thus presume that low-tax countries are, ceteris paribus, more likely to attract ownership of foreign-invented patents. To assess this hypothesis, we rank all countries in our data set according to the fraction of patents that were exclusively invented abroad distinguishing between tax haven economies, as defined in Dharmapala and Hines (2009), and non-tax havens.[9] Figure 1 plots country ranks according to the fraction of foreign invented patents along the vertical axis against ranks according to country size (as measured by the overall number of patent applications) along the horizontal axis. Blue symbols depict tax haven countries, while the red symbols depict non-haven countries.

In line with the presumption spelled out in Section 2, tax haven countries tend to be in the upper part of the figure and thus host an over proportional number of foreign invented patents. This pattern is confirmed in Table 1A which presents the fraction of foreign invented patents for a number of tax haven economies in the year 2005. In many cases the fraction is well beyond 80%, indicating that the majority of patents

[8]Note that information on the governance indicators is available on an annual basis back until 2002. Between 1996 and 2001, the information was published every second year. For those sample years for which information is unavailable in our data, we use the index information from the next year for which data is available.

[9] Foreign-invented patents are patent applications where all inventors noted on the patent application are located in a different country than the patent applicant. Note that this is a rather strict definition of a foreign patent application as our data also includes several applications where one or more patent inventors are located in a different country than the patent applicants. Our analysis below will account for the latter cases in robustness checks.

owned at tax haven locations was invented in a foreign country. Even the large and economically more relevant tax haven countries of Switzerland and Ireland observe a large fraction of foreign invented patents (33.1% and 45.1%). This is in sharp contrast to well-developed industrialized economies in Europe and Northern America. As shown in the table, the average share of foreign invented patents in non tax haven EU25 countries is 11.3%, while many large high-technology countries like Germany observe a fraction of foreign invented patents below 5%. Since most tax haven countries, especially the small island havens, do not feature institutional or economic characteristics which make them attractive patent holding locations, this descriptive pattern points to distortions in patent ownership for tax saving purposes.

Figure 2 illustrates how this phenomenon has developed over time. It depicts the time trend in the fraction of foreign-invented patents as well as the time trend in the fraction of foreign-invented patents that end up to be owned in a tax-haven economy. While the former variable shows a strong upward trend, the fraction of foreign-invented patents that are held at a tax-haven location has only slightly increased over the past decades.

Our theoretical discussion furthermore predicts that MNEs have an incentive to systematically distort their high-value patent holdings towards low-tax economies. This suggests that patents held at tax-haven locations exhibit an above average value and earnings potential. Figures 3a and 3b show the kernel density of the composite quality index as defined in the previous section and the family size quality variable, distinguishing between patents owned at tax haven locations (blue-colored density) and patents owned in non-haven countries (red-colored density). In both figures, the kernel density distribution for the tax haven patents lies to the right of the kernel density for the non-haven patents, thus featuring more probability mass on higher patent values which supports the theoretical notion spelled out in Section 2. Analogously, we find that patents which are relocated from high-tax inventor countries (with an above average patent income tax rate) feature above average quality and earnings characteristics (see Figures 4a and 4b for the composite and the family size index respectively), which again underpins the notion that the restructuring of patent holdings is especially attractive for high value patents.

5 Estimation Strategy

In the following, we will assess the role of taxation and patent quality in determining the patent location choice in more detail, controlling for observed and unobserved characteristics of patents and host locations. In our empirical baseline framework, we model the MNE's relocation decision as a two-step process in which we firstly analyse the determinants of the corporate decision to relocate a patent from the inventor location to a foreign country (Section 5.1) and then secondly investigate the host country features which attract ownership of foreign invented patents (Section 5.2). In robustness checks (Section 5.3), we model the MNE's decision problem as a simultaneous choice process in which firms decide to keep the patent at the inventor location or to relocate it to a foreign tax-haven or a foreign non-tax haven country respectively. In sensitivity checks, we furthermore link our data to firm level information and control for unobserved heterogeneity across firms and multinational groups.

5.1 Taxation and the Relocation from the Inventor Country

In the first part of our baseline analysis, we assess potential determinants of the relocation decision of patent holdings from the inventor country.[10] For that purpose, we define a binary variable $b_{j,i,t}$ which takes on the value 1 if patent j is relocated from its inventor location to a foreign country (in the sense that all patent applicants are located in a different country than all patent inventors) and 0 otherwise. The subscript i indicates the host country of the first inventor named on the patent application and the subscript t refers to the year in which the patent application is filed with the patent office. We follow the latent variable approach to binary choice models and specify an unobserved underlying stochastic variable $b^*_{j,i,t}$ as

$$b^*_{j,i,t} = \alpha_0 + \alpha_1 \tau_{i,t} + \alpha_2 V_{j,i,t} + \alpha_3 (V_{j,i,t} \times \tau_{i,t}) + \alpha_4 X_{j,i,t} + \mu_{j,i,t}. \tag{1}$$

The variable of main interest is the corporate tax rate $\tau_{i,t}$ in country i at time t. Our discussion in the previous section suggests that a higher tax rate on patent income in country i makes it more attractive to own the patent in a different country. Moreover,

[10] The model thus explains the probability of patent relocation *conditional* on the location of the inventor. We consider this to be a plausible design as R&D activities are one of the least mobile tasks within multinational groups and tend to be held with the parent firm (see e.g. Abramovsky et al. (2008) and Criscuolo et al. (2010)). Moreover, relocating a patent is perceived to be associated with smaller costs than relocating whole research units which require access to skilled labor and are prone to agency costs.

this incentive should be larger, the higher the value of the patent $V_{j,i,t}$ which suggests $\alpha_1 > 0$ and $\alpha_3 > 0$. The coefficient estimate for α_2 is in turn expected to be negative, as in tax haven countries with a patent income tax of zero ($\tau_{i,t} = 0$), MNEs face the reverse incentive from a taxation perspective and are expected to be less likely to relocate a patent from the inventor country if its value increases.

Moreover, our model accounts for a large set of control variables which are subsumed in the vector $X_{j,i,t}$. Precisely, we add a full set of year dummies to absorb shocks over time which are common to all patent applicants in our data. Moreover, we include a full set of inventor country fixed effects which account for time-constant country specific features that may determine the probability of a patent inventor to transfer ownership to a foreign country. Last, we include a full set of both industry fixed effects (for 130 industry classes) and industry-year fixed effects to account for the possibility that the probability to relocate patents abroad is critically determined by the industry classification and/or by industry shocks over time.

Last, $X_{j,i,t}$ contains several time-varying country controls, namely the market size (as captured by the population number), the country's level of development (as captured by the GDP per capita), the country's governance situation (as captured by governance indicators on the rule of law and corruption control provided by the World Bank (see Kaufmann et al., 2008)).[11]

As usual, the latent variable $b^*_{j,i,t}$ is related to the observed outcome $b_{j,i,t}$ by the following rule

$$\begin{aligned} b_{j,i,t} &= 1 \quad \text{if} \quad b^*_{j,i,t} > 0 \\ b_{j,i,t} &= 0 \quad \text{if} \quad b^*_{j,i,t} \leq 0 \end{aligned} \tag{2}$$

Accordingly, the probability to observe a patent relocation can be written as

$$P(b_{j,i,t} = 1) = \Psi(\alpha_0 + \alpha_1 \tau_{i,t} + \alpha_2 V_{j,i,t} + \alpha_3 (V_{j,i,t} \times \tau_{i,t}) + \alpha_4 X_{j,i,t}) \tag{3}$$

where we assume a normal distribution and let Ψ be the cumulative distribution function of it.[12] We estimate this model with maximum likelihood techniques to obtain the

[11] We also ran specifications which control for other World Bank governance indicators, precisely voice and accountability, political instability, regulatory system and government efficiency. This does not increase the explanatory power of the model (nor does it affect the results of interest), reflecting the very high correlation among the different governance indicators.

[12] We also assessed the sensitivity of our results to other distributions. This comparison is of particular importance since the number of geographical relocations is relatively small. As suggested by Greene (2008), we compare our results to those obtained from a logit model, which assumes a logistic distribution for Ψ which yields comparable results.

parameter estimates. We moreover assess the above relation using a standard linear probability model. This appears especially important as our set of regressors includes an interaction term between the corporate tax rate and the patent quality which is difficult to interpret in the context of a probit model.[13]

5.2 Taxation and the Relocation to a Tax Haven Country

In a second step, we assess whether and to what extent taxation plays a role in attracting foreign patent holdings and identify the determinants of patent location in a tax haven country - conditional on being relocated from the inventor country - by estimating a probit model with $h_{j,i,t}$ being a binary variable indicating whether patent j filed at time t with an inventor in country i is owned in a tax haven country (in the sense that the first applicant on the patent is located in a tax haven economy as defined in Dharmapala and Hines (2009)). Formally,

$$h^*_{j,i,t} = \beta_0 + \beta_1 V_{j,i,t} + \beta_2 X_{j,i,t} + \epsilon_{j,i,t} \tag{4}$$

The variable of main interest is the patent quality $V_{j,i,t}$. The hypothesis spelled out in Section 2 suggests that the corporate incentive to locate patents at tax haven affiliates is larger the higher the value of the patent and thus, we presume $\beta_1 > 0$. The set of control variables variables corresponds to the previous sections and comprises year fixed effects, inventor country fixed effects, time-varying inventor country characteristics as well as patent industry fixed efffects.

