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 quality and 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 goods are important assets in the modern economy, where knowledge is highly valued. The income derived from intangible assets is moreover 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 (Hejazi, 2006). 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. One core assumption of existing papers is moreover that the R&D input and output, i.e. the location of the R&D unit and the resulting patent holdings, accrues with one and the same affiliate within a multinational entity (MNE). Contrary to this assumption, practitioners argue that (one of) the most attractive patent income relocation scheme(s) involves 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 infra-structure 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 country of the patent applicant and the inventor of the technology. Our data indicates that the location of patent applicant and patent inventor is geographically

[1] Technically, such a split is implemented through contract research agreements where an R&D unit undertakes research for a group affiliate in a tax-haven country which formally 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.

split for around 8 percent of all patent applications. Descriptive statistics moreover 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 were 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 make up around 35% and 45% percent of all patent holdings. Most other European high-technology countries, in the contrary, observe much smaller foreign invented patent holdings, commonly below 10%.

We moreover set up an empirical model to assess the determinants of the geographical relocation of patent ownership. Most importantly, the results suggest that the probability of patents to be relocated from the inventor country is larger the higher the quality of the patent (whereas an index for the quality of each patent is derived from a factor analysis using information on forward citations of the patent, the size of the patent family and the patent's number of industry classes). Patent quality moreover turns out to be instrumental in explaining the location of foreign-invented patents in low-tax economies. 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 5%. This indicates that multinationals distort their patent holdings in a way that patents with a high expected value and earnings potential tend to be held in countries with favorable tax legislations. Moreover, complementary to these findings, we show that countries are more likely to attract foreign-invented patent holdings the lower their patent income tax rate. Again, the importance of a low-income tax rate turns out to be especially important in determining the location decision for high-value patents. Relocations of patents from the inventor country to a foreign tax haven are in turn less likely if so called controlled foreign company rules are imposed which may make patent income taxable in the parent country.

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 a number of major OECD countries.

In the contrary to these papers, a small number of recent studies 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 strongy 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 (2010) who show that intangible assets are distorted towards low-tax subsidiaries within a multinational group. The paper most closely related to ours is Karkinsky and Riedel (2009) where the authors provide evidence that corporate tax rates negatively impact on patent holdings of multinational subsidiary firms. 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 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) in the sense that high-value projects are located in countries with a low corporate tax rate and vice versa (see e.g. Becker and Fuest (2007) and Haufler and Stähler (2010)).

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 more or less strict assumptions, our paper offers compelling descriptive evidence that MNEs relocate income to tax haven economies as tax havens, in the contrary to well-developed industrialized countries, are reported to host a significant number of foreign invented patent applications.

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. Section 5 presents the estimation approach and Section 6 contains the model 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 within multinational groups.

The value of a patent stems from its provision of a temporary monopolistic right to exploit the associated technology within a given geographic area. Any party that wishes to use the technology in that geographic area will have to pay a royalty fee to the patent owner. To avoid knowledge dissipation, MNEs have a tendency to sell the right to exploit a patented technology to affiliated companies only whereas the latter are forced, by the transfer price system, to pay a royalty to the patent owner.

In recent years, corporate patents (and other intangible assets) have been increasingly perceived to be major determinants of firm value while the manufacturing of physical output only generates relatively low returns. A classic example are producers of pharmaceuticals that earn their profit by developing innovative patents while the manufacturing of the drugs usually does not yield considerable returns. As income derived from patents is subject to corporate taxation, multinational firms have an incentive to structure their patent holdings in such a way that the returns to valuable patents within the group are earned in tax-favorable locations. This incentive is especially strong as patented knowledge (like other intellectual property) has a trade price of zero and the location of patents and output production can henceforth be geographically separated at low costs.

Moreover, patents are by their very definition firm-specific assets which means that their value to the firm is hardly observable by national tax authorities. This opens up opportunities to tax-favorably distort the royalty payments of group affiliates to the patent-holding affiliate. 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.

Several countries around the world have tried to hedge against income shifting strategies to low-tax countries by introducing so-called ‘Controlled Foreign Company’ (CFC) rules which intend 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 satisfied, 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.

From a practical point of view, MNEs can exploit different organizational 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, practitionners claim that (one of) the most common structure(s) 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 owner differs from the location of its inventor. The purpose of our paper will be to determine the importance and the characteristics of patent applications with a geographical separation of patent applicant and inventor. From a theoretical perspective, we expect that patent relocations from the inventor country are more likely the larger the patent income tax rate of this country and the higher the value of the patent. In turn, binding CFC legislation may make patent relocations less attractive as they might make patent income taxable in the inventor country. Moreover, we expect that the attractiveness of a country as potential host location for the patent owner is inversely related to the tax rate levied on patent income, whereas a low tax rate again appears to be especially important for those patents with a high earnings potential. 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). The data contains information on all patent applications to the EPO, including information about the patent applicant and the patent inventor, about the technology of the patent and the patent citations. The information is available to us for 1978 to 2007. However, as we observe the majority of tax data until 1990, we take into account patent applications after the year 1990 only.

The patents data comes from the EPO's Worldwide Patent Statistical Database (PATSTAT) which contains information on *all* patent applications to the EPO dating back to 1978, including (among others) information on the name of the patent applicant and the application date. The data version used in this paper is October 2007 and comprises up to 100,000 patent applications per year. 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 firstly enables a firm to make a single application which is cheaper than filing separately in each national office and secondly allows it to 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 patent applications where the main inventor (i.e. the first inventor listed on the patent application) is located in an EU 25 or OECD country.[3] In total, our data comprises $516,139$ patent applications. As described above, the focus of our analysis are patent applications where patent inventor and patent applicant are located in different countries. This is the case for $41,012$ 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 scarce 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).

As we are interested in corporate patents only, we in a first step identify corporate patent applicants in the PATSTAT database. We then in a second step add information on various characteristics of the patent as well as the host country of the patent owner.

[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.

[3]In the baseline analysis, we abstract from tax haven economies, as defined in Dharmapala and Hines (2009), i.e. we exclude the countries of Cyprus, Ireland, Luxembourg, Malta and Switzerland.

First and foremost, our analysis requires information on the earnings potential of each patent as it has been demonstrated by previous research that the distribution of patent value is highly 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. As described in Section 2, multinational corporations may find it especially attractive to locate patents with a high earnings potential in tax-haven countries.

