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(Un)Intended Effects of Preferential Tax Regimes

The Case of European Patent Boxes*

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Abstract

Patent boxes have become an increasingly popular tax instrument in the European Union and the US to attract mobile tax bases of multinational enterprises (MNEs) as well as to foster productivity. This paper estimates the size of the (un)intended effects of the new preferential tax regime, which grants a reduction in the tax burden on income from intellectual property. We show that MNE affiliates that can benefit from the preferential regime report 8.5 percent higher profits. The profit change splits up into a profit shifting and a productivity effect in proportions 2/3 and 1/3. Surprisingly, the profit shifting effect includes an unintended, reversed profit shifting out of the affiliate. Contrary to expectation, the overall tax base adjustment might lower tax revenues collected from MNEs.

JEL-Classification: H25, H26, F23, C21, C23

Keywords: discriminatory taxation, patent box, productivity, multinational enterprise, profit shifting

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1 Introduction

Over the last decades, national governments have shown a wide interest in engaging in international tax competition by levying differentiated tax rates on mobile and less mobile tax bases. Implementing a preferential tax system helps to attract mobile tax bases, while retaining tax revenues collected from less mobile tax bases. In many cases, corporate taxes are the prime instrument to compete for mobile taxable income. Nowadays, attempts to directly differentiate corporate taxes for domestic and multinational firms are considered a harmful tax practice by the OECD (OECD, 2019). In response, OECD member countries revised their tax codes to comply with the OECD standard, but demonstrated a renewed interest to tax discriminate, this time in an indirect way. National governments seek to indirectly differentiate its corporate tax policy by offering a lower tax burden on income that is over-proportionally earned by multinational firms. Since the early 2000s, so-called patent boxes rapidly diffused in the European Union as well as the US.[1] Patent boxes grant a preferential corporate tax treatment of income derived from intellectual property (IP) rights. Multinational enterprises (MNEs) typically own a disproportionately high number of IPs and are therefore able to use the preferential tax treatment for tax saving purposes. While being central to the debate among economists and policy makers, empirical evidence on the fiscal effects of this preferential tax instruments is scarce to non-existent.[2]

In this paper, we provide empirical evidence on the economic implications of the new preferential corporate tax system. Using the introduction of a preferential tax treatment of IP income in European countries, we show that patent-box countries benefited from an increase in income that MNEs report in these countries. At the same time, MNEs reported less income that is subject to the ordinary corporate tax rate. Thus, MNEs shifted income that is eligible to the favorable tax treatment into the country with a patent box and regularly-taxed income out of that country. Our estimate of profit shifting into the patent box amounts to roughly 15 percent of pre-tax profits. After accounting for outward shifting, MNEs report on average only 5 percent higher pre-tax profits. Although the overall effect on pre-tax profits is positive, the shifting behavior of MNEs might have reduced corporate tax revenues in the patent-box countries. Intuitively, the preferential tax system levies a low tax rate of frequently around 50 percent or sometimes even 20 percent of the regular corporate tax rate on the in-flowing income, while the out-flowing income reduces tax revenues according to the regular corporate tax rate.

[1] Mostly after 2007, several European countries including Belgium, Cyprus, France, Hungary, Ireland, Liechtenstein, Luxembourg, Malta, the Netherlands, Portugal, Spain, Switzerland (Nidwalden), and the United Kingdom implemented patent box regimes. The 2017 US corporate tax reform 'Tax Cuts and Job Acts' (TCJA) has also introduced a patent box regime for the US tax system.

[2] Theoretical work on the desirability of preferential tax regimes includes Keen (2001), Janeba and Smart (2003), and Bucovetsky and Haufler (2007), for instance.

The findings are consistent with the political intention of the preferential tax policy, namely to attract mobile tax bases. However, contrary to expectation, the dual tax rate structure undermines the ability to fiscally capitalize on the inflow of pre-tax profits, possibly even lowering tax revenue which creates an efficiency cost.

For a number of reasons, existing empirical work on profit shifting is of limited value in the context of patent boxes and may paint a distorted picture of the effects of this new tax instrument.[3] First, the traditional measure of profit shifting, i.e. changes in pre-tax profit, might respond to the low-tax treatment of income from IP for reasons unrelated to profit shifting incentives. The low tax treatment offered by patent boxes might increase productivity, and result in higher pre-tax profit.[4] Additionally, patent boxes might interact with other channels of profit shifting. Motives for tax minimization not only give rise to profit shifting into the patent box, but also to reverted profit shifting out of the affiliate benefiting from the patent box, which lowers pre-tax profit. This blurs the extent to which the tax-saving effect of patent boxes can be estimated, when using pre-tax profit changes as an outcome variable. Assessing the effects of patent boxes on firm behavior and on social outcomes such as tax revenues requires to disentangle these effects. Second, the preferential tax treatment is not available to all firms, but only to those that have IP-related income. Such an income stream is endogenous to firm behavior, because it depends on a series of historical decisions related to R&D investments and patent acquisitions made at the conglomerate level. Empirical measures of the ability to benefit from the tax instrument need to account for this, to precisely estimate the behavioral response to the tax instrument.

In this paper, we address the concerns in the following way. Our first contribution is to provide a decomposition of the effects of patent boxes that have been introduced in Europe. In doing so, we create a comprehensive data set with affiliates that are located in patent box countries, and that either belong to domestic conglomerates or to world-wide MNEs. To disentangle the effect of patent boxes into a productivity and a profit shifting effect, we exploit the fact that affiliates of domestic conglomerates arguably cannot benefit from international tax rate differences to save on taxes. So, after controlling for input choices, changes in their pre-tax profit are residually related to productivity changes. Further, to analyze the relation between patent

[3] See Dharmapala (2014), among others, for an overview of the literature. Patent boxes are not considered in these works.

[4] The productivity might be related to intensified R&D, but also to increased effort in exploiting the income potential of IP rights, given the lower tax treatment of the return to effort. See e.g. Bloom et al. (2017) and Bender et al. (2018) for evidence on the effect of management practices on productivity in high-tech industries (as proxied by R&D and patent intensity) and the importance of managerial behavior. The productivity-enhancing role of patent boxes is also in line with the empirical finding that patent boxes increase research and development, either directly in affiliates in the patent box country (Ohrn, 2016) or indirectly in MNE affiliates that are not located in a patent box country, but have a sister affiliate in a patent box country (Schwab and Todtenhaupt, 2016).

boxes and other channels of profit shifting, we look at two frequently adopted tax saving strategies: the use of MNE-internal financial relationships and the use of tax havens. In particular, MNE-internal financial relationships take the form of interest payments between MNE affiliates, where internal interest payments flow from high-tax to low-tax affiliates.[5] Accounting profits no longer include these payments as they are deductible costs. To detect behavioral adjustments via this channel of profit shifting, we use an alternative outcome variable, earnings before interest and taxes (EBIT). This variable includes interest payments, so that differences between pre-tax profit and EBIT changes allow us to detect such adjustments, which are unintended consequences of the policy change. Further, we trace the link between the MNE affiliate and a tax haven, either because another affiliate within the MNE network or the majority shareholder locates in a tax haven. The two types of exposure to a tax haven might differently incentivize MNEs to re-adjust behavior to save on taxes (Schindler and Schjelderup, 2012).

Our second contribution is to construct a novel proxy for the ability of affiliates to benefit from the new tax instrument (our definition of treatment). We use historical patent ownership to proxy the ability to access the preferential tax treatment. Intuitively, our empirical strategy is to differentiate between affiliates with low and high costs of accessing the tax relief. IP creation and patent applications are subject to high (fixed) costs. Thereby, affiliates with no historical patent ownership face high costs of benefiting from the patent box regime, due to the complete absence of patents within their world-wide conglomerate. We use a broad definition of patent ownership to account for the possible behavioral response that the MNE relocates the patent within the conglomerate to the affiliate in the patent box country.[6] We define treatment by considering patent ownership that is either direct, at the affiliate level, or indirect, via the majority shareholder. The new measure of policy exposure might also be fruitfully used in different contexts, where the causal effect of policy changes on e.g. R&D is of interest.[7]

A very robust picture emerges from our regression analysis. When running a 'naive' regression, i.e. without addressing the decomposition concern discussed above, we find that treated affiliates of MNEs report on average 8.5 percent higher profits. This estimate cannot solely be attributed to profit shifting into the patent box country. Treated affiliates of domestic conglomerates report on average 3.5 percent higher profits, after controlling for input choices. To the extent that the magnitude of the productivity effect is representative for the affiliates of MNEs,

[5]Internal financial arrangements are important for firm performance for non-tax reasons (Antràs et al., 2009), but also serve the purpose of avoiding taxes (Egger et al., 2014). In fact, a significant fraction of up to one third of profit shifting runs via the adjustment of internal interest payments. See Dharmapala (2014) for a review of the literature.

[6]Patent location within MNEs has been shown to be tax sensitive with the consequence that low-tax affiliates have a disproportionately high share of patent holdings (Karkinsky and Riedel, 2012; Griffith et al., 2014; Alstadsaeter et al., 2018).

[7]Specifically to this paper, our approach allows to account for selection of firms into the group of patent holders, as well as for endogenous links to patent ownership and patent location within the firm conglomerate.

the estimate uncovers the MNE's actual amount of profit shifting of 5.0 ($= 8.5 - 3.5$) percent of pre-tax profits. Still, this estimate of profit shifting might not fully reflect the response of MNEs to shift profits into the affiliate in the patent box country. When looking at the alternative measure where interest payments are not deducted (the EBIT measure), we find a higher responsiveness of 11 percent. The latter estimate shows that the pre-tax profit change of 5.0 percent also captures some shifting of profits out of the treated affiliate through higher interest payments among affiliates of the MNE. The finding suggests that the location of the income in the patent box country is tax-driven and not in line with non-tax reasons for the location of income within an MNE, which incentivizes the MNE to use interest payments on internal debt to shift income out of the affiliate.[8] Decomposing the profit shifting response, our plain estimate of profit shifting *into* the patent box amounts to roughly 15 percent of pre-tax profits.[9]

We present a variety of robustness checks, including alterations to the definition of treatment, the time span of our analysis as well as to the matching procedure. We also uncover some heterogeneity in the behavioral responses. The profit shifting response (*i*) is higher in affiliates with an initially high corporate tax rate, as compared to the tax rate of the other affiliates in the MNE network, (*ii*) also applies to affiliates of MNEs with a historical link to a tax haven, unless the majority shareholder resides in the tax haven[10], and (*iii*) is smaller in magnitude (and possibly statistically insignificant) when the patent box regime grants the tax benefit only to newly created patents (essentially disqualifying pre-existing or acquired patents).

The findings help to shed light on 'bread-and-butter concerns in public economics', i.e. the cost of raising taxes, which are influenced by behavioral responses. The behavioral responses of MNEs to a patent box are key to policy discussions, where it is taken for granted that the MNE profit shifting response positively influences corporate tax revenues. The results of the paper qualify the assessment in two ways. First, patent boxes expand the tax base not only due to profit shifting, but also due to a rise in productivity. Second and perhaps surprisingly, given that

[8]The finding is in line with anecdotal evidence on how IKEA uses the tax benefits offered by the Dutch patent box, where the affiliate in the Netherlands internally acquires IPs to access the patent box benefits. The internal transaction is financed by internal debt with relatively high interest payments to the affiliate in Liechtenstein (Financial Times, 2017). In general, the inward-outward shifting offers a double tax benefit to the MNE and, thus, lowers corporate tax revenues, as further explained in Section 7 and 9. The profit shifting responses are not unidirectional, as classically observed with a uniform corporate tax where MNEs use internal interest payments and other profit shifting channels simultaneously to shift profits into a low-tax affiliate (Haufler and Schjelderup, 2000; Mintz and Smart, 2004).

[9]The estimate of 15 percent cannot be directly compared with recent estimates of profit shifting, as reviewed in Dharmapala (2014). In our analysis, the treatment effect relates to availability of patent boxes, while existing analyses typically relate the response to tax rate differentials. Once adopting a similar specification by computing the (weighted) tax rate change due to the patent box regimes, which is roughly 20 percentage points, we arrive at a pseudo semi-elasticity of 0.75. The estimate is in line with estimates reported in recent studies on profit shifting, where the consensus estimate is 0.8.

[10]The finding might reflect the incentives of the majority shareholder not to engage in a costly re-optimization of their tax planning strategy, where tax benefits would have to be shared with other shareholders (Schindler and Schjelderup, 2012).

the inflow of profits is taxed at the patent box tax rate while the outflow via interest payments is subsidized proportional to the higher, regular corporate tax rate, the net tax revenue effect of the overall profit shifting response might be negative. Illustrative calculations show that the critical tax differential, which renders the tax revenue change negative, is not implausibly high compared to observed tax rates.

There are multiple challenges to estimating the effect of interest. A natural concern is that the two groups of affiliates might be too different to be used as treatment and control groups. To address the concern, we use panel data, include a variety of fixed effects and employ matching techniques where we match on various historical affiliate-level information.[11] Our definition of treatment allows us to compare affiliates within patent box countries rather than between patent-box and non patent-box countries. In fact, in our main empirical analysis we match treated affiliates to control affiliates within a country and industry.[12] Finally, patent boxes offer the quite rare possibility to use stark changes in tax incentives to identify the behavioral responses of firms. Tax rates that are embedded in patent boxes are frequently 50 percent, for some up to 80 percent, lower than the regular statutory corporate tax rate. The tax variation is salient and presumably large enough for adjustment costs not to suppress the responses in firm behavior. Previous studies primarily rely on changes of corporate tax rates over time. In general, these are not too frequent and not overly significant in size, which raises concerns of identification (Dharmapala and Hebous, 2018).

The paper proceeds as follows. Section 2 provides an overview of the different patent box legislation in Europe. Section 3 lays out the theoretical predictions that we put to a test. Section 4 specifies the empirical strategy and Section 5 describes the data. Section 6 details the matching technique that we use in the analysis. Section 7 presents the estimation results followed by a series of robust analyses in Section 8. Section 9 provides a discussion of the results and, finally, Section 10 concludes.