While this approach is suited to identify the determinants of tax haven ownership of corporate patents, it does not allow to assess the impact of various host country characteristics in attracting foreign patent holdings. To account for this, we additionally estimate a conditional logit model which assesses the impact of a vector of host country features on patent ownership. To keep the analysis tractable, we again focus on the set of relocated patents, i.e. those patent applications where the inventor and the patent applicant are located in different countries. In doing so, we account for a choice set of 29 countries which are attractive host countries for patent applicants in the sense that they host the applicants of more than 50 patent applications in our sample period. We then expand our data set of relocated patents to reflect the choice set of these 29 countries and include various country characteristics potentially determining the patent location choice and a variable for the geographic distance between the inventor

[13]Complimentarily, we also address this problem by omitting the interaction term from the probit estimations and estimating the model separately for patents of different quality.

and the potential applicant country (as measured by the geographical distance between the economic centres of the two countries). Most importantly, we include the potential applicant country's patent income tax rate in the set of regressors.

The specification of the conditional logit model also accounts for the fact that the impact of tax-related host country characteristics may differ depending on the value of the patent. Precisely, we expect taxation to be of increasing importance for the location decision the higher the expected patent value. To account for that, we estimate the conditional logit model separately for patents with different earnings potential $V_{i,t}$.

5.3 Robustness Check

The estimation models presented so far account for the decision to relocate a patent from the inventor country and to choose a particular foreign country as a host location in separate frameworks. Complementary to these models, we estimate a multinomial choice model which helps to identify effects of patent characteristics and inventor country features on the choice of the ownership location of the patent in a unified framework. To keep the model tractable, we account for three potential firm choices: retaining ownership in the inventor country, relocating the patent to a foreign tax haven country and relocating the patent to a foreign non-tax haven country. The model results are presented in Section 6.3.

On top, we run robustness checks which link our patent information to firm level data provided by Bureau van Dijk. Making use of ownership information in this data, we reestimate the models outlined in equations (1) and (4) including a full set of multinational group fixed effects and thus controlling for time constant unobserved heterogeneity of groups. See Section 6.3 for details.

6 Results

The empirical results are presented in Tables 2A to 6. Following the structure of the methodology section, we first assess the determinants of the decision to relocate a patent from the inventor country (Section 6.1), and second identify host country characteristics that are instrumental in attracting foreign patent ownership (Section 6.2). We furthermore assess the robustness of our results in a number of sensitivity checks

(Section 6.3).[14]

6.1 Relocation from the Inventor Country

The baseline specifications in Tables 2A and 2B estimate the model specified in Section 5.1. Robust standard errors that are clustered at the level of the inventor country per year are shown in brackets below the coefficient estimates. All specifications include a full set of country and year fixed effects to absorb time-constant country-specific differences in the relocation probability and common time trends.

Specification (1) of Table 2A assesses the impact of patent income taxes in the inventor country and the patent's earnings potential, as proxied by the composite patent quality index, on the patent's relocation probability from the inventor country in the context of a probit model. The coefficient estimate for the tax rate variable is positive and marginally statistically significant, indicating that a higher tax rate in the inventor country raises the probability that the patent is relocated to a foreign economy. In line with our theoretical considerations, the specification moreover suggests that the relocation probability increases in patent quality, thus indicating that for high value patents in particular inventor and ownership location do not coincide. Calculating marginal effects suggests that the identified relationships are quantitatively relevant. An increase in patent quality by one standard deviation (=0.829, cf. Table 1B) is found to raise the relocation probability by 0.41 percentage points or, evaluated at the sample mean, by 5.2%. Somewhat smaller effects are derived for the tax variable where an increase in the patent income tax by 10 percentage points is suggested to increase the relocation probability by 0.3 percentage points or, evaluated at the sample mean, by 3.7%.[15]

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[14] Since our analysis aims to investigate tax-motivated relocations from the inventor country, the analysis disregards patents that were *invented* in tax-haven countries with EU25 or OECD, namely Cyprus, Ireland, Luxembourg, Malta and Switzerland. This sample restriction is not decisive for our results though. Furthermore note that we do not make any restrictions with respect to the applicant country. Thus patents where the inventor is located within an EU25 or OECD country but the patent applicant is located outside this country group are included in the analysis.

[15] The marginal effect for the quality index and corporate tax rate are calculated with 0.0050 and 0.0296 respectively. An increase in the patent quality by one standard deviation thus raises the probability of patent relocation by $0.41 (= 0.005 \cdot 0.829)$ percentage points. Evaluated at the sample mean $(= 0.079)$, this corresponds to an increase in the relocation probability by 5.2%. Analogously, an increase in in the patent income tax by 10 percentage points raises the probability of patent relocation by 0.3 percentage points $(= 0.0296 \cdot 0.10)$. Evaluated at the sample mean $(= 0.079)$, this corresponds

In specification (2), we augment the model by additional control variables for market size and the degree of development in the inventor country as captured by the country's GDP and GDP per capita as well as the country's governance situation as captured by the World Bank governance indices for the rule of law and corruption control. Specification (3) moreover accounts for a full set of patent industry-fixed effects. Both modifications leave the coefficient estimate for the quality index qualitatively and quantitatively unchanged, while the coefficient estimate for the patent income tax variable loses in significance.

The latter result may reflect that many of the patents in our data in fact carry a small industrial value only and their locational choice is for that reason hardly responsive to tax incentives. Following our argumentation in the previous section, we thus reestimate the model in specification (3) adding an interaction term between the patent income tax rate and the composite patent quality index. In line with expectations, we find a positive and statistically significant coefficient estimate for the interaction variable, indicating that patent relocation becomes more responsive to taxation when the patent carries a high industrial value. Put differently, increasing the patent value raises the relocation probability of the patent from high-tax inventor countries (positive coefficient estimate for α_3 in equation (1)) but tends to lower the relocation probability from low-tax economies (negative coefficient estimate for α_2 in equation (1)).

Since the quantitative interpretation of interaction effects in probit models is highly problematic, we reestimate specifications (3) and (4) in a linear probability model. The results are presented in specifications (5) and (6). The positive coefficient estimate for the quality index variable in specification (5) again suggests that the relocation probability increases in the value of the patent. Specification (6) again qualifies this finding and suggests that high-value patents have a higher probability to be relocated from inventor countries with high patent income tax rates (as indicated by the positive coefficient estimate for the interaction term between patent quality and the patent income tax rate). The baseline estimate for the quality index is determined with -0.028, suggesting that for countries with a patent income tax rate of zero, the inverse holds true and the relocation of patent income from their borders is diminished with rising patent quality. This is intuitive as keeping high-value patents in tax haven countries is an attractive tax saving strategy. Evaluated at the average patent income tax in our inventor countries (= 43.1%), an increase in the patent quality index by one standard deviation raises the relocation probability by 0.5 percentage points or, evaluated at the

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to an increase in the relocation probability by 3.7%.

sample mean, by 6.6%. Similar (but quantitatively slightly smaller) findings are derived when we reestimate the specifications using the family size quality index instead of the composite one (see columns (7) and (8)).

These baseline findings are corroborated in specifications (9) to (12) where we split the sample in inventor countries with an above and below patent income tax rate (=43.1% sample mean, see Table 1B). While patent quality does not significantly impact on the probability of relocation in the latter subsample, we find a positive and statistically significant effect in the former one. Here, an increase in patent quality by one standard deviation raises the probability of patent relocation by 1.2 percentage points, or evaluated at the sample mean by 14.7%.

Our results furthermore turn out to be insensitive to dropping particular inventor countries from the sample. Specifications (1) and (2) of Table 2B reestimate the baseline regressions in columns (5) and (6) of Table 2A excluding patents that were invented in one of the large countries that dominate our sample, namely the US, Great Britain, France and Germany. The general pattern of the results remains unchanged by this modification, with high-value patents having a higher (lower) probability to be relocated from high-tax (low-tax) inventor countries. The same holds true if we exclude patents that were invented in Eastern Europe[16], see specifications (3) and (4).

In columns (5) and (6), we moreover reestimate specifications (5) and (6) of Table 2A using a less stringent definition of a foreign patent. Precisely, while our baseline specifications define a patent to be foreign if all patent applicants are located in a different country than all patent inventors, we now adjust the definition in the sense that a patent is defined to be foreign if the first applicant on the patent is located in a different country than all inventors (while other applicants are allowed to be located in the same countries as the inventors of the patent). This yields findings comparable to the previous estimates.

6.2 Relocation to a Tax Haven Country

Following our theoretical presumptions, we would expect that increases in the earnings potential of patents do not only exert a positive effect on the probability of relocation from high-tax inventor countries but, inversely, also raise the probability that patents are relocated to foreign tax haven economies. To assess this hypothesis, we reestimate

[16]The Eastern European countries comprise Bulgaria, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovenia and Slovakia.

the linear probability model using a dummy for tax haven ownership as the dependent variable. Following our discussion in Section 3, the dummy takes on the value 1 if the first applicant on the patent is located in a tax haven economy as defined by Dharmapala and Hines (2009). The results are presented in specifications (7) to (10). Specification (7) regresses the tax haven dummy on the composite patent quality index. The coefficient estimate turns out significant, indicating that an increase in patent value by one standard deviation raises the probability of ownership location in a foreign tax haven economy by 0.3 percentage points. Evaluated at the sample mean (= 2.0 percent), this corresponds to a substantial relative increase of 16.6%.

As described in Section 2, several countries have introduced so-called Controlled Foreign Company (CFC) rules to hedge against income relocations from their borders. Since binding CFC legislations make passive (patent) income immediately taxable in the parent country, they are expected to diminish the incentive for patent relocations to foreign tax haven economies. To assess this hypothesis, we rerun specification (7) augmenting the set of regressors by a dummy variable which indicates whether the inventor country has implemented CFC laws. The results are presented in specification (8) and suggest that CFC clauses indeed make the relocation of patents to foreign tax haven economies less attractive as the coefficient estimate for the CFC dummy is negative and statistically significant. Quantitatively, the findings suggest that CFC clauses reduce the probability of relocation by 0.7 percentage points, or evaluated at the sample mean, by 35%. This finding is confirmed in specifications (9) and (10) which reestimate specifications (7) and (8) using family size as indicator for the patent's earning potential. Furthermore note that the quantitative effect of patent value as measured by family size on the probability of tax haven location turns out larger than the baseline estimate for the composite quality index. Precisely, an increase in family size by one standard deviation raises the probability for tax haven location by 22%.[17] This is in line with the notion that the patent's earnings potential in particular is decisive for relocations to tax haven economies (as family size is likely a better proxy for the patent's expected earnings than forward citations and industry classes).

