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On the International Changes of Patent Ownership: Strategic Relocation and Patent Boxes

Laurie Ciaramella
Mines ParisTech
CERNA
laurie.ciaramella@mines-paristech.fr

Abstract

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Jelcodes:O33,H32

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Laurie Ciaramella[1]

[1]Mines ParisTech, PSL - Research University, CERNA - Centre for Industrial Economics, i3, CNRS UMR 9217

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Abstract

Firms can make use of the discretionary aspect of the location of patent ownership to avoid taxation and maximise their profits. This paper investigates strategic patent transfers with regard to Patent Box regimes, and study how firms' incentives to relocate patents vary with the heterogeneity of the designs of Patent Box regimes. Using a comprehensive dataset on international patent transfers, we find that Patent Box countries significantly attract more patent relocations, and that incoming flows increase in the tax rebate. The fiscal incentives are stronger in countries with a high R&D level, suggesting multiple dimensions in firms' decisions of patent relocation. This is all the more so true for high quality patents. Finally, our results indicate that policy makers could play on the features of Patent Box regimes to affect firms' incentives, and deter relocation driven by fiscal optimization motives.

Keywords: market for technologies, patent boxes, patent
JEL Classification numbers: O3, F23, H3

1 Introduction

Intellectual Property assets represent a growing share of firms' revenues. In 2014, Samsung paid Microsoft more than one billion dollars of licensing royalties to use the Android technologies in its mobile phones (Wall Street Journal, 2014). This is much more than the sum of revenues earned by Microsoft in 2013 from the Xbox product line, Skype, Kinect and the Windows Phone line, totalling to 800 million dollars (Microsoft, 2013). Like profit earned from tangible assets, firm's revenues derived from Intellectual Property are also subject to taxation.

Firms can use the intangible nature of their patents to shift income and avoid taxation (Griffith et al., 2014). The discretionary aspect of the patent location decision allows firms to have their revenues earned from high-tax regimes countries taxed in attractive low-tax rates locations. Patent offices do not require patents to be legally owned in same location as where the corresponding technology is protected. Moreover, patent revenues are subject to taxes in the country where they are legally owned, which is not necessarily the same as the country where the technology is protected. Using the discreteness of patent location, firms may also differentiate between the location of R&D efforts, and the location of the resulting patent. As corporate income tax rates and the existence of advantageous tax systems for Intellectual Property revenues differ widely across countries, this profit maximizing strategy can lead to substantial tax savings.

In the recent years, many European countries have introduced advantageous tax regimes for income derived from Intellectual Property. These regimes, referred to as Patent Boxes in the rest of the paper, grant corporate revenues derived from patents a preferential tax rate. These tax schemes generate growing concerns, as it is feared that they might generate distortion between the location of patent legal ownership and firm's real R&D activities (Hines Jr (1999); Barrios et al. (2012)) and deteriorate governments' revenues (Huizinga and Laeven, 2008). The UK Patent Box, launched in 2013, allowed more than £340 million tax breaks during the first year of the program, beneficiaries being mostly large firms[1] .

This paper aims at contributing to the growing debate on the relationship between the distortion of the location of the revenue generated by patent protection and Patent Boxes, by investigating their relationship with firms' behaviours of international patent relocation. Patent Box regimes have been the subject of intense criticisms by intergovernmental organizations. The OECD identifies them as harmful when they encourage companies to "shift profits from the location in which the value was actually created to another location where they may be taxed at a lower rate". Over all the Patent Box regimes evaluated by the the OECD/G20 Base Erosion and Profit Shifting project, none of them was

[1] `http://www.worldipreview.com/news/uk-patent-box-claims-hit-343m-in-first-year-12290`

found successful in ensuring that only patents derived from substantial activities effectively carried out by the taxpayer are subject to preferential tax treatment. European governments are now invited by the European Council to adapt their Patent Box regimes in order to guarantee that the application of an IP preferential tax regime is dependent on the level of R&D carried out by the taxpayer itself. In the case of internationally relocated patents, the R&D effort undertaken to develop the patent is unlikely to have been realized by the taxpayer.

This paper tackles two questions. First, it investigates the role of Patent Boxes in firms' decisions to internationally relocate European patent applications to European countries. Second, this paper studies the impact of Patent Boxes designs on the attractiveness of the Patent Box for European patent relocation. Indeed, Patent Boxes vary in their allowance for acquired patents. They also differ in the conditions they impose on the patent acquirer to benefit from the tax rebate. Under some Patent Boxes designs, the patent acquirer has to perform further substantial R&D to benefit from the tax allowance.

To the best of our knowledge, no existing study has investigated Patent Boxes with regards to patents changes of ownership. Existing work on Patent Boxes is scarce and recent. Alstadsæter et al. (2015) find Patent Boxes to have a strong effect on attracting patents' initial location. Schwab and Todtenhaupt (2016) find positive cross-border externalities of domestic Patent Boxes on foreign countries' domestic R&D investments, suggesting a response to profit shifting opportunities.

To understand the dimensions at stake in firms' incentives to internationally relocate patent ownership, we derive a simple theoretical model. It examines a company's decision to transfer a patent ownership to a new owner in a new country, provided that the transfer will be realized only if the expected revenues from the patent's new ownership are higher than the expected revenues from the initial ownership. The condition under which a patent is internationally transferred becomes more stringent in the presence of a tax rebate in the originating country, and less stringent when the corporate income tax rate of the originating country increases. The reverse mechanisms occur when the fiscal characteristics of the destination country are considered. Conditions imposed on the taxpayer to benefit from the advantageous tax rebate by the destination country have an increasing effect on the threshold of effective tax rates' differences, above which the patent will be transferred. When the patent transfer occurs between companies that are part of the same economic entity, the expected profit from patent ownership relaxes the constraint. The threshold in the difference of effective tax rates for a patent to be transferred is lower the higher the quality of the patent.

We create a comprehensive dataset of international relocations of European granted patent applications for the period 1997-2015. This new dataset covers all the registered patent relocations to

European countries, and spans over a time period during which more than a dozen Patent Box regimes have been introduced. It provides an ideal set-up for the purpose of analysing Patent Boxes and their heterogeneity.

Using this original dataset, we provide first descriptive evidences of international patent relocation in Europe. European countries are highly heterogeneous, both in the volume of patent relocations they attract, and in their balance - defined as the index between attracted and lost patents. They can be sorted in three categories. First, countries attracting high volumes of patents with a neutral balance - like Germany, are likely to take active parts in real technology transfers transactions, where the transfers of patent rights are combined with knowledge transfers, therefore likely to be associated with follow-on R&D efforts. Second, countries with a very positive balance but attracting low volumes of patent relocations - like Malta, are likely to be preferred for fiscal reasons. Third, countries attracting high volumes of patent relocations and presenting very positive balance - like Ireland, are likely to be choice destinations for patent relocations, where firms can combine fiscal optimization and knowledge transfer to a qualified workforce in strategic geographical location.

We run a series of count data regressions on firms' yearly flows of international transfers of patent ownership. We investigate strategic patent transfers with regard to Patent Box regimes, and study how firms' incentives to relocate patents vary with the heterogeneity of the designs of Patent Box regimes. Countries with a Patent Box regime in force attract higher patent relocation flows. This result is significant at the 0.1% level and holds in a wide range of specifications. The more important is the tax rebate allowed through a Patent Box regime, the higher are patent relocation flows. Thus, firms' incentives to internationally relocate patent ownership are all the more stronger as the tax rebate on IP revenue is important.

Binding CFC rules are associated with fewer patent transfers, providing evidence for fiscal motives in the decision of relocation. The fiscal characteristics of the country of destination matter more than the fiscal characteristics of the country of origin in firms' decision to transfer patent ownership. It suggests that patent relocations are made with the objective to benefit from an advantageous tax regime , rather than to escape an unprofitable tax policy.