[11] We use the *coarsened exact matching* (CEM) method proposed by Blackwell et al. (2009) and Iacus et al. (2012) to select our control sample. In an alternative specification, we use propensity score matching to select the control group and find quantitatively similar results.

[12] The choice of control group (as well as the decomposition of the behavioral responses to patent boxes) is new to the literature. Chen et al. (2016) exploit cross-country variation in the implementation of patent boxes and use quasi-experimental analysis where treatment is defined by the location of the MNE affiliate in a patent box country. Ohrn (2016) uses country-level flows of royalty payments between the U.S. and foreign countries with a patent box. This differs from our research design that relies on within-country and -sector variation in policy exposure of affiliates of worldwide MNEs, while addressing heterogeneity in pre-reform characteristics of treated and non-treated affiliates within a country and sector (through matching procedures). The difference in analysis also relates to the decomposition of the effect. While informative, the use of royalty payments in Ohrn and earnings before interest and taxes (EBIT) in Chen et al. do not uncover productivity changes and reverse profit shifting. Also, royalty payment from the U.S. might capture only a subset of the overall effect of patent boxes on profit shifting, which also includes payments to patent box countries from countries other than the U.S.

2 Patent Box Regimes

Patent boxes have become increasingly popular in attracting mobile income. As of 2015, almost half of all EU countries have special tax rules that stipulate a reduced tax burden on IP income. France and Ireland were the first two countries to introduce precursory tax measures related to IP income in the early 1970s, followed by Hungary in 2003. However, the first patent box was introduced in the Netherlands in 2007 and only thereafter the use of patent box systems as a means of profit shifting became popular among MNEs (Evers, 2015). Luxembourg and Spain introduced a patent box in 2008 and the Belgium one became effective from the 2008 tax year onward (EY, 2008; Atkinson and Andes, 2011). France and the Netherlands substantially adjusted their IP-related tax treatment in 2010 followed by Hungary in 2012. In essence, the reforms resulted in a more generous tax treatment of IP income.[13]

Table 1 reports details about the specific characteristics of the IP box regimes considered in our empirical analysis. All IP box regimes feature a substantially lower tax burden on IP income vis-à-vis income derived from a firm's standard business activity. In France and the United Kingdom, a separate rate of 15 percent and 10 percent, respectively, is applied in taxing IP income. All other countries resort to adjustments of the tax base, exempting between 50 percent and 80 percent of the income derived from IP when computing taxable income. The effective tax rate on IP income varies greatly across countries and amounts to around 5 percent in Belgium, Luxembourg, and the Netherlands, around 10 percent in Spain, Hungary, and the United Kingdom, and up to 15 percent in France (EY, 2015).

The countries depicted in Table 1 represent the main subjects of our empirical analysis. Other European countries introduced IP box regimes later in time, such as Malta in 2010, Liechtenstein and the Swiss canton of Nidwalden in 2011, Cyprus in 2012, the United Kingdom in 2013, Portugal in 2014, and Italy in 2015, whereas Ireland abolished its IP box regime in 2010.[14] In an extension, we expand our data sample to include the years (and legislations) up to 2015, allowing us to also include the United Kingdom in the analysis. Due to data limitations, we are not able to include the remaining set of countries.

Patent boxes also differ with respect to the types of income that qualifies for the preferential

[13] In the Netherlands, the 2010 reform of the patent box resulted in a drop of the effective tax burden on IP income to 5 percent and additionally the cap on income qualifying for the patent box was abolished (EY, 2009, 2010). In France, the 2010 abolition of the surcharge on the corporate tax also impacted the taxation of IP income, reducing the effective tax burden on IP income to 15 percent versus 34.4 percent on regular income (PwC, 2013; Sakar, 2015). In Hungary, the threshold for firm profits that qualify for the reduced corporate tax rate of only 10 percent (5 percent for IP-related income) was significantly increased in 2012, resulting in a substantial reduction in the average tax burden on IP income (EY, 2005, 2012).

[14] The Irish IP Box scheme was withdrawn in 2010 under the National Recovery Plan 2011-2015 of the Republic of Ireland. At the time of the withdrawal, it was also announced that a new scheme, called Knowledge Development Box, would substitute the old one in 2015, offering a reduced tax rate of 6.25 percent on qualifying profits generated in periods commencing on or after 1 January 2016.

tax treatment. Narrowly defined IP boxes grant preferential tax treatment only to income derived from newly developed patents (i.e. IP registered *after* the introduction of the patent box regime) and associated IP rights, as is the case in Belgium, Luxembourg, and the Netherlands. In all countries except Spain, acquired IP is also eligible for the preferential tax treatment. In the Netherlands and the United Kingdom, acquired IP must, however, be developed further or actively managed in the country in order to qualify (EY, 2015). Several countries such as Spain, Luxembourg, or Hungary also allow trademarks to qualify for the IP box-related tax benefit, while Belgium, France, the Netherlands and the United Kingdom exclude trade marks (EY, 2015). In the empirical analysis, we also use these characteristics of patent boxes and analyze the sensitivity of the estimates with respect to the various dimensions of patent boxes.

For some time, in particular during our observational period, the various tax rules have not imposed a link between the place of innovation and the place of tax declaration of IP-related income. This allows MNEs to relocate patents within MNE conglomerates, and thereby their royalty payments, from countries where the innovation took place into countries with a patent box. However, the recent OECD initiative against base erosion and profit shifting (BEPS) specified that patent box regimes introduced after 2015 must comply with the modified nexus approach, imposing a link between the place of innovation and the palce of tax declaration of IP income. However, for existing patent box regimes, grandfathering rules have been agreed on, which stipulate that existing regimes will need to comply with the modified nexus approach from July 2021 onward (OECD, 2015).[15]

3 Theoretical Predictions

In this section, we develop a theoretical model of profit shifting that underpins our main prediction of how patent boxes affect pre-tax profits, and which we put to a test in the empirical analysis. Consider two firms, located in countries A and B, which are affiliates of the same multinational enterprise (MNE). The affiliate in country A sells the right to use intellectual property (IP) owned by affiliate A to the affiliate in country B for royalty payment q and the affiliate in country B uses the input to generate sales y_B. The *true* price of the IP input is unity and not directly observable by tax authorities. The MNE can set the royalty payment q different from unity subject to a concealment cost $\theta(q)$ that satisfies

$$\theta(1) = 0,\ \theta'(1) = 0,\ sign(\theta') = sign(q-1),\ \theta''(q) > 0.$$

[15]Whether the modified nexus approach conforms with European non-discrimination law at all seems to be subject of future court decisions. Even without the legal concerns, other popular IP-related tax planning mechanisms such as intra-group R&D arrangements or contracted R&D arrangements may still allow MNEs to disentangle the place of actual R&D activity from the place of ownership of the R&D output (Evers, 2015).

If $q > 1$ there is overpricing and if $q < 1$ there is underpricing of the internal input. The concealment cost increases overproportionally the higher the deviation from the true price. Similarly, affiliate A uses its IP to produce an output that leads to pre-tax profits $y_A(i)$ that depend on productivity-enhancing investment, i. Multiple interpretations of the investment are feasible. It may capture an investment in innovation, where the cost of generating innovations is $c(i)$, with $c'(i), c''(i) > 0$. Alternatively, one might interpret i as the level of effort the affiliate manager exerts in utilizing the income potential of the IP. With this interpretation, $c(i)$ measures the cost of managerial effort.

The total profits of the MNE are:[16]

$$\Pi = (1 - t_A)(y_A(i) + q - 1) + (1 - t_B)(y_B - q) - \theta(q) - c(i)$$

In choosing the profit-maximizing royalty payment, the MNE aligns the tax advantage $t_B - t_A$ with the marginal concealment cost:

$$t_B - t_A = \theta'(q). \tag{1}$$

For a positive (negative) tax differential $t_B - t_A > (<)\ 0$, the MNE overprices (underprices) the IP input (e.g., Haufler and Schjelderup, 2000; Gresik, 2001). The optimal investment level aligns the marginal return on investment with the marginal cost:

$$(1 - t_A)y'_A(i) = c'(i). \tag{2}$$

A patent box in country A leads to a preferential tax treatment of income that is eligible for the patent box. Provided the income $y_A(i)+q$ qualifies for the favorable tax treatment, the tax rate t_A that applies to this income stream decreases following the implementation of the patent box. The first-order conditions (1) and (2) imply that the drop in t_A increases the amount of profit shifted into affiliate A as well as the level of productivity-enhancing investment, i.e. $dq/dt_A > 0$ and $di/dt_A > 0$. The two adjustments increase pre-tax profits in country A.[17] To summarize:

[16] For illustration, we assume that $c(i)$ is not tax deductible. All what matters is that the cost and the return to investment are not subject to the same tax rate. For instance, the cost of investment might not be granted an immediate write-off and might only be tax deductible over time, which is usually the case for machinery and equipment. Even when investment outlays are granted an immediate write-off, the cost and return to investment might be taxed differently due to the existence of, i.e., super-deductions. This implies that the level of investment is tax-sensitive, as modeled above.

[17] The conclusion also holds when pre-tax profit of affiliate A, π_A, also includes a fraction of or possibly all of the cost of transfer pricing and investment in innovation. In the latter case, the total profit change of affiliate A is

$$d\pi_A/dt_A = \big(y'_A(i) - c'(i)\big)\, di/dt_A + \big(1 - \gamma'(q)\big)\, dq/dt_A.$$

Using the first-order conditions (1) and (2), the change in pre-tax profit reduces to $t_A y'_A(i) di/dt_A + (1 - t_B + t_A) dq/dt_A$, which is positive in sign.

Proposition: *Assume country A introduces a patent box. Then, provided affiliate A's patent income qualifies for the patent box, profit shifting into the patent box as well as productivity-enhancing investment increase. In response, pre-tax profits of affiliate A rises.*

The adopted specification is a parsimonious way of modeling the effect of innovations on profits. Alternatively, we might augment the specification by allowing the concealment cost to depend on i and to become less convex w.r.t. q as i increases. Intuitively, the investment possibly makes the intermediate input more productive and thereby idiosyncratic, which renders it more difficult for tax authorities to infer tax-induced deviations from the true price. In this case, the concealment cost $\theta(q,i)$ satisfies $sign(1-q) = sign(\partial^2\theta(q,i)/\partial q\partial i)$ in addition to the properties imposed above. With this extension, a higher investment level i following the existence of the patent box 'relaxes' the marginal concealment cost in (1) with the consequence that the MNE sets a higher transfer price to be paid to affiliate A. We might also allow the investment to increase the output of affiliate B, y_B, possibly due to the public good character of innovations and technology transfer within an MNE.[18] However, the relevant predictions of the model stated in the proposition will not change with these extensions.

In the empirical analysis, we put the proposition to a test. Testing the proposition is challenging for different reasons. Most notably, the majority of datasets trace the change in total pre-tax profit, without observing the separate change in profits due to transfer pricing and due to productivity gains. To infer the source of the profit variation due to the existence of a patent box, we might compare the change in profits of an affiliate of an MNE with the profit of firms that are either not affiliates of an MNE (domestic firms) or do not have income that qualifies for the patent box. Intuitively, in a firm that does have qualifying income and is affiliated with a domestic conglomerate, pre-tax profits only change due to higher investment i and the resulting productivity increase.[19] In this case, $q \equiv 0$ and the first-order condition (2) summarizes the adjustment in profits. At the same time, for affiliates of MNEs or domestic conglomerates that have no qualifying income, pre-tax profits will not change following the introduction of a patent box. Thus, looking at the profit differential of domestic affiliates with and without qualifying income separates the productivity effect that these firms experience, while looking at the pre-tax profit differential of MNE affiliates with and without qualifying income isolates the total profit effect for MNE affiliates. To the extent that the productivity estimate is representative for affiliates of MNEs, the estimates allow us to decompose the total effect for MNE affiliates into a profit shifting response and a productivity effect. In the empirical analysis we thus resort

[18] See Schwab and Todtenhaupt (2016), for instance.

[19] Domestic firms benefit from the lower tax rate on qualifying income, as MNEs do. However, the mechanical effect does not show up in pre-tax profits, our outcome of interest. We relegate a more detailed discussion of the potential tax savings that domestic firms enjoy due to patent boxes to Section 4.

to a triple diff-in-diff estimation strategy to isolate the different changes. We compare pre-tax profit before/after the introduction of the patent box (or a major adjustment to it) for affiliates with access to the patent box (treatment group) vs. affiliates without access to the patent box (control group). We allow the effect to vary across affiliates of domestic conglomerates and MNEs. The treatment status will not be determined by the availability of a patent box in the country in which the affiliate resides, but by the affiliate's ability to access the preferential tax treatment granted by the patent box, as detailed in the next section.

4 Empirical Strategy

We center our empirical analysis around the time of the introduction of patent box regimes or major adjustments to existing ones in European countries and compare the change in the pre-tax profits of affiliates belonging to domestic and multinational conglomerates. In order to identify the portion of profits shifted through patent box regimes, we exploit the fact that firms differ substantially in their costs of accessing the IP-related tax benefits. Our identification strategy is based on the assumption that affiliates of MNEs with an established path of investment in intangible assets and patented IP have an *easy access* to the preferential tax treatment related to patent boxes at relatively low or even no costs. They form our treatment group.

The treatment group not only includes affiliates with direct IP ownership within their unit, but also affiliates with indirect IP ownership via their shareholders. This implies that we can account for the number of patents owned by each shareholder of an observed European affiliate, which can potentially be relocated towards the respective country where both a patent box is available and an affiliate is located. This approach is a novelty in the literature. It allows us to directly account for an MNE's ability to use the tax benefits of the patent box by relocating the qualifying intangible asset internally and shifting income between affiliates by means of royalty payments to minimize tax payments. The presumed tax sensitivity of patent location is consistent with recent empirical analyses that find a negative relationship between corporate taxation and the location of IP within MNE conglomerates (Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012; Griffith et al., 2014).[20,21]

[20]For instance, Dischinger and Riedel (2011) find that low-tax MNE affiliates host significantly higher levels of intangible assets compared to their high-tax counterparts. Karkinsky and Riedel (2012) provide evidence that patent applications are more likely filed by MNE's affiliates located in low-tax countries and Griffith et al. (2014) estimate a negative elasticity of patent location to corporate tax rates. Finally, Boehm et al. (2015), show that the share of foreign-invented patents is as high as 35 to 45 percent in low-tax countries, such as Switzerland and Ireland, but only around 5 percent in high-tax countries such as Germany.