Table 3 presents specifications where we investigate the determinants of patent location at tax haven economies (as defined in Dharmapala and Hines, 2009), conditional on relocation from the inventor country. The sample is thus restricted to relocated

[17] The coefficient estimate for the family size variable is 0.008 (see specifications (8) and (10)). An increase in the family size index by one standard deviation (=0.56, cf. Table 1B) raises the probability for relocation by 0.4 percentage points. Evaluated at the sample mean (=2.0%), this corresponds to an increase by 22%.

patents. Specifications (1) to (3) present the results of a probit model with different sets of control variables. Again, the coefficient estimate for patent quality turns out positive and significant, confirming the notion that a high patent value increases the probability of tax haven ownership. We derive similar findings in a linear probability framework (specification (4)) and with family size as the quality indicator (specification (5)). Quantitatively, the effects are somewhat smaller than in the regressions presented in columns (7) to (10) of Table 2B but remain large in absolute terms. Specification (5) suggests that an increase in the composite quality index by one standard deviation raises the probability of tax haven ownership by 5.1%. Proxying quality by family size yields a slightly larger effect of 9.2%.

As described above, the definition of tax haven countries in our analysis follows Dharmapala and Hines (2009) and thus also comprises large well-developed tax haven economies, in particular Switzerland and Ireland. Specifications (6) and (7) reestimate the regressions in columns (4) and (5) making use of a more narrow tax haven definition which excludes the countries of Switzerland and Ireland. The results are qualitatively and quantitatively similar to our previous findings.

The obvious shortcoming of this binary model framework is that it does not allow us to assess whether and to what extent country characteristics, in particular tax legislations, attract patent holdings from abroad. To account for these aspects, we augment our analysis by a conditional logit framework for the patent location choice. As described in the previous section, we use the set of relocated patents and expand our data set to account for 29 potential host locations for the corporate patent (all countries in our data base where we observe more than 50 patent applications within our sample period). The central aim of the analysis is to assess whether high patent income taxes tend to deter the location of foreign patents.

Specification (1) of Table 4 estimates a conditional logit model which accounts for the patent income tax in the considered host economy and control variables for the market size of the host country (as measured by its GDP), the level of development (as measured by GDP per capita) and the distance between the inventor country and the considered host economy (as measured by the distance between the country's economic centres).[18] As expected, the results suggest a negative and statistically significant effect of the patent income tax rate on the choice of a patent location. The finding moreover

[18]Table 4 presents specifications where standard errors are clustered at the level of the patent. We assessed the sensitivity of the results to clustering at the inventor country year level which yields comparable results.

is confirmed if we additionally augment the set of regressors by control variables for the host country's governance situation in specification (2). Further note that the control variables exhibit the expected signs as country size, its degree of development and governance situation positively impact on the probability of patent location while distance to the inventor country tends to decrease the likelihood of patent ownership.

Since the calculation of marginal effects is difficult in the context of a conditional logit model (as it would require specifying a distribution for the fixed effects), specification (3) reestimates specification (2) in the context of an OLS model with patent fixed effects. Again, the coefficient estimate is negative and statistically significant, suggesting that an increase in the tax rate by 10 percentage points reduces the probability to attract a foreign patent by 0.24 percentage points, or evaluated at the sample mean, by 7.0%. To assess our hypothesis that tax considerations become more important the higher the expected earnings potential of the patent, we reestimate specification (3) splitting the sample in subsamples of patents with below and above average value (as measured by the composite patent quality index). The results are presented in specifications (4) and (5) of Table 4 and in line with our hypothesis suggest that the patent relocation choice is significantly more sensitive to changes in the patent income tax rate for the subsample of patents with an above average patent value. Evaluated at the sample mean, increasing the corporate tax rate by 10 percentage points reduces the location probability for patents with below average quality by 2.3%, while the location probability of patents with above average value decreases by 11.6%. Note that the coefficient estimates are statistically different from each other at the 1% level. This finding is corroborated by specification (6) which restricts the sample to patents in the upper quartile of the patent value distribution. Here, again the coefficient estimate for the tax variable turns out somewhat larger in absolute terms. Similar results are derived when we interact the tax variable with a quality index, as measured by the composite quality variable and the family size variable respectively in the full sample (see specifications (7) and (8)).

Furthermore, as described in Section 2, the attractiveness to locate a patent in a country may be significantly diminished if CFC legislations implemented in the inventor country are binding towards the country (i.e. if the country is considered a tax haven location in the inventor country's CFC legislations). To account for this possibility, we augment our set of regressors by a dummy variable indicating whether CFC legislations in the inventor country are binding with respect to the considered host location. The results of an OLS specification are presented in column (9) and yield a zero-effect for the CFC variable. While this may reflect that CFC legislations lack effectiveness in deterring income shifting through patent relocations, it may also reflect that our data comprises many patents with a low industrial value for which tax considerations do not play an important role. We thus reestimate specification (9), restricting the sample to patents with an above average quality index (specification (10)) and patents in the upper quartile of the patent value distribution (specification (11)). Consistent with our previous findings, this sample restriction raises the coefficient estimates for the tax variable in absolute terms. Moreover, the coefficient estimate for the CFC legislation variable turns negative and statistically significant. Specification (11) suggests that binding CFC legislations reduce the location probability for high value patents by 0.7 percentage points or, evaluated at the sample mean, by 20.3%.

6.3 Additional Robustness Checks

Our baseline findings thus confirm that taxation affects the location of patent ownership across countries and that these tax considerations become more important the higher the value of the patent. On top, we ran a number of robustness checks to assess the sensitivity of our analysis to alternative model specifications.

In a first check, we linked our patents data to firm level information provided in Bureau van Dijk's AMADEUS data base. The firm data offers accounting and ownership information for corporations located in Europe. The two data sets were merged using name matching procedures in a research effort undertaken by Grid Thoma. The match rates for our data set are satisfactory with around 60% of our patents being matched to firm level data. Note that the match rates are somewhat lower than in previous studies as our baseline sample also comprises patent applicants and inventors from OECD countries outside Europe which are not covered in AMADEUS. From the ownership information available in AMADEUS we identify firms belonging to the same multinational group (i.e. being ultimately owned by the same owner) and rerun our baseline estimations in Tables 2 and 3 accounting for time constant unobserved heterogeneity across groups by including a full set of group fixed effects. Specifications (1) and (2) reestimate the baseline regressions in Columns (5) and (6) of Table 2a. The findings are similar to our baseline results. Specification (1) suggests that an increase in the inventor country tax raises the probability for patent relocations whereas this effect is larger the higher the expected value of the patent as indicated by the positive coefficient estimate for the interaction term of inventor country tax and patent value. In line with our baseline findings this suggests that firms tend to relocate their high-value patents from inventor countries with a high patent income tax. Specification

(2) restricts the sample to patents in inventor countries which levy an above average patent income tax. The coefficient estimate for the patent quality variable again turns out positive although it does not fully gain statistical significance. Specifications (3) and (4) reestimate the regressions in columns (1) and (2) using the family size variable as a quality indicator instead of the composite quality variable. This yields comparable results, with the coefficient estimate for the quality index now also being significant in the restricted sample of high-tax inventor countries in specification (4).

Specifications (5) and (6) furthermore reestimate the effect of patent quality on the probability of tax haven location (regressions in Columns (4) and (5) of Table 3), again augmenting the set of regressors by a full set of group fixed effects. In both specifications, the coefficient estimates for the quality variable turn out positive, indicating that an increase in patent quality raises the probability of locating ownership in a tax haven economy. In a statistical sense, the estimate is significant in specification (5) only where we proxy patent quality by the patent's family size. This may again reflect that family size is somewhat better suited to proxy for a patent's earnings potential than forward citations and the number of industry classes on the patent which are accounted for in the construction of the composite quality index.

In other robustness checks (not reported in the paper), we reran our baseline specifications augmenting the vector of regressors by a full set of industry-year fixed effects which absorb industry-specific shocks over time. This leaves our results largely unaffected.

On top, our analysis so far considered the relocation of a patent to be a two stage process where the firm first decides whether to relocate the patent from the inventor country and second, conditional on relocation, chooses the new host country. In robustness checks, we assessed the sensitivity of our results to modelling an integrated choice structure where the corporation chooses between three options: to keep the patent in the inventor country, to relocate it to a tax haven economy (as defined in Dharmapala and Hines, 2009) and to relocate it to a foreign non-haven economy. Table 6 presents the results for a multinomial logit model (both the coefficient estimates and the marginal effects evaluated at the mean). Again, the variables of main interest are the patent's earnings potential as proxied by the composite quality index and the inventor country's patent income tax. We furthermore add inventor country fixed effects, year fixed effects and time varying country characteristics as well as fixed effects for the patents' industry class.[19] The base category for the results reported in Table 6 is patent owner-

[19]Convergence is often not achieved in maximum likelihood estimations if the number of regressors

ship in the inventor country. The pattern of the results is very similar to the findings reported above. A high value and earnings potential of the patent (as measured by the composite patent quality index) increases the probability that the patent is relocated from the inventor country, both to a tax haven economy and to a non-haven economy.

