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Disentangling business- and tax-motivated bilateral royalty flows

Multinational firms pay for the use of intellectual property and these rights could be located in other countries.
We do not know whether these payments are business or tax driven.
With a novel method we disentangle these motives.
We estimate that at least 18% of the size of the international royalty flows is tax driven.

The size of global missed tax revenues are estimated to be in the range of 6.5 to 16 billion US dollar.
The bandwidth would be lower if countries report more bilateral royalty flows to and from tax havens.

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Disentangling

business- and tax-motivated bilateral royalty flows

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Abstract

Shifting intellectual property (IP) rights across jurisdictions is a well-known strategy of multinationals to reduce corporate income taxation. We investigate the extent to which the flows of remunerations for the use of IP rights are affected by differences in corporate income and withholding taxation. Using OECD data between 2014 and 2019, we determine the influence of bilateral tax rates on the IP-location. These rates result from a network analysis that distinguishes between the potential gains from direct shifting of IP rights and treaty shopping. The latter are gains for multinationals from exploiting lower withholding taxes by routing royalty flows through conduit countries. We use these bilateral tax gains to isolate the flows that could be only business-motivated. Next we apply a gravity framework with PPML estimators. We estimate that at least 18% of the royalty flows is motivated by tax planning in this period, which reduces tax revenues by 6.5 to 16 billion US dollar in 2018. We argue that both estimates are lower bounds due to missing observations. More reporting by OECD countries of flows to and from tax havens would improve the precision of the estimates. To the best of our knowledge these are the first estimates of worldwide tax avoidance with royalties.

Keywords: bilateral royalty flows, international tax avoidance, treaty shopping, withholding tax, tax havens

JEL codes: H25, H26, H32

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1. Introduction

Strategic location of intellectual property (IP) rights is one of the tax planning mechanisms to reduce corporate income tax (CIT) payments. Multinationals use these tax planning strategies for several reasons (Fuest et al., 2013). First, many jurisdictions have introduced patent or IP box regimes to stimulate innovation. Out of 36 OECD countries, 30 offered some form of research and development (R&D) support in 2018, up from 19 countries in the year 2000 (Haufler and Schindler, 2023). Income in these IP boxes is taxed at lower rates than the statutory CIT rates in order to promote innovation and economic growth. Second, economies have become more digitalized, and IP rights can be attributed to almost any new tool. Third, legislators have difficulty in defining precisely which products and services are new, even though there are certain regulations about IP contributions and their nexus. As a result, multinationals shift IP rights between their holding companies in various jurisdictions to lower overall taxation (Fuest et al., 2013; Haufler and Schindler, 2023).

Multinationals reduce their tax payments by relocating IP rights to a low-tax jurisdiction, and making use of conduit, or pass-through, countries to reduce withholding taxes. A famous example is the double Irish-Dutch sandwich (Kleinbard, 2011; Zucman, 2014), which works as follows. Multinationals, often with beneficial owners in the United States (US), collect their overseas royalties in Ireland.[1] They have established an Irish holding company in a low-tax jurisdiction, quite often Bermuda, that owns the IP rights. By applying this structure, the overseas royalties are not taxed as corporate income in Ireland at 12.5%, but in the low-tax jurisdiction. Not surprisingly, these jurisdictions do not levy CIT at all. In 2005 Ireland introduced a withholding tax (WHT) of 20% on outgoing royalties. Since then it has not been attractive to use low-tax jurisdictions to store IP rights from Ireland directly. Because the Netherlands did not levy WHT on royalties (until 2021), and the European Union's (EU's) Interest and Royalties Directive forbids taxing royalty payments between related parties in EU countries, multinationals established a holding company in the Netherlands. The Irish WHT could be avoided due to this interposed holding company. In 2018 royalty payments between Ireland and the Netherlands, and between the Netherlands and Bermuda, amounted to about 25 billion US$, and were the largest in the world (Lejour et al., 2022).

The double Irish-Dutch sandwich is a striking example of the two tax planning strategies by multinationals we investigate in this paper - IP shifting and treaty shopping. We systematically analyse the shifting of IP rights and treaty shopping through sub-licensing IP rights, combining a network analysis with an econometric analysis. We use econometrics to predict the size of the royalty payments that are only motivated by business reasons. To identify these flows, we use results from the network analysis on potential treaty shopping. Finally we estimate the size of the tax-motivated flows, and the associated loss of tax revenue.

[1] An example is Google, which has its European headquarters in Dublin. We use the terms royalties, royalty payments and royalty flows for bilateral flows in which the payment is remuneration for using IP rights. The OECD, our main data source, mentions these payments as charges-received for the country hosting the IP rights, and charges-paid for the country in which multinational enterprises (MNEs) use these rights. The flows do not include the sale of IP rights - see Section 4 for details.

The amount of international royalty payments quadrupled between 2003 and 2019.[2] This provides a clear empirical motivation to examine the extent to which this is driven by tax planning strategies. Two well-known examples are the American companies Google and Uber, which have holding companies in the Netherlands, and IP rights located in Bermuda.[3] A second motivation is that most of the international tax planning literature focuses on transfer pricing and debt shifting as tax avoidance strategies.[4] Some recent literature emphasizes the role of intangible assets in profit shifting,[5] but not specific to IP shifting as we do in this paper.

First, we determine the potential tax gains from IP shifting and treaty shopping by applying a network analysis for 112 countries. The network analysis on royalty flows is new and differs from our earlier work on dividend flows (van 't Riet & Lejour, 2018) because of the different tax treatment of these flows - royalty payments are deducted from the tax base in the source country, whereas divided distribution is after corporate income taxation in the source country. The tax gains consist of direct planning gains (DPG) and treaty shopping gains (TSG).[6] They are computed from national CIT and bilateral withholding tax (WHT) rates. Based on these tax gains we differentiate between country pairs that are attractive to use in tax planning strategies of multinational enterprises (MNEs), and those country pairs that are not attractive for tax planning purposes. This distinction is key in the second step of our analysis. The network analysis on its own gives an assessment of the potential for treaty shopping with royalties in the international tax system.

Second, we explain the size of bilateral royalty flows using a gravity framework from the trade literature. We use the bilateral flows of the country pairs without potential tax gains to separate flows that are only business-motivated (OBM) from the other flows. The latter can be both business- and tax-motivated (BTM).[7] The regression outcomes are used to predict the size of these flows due to business reasons, or non-tax planning, for the other country pairs. We compare these predictions with the observed data to determine the impact of tax planning on the magnitude of bilateral royalty flows. Given the share of tax-motivated flows, we also estimate the associated loss of tax revenue.