[21]Exit taxation, i.e., the taxation of the sale of IP, is frequently mentioned as a potential barrier to avoid the relocation of IP and the profit shifting activity related therewith. In practice, this approach requires exact knowledge of the present value of each IP, which, arguably, might not even be known to the MNE. Instead, referring to the development costs of the respective IP likely results in substantial underestimation of the real value of the IP, giving further raise to a tax-motivated relocation of IP.

Conversely, affiliates of MNEs that operate on a similar scale in the same country and industry but without patented IP ownership, have *no easy access* to the patent box and are unable to access the tax benefit related to patent boxes at comparable cost. Consequently, affiliates that do not own IP, neither directly nor indirectly via their shareholders, form our control group. Naturally, this group of companies has the option of undergoing structural changes. They may purchase externally developed patents or may acquire the control of firms that do own patents. All of these options are expensive relative to the benefits offered by the patent box regime.[22] Also, innovation is a time-consuming process and firms starting to innovate face a transitional period of several years until they may reap the tax benefits of patent box legislation. On top of these arguments, we tackle the potential endogenous ownership of IPs for MNEs with no historical ownership in various ways. First, we keep the MNE's ownership structure constant, eliminating affiliates of MNEs with no historical IP ownership that undergo changes in firm structure, such as might be the case when purchasing affiliates with IP. Second, in a robustness analysis we also eliminate affiliates that do not historically own IP, but have filed for new IPs very close to our observational period.

For affiliates of domestic conglomerates we follow the same classification strategy. That is, we differentiate between affiliates that own IP, either directly or indirectly via the shareholders, and those affiliates, which do not own IP, neither directly nor indirectly. The fundamental difference between the two types of conglomerates is that the multinational conglomerate has an incentive to shift profits into the affiliate located in the country with the patent box regime, to exploit international tax rate differences. By definition, domestic conglomerates cannot take advantage of cross-country tax rate differentials for tax saving purposes.[23] Therefore, estimating the difference in the pre-tax profits of affiliates belonging to domestic conglomerates that own or do not own pre-existing IP, upon the introduction of a patent box, allows us to analyze the effects of patent boxes on pre-tax profits that are unrelated to profit shifting. However, comparing the response in pre-tax profits of MNE affiliates belonging to a conglomerate with historical IP ownership to the response of MNE affiliates with no connection to patented innovations leaves

[22] For instance, patents have been argued to constitute a barrier of entry due to the high set-up costs to generate patents and adapt firm structures that allow the IP to be used within the firm. See, for instance, Mueller and Tilton (1969), Klepper (1996), and Keller and Yeaple (2013).

[23] Domestic firms benefit from the lower tax rate on qualifying income, as MNEs do. The mechanical effect does not show up in pre-tax profits, our outcome of interest. Arguably, a patent box generates a domestic tax differential between the domestic regular statutory corporate tax rate and the reduced domestic corporate tax rate on IP income. Affiliates of domestic conglomerates could, in principle, take advantage of this domestic tax differential. However, and contrary to MNEs, domestic conglomerates have no incentive to relocate their patents within their group, and they are more likely to inflate royalty payments in favor of whatever group unit historically hosts the IP or patent. Because we only observe affiliates at a low level of the conglomerate, we will have a random mix of inflowing and outflowing domestic profit shifting, making this issue negligible on average. Furthermore, in the case of all-domestic conglomerates owning pre-existing IP, tax auditors have evidence of the non-strategically chosen IP-related transfer price (the *true* price) before the patent box was in place and might more readily detect tax-induced transfer pricing upon the implementation of the patent box.

us with a difference in pre-tax profits, which, according to the theoretical model, consists of two components: (i) a profit stream from royalty payments and (ii) a profit stream originating from the productivity gain associated with the patent box.

More specifically, as baseline estimation, we use the following triple-difference regression model:

$$\begin{aligned}\pi_{ist} &= \beta_0 + \beta_1 k_{it} + \beta_2 \ell_{it} + \beta_3 f_{it} + \beta_4 TAX_{it} \times MNE_i + \\ &\quad + \gamma_1 T_{it} \times DOM_i + \gamma_2 T_{it} \times MNE_i + \theta_\tau + \lambda_{st} + \eta_i + \epsilon_{ist}, \end{aligned} \tag{3}$$

where π_{ist} are the unconsolidated (logged) pre-tax profits reported for the European affiliate i, operating in sector s in year t. θ_τ is a set of treatment-year dummies. They account for the distance in time from the introduction of the patent box or the major adjustment to it, as measured by $\tau = t - t_{PB}$, with t_{PB} being the year in which the patent box has been introduced or amended in the affiliate's country of residence. We control for industry-year fixed effects, λ_{st}, and specify the composite error term as the sum of the affiliate unobserved fixed effects, η_i, and of the idiosyncratic error, ϵ_{ist}. To allow for correlation in the response of two affiliates controlled by the same shareholder, we cluster the standard errors at the majority shareholder level.

The baseline specification in (3) follows the literature on profit shifting and adopts the well-established approach first introduced by Hines and Rice (1994). As depicted by the terms in the first line of (3), the portion of profit generated through the production process is a function of capital and labor inputs, proxied by logged fixed assets (k_{it}), logged labor costs (ℓ_{it}) and financial leverage (f_{it}). The portion of profit shifted from other affiliates is, instead, dependent on the tax incentives faced by the MNE as a whole. $TAX_{it} \times MNE_i$ is a tax indicator that captures the tax incentives due to differences in the tax treatment between affiliate i and the rest of the MNE, given that the affiliate belongs to a multinational conglomerate. By augmenting (3) with the treatment interaction terms, our regression model extends the set-up generally adopted in the corporate tax literature to identify profit shifting behavior of MNEs. In detail, T_{it} is the treatment indicator variable that takes a value of 1 if affiliate i already owned IPs by the year 2000 and a patent box was introduced in or before the respective year.[24] Otherwise, the treatment variable is zero. The indicator variables DOM_i and MNE_i distinguish whether affiliate i belongs to an all-domestic or a multinational conglomerate. Thereby, the coefficient γ_1 measures the change in pre-tax profits of affiliates of domestic conglomerates, while γ_2 does the same for affiliates of MNEs. Since we control for inputs, the change for affiliates of domestic

[24]The year 2000 is chosen for the identification of historical patent ownership because it virtually precedes the time of any patent box in Europe. To check the robustness of our results, we experimented with moving the reference year to 1995 and 1997, respectively. The results are similar, except that the sample size is substantially reduced due to the limited number of observations for earlier patent ownership.

conglomerates reveals productivity gains due to the patent box.[25] The coefficient γ_2 mirrors the productivity change that we identify in the theoretical analysis in Section 3.

5 Data

The construction of our database follows four steps. First, we use corporate ownership data to identify the European affiliates of multinational and domestic conglomerates. We account for European affiliates located in Belgium, Spain, Luxembourg, France, the Netherlands, and Hungary.[26] Second, we collect data on the yearly balance sheets of affiliates around the year of the introduction of each patent box regime or latest adjustments to existing ones. Third, we use historical information to (i) identify affiliates with pre-existing IP ownership and (ii) account for affiliates' past performance. Fourth, we use corporate ownership data to track yearly changes in the incentives for profit shifting that are independent of the patent box legislation and apply to the conglomerate as a whole. Our main source is the ORBIS database (Bureau van Dijk), which provides historical information on firms' corporate ownership structures for the years 2007-2012, along with information on the affiliates' financial accounts and patent registration for the years 1996-2012. As we do not observe any ownership links beyond this time period, we only select active affiliates located in those European countries that have introduced a patent box or made major amendments to their patent box between 2007 and 2012 and whose majority shareholder is an active firm.

In a first step, we distinguish between affiliates of domestic and multinational conglomerates by accounting for the location of the affiliates' corporate shareholders. We use the historical ownership links in ORBIS, discarding links to individuals, mutual funds, employees, insurance companies, and corporations with unidentified location. If all shareholders are located and incorporated in the same country as the affiliate, we classify the conglomerate as domestic.

We define an affiliate's parent as the firm within the conglomerate that controls the largest share of the affiliate. For cases where the ownership of an affiliate is equally distributed among several shareholders, we take the global ultimate owner (GUO) as the parent firm.[27] We further exclude all firms in patent box countries that are independent standalone units, not linked to any other active firm, but rather fully controlled by individuals or funds. We follow the existing

[25] Our definition of treatment is based on the pre-determined (historical) ownership of patents within the affiliate conglomerate and on the country-level introduction of a patent box policy. This allows to assume away the endogeneity of our input measures (based on financial accounting data) with respect to the treatment itself and to plausibly relate the productivity estimate to the treatment in a causal way.

[26] As discussed in Section 2, these countries introduced a patent box or made major amendments to their patent box during our observational period 2007-2012. Table 1 provides an overview of the different patent box legislations. In an extension, we extend our data sample until 2015. This allows us to include the United Kingdom in the analysis, which introduced its patent box in 2013.

[27] We only use first level links and do not investigate whether domestic shareholders are themselves linked to any foreign corporation.

literature and limit our analysis to the sample of affiliates that report positive pre-tax profits for at least two consecutive years during our observational period 2007-2012. In addition, we condition on the affiliate to preserve the same ownership structure (domestic vs. multinational) over the entire observational period. The procedure leaves us with a sample of 90,662 affiliates, of which just short of 10 percent (8,249 affiliates) belong to multinational conglomerates.

In a second step, we collect unconsolidated financial accounts for the affiliates in our sample. The variables considered include pre-tax profits, EBIT, sales, financial leverage, capital measured by fixed assets, labor measured in terms of cost of employees, intangible asset, profit margin, liquidity ratio, industrial sector, number of patents and statutory tax rates on corporate income. Table 2 provides a description of all variables used in the estimation.

In a third step, we identify those affiliates that have a historical pattern of innovative activity and historical patent ownership, either directly within the affiliate or indirectly via the majority shareholder. For each affiliate, we collect data on the number of patents (IPs) owned and the respective year of patent registration. To overcome issues related to patent quality, patent double counting and skewness in the distribution of patents, we define an indicator variable which takes the value 1 if any patent is owned by the year 2000 and 0 otherwise. The year 2000 is chosen as a reference point for the identification of historical patent ownership because it virtually precedes any patent box regime in Europe.[28] Additionally, we interact the indicator variable with the respective firm level that controls the patent, which enables us to differentiate between the effects arising from direct patent ownership at the affiliate level versus indirect ownership at the upper tier (majority shareholder).

As it stands, our treatment group, namely affiliates that owned patents by the year 2000, either directly or indirectly via their majority shareholder, is composed of affiliates with low costs of accessing the tax benefits associated with a patent box (during the analyzed period 2007-2012). Conversely, the control group is composed of European affiliates that did not own any patent, directly or indirectly, by the year 2000. Firms belonging to the control group thus face comparably higher costs of accessing the tax benefit of the patent box, needing to incur substantial costs for the development or acquisition of eligible patents first.

In our baseline sample, we find that 24.65 percent of the MNE affiliates and 15.35 percent of the domestic affiliates qualify as treated, c.f. Table 3. Consistent with the literature on the tax-sensitive choice of IP location (Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012; Griffith, 2014), we observe that the introduction of a patent box coincides with an increase in direct and indirect patent ownership for affiliates of multinational conglomerates, but not

[28]Even though the French and Irish tax code had allowed for a reduced tax treatment of revenue from IP licensing or the disposal of IP since the mid 1970s, and the Hungarian from 2003 onward, the first patent box was introduced by the Netherlands in 2007. Only 2007 did the use of patent box systems as a means of profit shifting become popular among MNEs (Evers, 2015).

systematically so for affiliates of domestic conglomerates, c.f. Table 4. Further, on average, only between 0.7 and 3 percent of the multinational affiliates owned IPs directly within their establishment in the year 2000, while more than 30 percent (20 percent) of the multinational (domestic) group affiliates were owned by shareholders owning patents before the year 2000. The concentration of IP ownership at the level of the majority shareholders is substantial. Neglecting this link between indirect IP ownership and affiliates located in countries that provide a preferential tax treatment for IP income would generate biased estimates for the profit shifting of MNEs, given the high degree of transferability of IP within firm conglomerates. To the best of our knowledge, this paper is the first paper to explicitly account for this link.

In Step Four, we construct affiliate-time-specific tax measures that capture the incentives for profit shifting faced by the affiliates' foreign majority shareholder. For the design of the variable TAX_{it} in (3), we follow the established literature on profit shifting (Huizinga and Laeven, 2008). For each MNE affiliate, we utilize the ownership structure provided in ORBIS and reconstruct the list of subsidiaries owned by an affiliate's foreign majority shareholder in each year between 2007 and 2012. In detail, for each affiliate i that is part of MNE c, we identify the parent firm located in country p and its N other affiliates located in countries $j = 1, ..., J$, $\forall j \neq i$. We compute the difference in the regular statutory corporate tax rate levied in the country of affiliate i and the country of the parent p, i.e. $\tau_i - \tau_p$. Additionally, we construct a second tax measure consisting of the difference in the statutory corporate tax rate levied in the country of affiliate i and the country of the affiliate facing the lowest statutory corporate tax rate within the whole MNE, i.e. $\tau_i - \tau_{min}$, with $\tau_{min} = min\{\tau_j\}_{j=1}^{J}$. Table 5 reports the various tax measures faced by MNE affiliates in the treatment and the control groups, averaged over the time period 2007-2012.

6 Matching

In our identification strategy, the definition of treatment and control group is based on information on IP ownership prior to European patent box regimes (pre-2000). The assignment of an affiliate into the treatment group is affected by a firm's structural characteristics and therefore endogenous to a series of factors, which may imply self-selection of firms into the treatment group. Not accounting for the absence of random treatment assignment would bias our estimates. To achieve a balance between the treatment and control group, we resort to a procedure called *coarsened exact matching* (CEM).