The fiscal incentives provided by Patent Box regimes are stronger when the country has an high R&D activity. A firm response to a 1% higher tax rebate would be expected to be 2.25 times higher if the rebate occurred in an R&D intensive country, all else equal in the model. This indicates that firms consider several dimensions in their decisions to relocate patent ownership. Countries combining high R&D levels and advantageous taxation are destination of choice for patent relocation. They allow firm to associate fiscal optimization with developed communication networks, strategic geographic locations

and knowledge transfer to qualified workforces. Firms are more sensitive to fiscal characteristics when relocating high quality patents, and the additional fiscal incentive provided by countries with an intense R&D activity is stronger for high quality patents.

Patent Boxes with different features provide different incentives on firms' decisions to relocate patent ownership. When a development condition is imposed on the acquirer so that she is required to perform substantial additional R&D effort to benefit from the tax allowance, the tax rebate is no longer associated with more incoming patent flows. Although no causality should be inferred in the absence of data on variation of the features of a given Patent Box country, the results suggest that policy makers could play on the designs of the Patent Box regimes to affect the incentives for firms to relocate patents, and to deter transfers driven by fiscal optimization motives.

This paper is organised as follows. Section 2 reviews the existing literature this work relates to. Section 3 introduces a simple theoretical model. Section 4 describes the creation and the characteristics of the dataset we use. Section 5 presents the econometric specifications. Section 6 documents the results of the estimations. Section 7 concludes.

2 Background

This paper first relates to the literature on the empirical studies on the contemporary transfers of patent ownership, which is scarce, and recent. An important proportion of the existing work on patent changes of ownership uses US data, and therefore, focuses on the US market. This new stream of literature started with the work of Serrano (2010), who performed the first large-scale analysis on US data. He found that younger, more frequently cited and recently traded patents are more likely to be transferred. The rates of patent transfers depends on the characteristics of patents' owners: small firms are more active than larger ones (Serrano (2010); Figueroa and Serrano (2013)). Transferred U.S patents are highly skewed in terms of value (Serrano, 2011). The effect of patent transactions on the enforcement is heterogeneous, depending on the nature of the comparative advantages that generated the transfer (Galasso et al., 2013).Hochberg et al. (2014) investigate the relationship between patent transfers and venture lending, finding venture lending to be stimulated by more intense activity on the secondary market for patents.

Few studies use non-US patent data. Ménière et al. (2012) focuses on the market for patents valid in France. de Rassenfosse et al. (2013) use Australian data to study to which extent patent assist trade in technology. Gäßler (2016) explores the transfers of patents validated in Germany. Ciaramella et al. (2016) perform a first empirical analysis of patents' transfers at the European level using granted

EPO patents validated in different European countries. With the exception of de Rassenfosse et al. (2013) who use survey data, all the papers cited previously rely on registered transactions in patent offices.

This paper also connect to the literature on corporate taxation, Patent Boxes, and patent location. Several studies have investigated the impact of taxation on firm's behavior. The national level of corporate income tax is a significant determinant of the initial choice of patent location (Griffith et al. (2014) ; Bösenberg and Egger (2014)). It has been found to negatively affect firms' decisions to locate patents in a given country (Dischinger and Riedel (2011), 2011; Karkinsky and Riedel (2012)). Patent boxes are likely to attract the location of new patents (Griffith et al., 2014), this being particularly true for high quality patents (Alstadsæter et al., 2015). (Bösenberg and Egger, 2014) find significant effects of Patent Boxes on the volume of traded patents between countries, but the results are not robust to different specifications.

3 Simple theoretical model

Let A be the country where the patent x of firm i is initially owned. The expected revenue of firm i for the patent x during year t is $E(R_{x,i,A,t})$, defined as

$$E(R_{x,i,A,t}) = (1 - t_{A,t})E(\pi_{x,i}) - C_{A,t} \tag{1}$$

where $t_{A,t}$ is the level of effective taxation on corporate revenue derived from IP assets in country A at year t, $E(\pi_{i,t})$ is the expected profit from patent x from firm i and $C_{A,t}$ are the non fiscal costs derived from location A at time t. $C_{A,t}$ can be either negative or positive.

The expected revenue of firm j if it acquires patent x and relocate it in B is $E(R_{x,j,B,t})$, defined as

$$E(R_{x,j,B,t}) = (1 - t_{B,t})E(\pi_{x,j}) - C_{B,t}, \quad B \neq A \tag{2}$$

$C_{B,t}$ can be positive, for example in the case of further R&D efforts that need to be incurred to benefit from a Patent Box regime with a development condition. It can also be negative, for instance when the new location allows to benefit from knowledge spillovers. We make the assumption that the expected profit from patent x $E(\pi_{x,j})$ is independent from the location of patent legal ownership, but depends on the owner's ability to exploit its patent portfolio. Indeed, patent revenues are derived from patent protection, which is independent from the location of patent legal ownership.

Patent x will be transferred from i located in A to j located in B if with the transfer, a greater

profit on patent ownership can be achieved:

$$\sum_{t=1}^{T} E(R_{x,i,A,t}) < \sum_{t=1}^{T} E(R_{x,j,B,t}) \tag{3}$$

In equation (3), we make the assumption that the lifetime of the patent T is independent of its ownership. Let $\Delta_{t,A,B} = t_{t,A} - t_{t,B}$ be the difference between country A and country B effective tax rates on IP revenues. The effective tax revenue of a country y can be decomposed as $t_{y,t} = l_{y,t} - r_{y,t}$, where $l_{y,t}$ is the level of corporate taxation in country y at t, and $r_{y,t}$ the tax rebate if there is a patent box in force in country y at t. Then, patent x will be transferred if

$$\Delta_{t,A,B} > \widetilde{\Delta}_{t,A,B}, \quad B \neq A \tag{IR}$$

In the case of an transfer of ownership occurring between firms that are part of the same parent company, $i = j$. Under the assumption that the expected profit from patent protection do not vary with patent location, the buyer and seller, which are part of the same economic entity, have the same efficiency of patent portfolio management. Then,

$$\widetilde{\Delta}_{t,A,B} = \frac{C_{B,t} - C_{A,t}}{E(\pi_{x,i})} \tag{4}$$

The threshold $\widetilde{\Delta}_{t,A,B}$ is increasing in the cost of relocation $C_{B,t}$ and decreasing in the costs from the initial location $C_{A,t}$. It is decreasing in the expected profit from the patent $E(\pi_{x,i})$. An increase in the corporate tax rate $l_{A,t}$ relaxes the constraint, and so does a decrease in $l_{B,t}$. The presence of a tax rebate in A tightens the constraint, whereas the presence of a tax rebate in B relaxes it.

Then, the rational firm j will choose to transfer patent x to B rather than to an alternative destination B' if $E(R_{x,j,B,t}) \geq E(R_{x,j,B',t})$. A patent will be transferred to B rather than to B' if

$$\Delta_{t,B,B'} < \widetilde{\Delta}_{t,B,B'}, \quad \forall B' \neq B \tag{IC}$$

where

$$\widetilde{\Delta}_{t,B,B'} = \frac{C_{B',t} - C_{B,t}}{E(\pi_{x,j})} \tag{5}$$

The threshold is increasing in the cost of location $C_{B'}$ of the alternative country, and vice versa for the chosen country B. The constraint is tightened by an increase of the corporate income tax rate in B and relaxed by a tax rebate in B. The opposite mechanisms apply for taxation variations in the alternative country B'.

4 Data

4.1 Patent data

The original sample contains all European patent granted between 1997 and 2015 and transferred by firms before grant. The source of the data is the EPO PATSTAT Register - 2016 Spring Edition. We make use of the EPO Legal Status Database to identify granted patents applications that have been subject to a transfer of ownership. All flows transfers of ownership may not be registered, however registers remain one of the best available sources of information. 213,569 patents have been registered as having changed ownership. This represents 23% of the total number of patents granted during the period, a share slightly above what is found in the US for the most recent years in the study of Graham et al. (2015). This difference might be explained by the institutional differences between Europe in the US, giving actors of the market higher incentives to register before grant in Europe due to higher transaction costs.