The empirical literature on the relationship between IP rights and taxation mainly focuses on firm-level data and patents, whereas this paper focuses on countries and remuneration for the use of patents and licenses. Karkinsky and Riedel (2012) use panel data with the patents of European MNEs. They find that a 1% increase in the corporate tax rate reduces the number of patent applications by 3.8%. Using similar data, Dischinger and Riedel (2011) explain the size of intangible assets in subsidiaries by the difference between the subsidiary's corporate tax rate and the tax rate

[2] The source is *World Development Indicators* (World Bank). We use the variable charges paid and received for the use of IP rights (Balance of Payments, US$).
[3] Measures by Ireland and the Netherlands ended the profitability of the double Irish-Dutch sandwich from 2020 onwards (see also Samarakoon, 2023). In 2019 Uber shifted IP rights from Bermuda to the Netherlands in a response to new EU initiatives to combat tax avoidance. Our data is, however, up to 2019, when both the Google and Uber IP rights were located in Bermuda.
[4] See Beer et al. (2020) and Heckemeyer and Overesch (2017) for overviews of the literature on international corporate tax avoidance.
[5] See Beer and Loeprick (2015), Delis et al. (2021), and Bilicka et al. (2022).
[6] The abbrevations DPG and TSG are used throughout the paper for, respectively, direct tax planning gain and treaty shopping gain.
[7] The abbrevations OBM and BTM are used throughout the paper for, respectively, only business-motivated and business- and tax-motivated bilateral royalty flows.

average of all other affiliates of the multinational group. They conclude that a 1% decrease in the average tax difference to all other group affiliates raises a subsidiary's stock of intangibles by around 1.7% on average. Griffith et al. (2014) estimate a logit model on patent location with own-tax and cross-tax elasticities of the various jurisdictions. They identify that the mean marginal impact of tax on the pay-off from locating legal ownership of a patent is negative and statistically significant across all industries and parent firm size groups.

Beer and Loeprick (2015) conclude that profits of subsidiaries with above median intangible assets reduce by more in response to an increase in the tax rate than subsidiaries with less intangibles. This response is larger if the multinational group has a more complex structure. Delis et al. (2021) conclude that intangibles are a major driver of profit shifting, and that there is more profit shifting in countries with weaker institutions. Both papers exploit firm-specific information using the Orbis database. Using a global database on patent applications and transactions, Bilicka et al. (2022) find evidence of disproportionate use of tax havens in applying for new patents and purchasing existing ones.

Collins and Shackelford (1997) focus on royalty payments between US parents and affiliates (and then aggregate at country level) in 1990. Using a Tobit model, they derive that the tax coefficient is negative, and differs significantly from zero. The coefficient estimate on royalty tax implies that 1%-point lower tax increases royalty payments by 40,000 US$.

Only Dudar et al. (2015) analyse the impact of taxation on royalty flows in a multilateral context, and find a negative effect of higher taxes. Dudar et al. (2015) use OECD royalty data from 2006-2012, and apply a Poisson Pseudo-Maximum Likelihood (PPML) estimator. In the baseline specification, they find that on average a 1% decrease in the net tax rate on bilateral royalty payments leads to a 6.0% increase in their bilateral royalty flows. Hebous and Johannesen (2021) show that German multinationals import systematically more IP from tax havens than from non-tax havens, and these firms export less to tax havens. In 2001 there was hardly any difference between tax havens and other countries, but it has grown over time - at least until 2011, the end of the observation period. Hebous and Johannesen (2021) use Microdatabase Statistics on International Trade in Service and the MiDi database on German multinational firms from the Deutsche Bundesbank. In short, there is overwhelming evidence that country differences in taxation matter for IP location. This seems to also be the case for bilateral royalty flows, but this has been less extensively examined.

Our first set of findings come from the network analysis. Based on national CIT and bilateral WHT rates on royalties, we find that for 36% of the country pairs there is a direct tax planning gain by relocating IP rights, and it is beneficial to combine this with treaty shopping for only 9% of the cases. For these country pairs the potential direct planning gain is on average 7.6%; for treaty shopping it is on average 9.3%. This suggests that the double Irish-Dutch sandwich is not the exception to the rule, but also not as widespread as tax planning gains with divided flows (van 't Riet and Lejour, 2018 and Hong, 2018). Specific tax characteristics determine whether IP shifting with treaty shopping is beneficial - a low CIT rate in the residence country of the IP rights, and a low WHT rate in the source country. Russia, Switzerland, Netherlands, Sweden, and Norway are potentially the most attractive countries for sublicensing IP rights. For Russia, this is due to their favourable tax treaty with China. The other countries do not levy a withholding tax on royalties in the observation period.

The descriptive analysis of the bilateral royalty data shows that business- and tax-motivated (BTM) flows are on average larger than only business-motivated (OBM) flows. The direct planning gains for BTM flows are larger than for the OBM flows. Also the average withholding taxes on royalties and the treaty shopping gains are lower for BTM flows. The average CIT rate of receiving countries is lower for BTM flows than for OBM flows. These descriptives suggest the relevance of tax motives, which we formalize in the second, econometric, part of the analysis.

We apply the gravity model from the trade literature on bilateral royalty flows. This model explains the variation of the flows quite well, and WHT on royalties has a negative impact on these flows. The regression outcomes on OBM flows are used to predict their size. The differences between the observed and predicted flows are interpreted as the size of the flows motivated by tax planning gains. Overall, we estimate that at least 18% of bilateral royalty flows is due to tax planning. The associated tax revenue loss would be 6.5 billion US$ to 16 billion US$ in 2018. We argue that these estimates are lower bounds, and show that the accuracy of the estimates would improve with more reported royalty flows to and from tax havens.

Our paper contributes to the international tax avoidance literature in various ways. We are one of the first to analyse the tax benefits from IP shifting and treaty shopping with payments using IP rights. Recently Hong (2018), van ‘t Riet and Lejour (2018) and Petkova et al. (2020) focus on treaty shopping with dividends, but royalties have so far been ignored. Garcia-Bernardo et al. (2017) focus on the network of conduit countries using firm-level data on holding companies. Second, we distinguish between direct tax gains from IP shifting and treaty shopping gains in the network analysis. This distinction has already been made in Lejour et al. (2022), but only for bilateral dividends, interest and royalty flows to and from the Netherlands. Third, we analyse bilateral royalty data between 2014 and 2019. Dudar et al. (2015) focus on 2006-2012 data, a period in which bilateral royalty data were hardly available. We use a richer dataset with more reporting countries. Fourth, we are the first to estimate the impact of tax planning on the size of bilateral royalty flows.

We proceed as follows. Section 2 discusses possible tax planning gains for multinational firms using royalties, and distinguishes between direct planning gains and treaty shopping gains. It also introduces the network analysis on treaty shopping and the required tax parameters. Section 3 presents the outcomes of the network analysis on royalty flows in terms of tax gains, and identifies the main conduit countries. Section 4 explains how we disentangle tax-motivated and business-motivated royalty flows, and discusses the econometric strategy and data. Section 5 presents the estimation results, including estimates on the share of royalty flows motivated by tax planning. Section 6 concludes.

2. Tax gains with international royalties: definition, network analysis and tax parameters

The strategic tax planning of MNEs has two parts. First, MNEs may shift the final IP rights into a jurisdiction with a low or even negligible CIT rate. Second, given the source country of the user and residence country of the final IP rights, sub-licensing of the IP rights in conduit countries might minimize taxation of the royalty flow. We label the tax gain from IP shifting as a direct tax planning gain (DPG), and the gain from treaty shopping as a treaty shopping gain (TSG). The definitions of both tax gains are given below.