We use the patent quality information derived in Hall et al. (2007) who follow Lanjouw and Schankerman (2004) and construct a measure for the quality of the EPO patents based on factor analysis.[4] They formulate a factor model with three separate indicators (forward citations, family size and the number of technical fields) of the patent's underlying, latent, quality.[5] The estimates of the factor model can be used to construct an estimator for patent quality conditional on the indicators. In the following, we will give a brief description of the information used to derive the quality index. See Lanjouw and Schankerman (2004) and Hall et al. (2007) for a detailed description of the construction of the patent quality variable.

The first quality information used for the index construction is the number of forward citations received by a patent. Intuitively, 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. These citations have an important legal function in the sense that they limit the scope of property 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. As indicated above, the information on patent quality is taken from Hall et al. (2007) who construct a forward citation measure within a 5 year period from the publication date.[6]

[4] We are very grateful to Grid Thoma for providing us with this data.

[5] Each indicators' variation is assumed to consist of a quality related and an idiosyncratic component. Estimation of the factor model exploits that variation in patent quality induces variation common to all indicators.

[6] 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

Additionally, the patent quality measure accounts for the patent's family size, i.e. for the number of jurisdictions or countries that the patent has applied for. Note in this context that PATSTAT also contains information on patent applications to the US patent office and all other major national patent offices. This information is particularly useful for identifying equivalent applications filed outside of the EPO at an earlier time (priority applications). In a first step, all priorities for the EPO patents were identified. Moreover, in a second step, all applications that report the EPO application as a priority were identified. After removing any double counting, the number of patent applications plus those from step 1 constitute the size of the patent family.

Last, the construction of the patent quality index accounts for the number of technological classes which have been shown by previous research to be an indicator of technological quality similar to the number of citations (see Lerner, 1994). For the purpose of guaranteeing a reasonable level of precision, the construction of our quality measures accounts for an eight-digit IPC classification reported in the patent document.

In general, several authors have moreover stressed that the value of patents varies across industries and across time. To account for that, we follow previous studies (e.g. Hall et al., 2007) and use quality measures which control for technology and year fixed effects (i.e. determine deviations from the average patent quality in a technology class at a given point in time). Note that using quality measures which do not account for this type of normalization derive similar results to the ones reported in this paper, as our regression context accounts for year and technology fixed effects.

Descriptive statistics for the quality measures in our data are presented in Table 1b. The composite quality index accounts for all three quality dimensions (forward citations, family size and industry classes) and controls for technology and year fixed effects. The average index is 0, varying strongly though betwenn -2.5 and $+7.9$. Similar patterns are found for indices which account for one of the quality components only as indicated by the quality index using forward citations and the quality index using family size depicted in the table.

Beyond the quality measures, the data set comprises information on the first industry class which will allow us to control for industry fixed effects 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

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.

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. Most countries tax patent income at the same rate as other corporate income. As sketched in the introduction, a growing number of countries have however introduced special low tax rates in recent years (e.g. Belgium and Netherlands). Our tax measure accounts for these special low rates 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.

Last, we include information on several host country characteristics like GDP per capita (as a proxy for economic development), the size of population (as a proxy 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.[7] Table 1B presents our basic sample statistics.

4 Descriptive Statistics

The descriptive statistics indicate that tax haven countries, as defined in Dharmapala and Hines (2009), indeed have a higher probability of hosting foreign patent applicants, defined as patent applications where all inventors noted on the patent application are located in a different country than the patent applicant. Figure 1 depicts all applicant countries in our data set and reports the share of patents filed in the considered country that was exclusively invented abroad. 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 applicants are located in a different country than the patent inventors. Our main analysis below will account for the latter cases in robustness checks. In Figure 1, the vertical axis ranks the countries included in the analysis according to their share of patents invented in a foreign country while the horizontal axis depicts the countries ranked according to the overall number of patent applications as a measure of country size. Moreover, the blue symbols depict tax haven countries, as defined in Dharmapala and Hines (2009), while the red symbols depict non-haven countries.

[7]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.

Interestingly, conditional on their size, the tax haven countries tend to be in the upper part of the figure suggesting that they observe an overproportional number of patent applications of foreign invented patents. The pattern in this picture is confirmed by Table 2 which depicts the explicit fraction of foreign invented patents in tax haven countries for the year 2005. The table shows that the majority of patents is filed in tax haven countries, in many cases well beyond 80%, were invented in a different country. Even the large and economically more relevant tax haven countries of Switzerland and Ireland observe a large fraction of foreign invented patents, precisely 33.1% and 45.1%. This is in sharp contrast to well-developed industrialized economies in Europe and Northern America. As depicted in the table, the average shared of foreign invented patents filed in the average EU25 country in turn is 11.3%, whereas many high-technology countries like Germany observe a fraction of foreign invented patents below 5%.

Furthermore, Figure 2 depicts the development of the fraction of patents which are filed in a country other than the inventor economy over time. Precisely, the graph depicts the average fraction of relocated patents by inventor countries in EU 25 and suggests that strategies which separate the inventor location from the location of the patent applicant tend to become more common over time while the fraction of patents which are filed from foreign tax haven countries have remained rather constant in our sample period.

5 Estimation Strategy

Beyond this descriptive analysis, we are interested in identifying the determinants of the decision to geographically split the location of technology inventor and patent owner. To do so, we in a first step assess whether taxation impacts on the decision to relocate a patent from the R&D location and to transfer its ownership to a different country. In a second step, we then identify determinants of the choice of the target country, i.e. the country where the patent owner is located.

5.1 Taxation and the Relocation from the Inventor Country

In a first step, we assess potential determinants of the relocation decision of patent holdings from the inventor country.[8] For that purpose, we define a binary variable $b_{i,t}$

[8]Note that the model thus assesses the probability of patent relocation, *conditional* on the location of the inventor. We consider this to be a plausible design as firstly, R&D activities are often located with

which takes on the value 1 if the patent is relocated 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 regression approach to binary choice models (see e.g. Greene (2008) for a formal textbook description) and specify the unobserved underlying stochastic variable $b^*_{i,t}$ as

$$b^*_{i,t} = \alpha_0 + \alpha_1 \tau_{i,t} + \alpha_2 V_{i,t} + \alpha_3 (V_{i,t} \times \tau_{i,t}) + \alpha_4 X_{i,t} + \rho_t + \mu_i$$

The variable of main interest is the corporate tax rate $\tau_{i,t}$ of patent i in country m 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, this incentive should be larger, the higher the value of the patent $V_{i,t}$ 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 from a taxation perspective, face the reverse incentive 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. Precisely, we add a full set of year dummies to absorbs shocks over time which are common to all patent applicants in our sample. Moreover, we include a full set of country fixed effects which account for 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 industry fixed effects and industry-year fixed effects respectively 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, we add several time-varying country controls which are subsumed in the vector $X_{i,m,t}$ and comprise 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 voice and accountability, political instability, rule of law, regulatory system, corruption control and government efficiency provided by the World Bank (see Kaufmann et al., 2008)).