In our application, exact matching is problematic as we intend to account for multiple characteristics of the observed affiliates, something that would result in only very few matches. On the other hand, propensity score matching (PSM) is impractical, as we intend to match

affiliates within countries and industrial sectors. By these means, CEM constitutes a valuable alternative, as it supports monotonic imbalance bounding (MIB).[29] This method bounds the maximum imbalance in some features of the empirical distributions, in our case by coarsening the ex-ante chosen characteristics. The main advantage of this approach is that increasing the balance on one variable cannot increase the imbalance on others (which might happen when using PSM).

The matching is conditioned on structural affiliate characteristics that are found to be important in the innovation literature.[30] To reduce the imbalance in the pre-treatment variables, we coarsened on firm-specific characteristics that proxy for affiliates' type of business, performance, and R&D intensity. We match affiliates on their ownership structure, country of establishment, and sector of activity (in 2 digit NACE code) and coarsen them according to their age in the year 2000 and their financial performance. We collect affiliate-specific averages over the 1996-2006 decade for performance indicators such as size, profit margin, and intangible-to-total-asset ratio.[31] The volume of sales is used as a proxy for size and the ratio of pre-tax profits to sales as a proxy of operating profit margin. Finally, we collect information on the number of patents owned by minority shareholders, as registered before the year 2000.

Before the matching, global imbalance is measured through the $\mathcal{L}$ statistic, introduced by Iacus et al. (2012). It is based on the difference between the multidimensional histogram of the chosen pre-treatment characteristics. $\mathcal{L} = 1$ indicates complete imbalance and $\mathcal{L} = 0$ perfect balance. The value computed for the full sample is used as a reference point for the value obtained after the matching is completed. Table 6 reports the results from the CEM based on the above described pre-treatment variables. The first and fourth columns report $\mathcal{L}$, as computed for each single variable, before and after the matching. The second and fifth columns report the difference in means between treated and control group, before and after the matching. Our one-to-one matching solution resulted in a reduction of the overall $\mathcal{L}$ statistic from 0.9856 to 0.6350. Comparing Columns [3] and [6] in Table 6, it is evident that the matched sample achieves an increased balance in all pre-treatment covariates. As indicated in the results in Column [6], no statistically significant difference in the means of the treated and matched control group exist after matching. From the full sample of 14,686 treated and 75,976 control

[29] See Blackwell et al. (2009) and Iacus et al. (2012).

[30] Early work in the innovation literature such as Pakes and Griliches (1980), Bound et al. (1982), and Acs and Audretsch (1988) show that innovators are influenced by their patent system, as well as their industry structure. More recently, firms involved in innovative activity and patenting are generally found to be large, highly productive, intensive in research and development, involved in international trade, and unaffected by major financial frictions (Peeters and van Pottelsberghe, 2006; Hall and Lerner, 2010; Atkeson and Burstein, 2010; and Gorodnichenko and Schnitzer, 2013, for instance). A related literature finds a positive correlation between innovation and productivity. See, for instance, Griliches (1998), Klette and Kortum (2004), Hall et al. (2010), and Mohnen and Hall (2013).

[31] Taking the ten-year average ensures independence from the business cycle.

affiliates, this method allows us to select 14,266 one-to-one matches (see Table 7).

Figure 1 compares the evolution of yearly pre-tax profits and earnings before interest and taxes (EBIT) over the period 2007-2012, normalized around the year of introduction of the respective patent box regimes or major adjustments to existing ones. For the sample of multinational and domestic affiliates, we find that treated affiliates are large and do not share a common trend with the control affiliates. Figure 2 replicates the same plots for the CEM-matched sample. The matching procedure eliminates the largest affiliates of multinational conglomerates from the sample. We find that matched affiliates report on average lower pre-tax profits and EBIT. It also becomes evident that affiliates in the two matched groups (domestic and multinational) follow a similar trend until patent box regimes become effective. After treatment, pre-tax profits and EBIT of MNE affiliates gradually increase compared to the affiliates in the control group. Similarly, for domestic affiliates, no difference between treated and control affiliates emerges before treatment. After treatment, treated and control affiliates diverge slightly in pre-tax profits, but less so in EBIT.

To show that our results are not qualitatively affected by the choice of matching method, we also construct a matched sample using PSM, based on the same covariates that we use for CEM. In Section 8 (Table 15), we present the estimates based on the alternative matched sample.

7 Results

7.1 Baseline Estimates

Table 8 presents the results of the linear panel model that estimates the relationship between pre-tax profits, fixed assets, cost of employees, and financial leverage, all measured at the unconsolidated level. The model is estimated using the full unmatched sample in Column [1] and the matched sample in Column [2]. The results presented in Columns [3] to [6] are estimated on a sub-sample of MNE affiliates and the model is additionally augmented with affiliate-specific tax variables, which account for tax incentives to engage in profit shifting and are unrelated to patent boxes. In addition to affiliate-level fixed effects, all specifications in [1] to [6] include treatment-year dummies and industry-year dummies.[32]

The results in Columns [1] and [2] of Table 8 show that, despite the substantial difference in sample size, the relationship between pre-tax profits and the inputs of production is generally

[32]We additionally estimate a version of the model that includes majority-shareholder-country-year-fixed effects and affiliate-country-year-fixed effects. The results of these richer specifications are generally the same as those presented here. The latter set of fixed effects is not considered in the main analysis for two reasons. First, the restriction of only using affiliates whose ownership structure has not changed over time (between domestic and multinational status), limits the within-affiliate time-variability of the shareholder country-year pairs. Second, the inclusion of country-year-fixed effects drains the effects of the tax variables included in the analysis. The tax measures are crucial in identifying the effects of the confounding tax incentives - see Table 11).

unaffected by the sample composition. In the specification underlying Column [3], the affiliate-specific, time-variant tax measure that accounts for the conglomerates' incentives to shift profits is expressed by the tax rate differential between the affiliate in country i and the headquarter in the parent country p. In Specification [4], the applied tax measure refers to the tax rate differential between the affiliate in country i and the affiliate facing the lowest tax rate within the conglomerate. In the last two specifications, the tax measure takes the form of an indicator variable which equals 1 if the affiliate in country i faces a lower tax rate than the headquarter in the parent country, Column [5], or if the affiliate faces the lowest tax rate within the entire conglomerate, Column [6]. The tax measures are independent of the introduction of any patent box.

In line with the existing literature, the results show higher pre-tax profits for those affiliates facing a local tax rate lower than their parents. Specifically, we find semi-elasticities of around 0.004 in Specifications [3] and [4]. That is, a reduction of 10 percentage points in the tax rate differential between the country of the affiliate and the country of the parent increases the pre-tax profits of the affiliate by 4 percent. Additionally, we find that affiliates with a lower tax rate than their parents report on average 6.3 percent higher pre-tax profits than affiliates with higher tax rates than their parents. Similarly, affiliates facing the lowest tax rate within the entire conglomerate report on average 5.8 percent higher pre-tax profits than all other subsidiaries. The results of Specifications [5] and [6] are comparable in size with the results found in the literature using affiliate-level panel data.[33]

7.2 Heterogeneous Treatment Effect

The results from estimating the difference in difference (DD) model stated in equation (3) are presented in Table 9. The treatment definition, on which the matching is based (see section 6), identifies those affiliates with a low cost of accessing the preferential tax treatment of IP income granted by a patent box regime. These are affiliates that owned patents either directly or indirectly through the majority shareholder by the year 2000. The estimation results are reported for the simple case of a homogeneous treatment effect in Column [1], a specification where the treatment effect differs between affiliates of domestic and multinational conglomerates in Column [2], and a specification that includes the control variables already used in the profit shifting equation underlying the results in Table 8 in Column [3]. The results reported in Column [4] and [5] are the re-estimation of the specification used in [3], based on the full unmatched sample, and using earnings before interest and taxes (EBIT) as the dependent

[33] See Dharmapala (2014) for a discussion of the existing evidence on the size of tax semi-elasticities.

variable, respectively. In line with our hypothesis, we find that affiliates located in a patent box country and with a historical record of patent ownership report 4.7 percent higher pre-tax profits compared to affiliates that are similar, except that they did not own any patent by the year 2000. This result is significant at the 1-percent level.

Affiliates of domestic and international conglomerates might respond differently to the availability of patent box regimes. While a patent box might increase productivity due to innovations or more intensive utilization of the income potential of patents in both types of affiliates, only the multinational affiliate is able to use cross-country tax differentials to save on taxes via profit shifting. Hence, affiliates of multinational conglomerates might experience a higher change in their pre-tax profits, which is the sum of both a profit shifting response and a productivity effect. To identify the heterogeneous treatment effect, we expand the specification in Column [1] to allow for the effect of the patent box to vary across affiliates of domestic and multinational conglomerates. The results presented in Column [2] confirm our hypothesis. Pre-tax profits of affiliates located in a country with a patent box and belonging to a domestic conglomerate with historical IP ownership are 3.5 percent higher than the one of affiliates belonging to the control group, i.e., domestic conglomerates with no historical IP ownership. For affiliates of multinational conglomerates, the post-treatment difference between treated and control affiliates amounts to 13 percent and is thus 9 percentage points higher compared to domestic conglomerates. With an F-test of 13.77, we reject the hypothesis of no difference in the treatment effect of domestic and multinational affiliates at the 1-percent significance level. As shown in Column [3], introducing the control variables into the profit shifting equation reduces the absolute magnitude of the two treatment effects. The difference in the treatment effect between affiliates of domestic and multinational conglomerates is reduced to 5 percentage points. The results also hold when the estimation is conducted on the full unmatched sample, c.f. Column [4] in Table 9.

For the results presented in Column [5], the dependent variable pre-tax profits is replaced by logged EBIT. The treatment effect turns out to be larger in this specification. The difference in the change of EBIT for affiliates of multinational conglomerates located in a country with a patent box is 7.4 percentage points higher than the difference in the change of EBIT for affiliates of domestic conglomerates, while the point estimate for domestic conglomerates stays nearly at the same level as in Column [4]. The result confirms the hypothesis that multinational affiliates engage in profit shifting, a strategy that is not available to domestic affiliates. In fact, the difference in the coefficients offers a more nuanced perspective on the profit shifting behavior of MNEs compared to what the existing literature suggests.[34] The higher magnitude of the

[34]In existing literature, profit shifting via transfer pricing and internal debt shifting is considered unidirectional and MNEs might opt for one or the other (or possibly both) type of profit shifting into an affiliate in a low-tax

treatment effect on EBIT for affiliates of multinational conglomerates points to profit shifting behavior out of the country that offers a patent box. Given that MNEs shift income into the patent box for tax reasons, the location of income might not coincide with the optimal location based on non-tax reasons. MNEs can redirect shifted profits out of the affiliate in the country with a patent box via internal loans, for instance. Interest payments on internal loans, which are negatively accounted for in the pre-tax profit measure, reduce the magnitude of the estimate for pre-tax profits but not of the one for EBIT. The complementarity between inward profit shifting into the patent box and outward profit shifting out of the country via internal debt is in line with the observed level of corporate tax rates in patent box countries, c.f. Table 1. On average, the tax rate in these countries is relatively high as compared to the regular tax rate in *typical* low-tax countries where the financial center of MNEs frequently reside. This incentivizes MNEs to engage in internal debt shifting (Mintz and Smart, 2004). Thus, in addition to the tax savings offered by the patent box, MNEs can reap a tax subsidy when shifting profit out of an affiliate in a patent box country to an affiliate in a low-tax country via internal loans.[35] We relegate a detailed decomposition of the pre-tax profit response of MNE affiliates and an analysis of the tax revenue implications of the bi-directional shifting behavior of MNEs to Section 9.

Finally, a generalized Difference in Difference (DD) model is used to trace the dynamics of the treatment effect. The patent box impacts the affiliate productivity and, provided the affiliate belongs to an MNE, its profit shifting incentives. However, we expect the timing of the two effects not to be perfectly aligned. Specifically, any IP-related enhancement in productivity will arguably only appear later in time, while profit shifting incentives are expected to materialize soon after the patent box regime is effective. The results of the generalized DD model reported in Table 10 confirm this conjecture.

The estimates of Specification [1], which mirrors Specification [3] in Table 9, indicate that the pre-tax profits of treated affiliates belonging to multinational conglomerates with IP ownership immediately jump by 7 percent in the year of the treatment. The effect remains constant in the first year and then increases further in the second and all later years. In contrast, pre-tax profits

country (Haufler and Schjelderup, 2000; Mintz and Smart, 2004; Buettner et al. 2012). This reflects the fact that, in general, only a single statutory tax rates applies to all corporate income. This is not the case under patent boxes. Countries with a patent box are low-tax countries for IP income, but high-tax countries otherwise.

[35]The finding is in line with anecdotal evidence on how IKEA uses the tax benefits offered by the Dutch patent box (Financial Times, 2017). The IKEA affiliate in the Netherlands has internally acquired IPs to access the patent box benefits. The internal transaction has been financed by internal debt with relatively high interest payments to the affiliate in Liechtenstein, where interest income is taxed at a low rate. In general, such MNE behavior allows for double tax saving. For illustration, consider the MNE ultimately wants to shift EUR 1 from the affiliate in country A, which levies a corporate tax at rate τ, to country T(ax haven) with a rate of tax $t < \tau$. The tax saving is $\tau - t > 0$. Now, consider country P opens up a patent box. For simplicity, the regular corporate tax rate in country P is τ and the patent box tax rate is t. Shifting EUR 1 as royalty payment for the use of IP rights from A to P and then via internal loan payments from P to T, the tax saving is twice as high as the initial tax saving, i.e. $2(\tau - t) > 0$. The pattern is reminiscent of double-dip financing schemes that exist in different contexts.

of affiliates belonging to domestic conglomerates with IP ownership do not show any significant effect on pre-tax profits within the first two years after the treatment. Only after year three does a significant effect equal to 5 percent appear, similar in magnitude to the estimates found in the baseline specification. The timing of the effects is largely in line with the conjecture that the estimates for the group of domestic affiliates capture a productivity effect. Model [2] replicates Model [1], but additionally controls for pre-treatment effects. This is important as IP-box regimes are generally announced well in advance. We find no evidence of significant pre-treatment, while the different time patterns of the profit shifting and productivity effects found in Specification [1] are confirmed.