2.1 The tax gains of strategic IP location

2.1.1 Direct tax planning gain[8]

Corporate income is generated by an entity in source country S. This country levies a CIT rate of t_S. The entity has used IP rights owned in residence country R, which levies a CIT rate of t_R. This will lead to an income flow x from country S to R as remuneration for the use of these IP rights . In most cases the royalty payments made will be deductible from the CIT base in country S.[9] This implies a tax saving of $t_S x$. Source country S may levy a non-resident WHT w_{SR} on the income flow to country R. This gives a net flow of $(1-w_{SR})x$. Next, this flow will be subject to corporate income taxation in country R in most cases: $t_R(1-w_{SR})x$. The net tax savings of a royalty flow from country S to R, instead of profit income being taxed in S, equals: $t_S x - w_{SR}x - t_R(1-w_{SR})x$, or $(t_S - t_R - (1-t_R)w_{SR})x$. Clearly, there will only be a positive tax gain when the CIT rate in the source country is higher than that in the residence country, but the WHT rate matters as well. Residence country R may credit $w_{SR}x$ against taxes due in R as a form of double-tax relief. For passive income, like royalties and interest, crediting is the most common relief method. So, assuming that the CIT rate in the residence country is higher than the WHT rate of the source country, the tax savings are $(t_S - t_R)x$. When the net tax savings are positive, we call this a *direct tax planning gain*. This gain is relative to the situation where the IP would have been located in the source country.

Table 2.1 lists the taxation for three forms of double-tax relief systems - exemption (no taxation in R), credit and deduction (no taxation over the taxes already paid).

Table 2.1 Taxation on the direct route from source country S to residence country R

Tax relief in R	
Exemption	w_{SR}
Credit	$\max\{w_{SR}, t_R\}$
Deduction	$w_{SR} + (1-w_{SR})t_R$

[8] This section follows closely Lejour et al. (2022).
[9] This works in a similar way for interest flows.

2.1.2 Treaty shopping gain

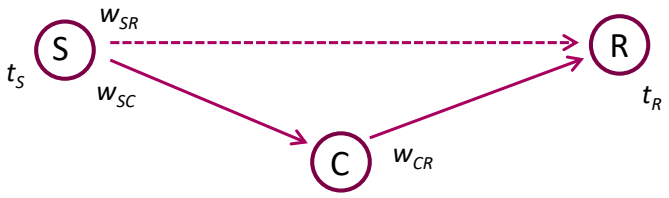
Royalty payments can be both directly paid by an entity of an MNE in country S to an entity of the same MNE in R, and indirectly via a holding company in another country, C - see Figure 2.1. Country C could levy CIT, because in principle royalties are taxable foreign income. However, we assume that it will immediately be deducted as it flows to a next destination country R. There will be no tax relief in the conduit country for the WHT paid in the source country. In addition, w_{CR} for royalties is often zero in conduit countries.[10] The multinational still pays w_{SC} because only taxation in the preceding country can be credited, as shown below. We define the *treaty shopping gain* (TSG) as the difference between taxation on the direct route and the indirect route for a country pair. In both bases there may be tax savings ($t_S x$), because the royalty payments are deductible from the tax base in source country S. These savings drop out in the difference.

Table 2.2 Taxation on the indirect route from S via C to R

Tax relief in R	Taxes on the indirect route	with $w_{CR} = 0$
Exemption	$w_{SC} + (1 - w_{SC}) w_{CR}$	w_{SC}
Credit	$w_{SC} + (1 - w_{SC}) \max\{w_{CR}, t_R\}$	$w_{SC} + (1 - w_{SC}) t_R$
Deduction	$w_{SC} + (1 - w_{SC})(w_{CR} + (1 - w_{CR}) t_R)$	$w_{SC} + (1 - w_{SC}) t_R$

The total tax planning gain (TPG) equals the sum of the direct tax gain and treaty shopping gain (TPG = DTG + TSG). A comparison of Tables 2.1 and 2.2 shows that differences in non-resident WHTs are paramount in determining treaty shopping gain - the conduit entity, which holds the IP sublicense, will be located in a country with which the source country has concluded a bilateral tax treaty with a reduced, or even zero, WHT on royalties.

Figure 2.1 Indirect royalty flow with one conduit country



2.2 Network analysis[11]

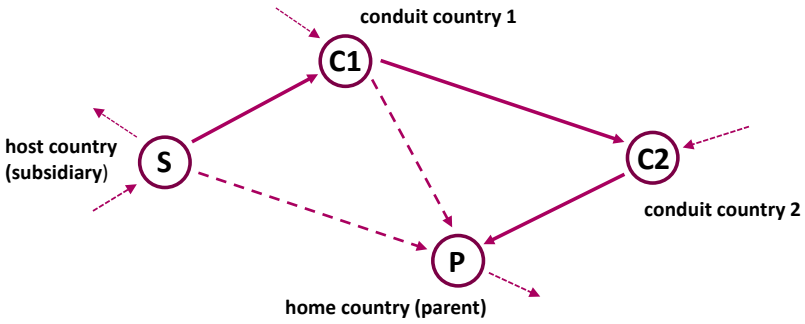
The network analysis looks at *treaty shopping* in a wider network. It considers the international tax system as a transportation network, and computes the 'shortest' routes that minimise the taxes that MNEs need to pay on repatriation of income. This income may be distributed as dividends, interest payments, or payments for the use of IP (royalties). The tax 'distances' are constructed from the rates of CIT, non-resident WHTs, and double-tax relief systems. Of particular interest are bilateral tax treaties with reciprocal reduction of WHT rates. The MNEs can reduce the taxes on their repatriated

[10] Observe that the tax will be identical in the credit and deduction cases when $w_{CR} = 0$.

[11] This section relies on earlier published work, in particular van 't Riet and Lejour (2018).

income by choosing the 'cheapest' route over the network. This could be a direct route, or an indirect route via a conduit entity residing in a third country, a conduit country. In the latter case we speak of *treaty shopping*. Optimal indirect routes - treaty *shopping routes* - may have more than one conduit country. This is depicted in Figure 2.2 for a case of two conduit countries. We use this figure to illustrate the basic idea of the network analysis.

Figure 2.2 Treaty shopping with two conduit countries



Consider the repatriation of corporate income from subsidiary S to parent company P. This income may be directly repatriated incurring a combined (per unit) tax cost of $t_{S,P}$. This tax may consist of a withholding tax levied by the host (S) and the corporate income tax in the home country (P). Alternatively, the income may be routed through a conduit country (C1), with a combined tax rate of $t_{S,C1,P}$. The latter rate may be less than the rate for direct repatriation - for instance, because of a double-tax treaty between countries S and C1, which stipulates a reduced WHT rate. Next, a repatriation route involving a second conduit country (C2) may be even more advantageous to the MNE - when $t_{S,C1,C2,P} < t_{S,C1,P} < t_{S,P}$. Ultimately, the entire network can be searched to find the cheapest tax route between a given pair of countries.

The number of possible routes over a network of more than 100 countries is huge, and it is almost impossible to examine them all. Fortunately, there are elegant and efficient algorithms from graph theory that can determine the shortest paths.[12] We apply an adapted version of such an algorithm to find the optimal tax routes. An optimal route may be direct, without intermediate stations or conduits, or indirect. The length of the optimal routes is an outcome of the algorithm.[13] Next, we assume that the MNEs structure their financing so that these tax-minimising routes will be used.