Evaluated at the sample mean, the marginal effect of a change in the quality variable by one unit raises the probability of tax haven location by 0.0016. Relative to the predicted probability for tax haven location at the mean (= 0.010), this corresponds to a change by 16.0%. Analogously, the marginal effect of a change in the quality variable by one unit raises the probability for relocation to a non-haven country by 0.0026. Relative to the predicted probability for patent location in a foreign non-haven at the sample mean (= 0.048), this corresponds to a change by 5.4%. The latter effect may potentially reflect relocations of patents from foreign subsidiaries to parent countries to reduce agency problems (see e.g. Dischinger and Riedel, 2009).

The patent income tax in turn does not exert a statistically significant impact on the probability of relocation to a non-haven country. A rising patent tax rate is however suggested to increase the probability that the patent is relocated to a foreign tax haven economy. The marginal effect is given by 0.0225. Hence, an increase in the patent income tax rate by 10 percentage points raises the probability for relocation to a tax haven economy by 0.225 percentage points, or, evaluated at the predicted probability for relocation to a tax haven economy at the sample mean (= 0.010), by 22.5%.

Specification (2) augments the set of regressors by a variable indicating whether the inventor country has enacted CFC legislations. In line with intuition, the coefficient estimate for the CFC dummy turns out negative and statistically significant, suggesting that CFC legislations diminish the probability of relocation to foreign tax haven and non-haven countries. Quantitatively, binding CFC legislations reduce the probability to locate a patent in a foreign tax haven country by -0.0055. Relative to the predicted probability for tax haven location at the sample mean (= 0.010), this corresponds to a strong decline by 55%. Analogously, binding CFC legislations reduce the probability to locate a patent in a foreign non-haven country by -0.0131. Relative to the predicted

is large. We encountered the same problems. To achieve convergence of the model, we adjusted our set of control variables in the sense that it only comprises indicator variables for countries with more than 100 patent applications during our sample period and indicator variables for large industry classes comprising more than 10,000 patent applications. Furthermore, we dropped information for the year 1990 from the analysis. We ran robustness checks though where we include information for the year 1990 but with a smaller number of industry and country controls. This yields comparable results to the ones reported in Table 6.

probability for patent location in a foreign non-haven country at the sample mean (= 0.048), this corresponds to a decline by 27.2%.[20]

Summarizing, this section has provided evidence that the locations of patent inventor and patent applicant are geographically separated in a non-negligible number of cases. The results moreover suggest that tax considerations play a role in determining patent ownership. High tax rates in the inventor country of the patent are shown to foster relocation to a foreign economy while low patent income taxes are instrumental in attracting patent ownership. This pattern is moreover stronger, the higher the expected earnings potential of the patent and turns out to be robust against a number of sensitivity checks.

7 Conclusion

The purpose of this paper was to assess multinational tax avoidance strategies through the relocation of patent income to low-tax countries. Anecdotal evidence suggests that corporations engage in significant income shifting by setting up contracting structures which allow R&D to remain located in high-technology countries with well-developed markets for high-skilled labor while the income related to the R&D accrues with a patent holding firm in a low-tax economy.

Using detailed data on the population of patent applications to the European Patent Office, this paper provides evidence that the patent applicant and the inventor are located in different countries in a non-negligible number of cases (around 8% of the granted patent applications).

Moreover, we set up an empirical model to assess the determinants of the decision to geographically split patent ownership from the R&D location. Our results suggest that high patent income tax rates in the inventor country increase the probability of relocating patent ownership to a foreign economy. Low patent income taxes are analogously instrumental in attracting ownership of foreign-invented patents. Furthermore, in line with intuition, patent location decisions tend to become more sensitive to tax considerations the higher the expected earnings potential of the patent. The analysis, however, also suggests that controlled foreign company rules are effective barriers for

[20] Note that one might also consider to refine the conditional logit model estimated above by adding specifications which account for all patents in our data (not only the relocated patents). Given the large number of patent applications in our data and the considerable number of choice locations, we have to refrain from this analysis though due to a lack of computational capacity to run such a model.

the implementation of patent relocation schemes and related income shifting behavior.

Our findings have implications for several strands of the economic literature. Firstly, the paper supports recent claims that corporations engage in significant income shifting to low-tax countries through the distortion of patenting decisions. Low patent income taxes are thus instrumental in attracting patent income to a country, in turn implying that governments have an incentive to lower their patent income taxes to attract the mobile tax base. From a theoretical perspective, one would thus expect a race-to-the bottom in patent taxes which is consistent with the downward trend in patent income tax rates in Europe during recent years. Secondly, the evidence suggests that firms strategically select patents with a high earnings potential for relocation to countries with low patent income taxes which confirms recent theoretical predictions which suggest that taxation does not only affect the size of investment activities but also their quality (i.e profitability), see e.g. Haufler and Stähler (2012) and Becker and Fuest (2007). Thirdly, our analysis shows that firms geographically split the location of R&D units and patent holdings. Following the argumentation in Hong and Smart (2010), the presence of tax haven countries and multinational profit shifting activities might thus actually increase the welfare of well-developed high-tax countries as the possibility to relocate income prevents firms from relocating the real economic activity (in our case the R&D unit) itself.

References

Abramovsky, L., Griffith, R., Macartney, G., Miller, H. (2008), The Location of Innovative Activity in Europe, The Institute of Fiscal Studies WP 08/10.

Becker, J., and C. Fuest (2007), Quality versus Quantity - The Composition Effect of Corporate Taxation on Foreign Direct Investment, CESifo Working Paper Series, No. 2126, CESifo Munich.

Bloom, N., R. Griffith and J. van Reenen (2002), Do R&D Tax Credits Work? Evidence from a Panel of Countries 1979-1997, Journal of Public Economics 85, pp. 1-31.

Criscuolo, C., J. E. Haskel and M. J. Slaughter (2010), Global Engagement and the Innovation Activities of Firms, International Journal of Industrial Organization 28 (2010), pp. 191-202.

Dischinger, M. and N. Riedel (2009), There's No Place Like Home: The Profitability Gap between Headquarters and their Foreign Subsidiaries, Oxford Centre for Business Taxation Working Paper WP 09/23.

Dischinger, M. and N. Riedel (2011), Corporate Taxes and the Location of Intangibles within Multinational Firms, Journal of Public Economics 95(7-8), p. 691-707.

Dharmapala, D. and J.R. Hines (2009), Which Countries Become Tax Havens?, Journal of Public Economics, Vol. 93, 2009, pp. 1058-1068.

Greene, W. H. 2008. Econometric Analysis. Prentice Hall.

Griffith, R., H. Miller and M. O'Connell, 2011, Corporate Taxes and the Location of Intellectual Property, CEPR Discussion Papers 8424, C.E.P.R. Discussion Papers.

Grubert, H. and J. Mutti (2008), The Effect of Taxes on Royalties and the Migration of Intangible Assets Abroad (Jan 2008), Paper prepared for the NBER/CRIW Conference on International Service Flows.

Hall, B. H. (1993), R&D Tax Policy During the Eighties: Success or Failure?, Tax Policy and the Economy 7, pp. 1-36.

Hall, B. H., G. Thoma and S. Torrisi (2007), The Market Value of Patents and R&D, Evidence from European Firms, NBER Working Paper No. 13426.

Hall, B. H., J. Mairesse and P. Mohnen (2010), Measuring the Returns to R&D, Handbook of the Economics of Innovation, Volume 2 (2010), pp. 10331082.

Hall, R. E. (2001), The Stock Market and Capital Accumulation, The American Economic Review, 91(5), pp. 1185-1202.

Harhoff, D., F. Narin, and K. Vopel (1999), Citation Frequency and the Value of Patented Inventions, Review of Economics and Statistics 81(3), pp. 511-15.

Haufler, A. and F. Stähler (2012), Tax Competition in a Simple Model with Heterogeneous Firms: How Larger Markets Reduce Profit Taxes, International Economic Review, forthcoming.

Hejazi, J. (2006), Assessing the Risks of Intangibles Migration, Tax Management - Transfer Pricing 15(10), pp. 399-401.

Hines, J. R. (1994), No Place Like Home: Tax Incentives and the Location of R&D by American Multinationals. Tax Policy and the Economy 8, pp. 65-104.

Hines, J. R. and E. M. Rice (1994), Fiscal Paradise: Foreign Tax Havens and American Business, Quarterly Journal of Economics 109, pp. 149-182.

Hines J. R. and A. B. Jaffe (2001), International Taxation and the Location of Inventive Activity, in: Hines, J. R. (ed) (2001), International Taxation and Multinational Activity, University of Chicago Press.

Hong, Q. and M. Smart, In Praise of Tax Havens: International Tax Planning and Foreign Direct Investment, European Economic Review 54(1), pp. 82-95.

Karkinsky, T. and N. Riedel (2012), Corporate Taxation and the Choice of Patent Location within Multinational Firms, Journal of International Economics, forthcoming.

Lang, M., Aigner, H.-J., Scheuerle, U., Stefaner, M. (2004), CFC Legislation, Tax Treaties and EC Law, Kluwer Law International.

Lanjouw, J.O. and M. Schankerman (2004), Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators, The Economic Journal 114, pp. 441-465.

Markusen, J. R. (1995), The Boundaries of Multinational Enterprises and the Theory of International Trade, Journal of Economic Perspectives 9, pp. 169-189.

OECD (2009), Transfer Pricing Aspects of Business Restructurings - Discussion Draft for Public Comment.

Quick, P. D. and T. L. Day (2006), Management of IP: Intercompany Transfers, Offshore Planning and Recent Developments Regarding Cost-Sharing, The Licensing Journal (1), pp. 14-21.

Sandler, D. (1998), Tax Treaties and Controlled Foreign Company Legislation: Pushing the Boundaries, Springer.

The Guardian (2009), Offshore and Out of Reach to the Revenue, February 3, 2009.