7.3 Patent Box Regimes and Confounding Tax Incentives

Our baseline analysis shows that a patent box generates a significant profit shifting incentive for affiliates of multinational conglomerates. In the following, we analyze whether the effects of a patent box regime depend on other dimensions of the tax environment MNE affiliates are facing. In a scenario where countries compete over corporate tax rates to attract foreign capital, a patent box could be seen as a valuable instrument in attracting firms through a preferential tax treatment of their IP income. It is the case that an MNE that uses a particular profit shifting channel, like income shifting into low-tax countries or tax havens, might reconsider its tax savings strategy once a patent box has become available in one of the countries the conglomerate is present. Whenever the use of low-tax countries such as tax havens is still superior in terms of lower concealment costs and/or higher tax savings, we expect no significant changes in the reported pre-tax profits (or EBIT) of affiliates, which already have a link to a tax haven or already benefit from a preferential tax treatment due to their location in a (relatively) low-tax country.

Table 11 augments the baseline DD specification (Column [3] in Table 9) with interaction variables that proxy for confounding tax incentives. Column [1] of Table 11 allows the effect on the treated multinational affiliates to vary according to whether the affiliate is located in a country with a lower tax rate than the country of its majority shareholders (parent country). Column [2] allows the effect on the treated multinational affiliates to vary according to whether the affiliate is located in a country with the minimum tax rate faced at the conglomerate level. Lastly, column [3] allows the effect on the treated multinational affiliates to vary, according to whether the affiliate is linked to a shareholder located in a tax haven.[36] Columns [4] to [6] repeat the exercise after substituting EBIT for pre-tax profit as the dependent variable.

The results show that confounding tax incentives are important in identifying the effect of

[36] As a matter of choice, we use the tax haven classification in Hines and Rice (1994).

the patent box legislation on profit shifting of MNEs. Specifically, the results are invariant for treated affiliates of domestic conglomerates. Instead, in case of affiliates of multinational conglomerates, the estimates show substantially larger pre-tax profits for affiliates located in high-tax countries vis-a-vis affiliates located in low-tax countries. Affiliates of multinational conglomerates located in a country with a patent box and which face a larger tax rate than their parent company report 13 percent higher pre-tax profits than the matched control affiliates. Affiliates of multinational conglomerates facing a tax rate higher than the minimum tax rate within the whole conglomerate report 12 percent higher pre-tax profits than the matched control affiliates. The effects are smaller for MNE affiliates that already benefit from a comparative tax advantage within the conglomerate, but they are still significant. Regarding the impact of tax havens, we find that the introduction of a patent box yields an effect of 11 percent higher pre-tax profits for affiliates of MNEs that are not linked to a tax haven within the conglomerate. Conversely, the effect is negative but insignificant for affiliates belonging to a multinational conglomerate that is additionally linked to a tax haven.

In a next step, we estimate the above specification on EBIT instead of pre-tax profits. EBIT disregards interest payments. As argued above, provided that multinational affiliates engage in higher outward profit shifting through internal loans in response to patent boxes, we expect the treatment coefficient for affiliates of multinational conglomerates in the EBIT specifications to be larger than in the specifications that use pre-tax profits as the outcome variable. The results presented in Columns [4] to [6] of Table 11 are consistent with this reasoning.

The estimates on the effects of tax havens mask some degree of heterogeneity. Table 12 presents the results from specifications where the treatment effect on affiliates belonging to multinational groups is allowed to vary according to the type of link they have to a tax haven country. Specifically, we differentiate between multinational conglomerates that have shareholders located in tax havens and those that have one or more subsidiaries located in tax havens. This distinction is relevant if we assume that shareholders ultimately intend to repatriate profits back to the headquarter, as in Dischinger et al. (2014). Similarly, a majority shareholder might not want to share the net tax savings by using the patent box instead of the tax haven in which it already resides, which discourages the shareholder from using the new tax savings option (Schindler and Schjelerup, 2012). Therefore, it could be argued that the profit shifting behavior of a multinational group whose headquarter is already located in a tax haven would not be affected by the patent box. Instead, the shifting behavior of a multinational group that relies on a tax haven affiliate to transfer profits might very well be affected by a patent box and the opportunity of repatriating profits toward the high-tax country by means of IP royalties. This seems particularly profitable for an MNE, provided it saves on concealment costs by shifting

profits into an affiliate in a European country with a patent box in place, such as France and Spain, instead of a tax haven affiliate.[37] Our results show that treated affiliates connected to multinational conglomerates and linked to shareholders in a tax haven report no effect on their pre-tax profits due to a patent box (Column [1] in Table 12). Instead, as shown in Column [2], treated affiliates of multinational conglomerates that have at least one or several tax haven subsidiaries report 9 percent higher profits compared to affiliates in the control group, essentially behaving in the same way as treated affiliates with no link to tax havens. Column [3] presents results based on a specification where the link to a tax haven exists because either an affiliate, the majority shareholder or both reside in a tax haven. Results also hold and are very similar for the specifications where EBIT is the dependent variable (Column [4] to [6]). Intuitively, since affiliates with a majority shareholder in a tax haven are not used for tax savings via patent boxes, the demand for outward profit shifting via internal loans does not exist, which renders the EBIT response statistically insignificant. Our results for treated affiliates belonging to domestic groups and for treated affiliates of multinational groups with no link to tax havens remain consistent and of comparable size to the previous findings in Table 11.

7.4 (In)Direct Patent Ownership and Restrictions for Qualifying IP Income

In this section, we further look into the heterogeneity of the baseline results by allowing the results to differ first for directly and indirectly owned patents and second across the various characteristics of patent box legislation. The first dimension of heterogeneity might matter in cases where MNEs use patent boxes for tax savings through transfer pricing. In this case, MNEs might relocate patents to affiliates in a country with a patent box. Thus, the effect of indirectly owned patents on pre-tax profits should be captured in the data. Furthermore, patent box regimes impose different restrictions on when patent income qualifies for the preferential tax treatment. As shown in Table 1, the patent box legislation differs as to whether acquired patents or patents that already exist prior to the introduction of the patent box can benefit from the reduced tax rate. This allows us to shed some light on the effectiveness of these restrictions, which are presumably intended to protect the domestic corporate tax base and/or to create incentives to generate new patents rather than acquiring existing ones.

In Table 13, we depart from the simple DD specification with heterogeneous effects among domestic and multinational affiliates and allow the treatment effect for multinational affiliates to vary according to whether the treated affiliate (i) had been directly involved in the registration of patents (Column [1]), (ii) is located in a country where acquired patents qualify for the

[37] Fiscal authorities might well use any shifting of profits into a tax haven affiliate as a signal of tax avoidance or tax evasion which increases concealment cost. This might apply to a lesser extent to MNEs that shift profits into an affiliate in a European country instead of the Cayman Islands, for instance.

preferential tax treatment granted by the patent box (Column [2]), and (iii) is located in a country where pre-existing patents also qualify for the tax benefit provided by the patent box (Column [3]). We find that the multinational treated affiliates that directly owned patents by the year 2000 report a negative, though insignificant, effect of a patent box, compared to control affiliates (Column [1]). On the contrary, multinational affiliates located in a country with a patent box and that were selected into the treatment group because of indirect historical patent ownership via their majority shareholder report 10 percent higher profits than the affiliates in the control group. Thus, indirect patent ownership appears to be important in proxying the ability of MNE affiliates to use patent boxes and in explaining the empirical findings.

As to the effectiveness of patent box restrictions, we find no significant effect for treated affiliates in countries where the IP income of acquired patents is not eligible for the preferential tax treatment (Column [2]), and a much smaller significant effect for the affiliates in countries where IP income from pre-existing patents does not qualify for the reduced tax rate granted by the patent box system (Column [3]). This suggests that restrictions on qualifying IP income have been effective in reducing the tax-sensitivity of profits of affiliates that belong to multinational conglomerates.

8 Robustness Analysis

In this section, we present various robustness analyses of the baseline results.

8.1 New Patent Ownership and Trademarks

First, we modify the sample composition first by excluding all affiliates that changed their patent ownership between 2000 and 2007 and second by accounting for trademarks in addition to patents.[38] The former exercise addresses concerns that affiliates assigned to the control group, due to the absence of historical patent ownership, acquire patents after 2000 and can thus still respond to the patent box regime. The second exercise addresses concerns related to the fact that some patent box legislation also allows income from trademarks to qualify for the preferential tax treatment, c.f. Table 1. Not accounting for trademark ownership might therefore result in some affiliates of the control group also responding to the patent box. Column [1] in Table 14 restates the baseline results. As shown in Column [2] in Table 14, excluding affiliates that acquired patents between 2000 and 2007 (Column [5]) does not affect the results, indicating that our estimates of the profit shifting effects are not due to the acquisition of patents after the year 2000 but before the introduction of the first patent box. In Column [3], any affiliate that owns trademarks prior to the year 2000 is excluded, while in Column [4]

[38] Although feasible, we refrain from extending the period beyond 2007 since in this case patent ownership is most likely an outcome variable rather than an explanatory variable.

affiliates that acquired trademarks between the year 2000 and the year of the first introduction of the patent box regime are additionally excluded from the sample. Again, the findings are robust to these modifications.

8.2 Propensity Score Matching

We further test the external validity of our results by using a different matching procedure. In Table 15, we restate the estimates of our baseline model (Column [1]) and then compare them to results from the same model estimated on two samples built on a propensity score (PS) matching (Columns [2] and [3]), and to results from the unmatched sample (Column [4]). For the PS matched sample, we choose a similar set up to the one applied with CEM. We estimate the propensity score of multinational and domestic affiliates separately and then include affiliate-country and industry-fixed effects. After estimating the propensity score, we proceed with a *within*-type (multinational and domestic) one-to-one matching of affiliates. To ensure common support, we discard the 5 percent of the treatment observations where the propensity score density of the control observations is the lowest, see Column [2], while we discard only 1 percent in Column [3]. For the full unmatched sample in Column [4], instead, we impose no restrictions for the specification. The overall results are consistent; however, the PS-matched samples are, compared to the CEM-matched sample, very different in composition. The common support restriction leaves us with a smaller total number of affiliates and a lower representation of the domestic conglomerates. Yet, our results confirm the previous findings. Affiliates connected to multinational conglomerates report a larger pre-tax profit response relative to affiliates of domestic conglomerates. Treated affiliates of multinational groups located in countries with a patent box report 10 percent higher pre-tax profits compared to their non-treated counterparts. Treated affiliates of domestic groups located in countries with a patent box report instead 3.8 percent higher pre-tax profits. The results are largely comparable in size with the CEM-matched sample (Column [1]) and the full sample (Column [4]).

8.3 Indirect Patent Ownership via Minority Shareholders

We proceed with testing our results on an alternative treatment definition. In our baseline model, we define an affiliate as treated if the affiliate historically owns patents, either directly at the affiliate level or indirectly at the level of the majority shareholder. In Table 16, we expand this definition and also include those affiliates as treated whose minority shareholders owned patents by the year 2000. We refer to this specification as 2nd tier IP ownership. The newly matched sample is larger than the baseline sample, summing up to a total of 29,422 affiliates, of which 1,669 are treated multinationals and 13,042 are treated domestic affilaites. The Results are qualitatively similar, however, we do find that the size of the effect is smaller than in the

baseline sample. For pre-tax profits, we find no significant effect for affiliates connected to either domestic or multinational conglomerates, c.f. Column [1] in Table 16. When replacing pre-tax profits with EBIT, see Column [2], we find a statistically significant point estimate of 7.7 percent. The slightly smaller estimates in this extended sample with 2nd tier IP ownership suggest that minority shareholders have not primarily relocated the IP to an affiliate in a country with a patent box. As such, majority shareholders appear to be the most relevant group to proxy the ability to use patent boxes and to measure the associated tax effects. This reasoning is in line with the diluted incentives of minority shareholders in shifting IP to an affiliate in which their ownership stake, and thereby their participation in profit changes, is only minor (Schindler and Schjelderup, 2012).

8.4 Sample Period 2007 to 2015

Finally, we estimate our DD model on yet another alternative sample, which spans a longer time frame than our baseline analysis. We collect data covering the period 2007 to 2015, and include affiliates that are geographically located in Belgium, France, Spain, the United Kingdom, and the Netherlands. This sample allows us to estimate the effects of the patent box in the United Kingdom, which was introduced in 2013. Furthermore, the longer sample allows us to analyze the effects of patent boxes in the baseline sample that materialize after 2012. However, there are also two shortcomings associated with this longer sample. First, we cover a period that is between two different phases of the economic cycle, and we presumably cannot fully control for confounding macroeconomic factors. Second, we lose a substantial amount of observations by matching on historical data, as the online ORBIS database does not allow us to track down as many affiliates in the historical balance sheet data as we were able to do with the version used in the baseline sample. From an initial 196,677 affiliates we are able to keep only 12,638 after the CEM matching. Tables 17 and 18 report the results for this alternative sample. For the simple DD model in Table 17, we again find estimates consistent with our previous results. The size of the profit shifting activity accounts for just below 4 percentage point of the change in pre-tax profits of treated affiliates belonging to multinational groups (Column [2]), and for just below 5 percentage points of the change in their EBIT. For the generalized DD model in Table 18, we again find confirmation of the different treatment dynamics observed in Table 10. Model [1] shows that the pre-tax profits of treated affiliates of multinational groups respond significantly to patent boxes from the second year onward. However, the pre-tax profits of treated affiliates of domestic groups start to increase only from the fifth year onward. When accounting for pre-treatment effects in Column [2], we find no effects for affiliates of multinational conglomerates and only a slightly significant effect for affiliates belonging to domestic groups.

9 Discussion

The empirical findings allow us to shed more light on the various behavioral responses of MNEs and their tax revenue implications.