The network analysis was first developed for dividends distributed in international participations (van 't Riet and Lejour, 2018). With the original network of 108 jurisdictions, treaty shopping leads to a potential reduction of the worldwide average of taxes on repatriated dividends of about 6%-points. Moreover, van 't Riet and Lejour (2018) use a centrality indicator to identify the countries most used as conduits for dividend repatriation. Based on 2013 data these are the United Kingdom

[12] The first and most famous of these is from Dijkstra (1959). The Floyd-Warshall algorithm is an extension of the Dijkstra algorithm, and computes the shortest paths for all pairs of nodes of the network – see, for instance, Minieka (1978).

[13] This is in contrast with some 'brute force' algorithms, which use a fixed maximum number of conduits - such as Hong (2018) and Petkova et al. (2020).

(UK), Luxembourg and the Netherlands. The original analysis has been adapted to accommodate bilateral royalty flows. Royalty payments can immediately be deducted from the tax base and hence will not be taxed, whereas this is different for distributed dividends.

From the network analysis follows the (optimal) treaty shopping gain - TSG(i, j) for each country pair. This is the essence of the network analysis. Based on the bilateral TSGs, we compute the world average potential for tax reduction by optimal sub-licensing of IP rights. For this we weight the individual country pairs. While for dividend repatriation we use double-GDP weights, we argue below that it is better to use different weights for royalties.

For each individual country pair (i, j), which we refer to as 'links' in the network, we calculate how often it is used on all optimal routes, LNK(i, j). More importantly, it shows if the link is not used at all, only used for direct flows, or is also used on treaty shopping routes. We use this indicator to distinguish between only business motivated and business- and tax-motivated royalty flows - LNK(i,j) correlates with TSG; TSG(i, j) > 0 implies LNK(i, j) = 0 ; optimal tax routes will never use this link.

Moreover, the network analysis generates the world average double-counting factor of royalty flows with optimal treaty shopping. Any data on bilateral royalty payments are likely to suffer from a degree of double counting. The same phenomenon appears in international trade with re-exports and foreign direct investment (FDI) (Damgaard et al., 2019).

Weights for royalties

The results of the network analysis are presented at three levels - world, country and bilateral levels. There are 112 x 111 = 12,432 bilateral links. This high number makes aggregation of the results unavoidable, and for this we use weighted averages. Van 't Riet and Lejour (2018) apply double-GDP weights; 100 units are distributed over the N countries according to their share in total (world = N) GDP. Next, for each of these N source countries they determine the flow to each of their (N-1) destinations, again proportional to GDP. The motivation is that the economic relevance between large economies, say the US and Japan, is more important for dividend repatriation than a link between two small economies. One could argue that bilateral FDI data should be used as weights, instead of GDP. However, these statistics contain the double counting of FDI stocks due to treaty shopping. Because tax havens dominate the top rankings of FDI, these weights would severely bias the presentation of the outcomes.[14]

Not all country pairs are relevant for shifting IP rights. Royalty payments are preferably deducted in countries with a high statutory tax rate, while the payments are supposed to end up in low-tax jurisdictions where the IP rights are "owned". This suggests an alternative weighting scheme for royalties. This weighting (wTPG) only has positive weights for those country pairs (A,B) for which there is a positive total tax gain - TPG(A,B) > 0. We assume here that the MNEs structure their IP rights so that the resulting payments do not incur an avoidable tax loss. We combine this condition with the economic relevance of source country A - GDP(A). Finally, the greater the total potential tax

[14] Our definition of tax havens consists both of low-tax jurisdictions, such as Bermuda and the British Virgin Islands, and conduit countries, such as Luxembourg and the Netherlands. For the econometric analysis we use the list of Tørsløv, Wier and Zucman, 2023 (TWZ). Earlier we applied the list of Gravelle (2013). The most important difference between the two is that TWZ includes Belgium and the Netherlands, whereas the Gravelle list does not.

gain, the greater the incentive to shift profits, and hence the weights. All this amounts to: wTPG(A,B) = TPG(A,B)*GDP(A) for the non-zero weights, scaled so that the sum equals one.

The impact of the weighting scheme is illustrated in Table 3.1 below by comparing the aggregate outcomes of the network analysis with double-GDP (2GDP) weights with the wTPG weights introduced above. Observe that for our econometric analysis we do not depend on the weights, as we only use bilateral tax variables.

Table 2.3 gives an overview of the tax variables. The bilateral WHT rate, bilateral direct tax gain (DPG), and bilateral treaty shopping gain (TSG) are explanatory variables in the regression analyses.[15] Link use (LNK) is not an explanatory variable, but is used to define a subset of the non-tax-motivated observations for the regressions.

Table 2.3 List of tax variables

Tax variable	Description	Equation	Regression
CIT_A , CIT_B	CIT rate in source A, residence B		
WHT_{AB}	WHT on outgoing royalty flows		Yes
TAX_{AB}	Tax on the direct route from A to B	See Table 2.1	
TAX_{ACB}	Tax on the optimal indirect route from A to B	See Table 2.2	
DPG_{AB}	Direct tax Planning Gain	= CIT_A - TAX_{AB}	Yes
TSG_{AB}	Treaty Shopping Gain	= max(TAX_{AB} - TAX_{ACB}, 0)	Yes
TPG_{AB}	Total tax Planning Gain	= DPG + TSG = CIT_A - TAX_{ACB}	
LNK_{AB}	Link use		

We use statutory (nominal) CIT rates rather than effective CIT rates in the calculation of tax burden for two reasons. First, as we are mainly interested in the routing decision for repatriating income given the ultimate host and home country, statutory or effective rates of both countries hardly affect the comparison. The second reason for not using effective tax rates is that these are simply not available for all countries in our data. For countries with IP boxes, we use these tax rates on royalty income instead of the CIT rate. These tax rates are substantially lower - see Shehaj and Weichenrieder (2021) for an overview. Note that for intermediate countries the flow is taxed when coming in to the country, and deducted from taxable income when it goes out. As the tax payments and deductions cancel each other out, neither the effective nor statutory rate is relevant.

2.3 Tax parameters

Tax rates are obtained from the International Bureau of Fiscal Documentation (IBFD). This was done for two reference years - 2013 and 2017/18. Data was first collected for the set of 108 jurisdictions used in the network analysis of van 't Riet & Lejour (2018), and later extended with four developing countries.[16] Together these countries cover more than 95% of world GDP, and a substantial number of countries are classified as tax havens.

We obtain three tax parameters by country and reference year. First, the CIT rate comes from the OECD tax database, and we chose the highest rate in case of multiple rates (see Annex A). However,

[15] From various econometric specifications we conclude that the results with DPG or TPG as explanatory variable are similar. We prefer to use DPG, because we can combine this with TSG and ignore TPG in the remainder.

[16] Bangladesh (BGD), Ethiopia (ETH), Uganda (UGA) and Zambia (ZMB).

for 22 countries with an IP or patent box tax regime we have collected these lower rates from Shehaj and Weichenrieder (2021) - see also Annex A. Combined with the other rates, this provides an alternative parameter set. Next, for royalties there are the default (standard) rates of non-resident withholding tax (see Annex A). These rates may vary by sector, where we have selected the most general one. Finally, countries have unilateral double-tax relief methods.