There may be concerns that our choice to focus on granted patent applications might induce a selection bias. First, preferential tax levels designed by patent box regimes are applicable for granted patents only [2]. Second, many transfers occur just before the grant of the patent (see Ciaramella et al. (2016)). It has been mentioned by practitioners that patent acquirers would generally wait during the application process, to reduce uncertainty about patent value. Gäßler (2016) finds a highly positive effect of the communication of EPO's intention to grant to the patent rights holder on the hazard rate of achieving a patent transaction, showing that the reduction in uncertainty induced by EPO internal communication (see also Gans et al. (2008)) has a positive effect on patent transfers.

Another concern could arise from our focus on patent applications' transfers of ownership . First, pre-grant changes of ownership are the most frequent type of patent ownership transfer in Europe. In a previous study (Ciaramella et al., 2016), we find that 60% of the inscriptions of patent changes of ownership are made pre-grant, the majority of them occurring less than a year before the grant (see also Gäßler (2016)). The share of real economic events taking place before the grant of the patent is likely to be much higher than this threshold, because of the presence of many duplicates among post grant inscriptions[3]. Moreover, in the recent years, there has been a growing importance in the relative share of pre-grant transfers in the US (Graham et al., 2015)[4]. Finally, younger US patents have been found to be more likely to be transferred (Serrano, 2010).

To identify the sequence of successive patent owners, we make use of the use of information

[2]Under the UK regime, it is possible to claim back for the pendency period once the patent has been granted.
[3]They are due to the necessity to register in each national office patent has been validated in.
[4]This result has to be nuanced: before 2002, only granted patents were published by USPTO.

contained the sequence of patent publications, as available in Patstat. At the patent level, the first publication is the European patent application. The last publication is the grant of the European patent. Each publication contains both name and country information on the patent applicant. We link publications the Eurostat-KUL EEEPAT database (Du Plessis et al., 2010), which provides harmonized names. We distinguish between national and international changes of ownership[5]. 14,121 patents of our sample have been internationally transferred to a European country [6].

4.2 Other data

Data on corporate income tax rates and Patent Box regimes was compiled using information from the OECD, KPMG, Deloitte, PWC and Ernst&Young, and is summarized in Table 1. The first Patent Box regime was introduced in Ireland in 1973, and withdrawn in 2010 for budgetary reasons. The second Patent Box was introduced by France (2000), followed by Hungary (2003), Belgium and the Netherlands (2007), Spain and Luxembourg (2008), Malta (2010), Cyprus, Liechtenstein and the Swiss Canton of Nidwalden (2011), the United Kingdom (2013), Portugal (2014) and Italy (2015). Few patent box regimes were also introduced in non-European countries. China (2008) and Turkey (2014) established their own preferential tax regimes for IP revenues.

	IE	FR	HU	BE	NL	CN	ES	LU	MT	CH	CY	LI	GB	PT	TR	IT
Year	1973	2000	2003	2007	2007	2008	2008	2008	2010	2011	2011	2011	2013	2014	2014	2015
CIT	12.5	33.4	19.0	34.0	25.0	25.0	25.0	29.2	35.0	21.1	12.5	12.5	20.0	29.5	20.0	31.2
EFTR	0.0	15.0	9.5	6.8	5.0	15.0	10.0	5.8	0.0	8.8	2.5	2.5	10.0	14.8	10.0	18.6
Acquired IP	N	Y	Y	Y	Y	Y	N/Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Development		N	N	Y	Y	N	N	N	N	N	N	N	Y		N	N
Non-related		N	N	N	N	N	N	Y	N	N	N	N	N		N	N

Year: Year of introduction, CIT: Corporate Income Tax Rate, EFTR: Effective Tax Rate after the tax rebate. CIT includes surcharges, local income taxes and deductions, and other applicable income taxes. The Swiss patent box applies only in the canton of Nidwalden. Patent box regimes of Italy and the United Kingdom have been phased over respectively three and five years, with increasing deductions over the years following the introduction of the advantageous regime.

Table 1: Patent Box regimes, 2016

Patent boxes widely differ. Their most important feature is the tax rate they apply for income derived from Intellectual Property assets. In 2016, it ranges from 0 in Malta to 18.6% in Italy. To be put in perspective, the IP tax rate allowed by Patent Box regimes should be compared to the corporate income tax rate applied in the country. In Patent Box countries, it ranges from 12.5 to

[5]We define an international change of ownership as a transfer of patent ownership during which a country loses legal ownership of a patent, and/or a country gains legal ownership of the patent.

[6]Countries included in Europe are : Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, the Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

35%. Patent Boxes also vary in the conditions they impose on the tax payer to benefit from the tax relief. Only Portugal - and the withdrawn Irish Patent Box, explicitly excludes acquired IP assets from the scope of its Patent Box. The Spanish regime was also applying to self-develop IP only, but this criterion was relaxed in 2013. Belgium, the Netherlands and the United Kingdom regimes require further R&D development to be made by the tax payer, in order to benefit from the tax relief. Under the Luxembourgian Patent Box regimes, IP acquired from directly related parties cannot benefit from the tax rebate.

Data on countries' macroeconomic characteristics was collected from the World Bank DataBank. The index of patent protection was obtained from Park (2008) and is released every five years. We linearly extrapolated it to retrieve the missing values. We obtain country-pair variables in Mayer and Zignago (2011) and Griffith et al. (2014). Table 2 displays summary statistics.

4.3 Descriptive statistics

Figure 1 displays the volume of attracted patents for the top 20 European countries. Germany is the most attractive European country, receiving 21% of patent flows. It is followed by Switzerland, the Netherlands and France, that attracts respectively 17%, 14% and 12% of patents' relocation flows. Figure 2 displays the number of patent gains relative to the number of patent losses, by country, represented as the index base 100 of patent gains relative to losses of patent legal ownership for the same countries as in Figure 1. The index is above 100 for almost every country because of the considered flows.

European countries are highly heterogeneous with regards to their relative attractiveness of patent relocation. The three countries attracting the more patents relatively to the number of patent they lose ownership of are Ireland, Luxembourg and Malta. For every patent whose ownership is lost in favour of another country, Ireland gains legal ownership of more than five patents. Malta and Luxembourg attract more than three time more patents than they lose. These three countries are known to practice attractive tax rates, and have -or have had, Patent Box regimes in force. Countries having implemented Patent Box regimes at early stages of the considered period - such as Belgium, the Netherlands or France, show positive balances, attracting in average more than two times more patent than they lose. Spain loses 2.5 more times patents that it attracts.