Decomposing MNE Responses To decompose the pre-tax profit changes into its various components, we return to the theoretical model from Section 3 and expand it to account for the difference between pre-tax profits and EBIT. For notational simplicity, we omit the country index here. Pre-tax profit, π, and EBIT of an affiliate located in a country with a patent box is given by $\pi = y + q - 1 - z$ and $EBIT = y + q - 1$, where z denotes interest expenses. Following the introduction of a patent box or a decline in the reduced tax rate on IP income, the change in pre-tax profits is

$$\Delta\pi = \Delta EBIT - \Delta z, \tag{4}$$

where

$$\Delta EBIT = \Delta y + \Delta q. \tag{5}$$

The first equation decomposes the change in pre-tax profit into a change in EBIT and a change in interest expenses. The second equation separates the change in EBIT into a change in productivity (output), y, and profit shifting, q, into the patent box. Given our estimates of the relative change in pre-tax profit and EBIT, we can back out the change in interest expenses Δz from the first equation after some synchronization of the unit of measurement (pre-tax profits and EBIT refer to different bases and therefore changes in these two measures cannot be directly compared).

In the empirical analysis, we estimate the relative changes in EBIT and pre-tax profits, which allows us to express the change in the two outcome variables, $\Delta\pi$ and $\Delta EBIT$, as a fraction of their respective pre-treatment values. To align the units of measurement for the two changes, we express the change in EBIT as a fraction of pre-tax profit, i.e. $\Delta EBIT/\pi = \Delta EBIT/EBIT \cdot EBIT/\pi$. In our baseline specification in Table 9, $\Delta EBIT = 0.11 EBIT$. To assess the ratio $EBIT/\pi$, we compute the average value of $EBIT/\pi$ of treated MNE affiliates in the pre-treatment years, i.e. in the years of our baseline sample period prior to the introduction of (or amendment to) the patent box, which is $EBIT/\pi = 1.7$. Using the information, we obtain $\Delta EBIT = 0.187\pi$. Coupled with the estimated pre-tax profit change in the baseline specification of $\Delta\pi = 0.085\pi$, the change in interest expenses is $\Delta z = 0.102\pi$. This suggests that the total change in earnings before subtracting interest payments is 18.7 percent of pre-tax profit. Interest expense adjustments due to internal debt shifting reduce the observed relative change in pre-tax profits to 8.5 percent.

Some of the observed change in EBIT might be due to profit shifting into the patent box, Δq, and the productivity effect, Δy. The estimated change in the pre-tax profits of domestic affiliates provides a measure of the productivity effect these affiliates face due to patent boxes. Provided the estimate is also representative for MNE affiliates, the decomposition in (5) allows us to back out the amount of profit shifting into the patent box.[39] Again, using the baseline estimate of $\Delta EBIT = 0.187\pi$ and a productivity effect of $\Delta y = 0.035\pi$, the level of profit shifting into the patent box is $\Delta q = 0.152\pi$. Thus, the total amount of profit shifting into the patent box is 15.2 percent of pre-tax profits, while, stated above, 10.2 percent of pre-tax profits are shifted out of the country via internal debt shifting. This leaves a net effect of profit shifting on pre-tax profits, as measured by $\Delta q - \Delta z$, of 5 percent of pre-tax profits.

We should emphasize that the magnitude of profit shifting into the patent box of 15.2 percent relates to the treatment effect, i.e. the implementation of or a major amendment to a patent box. It cannot be directly compared to estimates in the literature, which express the relative change per percentage point change in the tax rate. The difference between the regular corporate tax rate and reduced tax rate of the patent box is significant, c.f. Table 1. Weighting the tax differential by the number of treated MNE affiliates, the (weighted) average of the tax rate reduction amounts to 20 percentage points. Thus, the pseudo semi-elasticity of the profit shifting response into the patent box associated with a percentage point decrease in the tax rate for IP income is 0.76 (= 0.152/0.2), which is in line with recent estimates of profit shifting. The consensus estimate is 0.8 (Dharmapala, 2014; Heckemeyer and Overesch, 2017).

Tax Revenue Implications To assess the effect of the MNE response on domestic corporate tax revenues, we denote initial tax revenues that are collected from MNEs as $T = \tau\pi$, where τ is the regular statutory corporate tax rate and pre-tax profits π correspond to the tax base. Defining $\Delta\tau = \tau_p - \tau$ as the difference between the preferential tax rate of the patent box and the regular statutory corporate tax rate and π_p (π_{-p}) as the profit stream that is (is not) eligible for the patent box, the change in tax revenues following the introduction of the patent box is

$$\Delta T = \Delta\tau \cdot \pi_p + \underbrace{\tau_p \cdot \Delta\pi_p + \tau \cdot \Delta\pi_{-p}}_{=\Delta T_{beh}}. \tag{6}$$

[39] Domestic affiliates might serve as a unit of comparison when evaluating the behavior of MNE affiliates (Habu, 2017; Dharmapala and Hebous, 2018). In our analysis, we do not require the level of productivity or profits to be aligned. In line with theoretical predictions, these are different in our sample, c.f. Figure 1. The sufficient assumption for our context is that the responsiveness of the productivity of affiliates to tax incentives is comparable across domestic and international conglomerates at the level of the affiliate. This view is in line with the advantage of conglomerates to use inputs such as IP commonly across affiliates. The argument is not intrinsically related to the degree of internationalization. When MNE affiliates have a comparative advantage in responding to tax incentives, the computed estimate is still informative as it provides an upper bound on the extent of profit shifting into the patent box country.

The first term is the mechanical effect of the patent box on tax revenues, while the remaining terms summarize the behavioral effect on tax revenues due to adjustments in the tax base that qualifies for the preferential tax treatment of the patent box, $\Delta\pi_p$, and which does not qualify, $\Delta\pi_{-p}$. The mechanical effect is negative in sign, which leaves it to the behavioral response of the MNE to expand the tax base or at least limit the revenue shortfall. From (6), the behavioral response can be rewritten as

$$\Delta T_{beh} = \tau \left(\gamma \cdot \Delta\pi_p + \Delta\pi_{-p} \right), \tag{7}$$

where the tax rate of the patent box is expressed as a fraction γ of the regular tax rate, $\tau_p = \gamma\tau$. For $\tau > 0$ and $\Delta\pi_p > 0$, which we observe empirically, we can write

$$\Delta T_{beh} \gtreqless 0 \qquad \Leftrightarrow \qquad \gamma \gtreqless -\frac{\Delta\pi_{-p}}{\Delta\pi_p}. \tag{8}$$

The tax revenue change ΔT_{beh} is positive provided the tax advantage of the patent box is not too strong, i.e. γ is sufficiently high. Given our baseline estimates, the rise of patent box income due to profit shifting into the patent box is $\Delta\pi_p = 0.152\pi$.[40] Assuming that the productivity gain is subject to the regular tax rate, the corporate tax base π_{-p} increases due to the productivity rise by 3.5 percent of pre-tax profits and decreases due to higher interest expenses by 7.5 percent of pre-tax profits, i.e. $\Delta\pi_{-p} = (0.035 - 0.075)\pi$.[41] Thus, from (8) it follows that the value of γ at which the behavioral response of MNEs is revenue neutral is $\gamma^* = 0.44$. Based on Table 1, empirically observed values of γ range between 0.2 and 0.5. This implies that the tax base adjustments do not necessarily translate into higher corporate tax revenues collected from MNEs. In that sense, the tax costs associated with the empirically identified outward shifting of profits via internal debt might outweigh the positive effects on tax revenues due to inward profit shifting and higher productivity.

Overall corporate tax revenues also include tax revenues collected from domestic affiliates. These affiliates benefit from a productivity enhancement, while not being able to exploit the international tax differentials to save on taxes. Assuming, as above, that the productivity gains expand the tax base that is subject to the regular corporate tax rate, the tax revenue consequences of the tax base adjustments will become less negative and possibly positive when including domestic affiliates. However, domestic affiliates also receive a tax rate reduction on their IP income, which increases the negative mechanical effect on tax revenues. A more detailed evaluation of the tax revenue effects of the behavioral responses as well as the overall revenue

[40] Accounting profits, which we use in the empirical analysis, might differ from taxable profits. For the evaluation of the behavioral response of MNEs it suffices that the observed changes in productivity and profit shifting affect both measures similarly, which generally holds.

[41] Attributing the productivity gain to π_p would render the effect of the behavioral responses on corporate tax revenues more likely negative.

implications require the use of data on taxable profits of domestic and MNE affiliates and their decomposition in taxable profits which qualify for the patent box. However, the data are not available in the ORBIS database. For this reason, we have to leave such a comparison to future research.

10 Conclusion

In recent years, patent box regimes have become increasingly popular as a tool to attract taxable income from intellectual property (IP). In this paper, we quantify the effect of the European patent box regimes on the profit shifting behavior of MNEs. We find that affiliates that have been selected into the treatment group because of their historical patent ownership report a rise in their pre-tax profit levels of 8.5 percent. The estimated change in profits does not capture the full magnitude of the MNEs usage of the patent box legislation due to profit shifting for different reasons. First, patent boxes also increase productivity, raising profit levels unrelated to profit shifting. Second, MNEs shift profits into the patent box as well as out of the patent box country via internal debt arrangements. Only the net effect shows up in the change of estimated profits. When decomposing the in- and outward shifting behavior of MNEs, we find that the propensity to shift profits into the patent box is much higher, amounting to 15 percent of pre-tax profits.

The shifting behavior of MNEs has a possibly surprising influence on corporate tax revenues. Albeit only a fraction of the incoming profits leaves the patent box country again via internal debt arrangements, the type of 'round tripping' is costly for the patent box country. It certainly lowers corporate tax revenues and might even lead to a reduction in revenues that the patent box country collects from MNEs.

These findings are of policy relevance and provide a foundation for policies that have recently been suggested to combat the use of patent boxes for profit shifting. The modified nexus approach endorsed by the OECD and the G20 member countries constrains the use of patent boxes by introducing restrictions on whether, among others, acquired patents are eligible for the preferential tax treatment.[42] In future research, it will be interesting to analyze the overall effectiveness of the modified nexus approach. Our analysis already sheds some light on the effectiveness of such restrictions. Exploiting differences in the generosity of existing patent box regimes, we find that excluding acquired patents from the tax benefit reduces the tax sensitivity of MNE profits.

[42] In general terms, the modified nexus approach stipulates a nexus between the location of R&D activity, i.e., the patent creation, and the eligibility of the IP royalties for the preferential tax treatment granted by the patent box legislation (OECD, 2015).

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Tables & Figures

Table 1: **Characteristics of European Patent Box Regimes**

	BE	ES	LU	FR*	NL*	HU*	UK
Year (introd./reform)	2008	2008	2008	2010	2010	2012	2013
Top CIT Rate	0.330	0.280	0.292	0.333	0.250	0.190	0.21
Effective Tax Rate on IP	0.066	0.112	0.058	0.150	0.050	0.095	0.10
Base Exempted from CIT	0.80	0.60	0.800	0.00	0.80	0.500	0.00
Separate Rate on IP	No	No	No	Yes	No	No	Yes
New Patents	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Existing Patents	No	Yes	No	Yes	No	Yes	Yes
Acquired Patents	Yes	No	Yes	Yes	Yes**	Yes	Yes**
Know-How	No	Yes	Yes	No	No	Yes	No

Note: Listed countries introduced or substantially reformed their patent box regimes in the period 2007-2013. (*) Indicates countries with a major reform of the patent box regime in the year reported in the first row of the table and that resulted in a major reduction of the effective tax burden on IP income. The post-reform effective tax burden on IP income is as stated in the third row of the table. (**) Acquired IP must be further developed and/or actively managed.

Table 2: **Definition of Variables**

Variable	Definition
Pre-Tax Profits	Operating profits + Financial profits before tax (in logs)
EBIT	Earnings before interest and taxes (in logs)
Financial Leverage	Ratio of total debt to total assets
Capital	Volume of fixed assets (in logs)
Labour	Total cost of employees (in logs)
Intangible Assets	Volume of intangible fixed assets (in logs)
Profit Margin	(Profits before tax / Operating revenue) * 100
Liquidity Ratio	(Current assets - Stocks) / Current liabilities
Industrial Sector	Affiliate 2-digit NACE code
Number of Patents	Sum of all patents owned by affiliate and shareholders
Tax Rates*	Top statutory tax rate on corporate income (between 0 and 1)

Note: All financial variables are collected from ORBIS and are originally provided in EUR units, then converted to 2005 EUR units. Tax rates are collected from the Worldwide Corporate Tax Guide, EY (various years).

Table 3: **Sample Composition**

Affiliate Type	Treated	Control	Total
Domestic	12,653	69,760	82,413
Multinational	2,033	6,216	8,249
Total	14,686	75,976	90,662

Note: Number of treated and control affiliates, by conglomerate. Affiliate type depends on the corporate structure of the conglomerate that the European affiliate belongs to. Treatment is defined by historical (pre-2000) direct and indirect (via majority shareholder) ownership of IP.

Table 4: **Geographical Distribution of Patent Ownership (pre-2000 & post-PB)**

Affiliate Country	Domestic		Multinational		Number of Affiliates
	Pre-2000	Post-PB	Pre-2000	Post-PB	
Spain	0.111	0.096	0.197	0.239	47,284
France	0.024	0.201	0.233	0.269	35,964
Belgium	0.235	0.196	0.323	0.350	6,881
Hungary	0.216	0.199	0.396	0.422	365
Netherlands	0.034	0.065	0.172	0.282	145
Luxembourg	0.083	0.086	0.091	0.143	23

Note: Geographical distribution of the domestic and multinational European affiliates linked to IP registered by the year 2000, against those owned after patent box regimes have been put in place.. Patent ownership follows our treatment definition, and includes both patents directly owned by the affiliate, and patents owned by the affiliate majority shareholder. Total sample size is 90,662 affiliates, of which 82,413 belong to domestic (DOM) and 8,249 belong to multinational (MNE) conglomerates.

Table 5: **Tax Rates across Treatment and Control Groups (2007-2013 average)**

Tax Measure	Full Sample	Treated	Control
τ_i	32.58	32.76	32.37
τ_p	29.75	29.83	28.97
τ_{min}	27.40	27.59	27.19
$\tau_i - \tau_p$	2.83	2.94	3.39
$\tau_i - \tau_{min}$	4.80	5.18	5.12

Note: Average tax indeces computed for different samples of affiliates, over the observational period of 2007-2013. Tax indeces are defined as described in Section 5. The samples include the full sample and the treated and the control sample, before matching.