Most of the tax rates are bilateral. In double-tax treaties, countries often agree mutual lower tax rates than their default WHT rates. Reduced rates are sometimes conditional, again by sector or ownership. Without further information, and to keep computations manageable, we have applied the following heuristic to select one tax rate per country pair and income type. We take the one-but-lowest rate, because the lowest rate is often only applied to specific sectors. We have implemented the EU Interest and Royalties Directive (EU, 2003). This implies zero WHT rates and full double-tax relief on intrafirm flows between EU member states. On average, countries have 56 treaties with other countries in this sample.[17]

As an introduction to these tax rates, we give the world averages for the two reference years. The first two columns of Table 2.4 shows the GDP-weighted world averages for the CIT rate, default WHT rate, and bilateral WHT rate on royalties. We observe that the average tax rates are only slightly lower in 2017 compared to 2013. The fourth column presents unweighted averages for 2013. These rates are much lower given the high GDP-weight of the US and its high tax rates; the US CIT rate is 39% in 2013, and its default WHT rate on outgoing royalties is 30%.

Table 2.4 World average CIT and default withholding rates in our sample (in %)

	2013	2017	2013
Average	**Weighted**		**Unweighted**
CIT	29.9	29.7	22.6
Default WHT on royalties	21.0	20.3	14.5
Bilateral WHT on royalties	9.3	9.0	13.1

Source: IBFD and own calculations.

The level of the bilateral WHT rates is obviously much lower than the default rates, because of the mutually agreed reductions in the tax treaties. The level of the unweighted average is higher than the weighted average, which implies that larger economies have agreed on larger reductions of the WHT rates in treaties than smaller economies. This is confirmed by the bilateral rates of the US.

There is a large variation in WHT rates on royalties. Argentina levies a standard rate of 35%, Jamaica and France a rate of 33.3%, and Australia, Peru and the US have a standard rate of 30%. Twenty-six countries, in particular tax havens, do not levy WHT at all. The bilateral WHT rates are much lower, but the variation remains.

[17] The number or relevant double-tax treaties by country is also presented in Annex 1. Relevant implies the number of tax treaties with the other 111 countries in the sample.

3. Results of the network analysis

In this section we present the tax gains from international royalty flows that would result from optimal sub-licensing by MNEs. We express these gains as tax rates, as percentages of the size of the flows. For example, if sub-licensing in a conduit entity in a third country implies that only 9% tax is paid instead of 25%, the gain is 16%-points.

3.1 Direct Tax Planning Gain

The direct tax planning gain (DPG) is, strictly speaking, not an output of the network analysis. It follows from calculations with the CIT rates, IP box rates, bilateral WHT rates, and respective double-tax relief systems - see Table 2.1.

When we ignore WHT, the direct planning gain from country A to B is the opposite of the gain from country B to A.[18] The world average of DPG would be zero. However, WTH rates and double-GDP weights (2GDP) are not symmetrical. The actual world average DPG we find is -0.64% - see the first column of Table 3.1. This small negative number hides large tax benefits from possible profit shifting between specific country pairs. Examples are France to the United Arab Emirates with 33.3%, New Zealand to the Bahamas, Bermuda, Cayman Islands or the British Virgin Islands with 28%, Luxembourg to the same 4 jurisdictions with 27%, and Germany to Hungary with 22%. Because we are mainly interested in cases with positive overall tax planning gains, we use the wTPG weights, discussed in Section 2, for calculating average gains from IP shifting. These weights deliver a more significant world average DPG of 7.6%.

Table 3.1 Results of the network analysis for 112 countries using 2018 data

TAX RATES WITH IP BOX	**NO**	No	**Yes**	**Yes**
Weights	*2GDP*	*wTPG*	***2GDP***	***wTPG***
	(1)	(2)	**(3)**	**(4)**
Direct Planning Gain	**-0.64**	7.60	**-1.44**	**7.56**
Direct routes (% tax)	25.99	21.03	**21.75**	**18.88**
Optimal routes (% tax)	25.28	12.62	**20.68**	**9.18**
Treaty Shopping Gain (% tax)	0.71	8.41	**1.07**	**9.70**
Optimal indirect routes (% country pairs)	24.3	'34.1'	**28.9**	**'40.2'**
Factor of double counting	1.09	1.60	**1.14**	**1.70**
1 of top 5 conduits	RUS	CHE	**CHE**	**CHE**
2 of top 5 conduits	CHE	SWE	**RUS**	**SWE**
3 of top 5 conduits	NLD	NLD	**SWE**	**NLD**
4 of top 5 conduits	SWE	RUS	**NLD**	**NOR**
5 of top 5 conduits	NOR	NOR	**NOR**	**ESP**

Source: outcomes of the network analysis.

The third and fourth columns present the results of the network analysis using the CIT rates of the IP boxes instead of the statutory CIT rates. At first sight, the result that DPG outcomes hardly change with the IP box rates may be surprising (compare columns 2 and 4). Consider three countries with CIT rates of 30%, 20% and 0%. The average direct gain that can be realized, for positive gains, is (10% + 30% + 20%)/3 = 20%. When the second country introduces an IP box with a reduced CIT rate of 5%,

[18] DPG(A,B) = CIT(A) – CIT(B) = - { CIT(B) – CIT(A) } = - DPG(B,A), when ignoring withholding taxes.

we have the following (positive) gains: 25% + 30% + 5%. The average gain over the three pairs is again 20%, but it is different for the individual country pairs.

3.2 Treaty Shopping Gain

Taxation can be reduced or avoided by sub-licensing to a country that agreed a lower bilateral WHT rate with the source country, preferably zero. Another attractive feature is when the conduit country does not levy WHT, even to tax haven jurisdictions with no tax on foreign corporate income. Table 3.1 shows the world average tax rates on the direct routes and optimal routes. The difference is the (world average) treaty shopping gain.

For royalties the treaty shopping gain is only 0.7%-point with double-GDP weights. This is much lower than the 4%- to 5%-point for dividends (van 't Riet and Lejour, 2018). To explain this result we first observe that royalty flows are mainly taxed in the residence country, while outgoing dividend flows are mainly taxed by the withholding tax in the source country.[19] This follows from applying the relief systems for double taxation, and the fact that usually the CIT rate in the residence country is higher than the WHT rate in the source country. Crediting is by far the dominant double-tax relief system for royalties; whereas for dividend often exemption is applied as double-tax relief. So, with credits for paid WHT on royalties, there remains CIT in the residence country. On a different route with lower WHT rates the size of crediting is also lower, and total taxes remain the same. This implies that TSG could only occur in situations where the WHT rate is higher, or when there is no tax relief. We find that an indirect route is optimal for royalty flows in only about a quarter of all country pairs (24.3%), whereas for dividends it is the case for two-thirds of them (van 't Riet and Lejour, 2018). Most optimal indirect routes have only one conduit country; in about one-sixth of these routes two conduit countries are used.