Wallstreet Journal (2005), Irish Subsidiary Lets Microsoft Slash Taxes in U.S. and Europe, November 5, 2005.

8 Appendix

Table 1A: Share of Foreign Patents, by Tax Haven Country - Year: 2005			
	# Patent Applications	**Share Foreign Patents**	**# Foreign Patents**
Tax Haven Countries			
Aruba	1	1	1
Bahamas	14	1	14
Bahrain	2	1	1
Barbados	302	.983	297
Belize	1	1	1
British Virgin Islands	100	.870	87
Bermuda	42	.810	34
Cayman Islands	29	1	29
Cook Islands	3	1	3
Cyprus	24	.917	22
Gibraltar	12	.583	7
Hong Kong	25	.320	8
Ireland	226	.451	102
Jordan	4	0	0
Lebanon	2	.500	1
Liechtenstein	149	.779	116
Luxembourg	195	.703	137
Malta	5	.800	4
Mauritius	9	1	9
Monaco	14	.714	10
Netherland Antilles	84	.964	81
Panama	6	.833	5
Saint Vincent and Grenadines	1	1	1
Samoa	1	1	1
San Marino	7	.571	4
Seychelles	5	.600	3
Singapore	121	.496	60
Switzerland	3,677	.331	1,217
Vanatu	2	1	2
EU25 Non-Havens	45,411	.113	5,153

Notes:

The table depicts the tax haven countries included in Dharmapala and Hines (2009) which have a non-zero number of patent applications in the year 2005. *EU 25 Non-Havens* stands for all countries within EU 25 which are not classified as a tax haven according to Dharmapala and Hines (2009), i.e. all EU countries apart from Cyprus, Luxembourg, Ireland and Malta. The first column depicts the overall number of patent applications in a country in 2005, the second column depicts the fraction of the patent applications in a country for which all patent inventors are located in a different country. The third column depicts the number of foreign patent applications in a country.

Table 1B: Descriptive Statistics - Basline Regressions					
Variable	**Observations**	**Mean**	**Std.Dev.**	**Minimum**	**Maximum**
Relocation from Inv.-Ctry					
Foreign Patents (strict)	530,805	.079	.270	.0	1
Foreign Patents (lax)	530,805	.086	.280	.0	1
Patent Income Tax	530,805	.431	.0867	.15	.5967
CFC Dummy	530,805	.908	.289	.0	1
Patent Quality Index - Composite	530,805	.019	.829	-2.529	7.943
Patent Quality Index - Family Size	530,805	.003	.562	-1.956	6.267
Rule of Law	530,805	1.570	.221	-.506	1.967
Corruption Control	530,805	1.649	.438	-.796	2.560
Log GDP per Capita	530,805	10.178	.265	7.223	10.592
Log GDP	530,805	28.500	1.111	22.134	30.065
Patent Location Choice					
(Sample of Relocated Patents (strict))					
Tax Haven	41,961	.212	.409	.0	1
Small Tax Haven	41,961	.075	.263	.0	1
Patent Quality Index - Composite	41,961	.090	.848	-2.403	7.602
Patent Quality Index - Family Size	41,961	.081	.588	-1.956	5.292

Notes:

The descriptive statistics in the upper panel of the table comprise all patents in our data, comprising patents which are retained in the inventor country as well as patents whose first applicant is located in a different country than the patent inventors. The lower panel of the descriptive statistics refers to the latter group of patents only. Foreign patents depicts a dummy variable which takes on the value 1 if all patent applicants are located in different countries than all patent inventors. Patent income tax indicates the tax rate on patent income. While in most countries the tax on patent income corresponds to the corporate income tax rate, some countries levy special low tax rates on patent income. We account for these cases where applicable. CFC dummy is a dummy variable which indicates whether the inventor country has enacted CFC legislations. The Composite Patent Quality Index is an index which captures the quality of a corporate patent as determined by the number of forward citations, its family size and the number of industry classes (conditional on industry and year fixed effects). The Family Size Patent Quality Index is an analogous measure which accounts for the family size of the patent only. Rule of Law and Corruption Control indicate governance dimensions of the inventor country as captured by the World Bank government indicators which vary between -2.5 and +2.5, whereas larger values indicate a better governance situation. Log GDP per Capita and Log GDP are the logarithm of the GDP per Capita and GDP of the inventor's host country, measured in US dollars. Tax Haven is a dummy variable indicating patents whose (first) patent applicant is located in a tax haven country as defined by Dharmapala and Hines (2009). Small Tax Haven is an analogous indicator which abstracts from patents in large tax haven economies, most importantly Switzerland and Ireland.

Table 1c: CFC Legislation in 2003		
Country	*CFC Dummy*	*Tax Haven Definition*
Belgium	0	–
Czech Republic	0	–
Denmark	1	Effective tax < 75% of Danish Tax
Finland	1	Effective tax < 60% of Finish Tax
France	1	Effective tax < 66% of French Tax
Germany	1	Effective tax < 25%
Great Britain	1	Effective tax < 75% of British Tax
Greece	0	–
Ireland	0	–
Italy	1	Black List
Luxembourg	0	–
Netherlands	0	–
Norway	1	Effective tax < 66% of Norwegian Tax
Poland	0	–
Portugal	1	Effective tax < 60% of Portugese Tax
Spain	1	Effective tax < 75% of Spanish Tax
Sweden	1	Effective tax < 55% of Swedish Tax
Switzerland	0	–
Austria	0	–
Canada	1	Always Binding
Japan	1	Effective tax < 25%
United States	1	Effective tax < 75% of US Tax

Notes:

CFC Dummy takes on the value 1 if the parent country has a CFC legislation and the value 0 otherwise. In the case of Norway, the 66% rule does not apply if a bilateral tax treaty exists between Norway and the country of the controlled subsidiary, unless the majority of the income in that subsidiary is passive. We use our data on royalty withholding rates to determine whether a bilateral tax treaty exists. In the case of Italy the black list of tax havens is quite long to be listed here, but it is based on and is very similar to the OECD tax haven list.

Table 2A: Patent Relocation from Inventor Country
Dep. Variable: Binary Variable Indicating Patent Relocation from Inventor Country

Estimation Model	**Probit Model**				**OLS Model**							
Sample	**Full Sample**								**High Tax**	**Low Tax**	**High Tax**	**Low Tax**
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
Tax Rate	0.239*	0.223	0.215	0.409**	0.043	0.070**	0.043	0.075**	0.239***	-0.101	0.240***	-0.101
	(0.133)	(0.164)	(0.169)	(0.176)	(0.029)	(0.030)	(0.029)	(0.031)	(0.071)	(0.093)	(0.071)	(0.093)
Composite Quality Index	0.041***	0.040***	0.026***	-0.258***	0.004***	-0.028***			0.014***	0.000		
	(0.009)	(0.009)	(0.011)	(0.031)	(0.002)	(0.005)			(0.002)	(0.002)		
Composite Quality Index × Tax Rate				0.707***		0.077***						
				(0.074)		(0.012)						
Family Size Quality Index							0.005**	-0.062***			0.023***	-0.001
							(0.002)	(0.009)			(0.004)	(0.002)
Family Size Quality Index × Tax Rate								0.162***				
								(0.021)				
Rule of Law		0.055	0.130	0.104	0.019	0.015	0.019	0.013	-0.090	0.002	-0.085	0.002
		(0.137)	(0.134)	(0.139)	(0.023)	(0.023)	(0.023)	(0.023)	(0.059)	(0.028)	(0.058)	(0.028)
Corruption Control		-0.062	-0.072	-0.070	-0.014	-0.014	-0.015	-0.013	-0.099***	-0.005	-0.097***	-0.005
		(0.065)	(0.062)	(0.065)	(0.010)	(0.010)	(0.010)	(0.010)	(0.029)	(0.015)	(0.029)	(0.015)
Log GDP pC		-0.793	-0.614	-0.555	0.204**	0.202**	0.206**	0.209**	-0.034	0.043	-0.024	0.042
		(0.534)	(0.556)	(0.574)	(0.100)	(0.102)	(0.100)	(0.103)	(0.222)	(0.127)	(0.221)	(0.127)
Log GDP		0.564	0.324	0.332	-0.080	-0.077	-0.082	-0.079	-0.119	-0.114	-0.125	-0.113
		(0.415)	(0.415)	(0.444)	(0.072)	(0.075)	(0.072)	(0.076)	(0.244)	(0.085)	(0.244)	(0.085)
Year Fixed Effects	√	√	√	√	√	√	√	√	√	√	√	√
Inv. Country Fixed Effects	√	√	√	√	√	√	√	√	√	√	√	√
Industry Fixed Effects				√	√	√	√	√	√	√	√	√
# Observations	530,805	527,617	442,483	442,483	442,484	442,484	442,484	442,484	156,342	286,142	156,342	286,142

Notes:

*, **, *** indicate significance at the 10%, 5% and 1% level. The observational unit is the patent application. The dependent variable is a binary variable which takes on the value 1 if all patent applicants are located in a different country than all patent inventors. Specifications (1)-(4) estimate a probit model. Specifications (5)-(10) show the results of a linear probability model. In Specifications (9) and (11) the sample is restricted to inventor countries with a high patent income tax rate above the sample mean. In Specifications (10) and (12) the sample is restricted to inventor countries with a patent income tax rate below the sample mean. For the definition of the explanatory variables, see the notes for Table 1B.