Table 6: **Coarsened Exact Matching**

	Full Sample (N=90,662)			Matched Sample (N=28,532)		
	$\mathcal{L}$	Mean Diff.	T-test	$\mathcal{L}$	Mean Diff.	T-test
MNE/Domestic	0	0	-	0	0	-
Country	0.091	-0.096	-	0	0	-
Industrial Sector	0.217	-5.475	-	0	0	-
Age in year 2000	0.157	4.246	0.000	0.009	-0.0002	0.9767
Int. to Total Asset Ratio	0.033	-0.007	0.000	0.051	-0.0017	0.2376
Profit Margin	0.001	624.310	0.023	0.011	0.079	0.0789
Log(Sales)	0.203	0.803	0.000	0.047	0.019	0.2884
Num. Employees	0.176	36.457	0.000	0.026	0.003	0.9992
Number of Indirect Patents	0.137	339.360	0.000	0.063	4.7548	0.5665

Note: The "matched sample" includes 14,266 treated affiliates matched with an equal number of non-treated affiliates. The percentage of affiliates controlled by MNEs is equal to 9.09% in the original sample, and equal to 11.50% in the matched sample. After matching 846 out of 2,348 strata, the overall $\mathcal{L}$ statistic measure is reduced from 0.9856 to 0.6350. T-statistic in the third and sixth columns reports the result from a two sided test for the equality of means between the treated and control group, before and after the matching.

Table 7: **Matched Sample Composition**

	Full Sample		Matched Sample	
	Treated	Control	Treated	Control
Affiliates of MNEs	2,033	6,216	1,642	1,642
Affiliates of DOMs	12,653	69,760	12,624	12,624
Total	14,683	75,976	14,266	14,266

Note: Sample composition after CEM, listed by type of conglomerate. Treatment is defined by historical (pre-2000) direct and indirect (via majority shareholder) ownership of IP.

Table 8: **Benchmark Estimation - Profit Shifting Regression**

Dep. Variable: ln (Pre-Tax Profits)	Full Sample [1]	Matched Sample [2]	Parent Tax Differential [3]	Min. Tax Differential [4]	Parent Tax Dummy [5]	Min. Tax Dummy [6]
Fixed Assets	0.0300***	0.0215***	0.0440***	0.0435***	0.0442***	0.0440***
	(0.0043)	(0.0073)	(0.0102)	(0.0102)	(0.0102)	(0.0102)
Cost of Employees	0.2668***	0.2701***	0.3352***	0.3356***	0.3336***	0.3339***
	(0.0092)	(0.0164)	(0.0305)	(0.0305)	(0.0303)	(0.0303)
Financial Leverage	-0.1982***	-0.1750***	-0.2015***	-0.2011***	-0.2035***	-0.2031***
	(0.0091)	(0.0157)	(0.0245)	(0.0245)	(0.0244)	(0.0244)
Tax Differential: $\tau_i - \tau_j$			-0.0038*	-0.0032***		
			(0.0023)	(0.0010)		
Tax Dummy: 1 if $[\tau_i < \tau_j]$					0.0626***	0.0575**
					(0.0237)	(0.0225)
Treatment Year Dummies	YES	YES	YES	YES	YES	YES
Year x Industry Dummies	YES	YES	YES	YES	YES	YES
Observations	409,776	131,592	37,723	37,723	37,723	37,723
Affiliates	90,662	28,532	8,249	8,249	8,249	8,249

*Note: All models are estimated using a linear panel model with affiliate-level-fixed effects. In Column [1] and [2], both domestic and multinational affiliates are considered in the full and matched sample, respectively. In Columns [3]-[6], the full sample of multinational affiliates is included. The tax rate indexed j refers to the parent country in Column [3] and [5], and to the country with the lowest tax rate within the conglomerate in Column [4] and [6]. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 9: **Difference-in-Difference (DD) Model - Baseline Heterogeneous Treatment**

Dep. Variable:	Pre-Tax Profits				EBIT
	Homog. Treatment [1]	MNE vs DOM [2]	Controls [3]	Full Sample [4]	same as [3] [5]
After * Treated	0.0472***				
	(0.0142)				
After * Treated * DOM Affiliate		0.0358***	0.0346**	0.0346***	0.0320**
		(0.0147)	(0.0166)	(0.0130)	(0.0149)
After * Treated * MNE Affiliate		0.1335***	0.0854***	0.0755***	0.1063***
		(0.0300)	(0.0330)	(0.0261)	(0.0311)
Fixed Assets			0.0219***	0.0304***	0.0458***
			(0.0073)	(0.0043)	(0.0068)
Cost of Employees			0.2698***	0.2667***	0.2666***
			(0.0164)	(0.0092)	(0.0149)
Financial Leverage			-0.1745***	-0.1978***	-0.0327**
			(0.0157)	(0.0091)	(0.0140)
MNE Affiliate in Low-Tax Country			0.0535**	0.0907***	0.0602***
			(0.0268)	(0.0166)	(0.0245)
Treatment Year Dummies	YES	YES	YES	YES	YES
Year x Industry Dummies	YES	YES	YES	YES	YES
Observations	131,592	131,592	131,592	409,776	131,794
Total Number of Affiliates	28,532	28,532	28,532	90,662	28,379
Treated MNE Affiliates	1,624	1,624	1,624	2,033	1,624
Treated DOM Affiliates	12,624	12,624	12,624	43,298	12,624

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as patent ownership directly by the affiliate or indirectly by the majority shareholder by the year 2000. In columns [2] to [5], treatment is allowed to vary according to the time-invariant ownership structure of the affiliate conglomerate (multinational or domestic). Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 10: **Generalized Difference-in-Difference Model**

Dependent Variable: Pre-tax Profits	Short/Long Term Effects [1]		Pre- and Post-Treatment [2]	
	MNE	DOM	MNE	DOM
Treated x (1 and 2) Years PRE-T			0.0076	0.0112
			(0.0404)	(0.0217)
x Year of Treatment	0.0694**	0.0285*	0.0750*	0.0368
	(0.0327)	(0.0180)	(0.0477)	(0.0253)
x 1 Year POST-T	0.0687*	0.0309*	0.0744	0.0392
	(0.0369)	(0.0188)	(0.0494)	(0.0392)
x 2 Year POST-T	0.1250***	0.0156	0.1306***	0.0237
	(0.0407)	(0.0206)	(0.0524)	(0.0270)
x (3, 4 and 5) Year POST-T	0.2570***	0.0494***	0.2628***	0.0579**
	(0.0492)	(0.0236)	(0.0583)	(0.0293)
Controls	YES	YES	YES	YES
Treatment Year FE	YES	YES	YES	YES
Year x Industry FE	YES	YES	YES	YES
Observations	139,229	139,229	139,229	139,229
Affiliates	28,532	28,532	28,532	28,532
Treated MNE Affiliates	1,624	1,624	1,624	1,624
Treated DOM Affiliates	12,624	12,624	12,624	12,624

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as direct patent ownership by the affiliate or indirectly by the majority shareholder, by the year 2000. Treatment effects are allowed to vary over post-treatment (POST-T) years. Model in Column [2] controls for pre-treatment (PRE-T) effects. Control variables are identical to the ones in Column [3], Table 9, but are omitted from the table. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 11: **Difference-in-Difference Model - Confounding Tax Incentives**

Dep. Variable:	Pre-Tax Profits			EBIT		
	Parent Tax [1]	Minimum Tax [2]	Tax Haven [3]	Parent Tax [4]	Minimum Tax [5]	Tax Haven [6]
After * Treated * DOM Affiliates	0.0285*	0.0285*	0.0289*	0.0251*	0.0255*	0.0257*
	(0.0163)	(0.0163)	(0.0163)	(0.0147)	(0.0147)	(0.0147)
After * Treated * MNE Affiliates:						
in low-tax countries	0.0912*	0.1045**		0.1463***	0.1298***	
	(0.0549)	(0.0461)		(0.0526)	(0.0452)	
in high-tax countries	0.1306***	0.1219***		0.1495***	0.1389***	
	(0.0346)	(0.0320)		(0.0336)	(0.0308)	
linked to a tax haven			-0.0886			0.0608
			(0.1286)			(0.0955)
not linked to a tax haven			0.1088***			0.1317***
			(0.0306)			(0.0292)
Controls	YES	YES	YES	YES	YES	YES
Treatment Year FE	YES	YES	YES	YES	YES	YES
Year x Industry FE	YES	YES	YES	YES	YES	YES
Observations	139,229	139,229	139,229	144,400	144,400	144,400
Affiliates	28,532	28,532	28,532	27,896	27,896	27,896
Treated MNE Affiliates	1,624	1,624	1,624	1,624	1,624	1,624
Treated DOM Affiliates	12,624	12,624	12,624	12,624	12,624	12,624

*Note: Models are estimated using a linear panel model with FE. The sample includes all affiliates matched with CEM. Treatment is defined as direct patent ownership by the affiliate or indirectly by the majority shareholder, by the year 2000. For multinational affiliates, treatment is allowed to vary according to the confounding tax incentives faced by the conglomerate the affiliate belongs to. Control variables are identical to the ones in [3], Table 9, but are omitted from the table. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 12: **Difference-in-Difference Model - Role of Tax Havens (TH)**

Dep. Variable:	Pre-Tax Profits			EBIT		
	SH in TH [1]	AF in TH [2]	Any in TH [3]	SH in TH [4]	AF in TH [5]	Any in TH [6]
After * Treated * DOM Affiliate	0.0350**	0.0346**	0.0346**	0.0323**	0.0320**	0.0320**
	(0.0166)	(0.0166)	(0.0166)	(0.0150)	(0.0150)	(0.0150)
After * Treated * MNE Affiliate						
linked to Tax Haven	-0.1250	0.0878**	0.0789**	-0.0690	0.1178***	0.1129***
	(0.0861)	(0.0391)	(0.0382)	(0.0873)	(0.0388)	(0.0376)
not linked to Tax Haven	0.1003***	0.0838**	0.0907**	0.1186***	0.0983***	0.1010***
	(0.0339)	(0.0401)	(0.0413)	(0.0321)	(0.0372)	(0.0385)
Controls	YES	YES	YES	YES	YES	YES
Treatment Year FE	YES	YES	YES	YES	YES	YES
Year x Industry Dummies	YES	YES	YES	YES	YES	YES
Observations	139,229	139,229	139,229	144,400	144,400	144,400
Affiliates	28,532	28,532	28,532	28,379	28,379	28,379
Treated MNE Affiliates	1,624	1,624	1,624	1,624	1,624	1,624
Treated DOM Affiliates	12,624	12,624	12,624	12,624	12,624	12,624

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as direct patent ownership by the affiliate or indirectly by the majority shareholder, by the year 2000. For affiliates of multinationals, treatment effect varies according to the type of link the affiliate has with a tax haven (TH). SH (AF) indicates that the majority shareholder (an affiliate in the conglomerate) resides in a tax haven. The variable "Any" indicates that either an affiliate, the majority shareholder or both reside in a tax haven. Control variables are identical to the ones in [3], Table 9, but are omitted from the table. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 13: **(In)Direct Patent Ownership and Patent Box (PB) Restrictions**

Dep. Variable: Pre-Tax Profits	Direct Patents [1]	Acquired Patents [2]	Existing Patents [3]
After * DOM Treated Affiliates	0.0348**	0.0342**	0.0345**
	(0.0166)	(0.0166)	(0.0166)
After * MNE Treated Affiliates			
without direct patents	0.0955***		
	(0.0341)		
with direct patents	-0.0422		
	(0.0809)		
in unrestricted PB countries		0.0998***	0.1941***
		(0.0338)	(0.0715)
in restricted PB countries		-0.0592	0.0650*
		(0.1098)	(0.0352)
Controls	YES	YES	YES
Treatment Year FE	YES	YES	YES
Year x Industry Dummies	YES	YES	YES
Observations	139,229	139,229	139,229
Affiliaties	28,532	28,532	28,532
Treated MNE Affiliates	1,624	1,624	1,624
Treated DOM Affiliates	12,624	12,624	12,624

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as direct patent ownership by the affiliate or indirectly by the majority shareholder, by the year 2000. The treatment effect varies according to whether patents are owned (in)directly (Column [1]) and whether the patent box legislation allows to qualify acquired (Column [2]) or existing (Column [3]) patents. Control variables are identical to the ones in [3], Table 9, but are omitted from the table. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 14: **Sample Composition: Exclusion of Trademarks and New Patents**

Dep. Variable Pre-Tax Profits	Baseline Tab. 9 Col. 3 [1]	Excluding New Patents [2]	Excluding Trademarks Historical [3]	 Hist. & New [4]
After * Treated * DOM Affiliate	0.0346**	0.0350**	0.0354**	0.0337**
	(0.0166)	(0.0166)	(0.0167)	(0.0168)
After * Treated * MNE Affiliate	0.0854***	0.0889***	0.0892***	0.0906***
	(0.0330)	(0.0330)	(0.0331)	(0.0332)
Fixed Assets	0.0219***	0.0220***	0.0214***	0.0216***
	(0.0073)	(0.0073)	(0.0073)	(0.0074)
Cost of Employees	0.2698***	0.2681***	0.2738***	0.2701***
	(0.0164)	(0.0164)	(0.0162)	(0.0162)
Financial Leverage	-0.1745***	-0.1747***	-0.1757***	-0.1734***
	(0.0157)	(0.0157)	(0.0157)	(0.0158)
MNE Affiliate in Low-Tax Country	0.0535**	0.0492*	0.0512*	0.0461*
	(0.0268)	(0.0269)	(0.0270)	(0.0272)
Treatment Year Dummies	YES	YES	YES	YES
Year x Industry Dummies	YES	YES	YES	YES
Observations	131,592	129,413	130,638	129,434
Affiliates	28,532	28,089	28,341	28,092
Treated MNE Affiliates	1,642	1,642	1,642	1,642
Treated DOM Affiliates	12,624	12,624	12,642	12,642