The aggregated outcomes change with the wTPG weighting scheme, where we consider only country pairs with advantageous IP shifting. This is reflected in DPG of 7.6%; the potential TSG rises to 8.4%, and 9.7% with IP box rates. This illustrates, again, that the strategic location of IP rights, in combination with (optimal) sub-licensing, may lead to substantial tax gains.

Treaty shopping leads to double counting of flows, because every country registers its incoming and outgoing income flows; 1.00 suggests no double counting. With the double-GDP weights, it is 9% on top of the regular flows; with wTPG weights it is 60% (see column 2 of Table 3.1).

Next, we inspect the ranking of conduit countries. Switzerland and the Netherlands could be expected to be at the top of this ranking as they do not levy WHT on outgoing royalty flows. The same applies to Sweden and Norway. The high position of Russia is due to its favourable treaties with reduced WHT rates, often lower than their treaty partners agree with other jurisdictions. The prime example is China, which applies a rate of 6% on outgoing royalties to Russia instead of its default rate of 10%. As China is the second economy in the world it has a high weight in the country ranking. With the alternative weights, and application of IP box rates, Spain – which does have an IP box – enters the top 5 of conduit countries.

All combined, we conclude that there is ample opportunity for tax gains to be made with international royalty flows.

[19] We assume that for dividends the CIT in the source country is levied both on the direct route and on a possible indirect route, and therefore plays no role in the treaty shopping gain.

3.3 Tax gain characteristics of country pairs

Table 3.2 summarizes the outcomes of the network analyses in a different way. It shows that TSG is positive for almost 30% of the 12,432 country pairs. For optimal routes over the tax network this implies that these direct routes between the country pairs (links) will not be used at all – at least not for tax planning. This can be seen in the first row of Table 3.3. The sum of the values exceeds 100 in Table 3.3, implying double counting. The double-counting factor over the whole network is 1.14 (column 3 of Table 3.1). These tax gain characteristics of country pairs will be used to disentangle tax- and business-motivated flows in Section 4.

Table 3.2 Country pairs

	DPG<=0	DPG>0	DPG
TSG>0	2452 (19.7%)	1142 (9.2%)	3594 (28.9%)
TSG=0	5457 (43.9%)	3381 (27.2%)	8838 (71.1%)
TSG	7909 (63.6%)	4523 (36.4%)	12432 (100%)

Source: IBFD data and own calculations.

Table 3.3 Optimal link use

	DPG<=0	DPG>0	DPG
TSG>0	-	-	-
TSG=0	60.37 (53.1%)	53.35 (46.9%)	113.72 (100%)
TSG			

Source: IBFD data and own calculations.

4. Identifying business- and tax-motivated flows, econometric strategy and data

4.1 Business- and tax-motivated royalty flows

Based on the tax gains determined in Section 3, we can identify the underlying motives of (observed) royalty flows between two countries - see Table 4.1. For country pairs without a direct tax planning gain (DPG ≤ 0), IP shifting cannot be a motive for the royalty payment since the profit-maximising MNE would incur a tax loss on a flow between these countries. By the same reasoning, an observed flow for a country pair with a positive TSG cannot be a motive for treaty shopping, as a detour would bring a tax advantage.

Table 4.1 Underlying motives for royalty flows

	DPG<=0	DPG>0
TSG>0	only business reasons	business reasons and profit shifting
TSG=0	business reasons and treaty shopping	business reasons, treaty shopping and profit shifting

Note: The shaded cells identify the conditions for flows with business and tax motives (BTM).

The size of an observed royalty flow could also be affected by multinationals using the country pair as part of a treaty shopping route with other jurisdictions. This is captured by the two bottom cells

of Table 4.1. Then the size of the royalty flow between two jurisdictions is not only affected by business motives or IP shifting, but also by treaty shopping. This only makes sense when there is not a cheaper indirect route between these two jurisdictions - so TSG = 0.

The resulting schedule in Table 4.1 represents our analytical framework for the regression analysis. The left-upper corner in the table contains the bilateral flows for which no tax motives are identified, which we refer to as *Only* Business Motivated (OBM). The other three (shaded) cells in the table allow for Business *and* Tax Motives (BTM). Depending on a country's economic and institutional characteristics, some royalty flows will be mainly business-motivated and others will be mainly tax-motivated.

4.2 Econometric strategy

There is hardly any research on the impact of taxation on bilateral royalty flows, apart from Dudar et al. (2015) and Lejour et al. (2022). The first uses bilateral WHT on royalties from the OECD and CIT rates as explanatory variables, among others, and the latter uses bilateral data for the Netherlands. We measure the tax motives of multinationals by using the direct planning gain (DPG), which is the bilateral tax rate differential between the host and home country, as presented in Section 2. Overesch and Wamser (2014) use a similar tax differential for the impact on interest flows and internal debt lending, irrespective of treaty shopping.

Apart from DPG, we also want to estimate the impact of treaty shopping on bilateral royalty flows. However, we have to be aware that bilateral royalty data represents by definition a 'link' and not a 'route' in terms of the network analysis. The variable TSG in the network analysis represents the gain of an indirect route (on top of the direct route) that could be reaped from a first, second or further link at this route, or even by combining these links. Any observed flow between two countries could thus reflect a direct route between the source and residence country, a link between the source and conduit country, a link between two conduit countries, or a link between the conduit and residence country.

Most studies with annual bilateral data use panel regressions to exploit the time variation by country pair, as is done in bilateral trade and FDI literature,[20] and by Dudar et al. (2015) for bilateral royalty flows. These are often gravity models and use economic variables of both countries (such as GDP, trade openness, and institutional quality), and bilateral variables (such as distance and a common language) as explanatory variables for explaining bilateral trade or FDI flows over time. We think this is not the most fruitful approach in the current setting for two reasons. First, the magnitude of the bilateral flows depends heavily on the relative attractiveness of other routes. This determines whether a multinational firm uses a direct route or an indirect route via other links (treaty shopping). This suggests that the variation between the flows of various country pairs is most relevant for identification.[21] Therefore we do not use fixed effects for the country pairs, but only for individual countries. Second, the variation in WHT and DPG rates is limited over time, and the identification of tax havens remains the same over time. For these reasons, we focus on cross-country regressions. Our main specification reads as:

[20] See the overview of Head and Mayer (2014).

[21] In the bilateral trade literature this is captured by multilateral trade resistance terms derived from a theoretical model (Anderson and van Wincoop, 2004).

$$Flow_{ijt} = \alpha_0 + \alpha_1 G_{it} + \alpha_2 G_{jt} + \alpha_3 G_{ij} + \beta_1 TH_{it} + \beta_2 TH_{jt} + \beta_3 DPG_{ijt} + \\ + \beta_4 WHT_{ijt} + \gamma_{1t} YR_t + \varepsilon_{ijt} \quad (1)$$

Flow is the size of the royalty payments between countries i and j in year t. The holding companies of multinationals in country i have used the IP rights, and pay for the use of these rights. The holding companies of the multinationals in country j own the IP rights and receive the payments. Using the terminology of services trade, country i is the importing country. The holding companies in country j are not necessarily the headquarters of the multinationals. The official headquarters and the holding company owning the IP rights can be located in different jurisdictions, possibly to exploit treaty shopping gains. This is often the case if IP rights are stored in tax havens.