Such heterogeneity in the volumes and indexes may indicate that several forces are at stake on the market for patents, and on firms' decision to relocate ownership. Countries attracting a high volume of patents and having a neutral index, such as Germany, are likely to be involved in real technology transfers transactions, where the transfer of patents is combined with a transfer of knowledge, and is

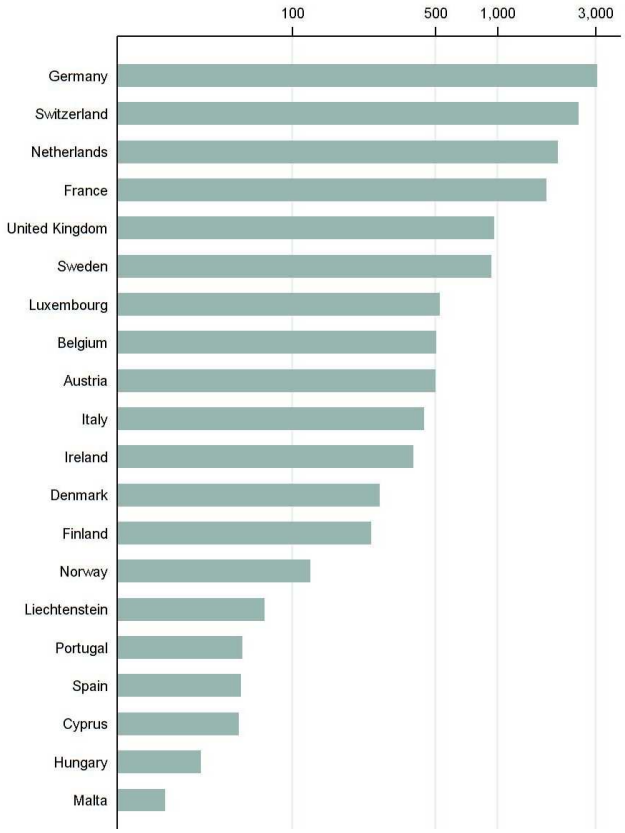

Figure 1: Volume of attracted patents

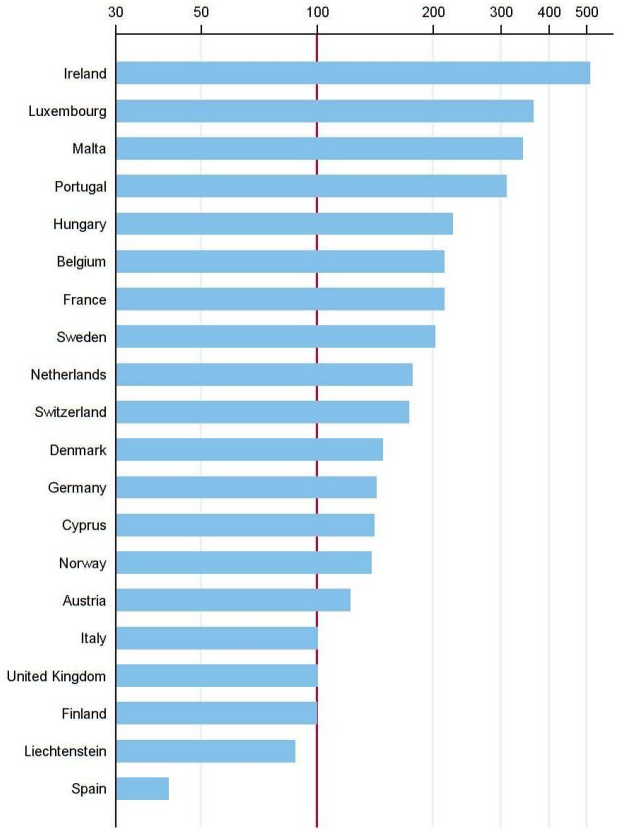

Figure 2: Index base 100: attracted vs lost patents

likely to be followed with R&D efforts. Countries that gain much more patents than they lose but attract relatively little flows in terms of absolute volumes - such as Malta where patent revenues are totally exempt of taxation, might be chosen as a destination for fiscal motives. This would reflect agents' strategic behaviour to lower the tax burden they are facing, and has little to do with patent trade and knowledge transfer. Finally, European countries presenting a very positive balance while attracting high volumes of patents - such as Ireland, Luxembourg, and Belgium, are likely to be a destination of choice for patent transfers. They offer very attractive tax regimes through advantageous patent boxes, but also high skilled workforce, strategic geographical location and developed telecommunications. Firms might thus combine knowledge transfer to a qualified workforce with fiscal optimization. Such destinations appear to provide the perfect incentives for firms to combine both follow-on Research & Development efforts, and profit maximization.

5 Econometric specification

The unit of observation is $Y_{F,A,B,t}$, the number of patents transferred from firm F, originally located in country A and relocated in European country B during year t. Following Griffith et al. (2014),

we exclude firms that patent infrequently. Our original dataset is composed of patent applications granted between 1997 and 2015. In order to have complete cohorts, we reduce our sample to the transfers of patent applications occurring between 1997 and 2015. By doing so, no pre-grant transfer of an eventually granted patent application is omitted from yearly cohorts.

We observe only strictly positive flows. We expand the data to account for the lack of flows. For the years during which firm F from country A has internationally transferred patents to one or several European countries B, we include 0 observations for the remaining countries B'. For each firm F, we compute the yearly pending patent portfolio, defined as the number of patent applications she owns that have not been granted yet, but will eventually be. For the years during which firm F has a non null pending patent portfolio, we include 0 observations flows for every country of potential relocation. By doing so, we make the assumption that, for every year t during which firm F has a positive pending patents portfolio, it has the possibility to transfer patents in each European country.

In order to relate the observables with the model defined in Section 3, we define g the indicator function defined over couples {firm, initial location, potential destination, patent, year}, equal to 1 when constraints IC and IR are satisfied. Formally

$$g : F, A, B, x, t \longrightarrow \begin{cases} 1 & \text{if } IC \cap IR \\ 0 & \text{otherwhise} \end{cases} \tag{6}$$

Then, the number of patents transferred from firm F, originally located in country A and relocated in European country B during year t is given by

$$Y_{F,A,B,t} = \sum_{i=1}^{N} g(F, A, B, ., t) \tag{7}$$

For patents having multiple owners, we slightly deviate from this representation, and ponder $Y_{F,A,B,t}$ accordingly.Let C_o and C_n be respectively the number of countries of initial ownership, and of new ownership, and C_d and C_a be respectively the number of countries that lost patent ownership, and that gain patent ownership. In the setting of an international transfer with multiple ownership, transfer will be weighted by:

$$s_n = \begin{cases} \dfrac{1}{C_o * C_n} & \text{if } C_o = C_d \\ 0 & \text{otherwhise} \end{cases} \qquad t_n = \begin{cases} \dfrac{C_d + C_a}{C_o * C_n} & \text{if } C_o \neq C_d \\ 0 & \text{otherwhise} \end{cases}$$

5.1 Patent Boxes and patent international relocation

We develop an empirical model to investigate the role of Patent Boxes in international relocations of patent applications to European countries. We estimate a count data model in the following form

$$\begin{aligned} Y_{F,A,B,t} = {} & \beta_1 \text{D\_CIT}_{\text{A,t}} + \beta_2 \text{D\_TaxReb}_{\text{A,t}} + \beta_3 \text{D\_Box}_{\text{A,t}} + \beta_4 \text{D\_R\&D}_{\text{A,t}} + \beta_5 \text{D\_IPR}_{\text{A,t}} + + \theta \text{D}_{\text{A,t}} \\ & + \beta_6 \text{O\_CIT}_{\text{B,t}} + \beta_7 \text{ O\_TaxReb}_{\text{B,t}} + \beta_8 \text{ O\_Box}_{\text{B,t}} + \beta_9 \text{O\_R\&D}_{\text{B,t}} + \beta_{10} \text{ O\_IPR}_{\text{B,t}} + \lambda \text{O}_{\text{B,t}} \\ & + \pi \text{C}_{\text{A,B}} + \rho_t + \alpha \text{App}_{\text{F,t}} + \epsilon_{F,A,B,t} \end{aligned} \tag{8}$$

where D stands for the country of destination and O stands for the country of origin. CIT_{t} represents the corporate income tax rate at year t and TaxReb_{t} is the tax rebate provided by the Patent Box in case there is one. Following Alstadsæter et al. (2015), we include Box_{t}, a dummy variable equal to 1 if there is a Patent Box in force in the country at time t in order to capture the non-fiscal effects of Patent Box regimes. $\text{R\&D}_{\text{t}}$ is the R&D expenditures of the country as a share of its GDP, and IPR_{t} captures the level of IP protection. $\text{D}_{\text{A,t}}$ and $\text{O}_{\text{B,t}}$ are a set of countries' control variables, including a dummy variable for European Patent Convention membership and the level of GDP. In addition, $\text{O}_{\text{B,t}}$ contains dummy variables to control for flows originating from US and Japan. These control variables are included to ensure that the variation in the flows of patent relocation are not driven by an unobserved correlation between such macroeconomic characteristics, and the level of taxation and patent relocation. $C_{\text{A,B}}$ contains variables controlling for country-pair specificities. It includes a dummy variable for common official language, the measure of distance between the most populated cities of each country. $\text{C}_{\text{A,B}}$ also contains a dummy variable to control for the existence of Controlled Foreign Company rules between a pair of countries. When CFC rules are binding, a company with home country A will still see its IP revenue taxed in A even if it has transferred its patents to a subsidiary located in B. CFC rules are designed to prevent firms locating income in lower tax countries in order to avoid higher taxation rates in their home country (see Griffith et al. (2014)). ρ_t is a full set of year dummies, included to capture common shocks over time. $\text{App}_{\text{F,t}}$ is the number of patents applied for during year t by firm F at the European Patent Office, representing the firm's patenting activity.