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

the, traditionally determined and rather immobile, parent firm of the multinational group. 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.

rule

$$
\begin{aligned}
b_{it} &= 1 \quad \text{if} \quad b_{it}^* > 0 \\
b_{it} &= 0 \quad \text{if} \quad b_{it}^* \leq 0
\end{aligned} \tag{1}
$$

According to this, the probability to observe a positive change in the business tax rate can be written as

$$
P(b_{it} = 1) = \Psi(b_{it}^*) \tag{2}
$$

where we assume a normal distribution and let Ψ be the cumulative distribution function of it.[9] We estimate this model with maximum likelihood techniques to obtain the parameter estimates. In robustness checks, 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.[10]

Last, the incentive to relocate a patent to a foreign country may be determined by so-called controlled foreign company (CFC) rules if the inventor location coincides with the MNE's parent country.[11] As CFC rules are expected to hamper the relocation to foreign tax haven countries only, we reestimate the above specification augmenting the set of regressors by a dummy variable which indicates whether the country under consideration has enacted CFC legislations and using an indicator for the relocation to a foreign tax haven (as defined by Dharmapala and Hines (2009)) as dependent variable.

5.2 Taxation and the Relocation to a Tax Haven Country

In a second step, we then further assess whether and to what extent taxation plays a role in attracting foreign patent holdings and identify the determinants and identify the determinants of patent location in a tax haven country - conditional on being

[9] We also present the results of other distributions as robustness checks, with similar results. 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.

[10] Note that we, complimentarily, also address this problem by omitting the interaction term from the probit estimations and estimating the model separately for patents of different quality. The results are presented in Section 6.

[11] In line with this presumption, there is evidence that innovative activity within multinational firms is largely concentrated at the parent company (see Criscuolo et al., 2010)

relocated from the inventor country - by estimating a probit model with $h_{i,t}$ indicating a binary variable for patent holdings where the first applicant is located in a tax haven country as defined in Dharmapala and Hines (2009). Formally, we estimate a model of the following form

$$h^*_{i,t} = \beta_0 + \beta_1 V_{i,t} + \beta_2 X_{i,t} + \rho_t + \mu_i$$

The variable of main interest is the patent quality $V_{i,t}$. 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 inventor country characteristics, precisely GDP per capita, GDP and governance indicators. Moreover, we also include controls for the inventor country's corporate tax rate and information on whether CFC rules are in place in the inventor country.

Note that while this approach is convenient in identifying 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. Thus, we additionally estimate a conditional logit model which assesses the impact of a vector of host country feastures and their role in determining 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 in determining the patent location choice. Most importantly, we include the potential applicant country's patent income tax rate in the set of regressors.

Moreover, the specification of the conditional logit model 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 tax characteristics to be more important for the location decision of the firm the higher the patent value. To account for that, we estimate the conditional logit model separately for patents with different earnings potential $V_{i,t}$. As above, we moreover include a large set of control variables which comprises characteristics of the potential host countries as well as a variable for the geographic distance between the inventor and the potential applicant country (as measured by the geographical distance between the economic centres of the two countries).

5.3 Multinomial Logit Model

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 in a final step 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.

6 Results

The empirical results are presented in Tables 2A to 5. In Tables 2A and 2B, we estimate the model specified in Section **??** to assess the determinants of the decision to relocate a patent to a country other than the host country of the inventor. The observational unit is the patent application i in year t. Robust standard errors which are clustered at the level of the inventor country per year are depicted 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.

In Specification (1) of Table 2A, we estimate a probit model to determine the impact of the inventor country's patent income tax rate and the patent's earnings potential (as proxied by patent quality index) on the relocation of a patent from the inventor country. 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 expectations, the specification moreover suggests that the relocation probability increases in patent value. This suggests that it is especially high value patents for which inventor and ownership location are geographically separated. Calculating marginal effects furthermore suggests that the identified effects are quantitatively relevant. An increase in patent quality by one standard deviation (=0.826, cf. Table 1B) raises the relocation probability by 0.41 percentage points or, evaluated at the sample mean, by 5.1%. Somewhat smaller effects are found for the tax variable where an increase in the patent income tax by 10 percentage points is suggested to dampen the relocation probability by 0.3 percentage points or, evaluated at the sample mean, by 3.6%.[12]

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, the country's governance situation as captured by the World Bank governance indices for political stability, government efficiency, regulatory quality, rule of law and corruption control. Specification (3) moreover accounts for a full set of 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 size and 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 thus 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 patent's 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 in high-tax countries (positive coefficient estimate for α_3 in equation (**??**)) but tends to lower the relocation probability from low-tax economies (negative coefficient estimate for α_2 in equation (**??**)). Evaluated at the average patent income tax (= 43.2%), an increase in the patent quality index by one standard deviation raises the relocation probability by 0.5 percentage points or, evaluated at the sample mean, by 6.6%.[13]

As a robustness check and since the interpretation of interaction effects in probit models is highly problematic, we reestimate specifications (3) and (4) employing 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 high-value patents have a higher probability to be relocated to a foreign

[12]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($= 0.005 \cdot 0.826$) percentage points. Evaluated at the sample mean (= 0.0813), this corresponds to an increase in the relocation probability by 5.1%. 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 (= 0.0813), this corresponds to an increase in the relocation probability by 3.6%.

[13]The marginal effects for α_2 and α_3 are $-.032$ and .089.

country, whereas the quantitative result is comparable to the probit model results. Specification (6) again qualifies this finding and suggests that high-value patents have a higher probability to be relocated from inventor country 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 -0.029, again 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 a rising patent quality. This is intuitive as keeping high-value patents in tax haven countries is highly attractive from a taxation perspective. The impact of patent quality on the relocation probability turns positive at a tax rate of around 36%.