The vectors G_i and G_j refer to country-specific variables. These are GDP, GDP per capita, trade-to GDP and institutional quality. We expect that a higher GDP leads to greater royalty flows because the economy is larger. This is also the case for GDP per capita and trade openness. For institutional quality we use the rule of law indicator from the Kaufman dataset (World Bank). A higher indicator reflects more institutional quality, which indicates a higher probability of contracts being respected.

The vector G_{ij} represent bilateral data, such as distance between both countries, a common border, common language, former colonial relationship, common membership of a former country (such as Yugoslavia and the Soviet Union). These time-invariant data are from the *CEPII* database (Conte et al., 2022). We also add an EU dummy when both countries are members of the EU.[22] This dummy reflects the idea that multinationals are more willing to shift IP rights, because these rights are better protected and could be better enforced due to the juridical institutions of the EU with its European Court of Justice.[23]

We add dummy variables for tax havens (*TH*), for which we expect a positive coefficient. This dummy reflects other reasons than direct planning gain for the attractiveness of tax havens. It could be that IP rights are stored there for tax benefits that relate to other countries than this country pair, an attractive investment treaty or business law, or other business services present in the tax haven. These dummies are based on the TWZ list, which is time-invariant. The variable DPG_{ij} is the relative direct tax planning gain, defined as DPG of the country pair, divided by the average direct tax planning gain. We use the relative DPG instead of the absolute DPG, because firm behaviour is not only affected by the possible tax gain at the bilateral level, but also by the possible tax gains via other countries. Because the average DPG is negative (see Table 4.4) we expect a negative sign, suggesting that larger absolute tax planning gains have a positive effect on the royalty flow. WHT_{ij} indicates the relative bilateral WHT on royalties as an indicator of the attractiveness of the link for treaty shopping. It is defined as the WHT of the country pair divided by average WHT. If the WHTs between other country pairs are much higher, it is more attractive for multinationals to use the current, *ij,* country pair for IP shifting. If the WHTs between other pairs are much lower, it is not attractive to use the current pair. Using relative tax costs in the gravity equation is comparable to using relative trade costs for bilateral trade, as is standard in the bilateral trade literature (Anderson and van Wincoop, 2004). The multinational in country i has to pay this withholding tax for royalties

[22] We do this for the years 2014 to 2019, so the UK counts as an EU member.

[23] Note that the dummy does not reflect the Interest and Royalty directive, because the zero rates of bilateral WHT and double-tax relief for intra-firm royalty payments are already included in DPG and WHT.

destined to country j. If the tax rate is high, the direct link is not very attractive for treaty shopping. Because we pool the data between 2014 and 2019, we also use year dummies,YR, in the cross-country regressions.[24] Moreover, in various specifications we include dummies for the countries paying and receiving the royalty flow. The summary statistics are shown in Table 4.4 below.

We analyse the bilateral royalty flows in a gravity framework. We use the PPML estimator because of the zero values for royalty flows. We can also deal with the zeros using a transformed logarithmic function, but there could be collinearity between the explanatory variables and the truncated error distribution. Therefore, Santos Silva and Tenreyro (2006) propose PPML.

4.3 Bilateral royalty data

The bilateral royalty data are derived from the OECD database on International Trade in Services. The data are gathered by national statistical offices using the Extended Balance of Payments Services (EBOPS) classification. We use the category *Charges for the use of intellectual property n.i.e*.[25] In addition to this category, EBOPS classifies the sale of proprietary rights arising from R&D separately (SJ112). This includes patents, copyrights arising from R&D, industrial processes and designs, and other sales of proprietary rights. Because only a few countries report these data we ignore these, and focus on the data of the first category.[26] The data include inter- and intra-firm flows, but these are not separately identified.

Annex Figures B1 and B2 show charges paid and received for the use of IP rights.[27] These figures show a steep rise in totals between 2009 and 2014, when 13 additional countries start to report according to the new EBOPS classification in 2010.[28] There is also an increase in 2014, when the Netherlands, Japan and some other countries start to report. The figures also show that royalty payments are dominated by the US, in particular for exports. Although only OECD countries report royalties, the reported data cover most of the global flows. According to the World Bank, charges-paid amount to 430.7 billion US$ in 2018, and charges-received to 397.6 billion US$ globally. The OECD totals for reporting countries are 358.9 billion US$ and 381.0 billion US$, respectively. Because the reporting countries are also the largest and most R&D-intensive economies, the reporting gap in charges-received is only 4%. For charges-paid, the reporting gap is 17%. The main reason is that the OECD statistics do not include reporting middle-income countries, because most of these countries are not members of the OECD.

[24] Except a year dummy for 2014 because of the constant term included in equation (1).
[25] The phrase n.i.e. (not identified elsewhere) is misleading for this category. Often this phrase identifies a rest category, however for remunerations for use of IP n.i.e. includes nearly all international payments - franchises and trademarks licensing fees, licenses for the use of outcomes of research and development, licenses to reproduce and/or distribute computer software, and licenses to reproduce and/or distribute audio-visual and related products.
[26] Annex Table B2 presents the number of observations for each service category by year.
[27] In the services trade literature, countries using IP rights are importers, and countries licensing their IP rights are exporters. In this paper we call these countries as paying and receiving countries. The paying country is the source country, where the IP rights are effectively used. The receiving country is the residence country of IP rights. Due to treaty shopping either or both countries could be a conduit country.
[28] Before 2010, nearly all countries followed the EBOPS 2002 classification. For many service categories the difference in EBOPS classifications are minor, but this is not the case for international IP payments. Therefore the data of both classifications cannot be linked. We only use data from 2014 to 2019, as we have most observations for these years due to a higher number of reporting countries.

At the bilateral level, the 25 largest flows are dominated by the US as recipient and paying country – see Annex Table B1 for these in 2018. There are some exceptions, such as export flows from the Netherlands to Ireland, and corresponding charges-paid for the use of IP by Ireland to the Netherlands, which illustrate the well-known double Irish-Dutch sandwich. In addition, we notice large flows between other large economies like Japan, China, and Germany. The variation in the size of the flows is very large. Whether these royalty flows are paid or received, the ten largest flows account for about 25% of the total reported value. In the empirical analysis we also run regressions without the largest flows to check the impact of these flows on the robustness of the results.

OECD countries report data on charges-paid and received for IP rights. In principle we have two reporting countries for charges between OECD countries. We use the charges-paid from reporting countries, because coverage between OECD countries is better. We add charges-received from other reporting countries if charges-paid is missing.[29]

We have about 2,000 country pairs and 10,500 observations of bilateral royalty flow data between 2014 and 2019. About half the observations are intra-OECD flows - the others are between a reporting OECD and non-reporting non-OECD country. There are about 130 different non-OECD countries, but almost all OECD countries only report royalty flows to a sub-set of these countries, and this varies over time.