Table 2B: Patent Relocation from Inventor Country

Dep. Variable: Binary Variable Indicating Patent Relocation from Inventor Country / Relocation to a Tax Haven Country

Dep. Variable	**Foreign Patent Strict**				**Foreign Patent Lax**		**Location in Tax Haven**			
Sample	**No Big OECD**		**No East**		**Full Sample**					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Composite Quality Index	0.005***	-0.028***	0.004***	-0.028***	0.005***	-0.024***	0.004***	0.004***		
	(0.002)	(0.010)	(0.002)	(0.005)	(0.002)	(0.006)	(0.001)	(0.001)		
Family Size Quality Index									0.008***	0.008***
									(0.001)	(0.001)
Tax Rate	0.079	0.088	0.040	0.067**	0.045	0.069**	0.025	0.022	0.025	0.022
	(0.055)	(0.056)	(0.029)	(0.030)	(0.029)	(0.030)	(0.016)	(0.015)	(0.015)	(0.015)
Composite Quality Index × Tax Rate		0.076***		0.077***		0.069***				
		(0.022)		(0.012)		(0.013)				
CFC Dummy								-0.007*		-0.007*
								(0.004)		(0.004)
Rule of Law	0.028	0.032	0.018	0.015	0.013	0.010	-0.007	-0.013	-0.007	-0.013
	(0.025)	(0.025)	(0.023)	(0.023)	(0.024)	(0.024)	(0.013)	(0.013)	(0.013)	(0.013)
Corruption Control	0.001	-0.000	-0.015	-0.014	-0.006	-0.005	-0.005	-0.003	-0.005	-0.003
	(0.014)	(0.014)	(0.011)	(0.010)	(0.011)	(0.011)	(0.006)	(0.006)	(0.006)	(0.006)
Log GDP pC	0.178	0.146	0.212**	0.210**	0.072	0.070	-0.125***	-0.103**	-0.121***	-0.100**
	(0.207)	(0.208)	(0.101)	(0.104)	(0.097)	(0.099)	(0.047)	(0.047)	(0.047)	(0.046)
Log GDP	-0.100	-0.071	-0.082	-0.080	-0.001	0.001	0.114***	0.101***	0.110***	0.098**
	(0.188)	(0.189)	(0.073)	(0.076)	(0.071)	(0.074)	(0.039)	(0.038)	(0.039)	(0.038)
Year Fixed Effects	√	√	√	√	√	√	√	√	√	√
Inv. Country Fixed Effects	√	√	√	√	√	√	√	√	√	√
Industry Fixed Effects				√	√	√	√	√	√	√
# of Observations	166,825	166,825	442,002	442,002	442,485	442,485	442,485	442,485	442,485	442,485

Notes:

*, **, *** indicate significance at the 10%, 5% and 1% level. The observational unit is the patent application. The dependent variable in Specifications (1) to (4) is a binary variable which takes on the value 1 if all patent applicants are located in a different country than all patent inventors. In Specifications (5) and (6), the definition of the dependent variable is altered slightly in the sense that the variable takes on the value 1 if the first applicant on the patent application is located in a different country than all patent inventors (while other patent applicants may be located in the same country as the patent inventor. In Specifications (7) to (10), the dependent variable indicates patents that are relocated to a tax haven economy as defined by Dharmapala and Hines (2009). All specifications show the results of a linear probability model. For the definition of the explanatory variables, see the notes for Table 1B.

Table 3: Patent Location at a Tax Haven Country Dep. Variable: Binary Variable Indicating Patent Applicants in Tax Havens							
Estimation Model	**Probit Model**			**OLS Model**			
Dep. Variable	**Tax Haven Def. Dharmapala/Hines**					**Small Tax Havens**	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Composite Quality Index	0.086***	0.087***	0.047***	0.013***		0.010***	
	(0.014)	(0.014)	(0.015)	(0.004)		(0.003)	
Family Size Quality Index					0.035***		0.017***
					(0.006)		(0.005)
Tax Rate	1.073***	0.561	0.629*	0.160	0.160	0.010	0.009
	(0.253)	(0.360)	(0.371)	(0.102)	(0.102)	(0.055)	(0.054)
Rule of Law		-0.499**	-0.183	-0.055	-0.050	0.025	0.028
		(0.228)	(0.217)	(0.057)	(0.058)	(0.037)	(0.037)
Corruption Control		0.011	0.077	0.026	0.025	0.003	0.003
		(0.122)	(0.125)	(0.031)	(0.031)	(0.019)	(0.019)
Log GDP pC		-3.549***	-3.573***	-0.866***	-0.853***	-0.657***	-0.651***
		(0.956)	(0.997)	(0.253)	(0.253)	(0.145)	(0.145)
Log GDP		2.878***	3.126***	0.863***	0.851***	0.600***	0.593***
		(0.708)	(0.751)	(0.207)	(0.206)	(0.123)	(0.124)
Year Fixed Effects	√	√	√	√	√	√	√
Inv. Country Fixed Effects	√	√	√	√	√	√	√
Industry Fixed Effects			√	√	√	√	√
# of Observations	41,912	41,595	35,470	35,543	35,543	35,543	35,543

Notes:

*, **, *** indicate significance at the 10%, 5% and 1% level. The observational unit is the patent applicantion whereas the sample is restricted to patent applications where all patent applicants are located in a different country than all patent inventors. The dependent variable is a binary variable which takes on the value 1 if the patent applicant is located in a tax haven country, whereas the definition of a tax haven country follows Dharmapala and Hines (2009) in Specifications (1)-(5). In Specification (6)-(7), we apply a more restricted tax haven definition which abstracts from large tax haven countries, namely Switzerland and Ireland (see the definition of "Small Tax Haven" in Table 1B). Moreover, Specifications (1)-(3) estimate a probit model while Specifications (4)-(7) show the results of a linear probability model. For the definition of the explanatory variables, see the notes for Table 1B.

Table 4: Conditional Logit Model - Relocated Patents
Dep. Variable: Binary Variable Indicating the Location of Patent Applicant

Estimation Model	**Conditional Logit**		**OLS Model**								
Sample	**Full Sample**			**< Avg. Quality**	**> Avg. Quality**	**> 75% Per. Quality**	**Full Sample**			**> Avg. Quality**	**> 75% Per. Quality**
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*
Tax Rate	-2.854***	-2.886***	-0.024***	-0.008***	-0.040***	-0.045***	-0.022***	-0.020***	-0.022***	-0.050***	-0.060***
	(0.053)	(0.058)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)
Composite Quality Index × Tax Rate							-0.019***				
							(0.002)				
Family Size Quality Index × Tax Rate								-0.054***			
								(0.003)			
Binding CFC Legislation									0.001	-0.005***	-0.007***
									(0.001)	(0.001)	(0.001)
Log GDP pC	1.521***	0.823***	0.0303***	0.032***	0.029***	0.027***	0.030***	0.030***	0.030***	0.029***	0.027***
	(0.025)	(0.035)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Log GDP	0.819***	0.935***	0.023***	0.023***	0.023***	0.022***	0.023***	0.023***	0.023***	0.023***	0.022***
	(0.005)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log Distance	-0.464***	-0.341***	-0.005***	-0.006***	-0.003***	-0.003***	-0.005***	-0.005***	-0.005***	-0.003***	-0.003***
	(0.005)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Rule of Law		0.921***	-0.055***	-0.062***	-0.048***	-0.042***	-0.055***	-0.055***	-0.055***	-0.049***	-0.043***
		(0.069)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Corruption Control		0.710***	0.031***	0.034***	0.029***	0.027***	0.031***	0.031***	0.031***	0.029***	0.027***
		(0.034)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
# of Obs. (Choice Options)	1,028,222	1,028,222	1,028,222	519,948	508,274	256,149	1,028,222	1,028,222	1,028,222	508,274	256,149

Notes:

*, **, *** indicate significance at the 10%, 5% and 1% level. Standard errors are clustered at the patent level. The data comprises the subsample of patent applications where all patent applicants are located in a different country than all patent inventors. The data is then expanded to reflect a choice set of 29 potential locational options for the location of the patent ownership. The dependent variable is a binary variable which takes on the value 1 if the patent applicant is located in the considered country and 0 otherwise. Specifications (1) and (2) present the results for a conditional logit model, Specifications (3) to (11) present OLS estimates. For the definition of the explanatory variables, see the notes of Table 1B. The patent quality measure used for the analysis and sample restriction in Specifications (4)-(6) and (10)-(11) is the composite patent quality index (apart from specification (8)). Binding CFC Legislation is a dummy variable which takes on the value 1 if a CFC legislation is implemented in the inventor country and the CFC legislations defines the respective host country for the patent application as a tax haven economy for which CFC rules apply.

Table 5: Patent Relocation from Inventor Country and Location at a Tax Haven Group Fixed Effects						
Dep. Variable	**Foreign Patent Strict**				**Location in Tax Haven**	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Tax Rate	0.034*	0.074	0.038**	0.074	0.054	0.053
	(0.018)	(0.064)	(0.018)	(0.064)	(0.036)	(0.035)
Composite Quality Index	-0.051***	0.001			0.001	
	(0.003)	(0.001)			(0.001)	
Composite Quality Index × Tax Rate	0.103***					
	(0.008)					
Family Size Quality Index			-0.089***	0.005***		0.005**
			(0.005)	(0.001)		(0.002)
Family Size Quality Index × Tax Rate			0.191***			
			(0.011)			
Rule of Law	0.006	-0.016	0.002	-0.015	-0.034	-0.034
	(0.014)	(0.050)	(0.014)	(0.050)	(0.023)	(0.023)
Corruption Control	-0.010	-0.003	-0.009	-0.002	-0.002	-0.002
	(0.008)	(0.027)	(0.008)	(0.027)	(0.014)	(0.014)
Log GDP pC	0.327***	0.215	0.332***	0.222	0.229**	0.226**
	(0.057)	(0.210)	(0.057)	(0.210)	(0.100)	(0.100)
Log GDP	-0.066	-0.262	-0.062	-0.265	-0.175**	-0.174**
	(0.043)	(0.171)	(0.043)	(0.171)	(0.074)	(0.074)
Year Fixed Effects	√	√	√	√	√	√
Industry Fixed Effects	√	√	√	√	√	√
Inv. Country Fixed Effects	√	√	√	√	√	√
Group Fixed Effects	√	√	√	√	√	√
# of Observations	277,487	88,538	277,487	88,538	24,366	24,366
# of Groups	23,643	8683	23,643	8,683	2717	2717

Notes:

*, **, *** indicate significance at the 10%, 5% and 1% level. The observational unit is the patent application. In Specifications (1) to (4) the dependent variable is a binary variable which takes on the value 1 if all patent applicants are located in a different country than all patent inventors. In Specifications (5) and (6) the sample is restricted to patents where all patent applicants are located in a different country than all patent inventors. The dependent variables in these specification is an indicator for location in a tax haven country as defined in Dharmapala and Hines (2009). All columns present results of a linear probability model. For the definition of the explanatory variables, see the notes for Table 1B.