This result is confirmed if we split the sample in patents that are invented in high-tax inventor countries with a patent income tax above 43.2% (= sample mean, see Table 1B) and patents that are invented in low tax countries with a patent income tax below 43.2%. The results are presented in specifications (7) and (8). 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 1.27 percentage points, or evaluated at the sample mean by 15.6%. Similar results are moreover derived if we use a patent quality index capturing information on patent family size only (see specifications (9) and (10) which reestimate the baseline regressions in columns (5) and (6)).[14]

Furthermore, we assess whether our results are driven by patents from particular inventor countries. For that purpose, specifications (1) and (2) of Table 2B reestimate our baseline regressions excluding patents that were invented in one of the countries that largely dominate our sample, i.e. 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[15], see specifications (3) and (4).

In columns (5) and (6), we moreover reestimate specifications (5) and (6) of Table

[14] As stressed above, we consider the family size of the patent to be the best indicator for its earnings potential (while in contrast, the number of forward citations primarily capture its scientific value, which, although likely correlated, may be a less appropriate proxy for the earnings potential).

[15] Eastern Europe comprises Bulgaria, Czech Republic, Estonia, Lithuania, Latvia, Poland, Romania, Slovenia and Slovakia.

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 may be located in the same countries as the inventors on the patent).[16] This derives findings comparable to the previous estimates.

Last, as described above, several countries have introduced so-called Controlled Foreign Company (CFC) rules to hedge against income relocations from their borders. Since income may become immediately taxable in the parent country with binding CFC legislations, the incentive for patent relocations to foreign tax haven countries is expected to be smaller in this scenario. To assess this hypothesis, we define a dependent variable which indicates patents that were relocated to tax haven economies and regress it on the tax and patent quality as well as a dummy variable indicating inventor countries which enacted CFC legislations. The results are presented in specifications (7) and (8) of Table 2B. Thus relocations from inventor countries to tax haven economies should be reduced if the country under consideration has a binding CFC rule in place. This finding is confirmed in specification (7). The results suggest that the probability to be relocated to a tax haven location is significantly reduced by around 1.1 percentage points if CFC rules are enacted.

To further assess which types of patents are located at tax haven economies, we identify the determinants of tax haven location conditional on patent relocation in Table 3A. The observational unit is the patent application i in year t where the sample is now restricted to the set of relocated patents (see section **??**). Again, the dependent variable indicates patent applicants in a tax haven economy as defined in Dharmapala and Hines (2009). In Specification (1) the vector of explanatory variables includes

[16] Note that the definition defines a patent to be domestic if the first applicant and the first inventor stated on the patent are located in the same country. In our baseline regressions, a patent is defined as foreign if all patent applicants are located in a different country than all inventors. For our empirical specifications, we account for the home characteristics of the first inventor country on the patent application. Note that in the baseline specification, 'intermediate' cases with multiple inventors and applicants in different countries are dropped from the analysis if they are not conform with the definition of a foreign patent explained above. The robustness check in Specification (7) additionally includes patents where the first applicant is located in a different country than all patent inventors and considers these cases as foreign patents. Apart from that, we ran additional sensitivity checks (not reported in the paper) that include the intermediate cases in the analysis (either as foreign or domestic patents), which does not turn out to affect our results.

the composite patent quality index, the patent income tax of the inventor country and a full set of country and year fixed effects. In line with expectations, the results indicate that tax havens do not only attract an overproportional *number* of patents as suggested by our descriptive analysis but also have a higher probability to host high value patents. Retrieving the marginal effects suggest that an increase in patent quality by one standard deviation (=0.826, cf. Table 1B) raises the probability of a patent to be held in a tax haven economy by 2.0 percentage points or, evaluated at the sample mean, by 9.4%. This result is moreover confirmed in specification (2) which includes additional control variables to capture industry specific effects as well as effects related to the level of development, market size and governance situation in the inventor country. Quantitatively, the effect of patent quality on the probability of patent location in a tax haven country remains unaffected by the inclusion of the additional control variables. Specification (3) reestimates the model in an OLS framework and again finds qualitatively and quantitatively comparable results.

As described above, the definition of tax haven countries in our analysis follows Dharmapala and Hines (2009) and thus also include large well-developed tax haven economies, in particular Switzerland. Specifications (4) and (5) reestimate the baseline regressions in columns (2) and (3) and assess the robustness of our results to a more narrow tax haven definition which excludes the countries of Switzerland and Ireland. The results show qualtiatively and quantitatively similar results to our baseline specifications. Specifications (6) and (7) moreover reestimate specifications (2) and (3) using the quality measure as determined by family size instead of the composite measure. Again, we find results which are qualitatively and quantitatively comparable to our baseline estimates. Table 3B moreover shows that the results are robust against the inclusion of a dummy variable indicating whether the patent inventor country has implemented CFC legislations.

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 out 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 main intention 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 considered 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 country (as measured by the distance between the country's economc centres). 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 is confirmed if we additionally augment the set of regressors by control variables for the host country's governance situation in specification (2).

Our theoretical considerations in Section 2 suggest that the impact of host country taxation on patent ownership increases in the value of the patent. To assess this hypothesis, we reestimate specification (2) splitting the sample in a sample of low-value and a sample of high-value patents. The results are presented in specifications (3) and (4) of Table 4 and in line with our hypothesis suggest that the patent relocation choice is significantly more sensitive to changes in the corporate tax rate for the subsample of patents with an above average patent value. This finding is moreover additionally supported by the regressions in columns (5) and (6) which reassess the impact of taxation on the location probability for patents in the upper quartile and decile of the patent value distribution.

Furthermore, as described above, the attractiveness to locate a patent in a low-tax country may be significantly diminished by CFC legislations implemented in the inventor country (if the inventor country is also the headquarter location of the multinational group). To account for this possibility, we reconstruct our taxation variable in the sense as that if CFC regulations in the inventor country are binding with respect to a particular host location of the patent, then we assume that the associated patent income becomes taxable at the inventor country tax rate. The new tax variable thus reflects the host country patent income tax in the case on non-binding CFC legislations and the inventor location tax rate in the case of binding CFC legislations. The results are presented in specifications (7) and (8) and in line with the previous estimations suggest a negative impact of corporate taxation on the patent location choice.