The dependant variable $Y_{F,A,B,t}$ contains a lot of zeros, and is highly over dispersed. Therefore, a negative binomial model is more appropriate than a Poisson model. This is confirmed by the computation of AIC and BIC criterion. Firms are not equally exposed to the opportunity to transfer patents. To account for this asymmetry, we include an exposure term, equal to the pending patent portfolio of firm F from country A during year t. This term represents the maximum number of eventually granted patent applications that firm could have transferred. To account for the fact that

transfers originating from a firm might not be independent from each others, we cluster standard errors at the originating firm level.[7]

5.2 Patent Box designs

We design a second model to investigate the effect of the features of Patent Boxes on the attractiveness of the Patent Box for patent relocation.

$$\begin{aligned} Y_{F,A,B,t} = {} & \beta_1 \text{D\_CIT}_{\text{A,t}} + \beta_2 \text{D\_TaxReb}_{\text{A,t}} + \beta_3 \text{D\_Condition}_{\text{A,t}} + \beta_4 (\text{D\_Condition}_{\text{A,t}} \text{ x } \text{Tax}_{\text{A,t}}) \\ & + \beta_5 \text{D\_R\&D}_{\text{A,t}} + \beta_6 \text{D\_IPR}_{\text{A,t}} + + \theta \text{D}_{\text{A,t}} + \beta_7 \text{O\_CIT}_{\text{B,t}} + \beta_8 \text{ O\_TaxReb}_{\text{B,t}} \\ & + \beta_9 \text{ O\_Box}_{\text{B,t}} + \beta_{10} \text{O\_R\&D}_{\text{B,t}} + \beta_{11} \text{ O\_IPR}_{\text{B,t}} + \pi \text{C}_{\text{A,B}} + \lambda \text{O}_{\text{B,t}} + \rho_t + \alpha \text{App}_{\text{F,t}} + \epsilon_{F,A,B,t} \end{aligned} \tag{9}$$

In this specification, we focus on flows to countries having a Patent Box regime in force at date t. $\text{D\_Condition}_{\text{A,t}}$ is a dummy variable equal to one if the Patent Box features the specific condition. For a regression considering the development condition of some Patent Box regimes, the dummy $\text{D\_Condition}_{\text{A,t}}$ is equal to one if further development is required from the taxpayer to benefit from the tax relief. The associated coefficient captures the non-fiscal direct effects of the condition, for example the associated administrative burden. The interaction term ($\text{D\_Condition}_{\text{A,t}}$ x $\text{Tax}_{\text{A,t}}$) captures the additional effect of the condition on the Patent Box fiscal attractiveness.

6 Results

6.1 Patent Boxes and patent international relocation

Table 3 displays the results of the first model outlined in Section 5. The objective is to assess the role of Patent Box regimes in firms' incentives to relocate patents. Columns (1) only contains the corporate income tax rate of the country of destination, as well as a dummy variable to take into account the presence of a Patent Box regime. The tax advantage provided by the Patent Box regime is included in Column (2), along with macroeconomic variables for the country of destination. It is removed in Column (6), in order to derive the global coefficient associated with Patent Box regimes. Fiscal and Macroeconomic variables of the origin country, as well as country-pair variables are incrementally added in Columns (3) and (4). The yearly number of patents applied for at EPO is added in Column (5). This measure of firm's patenting activity is used as a proxy for the firm's expected revenue from patent ownership specified in Section 3. Indeed, small entities such as start-ups are more likely to sell their patents (see Serrano (2010)). Under this statement, greater patenting activity means a greater

[7] Results hold when clustering the standard-errors at the country-pair level.

ability to efficiently exploit patent ownership, and thus, higher expected revenues. This measure is highly imperfect, as it does not consider patent characteristics. To account for this, we run a second set of regressions on the transfers of high quality patents only. Patent quality is proxied by the number of jurisdictions in which patent protection has been sought, i.e. by the family size (see Harhoff et al. (2003)). High quality patents are defined as patents belonging to the top quartile in terms of family size. Results of the regressions considering only international transfers of high quality patents are reported in Columns (7) to (10).

Our main variable of interest $TaxRebate, Destination$ captures the effect of tax reduction due to Patent Boxes on firms' decision to relocate patents. It has a positive effect on patent relocations in every specification, this effect being significant at the 0.1% level in almost every specification. It indicates that, all else equal in the model, countries offering a fiscal advantage for IP revenue significantly attract more patent relocation flows.The more tax reduction is allowed through a Patent Box regime implemented in a country, the more patents will be relocated to that country.

$PatentBox, Destination$ captures the non fiscal effect of Patent Box regimes - when associated with $TaxRebate, Destination$. In opposition to what is found by Alstadsæter et al. (2015) for patent applications, it does not have a significant effect at the 5% level on patent transfers, although it is also negative. This might reveal that the administrative burden, or the difference of treatment due to Patent Box regimes faced by firms is lower for patent relocation than for patent location. The coefficient associated with the dummy variable is positive and significant in Column (6), which does not include the $TaxRebate, Destination$ variable. It indicates that, all else equal in the model, countries with a Patent Box regime in force significantly attract greater volumes of patent relocation. Binding CFC rules between country pairs, preventing firms for making fiscal optimization through assets relocation, is negatively associated with international patent relocation. This effect is significant at the 1% level.

The fiscal characteristics of the country of origin do not display significant coefficients. This finding indicates that firms do not significantly consider the fiscal characteristics of the country they are relocating their patents from. Altogether, the results show that the fiscal characteristics of the country of destination matter more than the fiscal characteristics of the country of origin in firms' decisions to relocate patents. It suggests that patents transfers are made with the objective to benefit from an advantageous tax policy, rather than with the objective to escape an unprofitable tax regime.

The level of firm's patenting activity is negatively associated with patent transfers, this effect being significant at the 0.1% level. Under the hypothesis that a bigger patent portfolio is associated with a more efficient use of the portfolio, this finding suggests that patents are transferred from entities with

a lower ability to exploit efficiently patent ownership. Assuming that a more efficient management of patent portfolio generate higher patent revenues, the results show that patents are transferred from firms with lower expected revenues from patent ownership.[8]

Results on the sub-sample of high quality patents are similar, but of higher magnitude. The coefficient for $TaxRebate, Destination$ in column (10) indicates that, if a country were to increase its tax rebate by 1%, a firm's rate of international transfer of high quality patents to that country would be expected to increase by 12.3%, all else equal in the model. This expected rate is of 8.3% when considering all patents (Column (5)). These results indicate that the higher the expected patent quality, the more firms are sensitive to advantageous tax regimes when considering patent relocation. Under the hypothesis that a bigger family size is associated with higher expected patent revenues, the results show that the incentives provided by Patent Boxes in firms' decisions to internationally relocate their patents are higher for patents with greater expected revenues.