Table 6: Multinomial Logit Model Base Category: Patent Applicant in Inventor Country				
	(1)		*(2)*	
Variable	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.
Foreign Tax Haven				
Patent Quality Index	.161***	.0016***	.162***	.0016***
	(.029)	(.0003))	(.029)	(.0003)
Corporate Tax Rate	2.234***	.0232***	2.187***	.0225***
	(.597)	(.0062)	(.604)	(.0062)
CFC Dummy			-.462***	-.0055**
			(.156)	(.0023)
Log GDP	.377*	.0041*	1.123*	.0116*
	(.211)	(.0022)	(.638)	(.0065)
Log GDP pC	-1.060**	-.0109**	-2.618*	-.0267*
	(.473)	(.0048)	(1.451)	(.0147)
Rule of Law	-.113	-.0012	-.575	-.0060
	(.422)	(.0043)	(.523)	(.0053)
Corruption Control	.178	.0019	.147	.0015
	(.230)	(.0023)	(.224)	(.0023)
Country Fixed Effects	√	√	√	√
Year Fixed Effects	√	√	√	√
Industry Fixed Effects	√	√	√	√
Foreign Non-Tax Haven				
Patent Quality Index	.058***	.0026**	.058***	.0026**
	(.023)	(.0011)	(.023)	(.0011)
Corporate Tax Rate	-.061	-.0039	-.140	-.0075
	(.312)	(.0142)	(.291)	(.0132)
CFC Dummy			-.265***	-.0131***
			(.061)	(.0033)
Log GDP	-.327***	-.0152***	-.032	-.0020
	(.125)	(.0057)	(.209)	(.0096)
Log GDP pC	-.188	.0081	-.454	-.0195
	(.240)	(.0109)	(.531)	(.0242)
Rule of Law	.126	.0059	.141	.0068
	(.241)	(.0110)	(.208)	(.0095)
Corruption Control	-.125	-.0059	-.059	-.0028
	(.128)	(.0059)	(.122)	(.0056)
Country Fixed Effects	√	√	√	√
Year Fixed Effects	√	√	√	√
Industry Fixed Effects	√	√	√	√
# Observations	404,962	404.962	404,962	404,962

Notes:

Both specifications estimate a multinomial choice model. The left column of each specification contains the estimated coefficient, the right column the marginal effect evaluated at the sample mean. Standard errors clustered at the level of the inventor country per year in parantheses. *, **, *** indicate significance at the 10%, 5% and 1% level. The data comprises all patent applications. The dependent variable indicates the location of the patent applicant that may firstly, be located in the same country as the inventor of the technology (base category), secondly, be located in a foreign tax haven country and thirdly, be located in a foreign non-haven country. For the definition of the explanatory variables, see the notes to Table 1B. Both specifications use the composite patent quality variable as measure for the patent's earnings potential.