Finally, while the analysis so far considered the decision to relocate the patent from the inventor country and the host country choice in two separate steps, one might argue that models which capture both decisions in one and the same framework to be also and potentially more suitable to analyse the data. This specifically calls for multinomial choice models to determine the effect of patent-related characteristics (mainly the expected value and earnings potential of the patent and characteristics of the inventor country) on the patent location choice. In Table 5, we assess the robustness of our previous findings to a multinomial logit specification. As described above, to keep the analysis tractable, we account for three choice options of the corporation: firstly, the option to keep the patent in the inventor country, secondly, to relocate it to a tax haven economy (as defined in Dharmapala and Hines, 2009) and thirdly, to relocate it to a non-haven economy. Specification (1) identifies the determinants of this choice accounting for the quality of the patent as well as the inventor country's tax rate and a dummy variable indicating whether the inventor country imposes a CFC legislation. Moreover, we include a full set of country fixed effects and inventor country size as measured by the overall GDP as additional control variables. Note that adding more control variables to the model gives rise to convergence problems in finding the maximum of the likelihood function. The base category for the results reported in Table 5 is patent ownership in the inventor country. The pattern of the results is very similar to the findings reported above. Precisely, a high value and earnings potential of the patent (as measured by the composite patent quality index) appears to increase the probability that the patent is relocated from the inventor country. Quantitatively, the effect is moreover significantly larger for relocations to tax haven countries than for relocations to non-tax haven economies.[17] Moreover, in line with the previous estimates, we find that CFC legislations in the inventor country tend to hamper patent relocations to foreign patent owners.[18]

Summarizing, this section provides evidence that tax considerations affect the corporate decision to geographically split the location of R&D units and corporate patent holdings. Precisely, the findings suggest that binding CFC legislations in the inventor and parent country deter the relocation of patent ownership to foreign firms, while low patent income taxes attract foreign-invented patents. Moreover, we provide evidence that firms strategically select patent holdings across countries in the sense that especially high value patents tend to be held in tax haven economies.

[17]The positive selection effect for non-haven countries may potentially reflect relocations to circumvent agency problems. Multinational firms may, for example, have an incentive to hold valuable patents with the headquarters firms. To the extent that the inventor countries in our sample do not coincide with the multinational headquarters, relocations to foreign tax haven countries might reflect locations of patent holdings with the headquarters firm.

[18]Note that one might also think about refining the conditional logit model estimated above by adding specifications which accounts 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.

7 Conclusion

The purpose of this paper was to assess 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 (depending on the definition, around 8% to of the 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 it is especially high-value patents whose ownership is relocated from the R&D unit to a tax haven country. Moreover, we find that binding controlled foreign company rules hamper the implementation of such relocation structures.

The results 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. Thus, it supports the notion that low patent income taxes are instrumental in attracting patent applications to a country. This eventually leads to a race-to-the bottom in patent income taxes which is in line with the sharp decline in patent income tax rates by several European countries in recent years. Secondly, the evidence suggests that firms engage in the selection of projects across affiliates in the sense that those projects with the highest expected earnings tend to be located at low-tax countries (see e.g. Becker and Fuest (2007) for a theoretical paper on that issue). Thirdly, the decision to geographically split the location of R&D units and patent holding entities supports recent theoretical claims which suggest that the presence of tax haven countries and multinational engagement in profit shifting activities might actually increase the welfare of well-developed high-tax countries as the possibility to relocate income refrains firms from relocating the real activity (in our case the R&D unit) itself (see e.g. Hong and Smart, 2010).

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	516,139	.0813	.273	.0	1
Patent Income Tax	516,139	.432	.0867	.15	.5967
CFC Dummy	516,139	.911	.285	.0	1
Patent Quality Index - Composite	516,139	.0130	.826	-2.529	7.943
Patent Quality Index - Family Size	516,139	-.00177	.559	-1.956	6.267
Political Stability	516,139	1.024	.262	-1.642	1.662
Government Efficiency	516,139	1.766	.379	-.675	2.319
Regulation Quality	403,633	1.117	.385	-.243	2.011
Rule of Law	516,139	1.570	.219	-.506	1.967
Corruption Control	516,139	1.646	.437	-.796	2.560
Log GDP per Capita	513,048	10.181	.262	7.279	10.592
Log GDP	516,139	28.515	1.1028	22.134	30.065
Patent Location Choice					
(Sample of Relocated Patents)					
Tax Haven	41,912	.212	.409	.0	1
Small Tax Haven	41,912	.075	.264	.0	1
Patent Quality Index - Composite	41,912	.0893	.848	-2.403	7.602
Patent Quality Index - Family Size	41,912	.0819	.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. Political Stability, Government Efficiency, Regulatory Quality, Rule of Law and Corruption Control indicate several 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 2A: Patent Relocation from Inventor Country
Dep. Variable: Binary Variable Indicating Relocated Patents

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Quality Index	0.0405***	0.0430***	0.0300**	-0.272***	0.00454**	-0.0288***	0.0154***	0.0000391	0.00589**	-0.0610***
	(0.00887)	(0.0104)	(0.0125)	(0.0343)	(0.00182)	(0.00633)	(0.00272)	(0.00173)	(0.00260)	(0.0102)
Quality Index × Patent Income Tax				0.751***		0.0790***				0.160***
				(0.0795)		(0.0141)				(0.0235)
Patent Income Tax	0.239*	0.119	0.0710	0.240	0.0211	0.0440	0.342***	-0.0389	0.0206	0.0447
	(0.133)	(0.182)	(0.188)	(0.194)	(0.0320)	(0.0334)	(0.0502)	(0.0876)	(0.0319)	(0.0330)
Political Stability		-0.196***	-0.173***	-0.164***	-0.0283***	-0.0266***	1.340	-0.0207*	-0.0281***	-0.0259***
		(0.0517)	(0.0512)	(0.0512)	(0.00748)	(0.00756)	(.)	(0.0111)	(0.00747)	(0.00749)
Government Efficiency		0.118*	0.115*	0.137**	0.0363***	0.0378***	0.560	0.0543***	0.0362***	0.0398***
		(0.0712)	(0.0685)	(0.0695)	(0.0115)	(0.0118)	(.)	(0.0180)	(0.0115)	(0.0118)
Regulatory Quality		-0.0886	-0.0923	-0.123	-0.0320**	-0.0356**	0.644	-0.0314*	-0.0320**	-0.0379**
		(0.0883)	(0.0906)	(0.0925)	(0.0150)	(0.0152)	(.)	(0.0161)	(0.0149)	(0.0151)
Rule of Law		0.338**	0.405***	0.399***	0.0717***	0.0706***	-1.903	0.0257	0.0722***	0.0700***
		(0.153)	(0.149)	(0.153)	(0.0253)	(0.0256)	(.)	(0.0332)	(0.0251)	(0.0254)
Corruption Control		-0.116	-0.110	-0.113	-0.0256*	-0.0240*	0.831	-0.0202	-0.0256*	-0.0231*
		(0.0870)	(0.0883)	(0.0881)	(0.0137)	(0.0136)	(.)	(0.0242)	(0.0137)	(0.0135)
Log GDP pC		-1.118*	-0.900	-0.965	0.0760	0.0654	-0.198	-0.0494	0.0784	0.0634
		(0.608)	(0.654)	(0.671)	(0.128)	(0.130)	(0.261)	(0.150)	(0.128)	(0.131)
Log GDP		0.540	0.334	0.447	-0.0515	-0.0392	0.180	0.00661	-0.0541	-0.0333
		(0.439)	(0.455)	(0.469)	(0.0819)	(0.0831)	(0.178)	(0.0966)	(0.0820)	(0.0837)
Country and Year FE	√	√	√	√	√	√	√	√	√	√
Industry FE			√	√	√	√	√	√	√	√
# Observations	516,139	411,719	345,061	345,061	345,073	345,073	125,619	219,454	345,073	345,073