We create a dummy variable, $R\&DHigh, Destination$ equal to 1 if the country of destination has a high level of R&D expenditure, defined as being above 2.5% of the GDP.[9] The objective is to test whether the effect of the tax advantage provided by Patent Box regimes is higher for R&D-intensive countries, i.e. whether firms are more sensible to tax incentives when they can more easily combine follow-on R&D efforts, and profit maximization. To make the link with the simple theoretical model presented in Section 3, higher R&D expenditures in the country of destination could be interpreted as a negative cost of owning a patent in the country. Table 4 reports the results of the new set of regressions. Regressions in Columns (1) to (4) are run on the whole sample, whereas Columns (5) to (8) focus on high quality patents.

The coefficient associated with the tax rebate provided by Patent box regimes is significant in every specification at the 0.1% level. The higher is the tax advantage on IP revenues, the more patents are relocated to the country. Countries with a high share of R&D expenditure relative to their GDP significantly attract more patent relocations, this effect being significant at the 0.1% level in every specification. The third row shows the additional effect of the tax rebate when the Patent Box is implemented in a country with high R&D expenditures. The associated coefficient is positive and significant at the 0.1% level in every specification. It means that, all else equal in the model, the fiscal incentives for firms to relocate patents provided by Patent Box regimes are higher when the country has a high level of R&D activity.

Regressions on the sub-sample of high-quality patents present similar results, but of higher magni-

[8] Results from Table 3 hold in various robustness checks.

[9] Results hold when considering various thresholds to define a high level of R&D.

tude. It first means that, the higher the expected revenues of the patent, the more sensitive firms are to tax incentives on patent revenue. Second, it indicates that, the additional fiscal incentives provided by intensive R&D countries are higher for the relocation of high quality patents. Altogether, the results provide evidence that firms do consider several dimensions when deciding to relocate patents. Although international patent relocation can be driven by fiscal optimisation motives, the fiscal incentives are stronger in countries with high levels of R&D expenditures. Indeed, such countries are likely to be a destination choice, as they allow firm to associate profit maximisation with follow-on R&D on profitable patents. This is all the more so true for high quality patents. All else equal in the model, a firm response to a 1% higher tax rebate would be expected to be 2.25 times higher if the rebate occurred in an R&D intensive country.

6.2 Patent Box designs

Table 5 displays the results of the regressions on the second model defined in Section 5. The objective is to investigate the effects of the various designs of Patent Box regimes on firms incentives to relocate patents. Regressions in Columns (1) to (3) are run on the sub-sample of countries with a Patent Box regime in force, and investigate the possibility for Patent Box regimes to allow for acquired IP. Regressions in Columns (4) to (6) are run on the sub-sample of countries with a Patent Box regime in force and allowing for acquired IP, and examine the development condition that can be imposed on a taxpayer to benefit from tax advantages on acquired IP. Regressions in Columns (7) to (9) are run on the sub-sample of countries with a Patent Box regime in force and allowing for acquired IP, and explore the possibility for Patent Box regimes to forbid IP acquired from a related company to benefit from a preferential tax regime.

The level of corporate income tax rate of the destination country has a negative and significant effect in every specification. It means that, among countries with a Patent Box regime in force, countries with a lower corporate income tax rate attract significantly more patent relocations. As in the previous sets of regressions, the coefficient associated with the fiscal variables of the origin country are not significant.

Patent Box regimes can allow, or conversely forbid acquired IP to benefit from advantageous taxation rates. The coefficient associated with the tax rebate when the corresponding Patent Box regime does not allow for acquired IP is not significantly different from zero. In opposition , the coefficient associated with the tax rebate of Patent Box regimes allowing for acquired IP is positive and significant at the 0.1% level in the three specifications. It means that, a higher tax rebate is associated with more patent relocations in countries allowing for acquired IP, whereas this is not

the case for countries not allowing revenues from acquired patents to benefit from advantageous tax conditions. In the absence of changes in the design of the Patent Box regime of a given country, the results should not be interpreted as causal. Indeed, only one country - namely Spain, has changed its policy regarding the allowance of its Patent Box regime for acquired IP. However, the few associated number of observations does not allow us to derive exploitable results.

Patent Box regimes can impose on the taxpayer to perform further and substantial development of the acquired IP asset to benefit from the advantageous tax rebate. The coefficient associated with the tax reduction when the Patent Box does not impose a development condition is positive and significant at the 0.1% level in the three specifications. It becomes not significantly different from zero when the regime requires further development from the tax payer. These results indicate that higher tax rebates are not significantly associated with more incoming patent flows when the Patent Box designs impose the taxpayer to invest on R&D efforts. Although this finding should not be interpreted as causal in the absence of variation within countries, it suggests that regimes with a development condition might deter relocations only driven by fiscal optimisation motives.

Patent Box regimes can also allow for acquired IP in general, but forbid IP acquired from related parties -such as parent companies, subsidiaries or sister companies, to benefit from an advantageous tax rebate. The coefficient associated with the tax rebate when the Patent Box design allow for related acquired IP is positive and significant at the 1% level in the three specifications. However, it becomes not significantly different from zero when the rebate cannot apply to IP acquired within the boundaries of the company group. Although no causality should be inferred, this result might indicate that an important share of the registered transfers of patent ownership are made between companies belonging to the same parent group. Such intra-group transfers can be tricky to identify in the data, as firms are likely to use shell companies in order to create confusion. The non significance of the coefficient associated with the tax rebate when intra-group transfers are not permitted to benefit from the tax allowance might be an indicator of the magnitude of the phenomenon.

Altogether, results from Table 5 indicate that Patent Boxes with different designs provide different incentives on firms to relocate patents. In the absence of variation of the features of the Patent Box regime in a given country, the relationship between the design of the policy and the incoming patent flows cannot be interpreted in a causal way. However, the results suggest that policy makers could play on the designs of the Patent Box regimes to affect the incentives for firms to relocate patents, and to deter changes of ownership driven by fiscal optimization motives.

7 Conclusion

This paper investigates the international strategic changes of patent ownership with regards to the fiscal characteristics of the involved countries, with a specific focus on Patent Box regimes. It also pays particular attention to how firms' incentives to relocate patent ownership vary with the heterogeneity of Patent Box designs.

We find that countries with a Patent Box regime in force significantly attract more patents, and that the volume of incoming patent flows is increasing in the offered tax rebate. The fiscal incentives provided by tax allowance are stronger when the Patent Box is in force in a country with a high R&D activity, suggesting that firms take several dimensions into account in their decisions to relocate patents. Results also indicate that, when firms decide to internationally transfer their patents, they take advantage of an advantageous tax regime rather than they escape an unprofitable tax scheme.

We do not control for the reasons of implementation of the Patent Box regimes, and for unobserved chocks that could possibly affect some countries during some years of our period of observation. Therefore, no direct causality should be inferred from our estimations. Nevertheless, the results show that firms respond to incentives provided by countries with Patent Box regimes in force, and that these responses are stronger the higher is the tax rebate, and the greater is the expected profit from patent revenue.

We also find that a higher tax rebate is significantly associated with greater incoming patent flows only in countries where the Patent Box regime does not impose conditions on the taxpayer to benefit from the tax rebate. Although no causality should be inferred in the absence of variation in Patent Box designs within countries, the results indicate that policy makers could make use of the variability of the features of Patent Box regimes to deter transfers driven by fiscal optimization purposes.

The findings of this paper support the conclusions of the OECD/G20 Base Erosion and Profit Shifting project. Under their current designs, European Patent Box regimes that do not impose conditions on the taxpayer to benefit from a tax rebate on her acquired patents allow from a shifting of profit from where the value was created to another location. Such practices are in contradiction with the stated objective of Patent Box regimes. Patent Boxes aim at stimulating R&D efforts by creating a favourable fiscal environment. However, in the absence of stricter regulation regarding acquired patents, firms can take advantage of the discretionary aspect of the patent location decision.