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The samples vary across columns: [1] uses the matched sample of Table 9, Column [3]; [2] uses the full matched sample, after excluding the affiliates in the control group that created new patents between 2000 and 2007 (this reduces the control sample to 12,524 domestic and 1,608 multinational affiliates); [3] uses the full matched sample, excluding the affiliates in the control group that owned any trademark before the year 2000 (this reduces the control sample to 12,483 domestic and 1,592 multinational affiliates); [3] also excludes the affiliates in the control group that registered new trademarks between the year 2000 and 2007 (this reduces the control sample to 12,276 domestic and 1,550 multinational affiliates). Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 15: **Sample Selection: Propensity Score (PS) Matching and Full Sample**

Dep. Variable	Baseline	PS Matching		Full
Pre-Tax Profits	CEM Matching	PS (5%)	PS (1%)	Sample
	[1]	[2]	[3]	[4]
After * Treated * DOM Affiliate	0.0346**	0.0378**	0.0380**	0.0346***
	(0.0166)	(0.0191)	(0.0186)	(0.0130)
After * Treated * MNE Affiliate	0.0854***	0.1033***	0.1023***	0.0755***
	(0.0330)	(0.0382)	(0.0378)	(0.0261)
Fixed Assets	0.0219***	0.0330***	0.0335***	0.0304***
	(0.0073)	(0.0098)	(0.0097)	(0.0043)
Cost of Employees	0.2698***	0.3264***	0.3271***	0.2667***
	(0.0164)	(0.0243)	(0.0238)	(0.0092)
Financial Leverage	-0.1745***	-0.1823***	-0.1881***	-0.1978***
	(0.0157)	(0.0212)	(0.0207)	(0.0091)
MNE Affiliate in Low-Tax Country	0.0535**	0.0148	0.0141	0.0907***
	(0.0268)	(0.0304)	(0.0302)	(0.0166)
Treatment Year Dummies	YES	YES	YES	YES
Year x Industry Dummies	YES	YES	YES	YES
Observations	131,592	84,166	86,795	409,776
Affiliates	28,532	17,816	18,328	90,662
Treated MNE Affiliates	1,642	1,003	1,009	2,033
Treated DOM Affiliates	12,624	7,905	8,155	43,298

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The samples vary across columns: [1] uses the CEM matched sample of Table 9 Column [3]; [2] and [3] use propensity score (PS) matching where we discard the 5 percent and 1 percent of the treatment observations at which the propensity score density of the control observations is the lowest; [4] uses the full unmatched sample. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 16: **Alternative Treatment: Historical 2nd Tier IP Ownership**

Dep. Variable:	Pre-Tax Profits	EBIT
	[1]	[2]
After * Treated * DOM Affiliate	0.0143	0.0152
	(0.0163)	(0.0148)
After * Treated * MNE Affiliate	0.0472	0.0771***
	(0.0324)	(0.0307)
Fixed Assets	0.0186***	0.0376***
	(0.0072)	(0.0068)
Cost of Employees	0.2861***	0.2753***
	(0.0159)	(0.0149)
Financial Leverage	-0.1988***	-0.0540***
	(0.0155)	(0.0136)
MNE Affiliate in Low-Tax Country	0.0737***	0.0554***
	(0.0257)	(0.0245)
Treatment Year Dummies	YES	YES
Year x Industry Dummies	YES	YES
Observations	135,887	136,162
Affiliates	29,422	29,266
Treated MNE Affiliates	1,669	1,669
Treated DOM Affiliates	13,042	13,042

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as patent ownership directly by the affiliate or indirectly by the majority shareholder or minority shareholders, by the year 2000. Standard errors are clustered at the shareholder level and reported in parentheses: ***$p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 17: **Alternative Sample with Longer Time Span (2007-2015) - DD Model**

Dep. Variable:	Pre-Tax Profits			EBIT
	MNE vs. DOM	Controls	Full Sample	same as [3]
	[1]	[2]	[3]	[4]
After * Treated DOM Affiliates	0.0370**	0.0358**	0.0240*	0.0383**
	(0.0179)	(0.0182)	(0.0142)	(0.0166)
After * Treated MNE Affiliates	0.0824***	0.0729***	0.0551***	0.0849***
	(0.0221)	(0.0232)	(0.0178)	(0.0211)
Controls	YES	YES	YES	YES
Treatment Year FE	YES	YES	YES	YES
Year x Industry Dummies	YES	YES	YES	YES
Observations	74,186	67,853	861,905	67,456
Affiliates	12,638	12,638	196,677	12,638
Treated MNE Affiliates	1,428	1,428	3,404	1,428
Treated DOM Affiliates	4,891	4,891	54,639	4,891

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as patent ownership directly by the affiliate or indirectly by the majority shareholder, by the year 2000. The sample spans the period 2007-2015 and includes affiliates located in Belgium, France, Spain, United Kingdom and the Netherlands. Control variables are identical to the ones in [3], Table 9, but are omitted from the table. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Table 18: **Alt. Sample with Time Span 2007-2015 - Generalized DD Model**

Dep. Variable: Pre-Tax Profits	Short/Long Term Effects [1]		Pre and Post Treatment [2]	
	MNE	DOM	MNE	DOM
Treated × (1 and 2) Years PRE-T			-0.0063	0.0473*
			(0.0285)	(0.0255)
× Year of Treatment	0.0448	0.0395	0.0406	0.0716**
	(0.0324)	(0.0255)	(0.0374)	(0.0308)
× 1 Year POST-T	0.0484	0.0267	0.0441	0.0587*
	(0.0328)	(0.0261)	(0.0378)	(0.0313)
× 2 Year POST-T	0.0758**	-0.0081	0.0717*	0.0238
	(0.0332)	(0.0270)	(0.0380)	(0.0317)
× 3 Year POST-T	0.1825***	0.0338	0.1772***	0.0680*
	(0.0448)	(0.0353)	(0.0494)	(0.0398)
× 4 Year POST-T	0.1452***	0.0561	0.1401***	0.0902**
	(0.0455)	(0.0364)	(0.0499)	(0.0410)
× 5+ Year POST-T	0.0851*	0.1917***	0.0799	0.2255***
	(0.0475)	(0.0392)	(0.0518)	(0.0432)
Treatment Year FE	YES	YES	YES	YES
Year x Industry FE	YES	YES	YES	YES
Observations	67,853	67,853	67,853	67,853
Affiliaties	12,638	12,638	12,638	12,638
Treated MNE Affiliates	1,428	1,428	1,428	1,428
Treated DOM Affiliates	4,891	4,891	4,891	4,891

*Note: All models are estimated using a linear panel model with affiliate level fixed effects. The sample includes all affiliates matched with CEM. Treatment is defined as patent ownership directly by the affiliate or indirectly by the majority shareholder, by the year 2000. The sample spans the period 2007-2015 and includes affiliates located in Belgium, France, Spain, United Kingdom and the Netherlands. Control variables are identical to the ones in [3], Table 9, but are omitted from the table. Treatment effects are allowed to vary over post-treatment (POST-T) years. The model in Column [2] controls for pre-treatment (PRE-T) effects. Control variables are identical to the ones in Column [3], Table 9, but are omitted from the table. Standard errors are clustered at the shareholder level and reported in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Figure 1: **Full Sample, before Matching**
(N = 90,662 - figures in Mil. EUR)

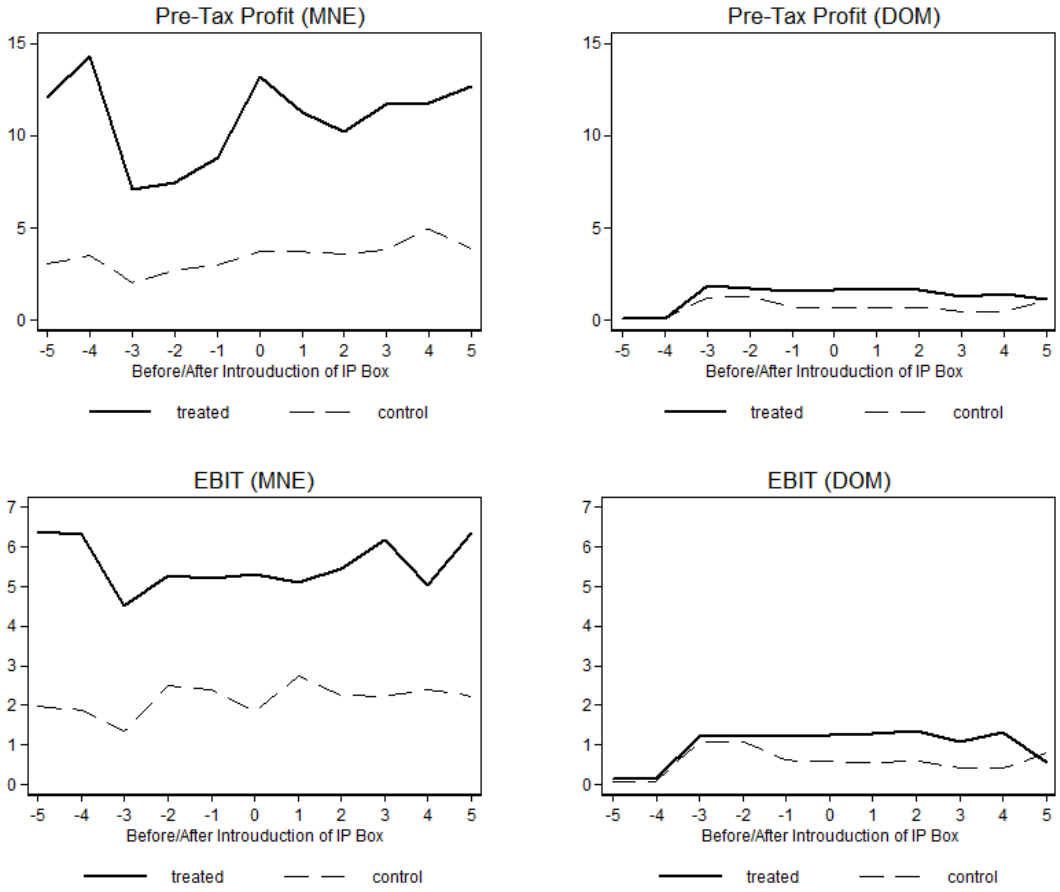
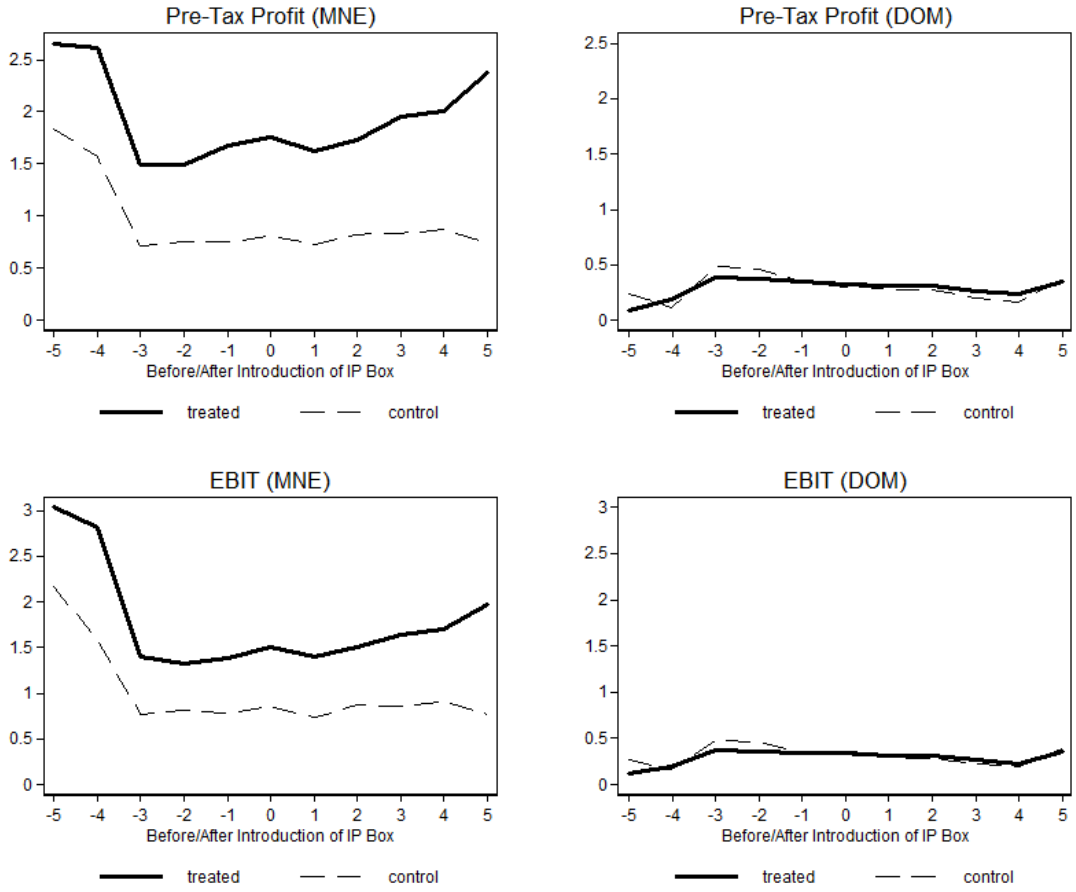


Figure 2: **CEM Matched Sample**
(N = 28,532 - figures in Mil. EUR)



EconPol Europe

EconPol Europe – the European network for economic and fiscal policy research – is a network of 14 policy-oriented university and non-university research institutes across 12 countries, who contribute scientific expertise to the discussion of the future design of the European Union. The network's joint interdisciplinary research covers sustainable growth and best practice, reform of EU policies and the EU budget, capital markets and the regulation of the financial sector, and governance and macroeconomic policy in the European Monetary Union.

The network was founded in spring 2017 by the ifo Institute, along with eight renowned European research institutes. A further five associate partners were added to the network in January 2019.

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- Reform of EU policies and the EU budget
- Capital markets and the regulation of the financial sector
- Governance and macroeconomic policy in the European Monetary Union

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