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. Moreover, Specifications (1)-(4) estimate a probit model while Specifications (5)-(10) show the results of a linear probability model. For the definition of the explanatory variables, see the notes to Table 1B.

Table 2B: Patent Relocation from Inventor Country
Dep. Variable: Binary Variable Indicating Relocated Patents

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Quality Index	0.00573***	-0.0224**	0.00451**	-0.0288***	0.00499***	-0.0255***	0.00356***	-0.00139
	(0.00189)	(0.0110)	(0.00182)	(0.00634)	(0.00190)	(0.00653)	(0.000722)	(0.00304)
Patent Income Tax	0.134**	0.138**	0.0177	0.0406	0.0222	0.0431	0.0179	0.0213
	(0.0600)	(0.0611)	(0.0319)	(0.0333)	(0.0338)	(0.0350)	(0.0176)	(0.0178)
Quality Index × Patent Income Tax		0.0648***		0.0788***		0.0722***		0.0117*
		(0.0245)		(0.0141)		(0.0144)		(0.00711)
CFC Dummy							-0.0108***	-0.0109***
							(0.00354)	(0.00351)
Political Stability	-0.0330*	-0.0336*	-0.0285***	-0.0268***	-0.0238***	-0.0222***	-0.0121***	-0.0118***
	(0.0196)	(0.0196)	(0.00755)	(0.00763)	(0.00743)	(0.00757)	(0.00434)	(0.00435)
Government Efficiency	0.0396**	0.0389**	0.0358***	0.0374***	0.0348***	0.0362***	0.00950*	0.00975*
	(0.0167)	(0.0168)	(0.0116)	(0.0118)	(0.0110)	(0.0112)	(0.00503)	(0.00505)
Regulatory Quality	-0.0209	-0.0205	-0.0320**	-0.0356**	-0.0250*	-0.0284*	0.00175	0.00122
	(0.0182)	(0.0182)	(0.0151)	(0.0154)	(0.0143)	(0.0145)	(0.00597)	(0.00598)
Rule of Law	0.0684**	0.0728**	0.0703***	0.0693***	0.0540**	0.0531*	-0.0203	-0.0205
	(0.0303)	(0.0306)	(0.0254)	(0.0258)	(0.0273)	(0.0276)	(0.0125)	(0.0125)
Corruption Control	-0.0109	-0.0120	-0.0253*	-0.0238*	-0.0138	-0.0124	-0.0102	-0.00996
	(0.0196)	(0.0197)	(0.0137)	(0.0136)	(0.0148)	(0.0148)	(0.00736)	(0.00737)
Log GDP pC	0.0669	0.0421	0.0920	0.0812	-0.0564	-0.0663	-0.151***	-0.153***
	(0.237)	(0.239)	(0.131)	(0.133)	(0.138)	(0.140)	(0.0561)	(0.0565)
Log GDP	-0.121	-0.0956	-0.0587	-0.0463	0.0378	0.0491	0.118***	0.120***
	(0.195)	(0.196)	(0.0828)	(0.0840)	(0.0887)	(0.0901)	(0.0424)	(0.0427)
Country and Year FE	√	√	√	√	√	√	√	√
Industry FE	√	√	√	√	√	√	√	√
# Observations	130,652	130,652	344,689	344,689	344,690	344,690	345,074	345,074

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) and (8), 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 to Table 1B.

Table 3A: Patent Location at a Tax Haven Country Dep. Variable: Binary Variable Indicating Patent Applicants in Tax Havens							
Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Quality Index	0.0863***	0.0868***	0.0249***	0.0923***	0.0146***	0.212***	0.0610***
	(0.0136)	(0.0145)	(0.00456)	(0.0219)	(0.00390)	(0.0195)	(0.00619)
Corporate Tax Rate	1.073***	0.343	0.103	-0.0765	-0.000279	0.332	0.1000
	(0.253)	(0.414)	(0.120)	(0.447)	(0.0630)	(0.414)	(0.120)
Political Stability		0.0483	0.00310	0.105	0.0109	0.0690	0.00809
		(0.102)	(0.0305)	(0.133)	(0.0233)	(0.104)	(0.0307)
Government Efficiency		-0.128	-0.0273	-0.366*	-0.0528*	-0.130	-0.0261
		(0.119)	(0.0330)	(0.189)	(0.0270)	(0.119)	(0.0327)
Regulatory Quality		-0.0785	-0.0208	-0.504***	-0.0469**	-0.0710	-0.0187
		(0.157)	(0.0436)	(0.194)	(0.0230)	(0.158)	(0.0435)
Rule of Law		-0.788***	-0.218***	-0.0802	0.00645	-0.775***	-0.209***
		(0.228)	(0.0639)	(0.262)	(0.0358)	(0.232)	(0.0653)
Corruption Control		-0.0618	-0.00229	-0.0823	0.00239	-0.0792	-0.00677
		(0.173)	(0.0441)	(0.148)	(0.0186)	(0.175)	(0.0445)
Log GDP per Capita		-3.523***	-0.861***	-3.738***	-0.522***	-3.447***	-0.833***
		(1.106)	(0.295)	(1.264)	(0.185)	(1.120)	(0.296)
Log GDP		3.169***	0.859***	3.133***	0.487***	3.115***	0.834***
		(0.784)	(0.228)	(0.998)	(0.169)	(0.790)	(0.228)
# Observations	41,912	31,755	31,798	31,714	31,798	31,755	31,798

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)-(3), (6) and (7). In Specification (4)-(5), we apply a more restricted tax haven definition which abstracts from large tax haven countries like Switzerland and Ireland (see the definition of SSmall Tax Havenïn Table 1B). Moreover, Specifications (1)-(2), (4) and (6) estimate a probit model while Specifications (3), (5) and (7) show the results of a linear probability model. For the definition of the explanatory variables, see the notes to Table 1B.