Moreover the concerns regarding the differentiation between the location of R&D efforts and the taxation location goes beyond the issue of acquired patents. Indeed, under their current features,

the majority of the Patent Boxes regimes allow for the taxpayer to perform R&D efforts abroad, and therefore to differentiate between R&D and taxation location also for non-acquired patents.

It has been revealed in December 2016 that Google has been able to avoid more than three billions euros of taxation on its revenues derived from its patent portfolio in 2015. This legal tax avoidance has been possible partially thanks to the "Dutch Sandwich/Double Irish" technique, that takes advantage of the heterogeneity of European regulations on taxation of profits derived from IP. This recent news provides additional evidence that the lack of coordination at the European level, along with very permissive conditions, can lead to substantial losses of revenues for governments.

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Variable	Mean	Std. Dev.	Min.	Max.	N
Patent relocation	0.016	0.597	0	185	530323
Corporate Income Tax Rate, Destination	23.607	9.911	0	56.8	530323
Patent Box Dummy, Destination	0.137	0.344	0	1	530323
Tax Rebate, Destination	2.504	6.868	0	36	530323
R&D expenditures, Destination	1.349	0.871	0.037	3.914	428305
IP protection, Destination	4.207	0.458	2.233	4.667	370309
Log GDP, Destination	25.189	1.948	20.467	28.984	518974
Corporate Income Tax Rate, Origin	34.966	7.94	0	56.8	529768
Patent Box Dummy, Origin	0.119	0.324	0	1	529768
Tax Rebate, Origin	2.28	6.386	0	36	529768
Controlled Foreign Compagnies	0.47	0.499	0	1	530323
R&D expenditures, Origin	2.445	0.570	0.205	4.407	466456
IP protection, Origin	4.656	0.215	2.565	4.875	522026
Log GDP, Origin	28.583	1.5	21.555	30.518	526303
Distance	3897.5	3178.146	59.617	18190.617	483817
Common official language	0.088	0.283	0	1	483817
Patenting Activity	65.651	182.949	0	2742	530323

Table 2: Summary statistics

Table 3: Estimated parameters: International patent relocation

	(1) All patents	(2) All patents	(3) All patents	(4) All patents	(5) All patents	(6) All patents	(7) High Quality	(8) High Quality	(9) High Quality	(10) HIgh quality
Tax Rebate, Destination		0.093**	0.102***	0.078***	0.080***		0.117***	0.130***	0.117***	0.116***
		(0.03)	(0.03)	(0.02)	(0.02)		(0.03)	(0.03)	(0.03)	(0.03)
Patent Box Dummy, Destination	0.801***	-0.797	-0.639	-0.227	-0.316	1.207***	-1.058+	-0.978+	-0.718	-0.790
	(0.16)	(0.55)	(0.51)	(0.45)	(0.44)	(0.20)	(0.58)	(0.57)	(0.56)	(0.53)
Corporate Income Tax Rate, Destination	0.148***	0.022	0.013	0.027+	0.026+	0.046***	0.003	-0.011	0.001	-0.001
	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
R&D expenditures, Destination		1.123***	1.154***	1.116***	1.081***	1.076***	1.200***	1.194***	1.131***	1.059***
		(0.10)	(0.10)	(0.09)	(0.09)	(0.09)	(0.12)	(0.12)	(0.11)	(0.11)
IP protection, Destination		1.886***	1.692***	1.473***	1.412**	1.497***	1.083+	0.934+	0.775	0.588
		(0.50)	(0.44)	(0.45)	(0.43)	(0.44)	(0.57)	(0.54)	(0.53)	(0.50)
Log GDP, Destination		0.537***	0.538***	0.607***	0.602***	0.536***	0.741***	0.758***	0.798***	0.792***
		(0.11)	(0.11)	(0.08)	(0.08)	(0.08)	(0.11)	(0.11)	(0.11)	(0.10)
Controlled Foreign Compagnies			-0.619**	-0.594**	-0.587**	-0.490*		-0.678*	-0.760**	-0.779**
			(0.21)	(0.23)	(0.22)	(0.22)		(0.27)	(0.29)	(0.26)
Tax Rebate, Origin			-0.014	0.004	0.006	-0.002		-0.005	-0.018	-0.026
			(0.06)	(0.06)	(0.06)	(0.06)		(0.04)	(0.05)	(0.04)
Patent Box Dummy, Origin			0.409	-0.637	-0.643	-0.464		-0.223	-0.609	-0.417
			(1.30)	(1.27)	(1.26)	(1.29)		(0.93)	(1.03)	(0.94)
Corporate Income Tax Rate, Origin			-0.013	0.016	0.016	0.016		-0.034*	-0.033	-0.034+
			(0.01)	(0.02)	(0.02)	(0.02)		(0.02)	(0.02)	(0.02)
R&D expenditures, Origin				-0.476**	-0.449**	-0.459**			-0.578**	-0.551**
				(0.15)	(0.14)	(0.14)			(0.20)	(0.18)
IP protection, Origin				0.273	0.359	0.391			1.514+	1.891*
				(0.75)	(0.75)	(0.75)			(0.78)	(0.74)
Log GDP, Origin				-0.088	-0.132	-0.153			-0.090	-0.162
				(0.11)	(0.11)	(0.11)			(0.14)	(0.14)
Patenting Activity of the firm					-0.002***	-0.002***				-0.003***
					(0.00)	(0.00)				(0.00)
Distance				-0.000	-0.000	-0.000			-0.000	-0.000
				(0.00)	(0.00)	(0.00)			(0.00)	(0.00)
Common official language				1.042***	1.030***	1.074***			0.990***	0.867***
				(0.19)	(0.19)	(0.19)			(0.26)	(0.25)
Constant	-13.897***	-35.512***	-33.794***	-33.386***	-31.914***	-30.733***	-39.589***	-37.439***	-40.568***	-38.705***
	(0.67)	(2.85)	(2.91)	(4.08)	(4.07)	(4.04)	(2.50)	(2.53)	(4.03)	(3.82)
Ln(alpha)	5.803***	5.150***	5.138***	4.991***	4.957***	4.961***	5.157***	5.123***	4.981***	4.852***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.09)	(0.09)	(0.10)	(0.10)
N	530323	329398	329081	298919	298919	298919	176835	176721	158745	158745
chi2	358.0	739.6	859.4	1398.2	1466.3	1421.7	656.3	745.6	962.3	1094.6
alpha	331.4	172.4	170.5	147.1	142.2	142.8	173.7	167.8	145.6	128.0

Dependant variable: Number of relocated patents. Standard Errors are clustered at the firm level. Exposure term: Yearly portfolio of patents eventually granted.
Year fixed effects are included. Fixed effects for US and Japan as originating states are included. Fixed effects for EPC membership are included.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Estimated parameters with interaction terms between R&D and tax rebate