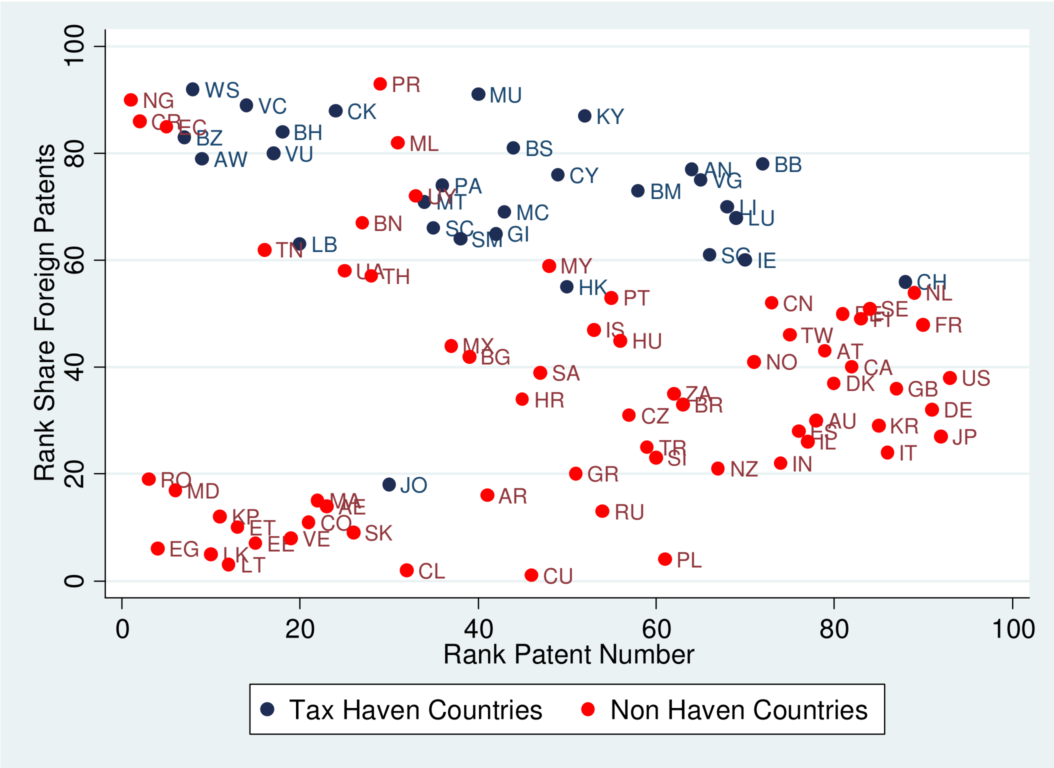

Figure 1: Rank Share of Foreign Patents and Country Size

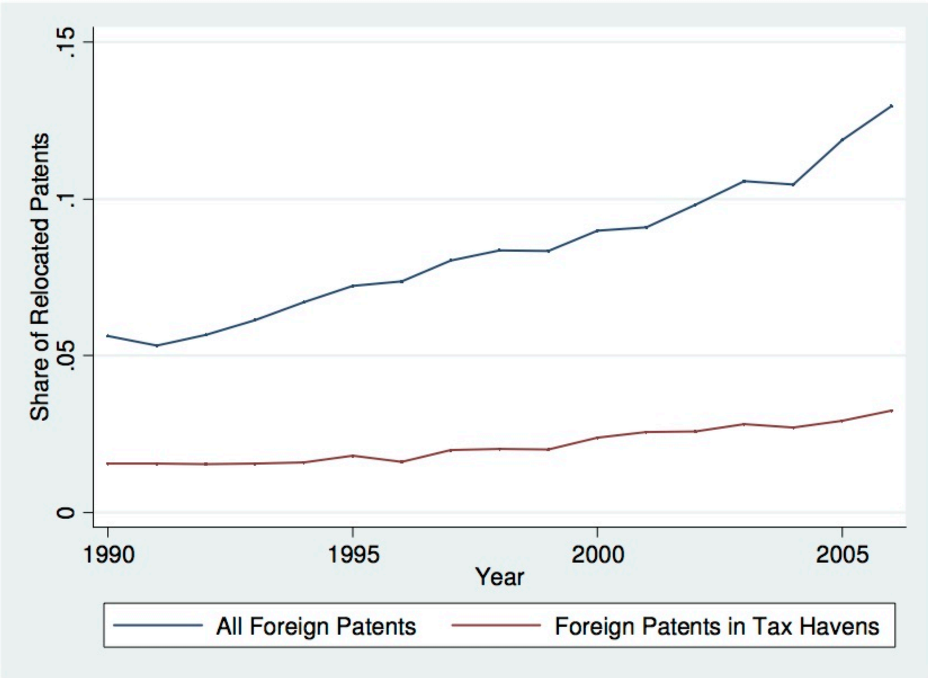

Figure 2: Development of Foreign Patents (in Tax Havens) over Time

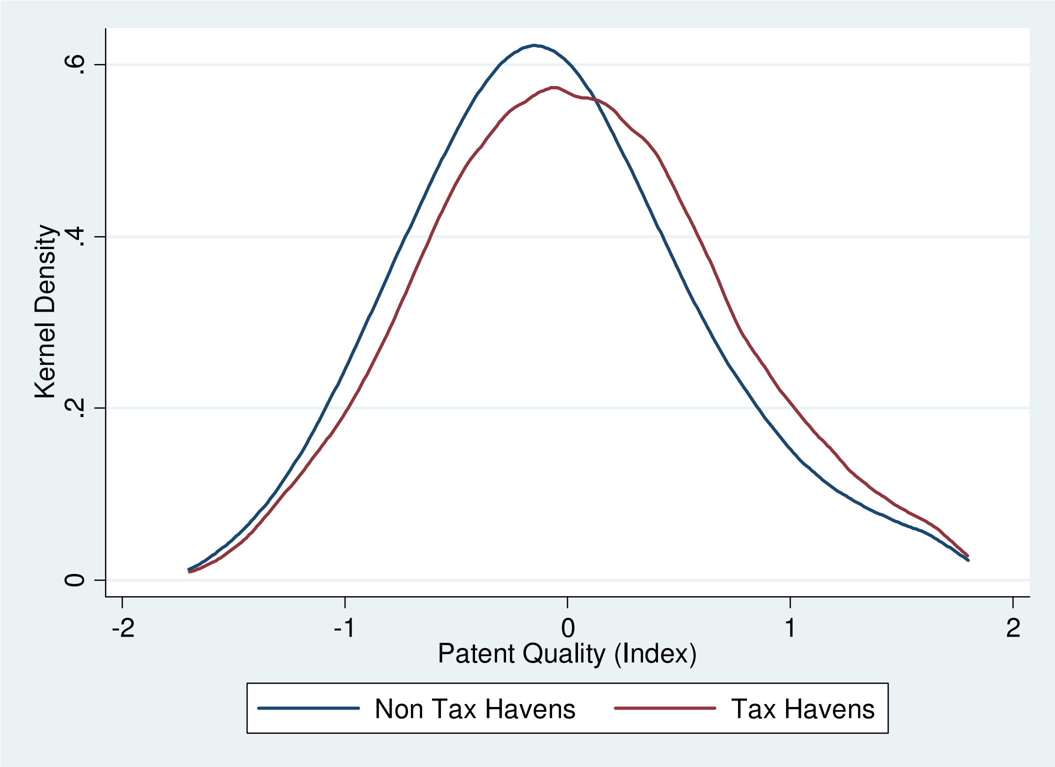

Figure 3a: Patent Location in Tax Haven Country – Composite Quality Index

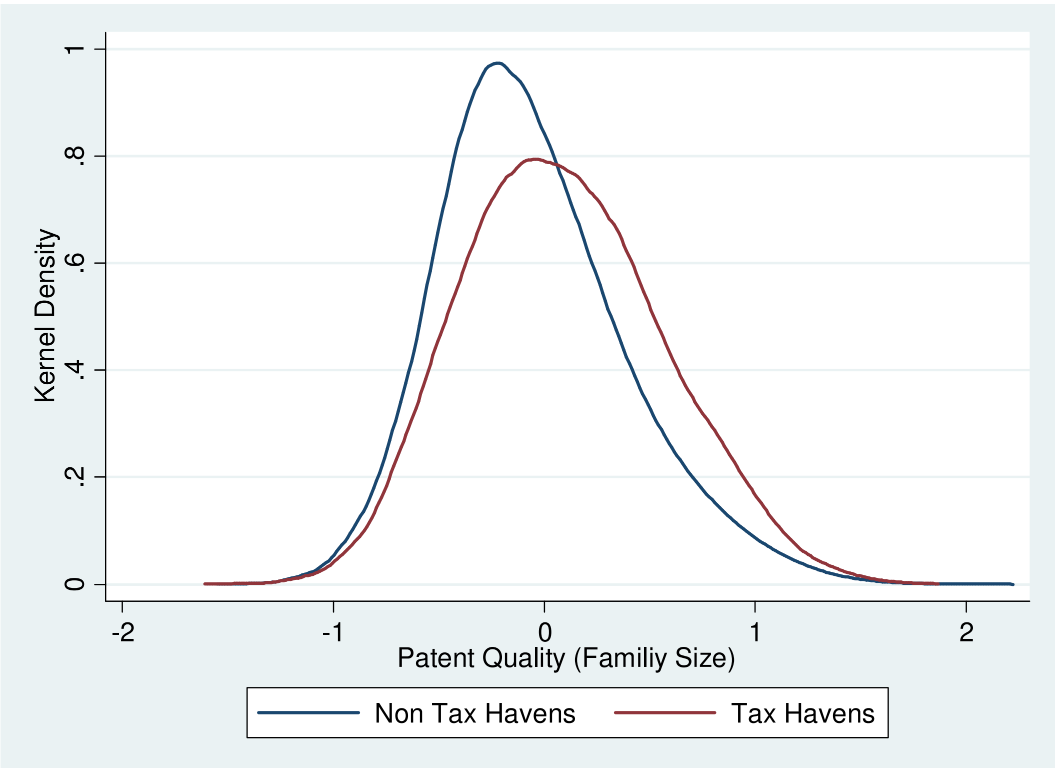

Figure 3b: Patent Location in Tax Haven Country – Family Size Quality Index

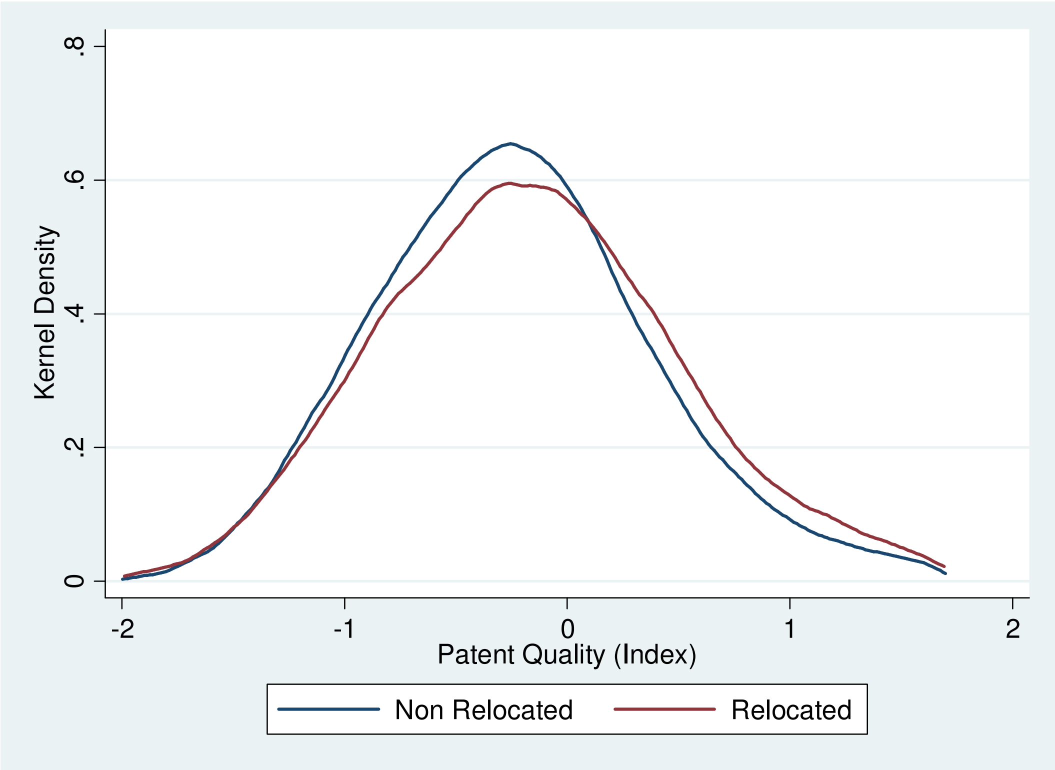

Figure 4a: Patent Relocation from the Inventor Country – Composite Quality Index

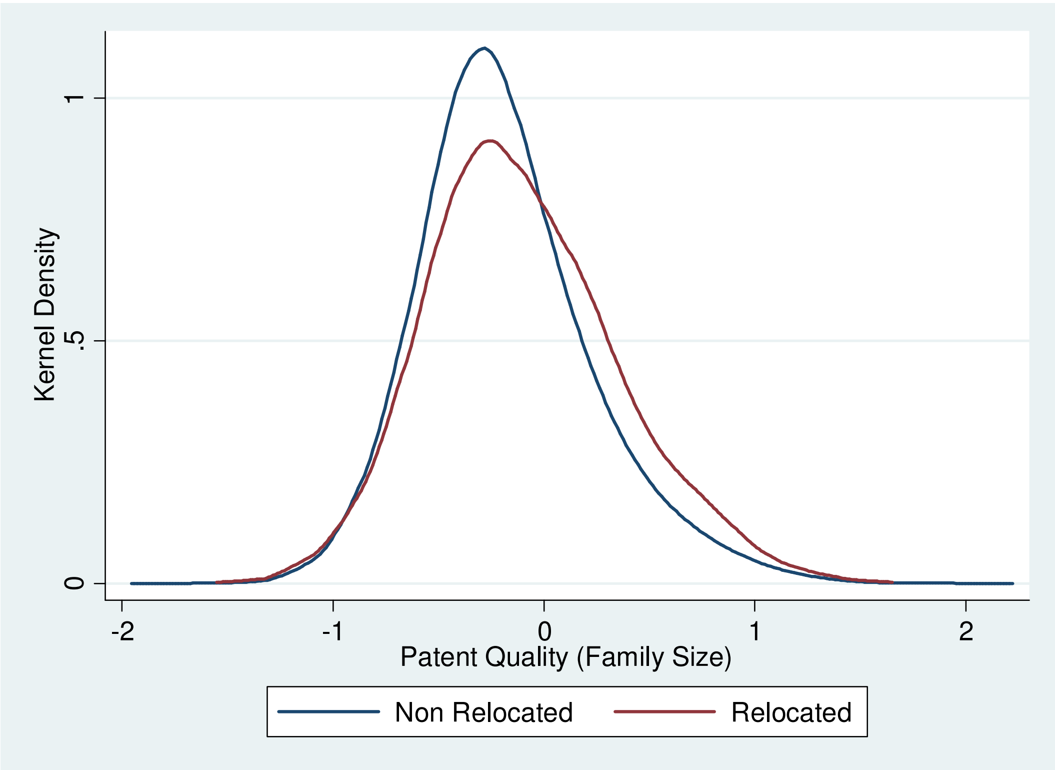

Figure 4b: Patent Relocation from the Inventor Country – Family Size Quality Index