Table 3B: Patent Location at a Tax Haven Country Dep. Variable: Binary Variable Indicating Patent Applicants in Tax Havens							
Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Quality Index	0.0863***	0.0869***	0.0249***	0.0924***	0.0147***	0.212***	0.0610***
	(0.0136)	(0.0145)	(0.00457)	(0.0219)	(0.00390)	(0.0195)	(0.00619)
Patent Income Tax	1.072***	0.322	0.0964	-0.0923	-0.00473	0.314	0.0945
	(0.251)	(0.405)	(0.117)	(0.438)	(0.0644)	(0.406)	(0.117)
CFC Dummy	-0.00435	-0.0545	-0.0155	-0.0907	-0.0106	-0.0483	-0.0130
	(0.0627)	(0.0813)	(0.0226)	(0.114)	(0.0160)	(0.0820)	(0.0227)
Political Stability		0.0608	0.00596	0.127	0.0129	0.0800	0.0105
		(0.106)	(0.0308)	(0.135)	(0.0234)	(0.107)	(0.0311)
Government Efficiency		-0.124	-0.0254	-0.364**	-0.0514*	-0.126	-0.0245
		(0.118)	(0.0330)	(0.184)	(0.0272)	(0.118)	(0.0328)
Regulatory Quality		-0.0575	-0.0158	-0.466**	-0.0434*	-0.0523	-0.0145
		(0.159)	(0.0436)	(0.191)	(0.0224)	(0.159)	(0.0434)
Rule of Law		-0.874***	-0.240***	-0.223	-0.00832	-0.851***	-0.227***
		(0.279)	(0.0733)	(0.332)	(0.0457)	(0.284)	(0.0747)
Corruption Control		-0.0454	0.00188	-0.0559	0.00524	-0.0647	-0.00328
		(0.168)	(0.0431)	(0.145)	(0.0185)	(0.171)	(0.0436)
Log GDP pC		-3.440***	-0.841***	-3.626***	-0.508***	-3.373***	-0.816***
		(1.116)	(0.296)	(1.252)	(0.186)	(1.131)	(0.298)
Log GDP		3.128***	0.849***	3.064***	0.480***	3.079***	0.826***
		(0.789)	(0.229)	(0.987)	(0.169)	(0.796)	(0.230)
# Observations	41,912	31,755	31,798	31,714	31,798	31,755	31,798

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)-(3), (6) and (7). In Specification (4)-(5), we apply a more restricted tax haven definition which abstracts from large tax haven countries like Switzerland and Ireland (see the definition of SSmall Tax Havenïn Table 1B). Moreover, Specifications (1)-(2), (4) and (6) estimate a probit model while Specifications (3), (5) and (7) show the results of a linear probability model. For the definition of the explanatory variables, see the notes to Table 1B.

Table 4: Conditional Logit Model - Relocated Patents Dep. Variable: Binary Variable Indicating the Location of Patent Applicant								
Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Patent Income Tax	-2.819***	-3.070***	-2.461***	-3.663***	-3.602***	-3.512***		
	(0.0529)	(0.0758)	(0.107)	(0.107)	(0.150)	(0.225)		
Patent Income Tax, CFC							-0.215**	-1.507***
							(0.0984)	(0.319)
Log GDP pC	1.495***	0.809***	0.683***	0.944***	1.039***	1.214***	0.839***	1.226***
	(0.0245)	(0.0517)	(0.0760)	(0.0707)	(0.0936)	(0.128)	(0.0471)	(0.119)
Log GDP	0.816***	0.985***	1.032***	0.951***	0.899***	0.860***	0.837***	0.729***
	(0.00476)	(0.00938)	(0.0135)	(0.0131)	(0.0178)	(0.0258)	(0.00770)	(0.0213)
Log Distance	-0.460***	-0.330***	-0.425***	-0.241***	-0.207***	-0.166***	-0.344***	-0.180***
	(0.00529)	(0.00667)	(0.00965)	(0.00948)	(0.0134)	(0.0201)	(0.00621)	(0.0190)
Voice		1.128***	0.939***	1.360***	1.458***	1.375***	0.675***	0.916***
		(0.0520)	(0.0815)	(0.0699)	(0.0933)	(0.117)	(0.0426)	(0.0994)
Pol. Stability		0.732***	0.743***	0.709***	0.633***	0.552***	0.392***	0.291***
		(0.0340)	(0.0483)	(0.0479)	(0.0684)	(0.102)	(0.0327)	(0.0986)
Government Eff.		1.475***	1.477***	1.486***	1.525***	1.430***	1.972***	1.829***
		(0.0492)	(0.0739)	(0.0672)	(0.0907)	(0.126)	(0.0476)	(0.127)
Reg. Quality		0.0213	-0.284***	0.309***	0.570***	0.697***	0.196***	0.850***
		(0.0404)	(0.0583)	(0.0560)	(0.0771)	(0.113)	(0.0441)	(0.121)
Rule of Law		-2.096***	-1.719***	-2.423***	-2.378***	-2.447***	-0.923***	-1.220***
		(0.104)	(0.154)	(0.142)	(0.193)	(0.280)	(0.0993)	(0.266)
Corrupt Control		0.654***	0.659***	0.616***	0.408***	0.396**	-0.148***	-0.375***
		(0.0527)	(0.0749)	(0.0752)	(0.106)	(0.157)	(0.0483)	(0.140)
N	1,050,807	768,914	386,092	382,822	191,850	83,876	761,597	82,773

Notes:

*, **, *** indicate significance at the 10%, 5% and 1% 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. All specifications present the results for a conditional logit model. For the definition of the explanatory variables, see the notes to Table 1B. The Quality measure indicates the Composite Patent Quality Index in all specifications.