	(1) All patents	(2) All patents	(3) All patents	(4) All patents	(5) High Quality	(6) High Quality	(7) High Quality	(8) High Quality
Tax Rebate, Destination	.147***	.152***	.114***	.113***	.19***	.194***	.17***	.168***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)	(0.03)	(0.03)
High R&D, Destination	1.2***	1.22***	1.34***	1.3***	1.16***	1.17***	1.27***	1.2***
	(0.21)	(0.19)	(0.18)	(0.18)	(0.25)	(0.23)	(0.23)	(0.21)
Tax Rebate × High R&D, Destination	.311***	.303***	.225***	.214***	.351***	.348***	.263***	.247***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Patent Box Dummy, Destination	-2.02**	-1.86**	-1.14*	-1.18*	-2.86***	-2.56**	-2.06***	-2.08***
	(0.67)	(0.61)	(0.54)	(0.52)	(0.86)	(0.80)	(0.62)	(0.59)
Corporate Income Tax Rate, Destination	.0329	.0268	.04*	.0393*	.019	.0133	.0206	.0204
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)
IP protection, Destination	3.31***	3.17***	2.89***	2.78***	3.21***	2.9***	2.66***	2.48***
	(0.47)	(0.42)	(0.42)	(0.40)	(0.54)	(0.48)	(0.46)	(0.44)
Log GDP, Destination	.497***	.5***	.564***	.559***	.519***	.534***	.629***	.637***
	(0.11)	(0.10)	(0.08)	(0.08)	(0.14)	(0.13)	(0.11)	(0.10)
Corporate Income Tax Rate, Origin		-.0167	.0154	.0163		-.0244+	-.00447	-.0000638
		(0.01)	(0.02)	(0.02)		(0.01)	(0.02)	(0.02)
Patent Box Dummy, Origin		.305	-.239	-.218		1.16	.228	.587
		(1.21)	(1.28)	(1.26)		(1.22)	(1.41)	(1.36)
Tax Rebate, Origin		-.0136	-.0194	-.0182		-.0672	-.0536	-.0709
		(0.06)	(0.06)	(0.06)		(0.06)	(0.06)	(0.06)
Controlled Foreign Compagnies		-.457*	-.428+	-.406+		-.667**	-.702*	-.666*
		(0.21)	(0.24)	(0.22)		(0.24)	(0.28)	(0.26)
R&D expenditures, Origin			-.493***	-.472***			-.414*	-.399*
			(0.15)	(0.14)			(0.19)	(0.18)
IP protection, Origin			.297	.429			.691	.881
			(0.73)	(0.73)			(0.87)	(0.86)
Log GDP, Origin			-.0909	-.144			.0137	-.0602
			(0.11)	(0.11)			(0.14)	(0.14)
Distance			-.000189+	-.000193+			-.000128	-.000131
			(0.00)	(0.00)			(0.00)	(0.00)
Common official language			1.11***	1.1***			1.03***	1.08***
			(0.20)	(0.19)			(0.24)	(0.24)
Patenting Activity of the firm				-.00176***				-.00173***
				(0.00)				(0.00)
Constant	-39.1***	-37.5***	-36.6***	-35***	-39.1***	-36.9***	-41.1***	-39.5***
	(2.94)	(3.01)	(4.18)	(4.16)	(3.87)	(3.89)	(4.94)	(4.79)
Ln(alpha)	5.19***	5.18***	5.02***	4.99***	5.01***	4.99***	4.85***	4.81***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.09)	(0.08)	(0.09)	(0.09)
N	329398	329081	298919	298919	176835	176721	158745	158745
chi2	797.8	870.5	1377.8	1481.7	580.8	673.7	995.4	1087.5
alpha	178.6	176.8	152.0	147.0	150.2	146.8	127.4	123.1

Dependant variable: Number of relocated patents. Standard Errors are clustered at the firm level. Exposure term: Yearly portfolio of patents eventually granted.
Year fixed effects are included. Fixed effects for US and Japan as originating states are included. Fixed effects for EPC membership are included
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Estimated parameters: Patent Box designs

	(1) Allowance acquired	(2) Allowance acquired	(3) Allowance acquired	(4) Development condition	(5) Development condition	(6) Development condition	(7) Allowance intragroup	(8) Allowance intragroup	(9) Allowance intragroup
Condition, Dummy	-2.01	-1.66	-.197	6.41**	7.53***	4.08+	1.24	-2.47	-4.95
	(1.83)	(1.76)	(1.45)	(1.97)	(2.28)	(2.37)	(14.34)	(13.13)	(13.38)
Condition=0 × Tax Rebate, Destination	-.0879	-.083	-.00916	.546***	.428***	.512***	.592	.388	.254
	(0.12)	(0.12)	(0.10)	(0.12)	(0.13)	(0.13)	(0.61)	(0.56)	(0.57)
Condition=1 × Tax Rebate, Destination	.188***	.168***	.162***	.0865	-.053	.166	.316***	.247**	.241**
	(0.04)	(0.04)	(0.03)	(0.16)	(0.18)	(0.18)	(0.09)	(0.09)	(0.08)
Corporate Income Tax Rate, Destination	-.107**	-.104**	-.103**	-.408***	-.303*	-.413**	-.295***	-.285***	-.276***
	(0.04)	(0.04)	(0.03)	(0.12)	(0.13)	(0.13)	(0.06)	(0.06)	(0.06)
R&D expenditures, Destination	2.07***	1.82***	1.5***	3.43***	3.43***	2.53***	1.56***	1.57***	1.39***
	(0.33)	(0.37)	(0.36)	(0.43)	(0.49)	(0.54)	(0.37)	(0.37)	(0.35)
IP protection, Destination	-.685+	-.345	-.295	8.3***	8.71***	6.77***	-.473	1.52	1.06
	(0.41)	(0.42)	(0.53)	(1.68)	(1.76)	(2.02)	(1.56)	(1.74)	(1.65)
Log GDP, Destination	.592***	.572**	.662***	-.315	-.626	.00807	1.95***	1.74***	1.69***
	(0.17)	(0.18)	(0.18)	(0.39)	(0.43)	(0.46)	(0.36)	(0.38)	(0.36)
Corporate Income Tax Rate, Origin		.0252	.0327		.0497	.0419		.0421	.0382
		(0.03)	(0.03)		(0.03)	(0.04)		(0.03)	(0.03)
Patent Box Dummy, Origin		-1.17	-.278		-.985	-.552		-.768	-.599
		(1.55)	(1.43)		(1.55)	(1.40)		(1.38)	(1.34)
Tax Rebate, Origin		.0404	-.0173		.0278	-.0127		.00725	-.0131
		(0.07)	(0.07)		(0.08)	(0.07)		(0.07)	(0.07)
Controlled Foreign Compagnies		.243	.0885		.481	.195		.349	.00283
		(0.49)	(0.44)		(0.46)	(0.46)		(0.43)	(0.44)
R&D expenditures, Origin		-1.05**	-1.08***		-1.31***	-1.09***		-1.37***	-1.24***
		(0.33)	(0.27)		(0.29)	(0.29)		(0.27)	(0.26)
IP protection, Origin		3.05**	3.64**		2.38*	2.59*		2.58*	2.89**
		(1.13)	(1.14)		(1.20)	(1.20)		(1.04)	(1.05)
Log GDP, Origin		-.439+	-.582**		-.507*	-.762***		-.446*	-.524*
		(0.23)	(0.20)		(0.22)	(0.21)		(0.22)	(0.20)
Distance			.0000424			-.000882**			-.000301
			(0.00)			(0.00)			(0.00)
Common official language			.898*			.353			.197
			(0.37)			(0.38)			(0.34)
Yearly application count			-.00224***			-.00217***			-.00217***
			(0.00)			(0.00)			(0.00)
Constant	-17.5***	-18.2*	-22.8*	-40.5***	-31.9**	-24.1+	-59.3***	-56.8***	-47.4**
	(5.20)	(8.51)	(9.01)	(7.75)	(11.75)	(12.51)	(15.05)	(15.74)	(15.68)
Ln(alpha)	5.04***	4.89***	4.84***	4.9***	4.76***	4.69***	4.85***	4.69***	4.65***
	(0.09)	(0.11)	(0.10)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)	(0.09)
N	61421	55035	55035	45006	40069	40069	45006	40069	40069
chi2	571.0	620.9	722.7	377.1	411.0	632.4	177.3	323.1	476.0
alpha	154.2	133.0	126.6	134.1	116.7	108.9	128.2	109.0	104.2

Dependant variable: Number of relocated patents. Standard Errors are clustered at the firm level. Exposure term: Yearly portfolio of patents eventually granted. Year fixed effects are included. Fixed effects for US and Japan as originating states are included. Fixed effects for EPC membership are included

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$