Table 5: Multinomial Model
Base Category: Patent Applicant in Inventor Country

Variable	*(1)*	*(2)*	*(3)*
Foreign Tax Haven			
Patent Quality Index	.198***	.237***	.203***
	(.0198)	(.0335)	(.0195)
CFC Dummy	-.293**	-.580***	-.310***
	(.147)	(.178)	(.135)
Corporate Tax Rate	.393	.671	.184
	(.349)	(.569)	(.358)
Log GDP	1.663***	2.862***	1.683***
	(.251)	(.299)	(.250)
Country Fixed Effects	√	√	√
Foreign Non-Tax Haven			
Patent Quality Index	.0638***	.0800***	.0697***
	(.0213)	(.020)	(.0206)
CFC Dummy	-.267***	-.225***	-.202***
	(.0642)	(.0647)	(.0589)
Corporate Tax Rate	-.929***	-.463	-.604**
	(.343)	(.313)	(.290)
Log GDP	1.532***	1.638***	1.239***
	(.108)	(0.119)	(0.102)
Country Fixed Effects	√	√	√
N	516,139	516,139	519,785

Notes:

*, **, *** 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. All three specifications estimate a multinomial choice model. In Specification (1) the definition of a tax haven country follows Dharmapala and Hines (2009), while in Specification (2) the definition comprises small tax haven countries only (see the notes to Table 1B). Moreover, Specifications (1) and (2) follow our baseline definition of a foreign patent application, being an application where all patent applicants are located in a different country than the patent inventor. Specification (3) in turn defines a foreign patent application to be an application where the first applicant on the patent is located in a different country than all inventors. All specifications present the results for a conditional logit model. For the definition of the explanatory variables, see the notes to Table 1B. The Quality measure indicates the Composite Patent Quality Index in all specifications.

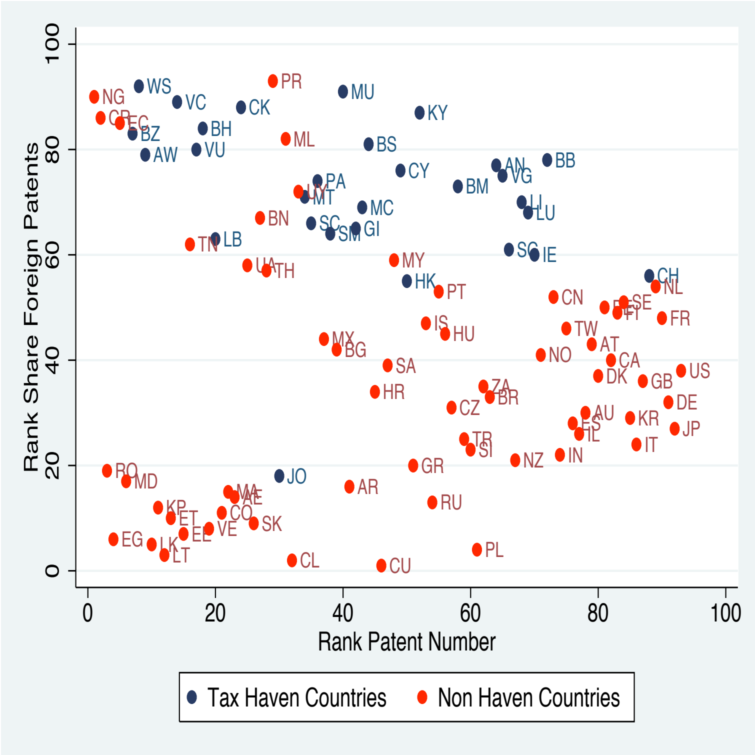

Abbildung 1: Perspective of the Applicant Country: Rank of Share of Patents Developed in Foreign Country

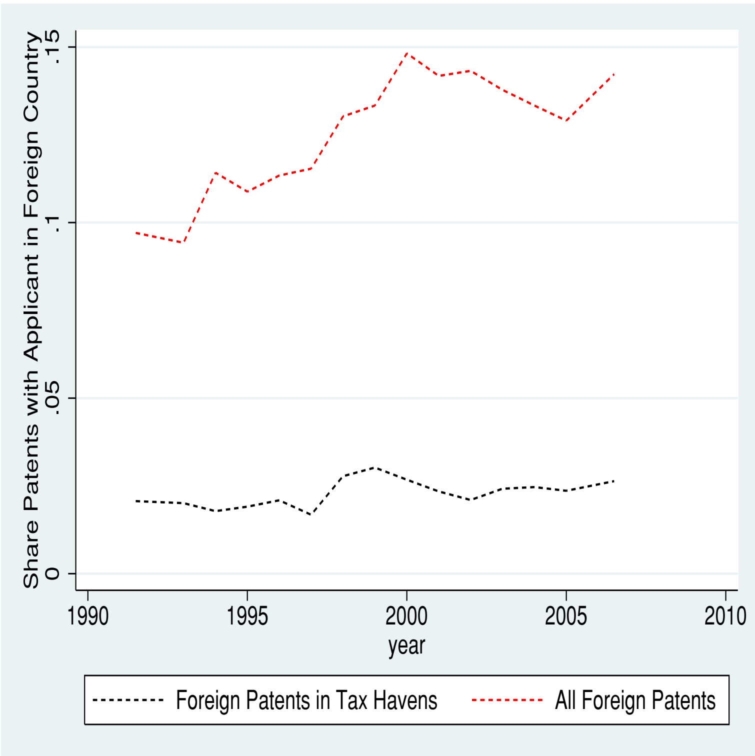

Abbildung 2: Perspective of the Inventor Country: Share of Relocated Patents over Time

References

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. 191202.

Dischinger, M. and N. Riedel (2010), Corporate Taxes and the Location of Intangibles within Multinational Firms, Journal of Public Economics, forthcoming

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.

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, 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. Sthler (2010), Tax Competition in a Simple Model with Heterogeneous Firms: How Larger Markets Reduce Profit Taxes, Oxford University Centre for Business Taxation Working Paper No. 10/20.

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 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 (2009), Corporate Taxation and the Choice of Patent Location within Multinational Firms, Oxford University CBT Working Paper No. 09/31.

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.

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.