Although world totals for reporting OECD countries seem to cover nearly all charges paid and received for use of IP, this is not the case for the reported bilateral flows. In particular, Ireland, Korea and the Netherlands report less bilateral flows (in value terms), see Table B3 in the Annex. Other OECD countries only report global paid and received charges for the use of IP-rights, but not data at the partner country level. Examples are Luxembourg, Singapore and the UK. Many other countries only report charges-paid and received to a limited number of countries - often the most important ones, which is administratively easier for statistical offices and firms that have to report. This suggests that the values of missing country-pair data for reporting countries are often low or negligible.

Table 4.2 Aggregate value of royalty flows, 2014 - 2019 (billion US$)

Year	All observations	<=4000	>4000	Tax haven >4000	Balanced
2014	280.7	167.7	112.9	47.0	268.9
2015	255.2	162.5	92.8	32.0	250.5
2016	288.1	168.5	119.6	59.0	251.7
2017	307.9	184.3	123.6	56.1	270.6
2018	335.9	191.3	144.6	81.1	289.7
2019	341.2	183.7	157. 5	88.6	296.0

Sources: OECD International payments in services, Tørsløv et al. (2023) for the tax haven definition, and own calculations.

The aggregate amount of royalty flows increases from 255 billion US$ to 341 billion US$ between 2015 and 2019 - see Table 4.2. This is mainly due to extra observations in these years, with relatively large flows. The increase in bilateral flows for which we have observations for all years is only by 46 billion US$ (column 'balanced'), instead of 86 billion US$ (column 'all observations'). We define flows

[29] Because we also use charges paid from non-OECD countries to OECD members, 61% of the observations are charges-paid and 39% are charges-received for use of IP rights.

as large if they exceed 4 billion US$ (column '>4000'). In particular, flows to tax havens have increased by 56 billion US$, as seen in Table 4.2 (column 'tax haven >4000').

The table indicates the sensitivity of including large flows that are only reported for a few years. These could have a large impact on the size of tax-motivated flows because they are mainly tax haven-related, suggesting that the share of tax-motivated flows could vary quite substantially over time.

Countries could also abstain from reporting because of confidentiality reasons.[30] Transactions with traditional tax havens like Bermuda, Channel Islands and the British Virgin Islands seem to be underreported. According to Bilicka et al. (2022), many MNEs use tax havens as a base for IP ownership, but this is not reflected in the reported charges-received in tax havens. Only Russia, and sometimes Canada and the US, report transactions to these havens. This implies that the famous double Irish-Dutch sandwich is only partially covered by the royalty payments from Ireland to the Netherlands, but not from the Netherlands to Bermuda, where the IP-IP rights 'resided' until 2020.[31] This lack of data is a limitation for the analysis and its conclusions. It will underestimate the predicted tax revenue loss from IP shifting. To get some understanding of an upper bound of tax revenue losses, we assume that the partner country of non-reported bilateral flows is a tax haven with zero tax rates in Section 5.3. This makes it possible to estimate the tax planning gains for the non-reported flows.

The data show large royalty flows to and from tax havens, most of them are also identified as conduit countries.[32] Tax haven countries pay 105 billion US dollar on charges-paid to other countries in 2018, see Table 4.3. Tax havens receive nearly 92 billion US$. This is a substantial share of the total amount of 336 billion US$. As paying country Ireland dominates the tax havens. Other important tax havens are the Netherlands, Switzerland, Singapore, Belgium and Luxembourg.[33] Not only in value, but also in the number of flows, these tax havens dominate the others. If the royalty flows to and from these countries are mainly driven by tax motives, a large share of the total flows is tax-motivated. The total reported flows to and from tax havens amount to 197 billion US$, about 60% of total flows. Because some of these tax havens are mainly conduits, there is a considerable amount of double counting involved. Assuming that all charges-received are already included in charges-paid, this is still 105 billion US$ - 32% of the total flow of 330 US$ (see Annex Table B3).

[30] If less than five multinationals report charges paid to or received from a country, totals are often not reported by statistical offices. This could be the case with more observations if one observation would dominate the aggregate flow.

[31] From other data sources we know that this specific flow amounts from 20 billion € to 25 billion € (see also Lejour et al. 2022), which covers a substantial part of charges-paid that are not reported at the bilateral level by the Netherlands.

[32] See Garcia-Bernardo et al. (2017), Van 't Riet and Lejour (2018) and Lejour (2021).

[33] Although Luxembourg, Singapore and other tax havens do not report bilateral charges for the use of IP, reporting countries mention these countries as partner countries. Because not all reporting countries include tax havens as a partner country, the size of royalty flows in Table 4. 3 are probably higher in reality, in particular for non-reporting tax havens. This could explain the high ranking for Ireland, the Netherlands and Switzerland in this list.

Table 4.3 Royalty flows and tax havens in 2018

Tax haven as paying country					Tax haven as receiving country				
Country	**Value royalties**	**Number of flows**	**Number TSG=0**	**Number DPG>0**	**Country**	**Value royalties**	**Number of flows**	**Number TSG=0**	**Number DPG>0**
Ireland	519976	30	30	3	Netherlands	40146	47	39	42
Netherlands	18307	45	45	3	Switzerland	22042	44	44	14
Switzerland	16732	41	41	28	Ireland	15105	32	30	27
Singapore	7561	20	19	1	Luxembourg	5712	23	21	21
Belgium	4221	35	33	3	Singapore	3951	20	16	13
Luxembourg	2829	22	22	2	Belgium	2680	39	35	32
Hong Kong	1880	32	11	10	Cyprus	989	20	20	16
Bermuda	1061	2	2	0	Hong Kong	968	25	20	9
Malta	343	12	12	12	Malta	138	16	16	0
Cyprus	286	16	16	4					
Panama	114	3	0	0					
Total	*105443*	*280*	*248*	*69*	*Total*	*91785*	*290*	*243*	*184*

Sources: OECD International payments in services, Tørsløv et al. (2023) for the tax haven definition, and own calculations. Note that totals are higher than the aggregation of the individual countries in the table, because tax havens with royalty values lower than 100 million US$ are included in the totals.

The other columns show some other characteristics of tax havens. For nearly all flows to and from tax havens, with the exception of flows from Hong Kong, there is no other tax-saving alternative. This is a plausible outcome, because tax havens would not be a conduit if there were other alternatives. Treaty shopping via tax havens is only attractive if there is also a direct tax planning gain to or from tax havens, which is quite often the case for royalty flows to tax havens.

Table 4.4 gives an overview of all observed royalty flows in 2018, characterized by possible tax gains. There is a possible tax gain by treaty shopping (TSG>0) for only 11.6% of reported country pairs. Considered by value of the flows, this share is even lower - 6.6%. This is also much lower than the 29% found in the network analysis (Table 3.2). The apparent behaviour shown in the reported number and value of the flows could be expected from profit-maximising multinationals. However, it is not zero which could be due to other business motivations.

Table 4.4 Number and value (billion US$) of observations in 2018

Number of flows	**DPG<=0**	**DPG>0**	**DPG**
TSG>0	122 (7.0%)	81 (4.6%)	203 (11.6%)
TSG=0	858 (48.9%)	693 (39.5%)	1551 (86.4%)
TSG	980 (55.9%)	774 (44.1%)	1754 (100%)
Value of flows	**DPG<=0**	**DPG>0**	**DPG**
TSG>0	15.6 (4.7%)	6.7 (2.0%)	22.4 (6.6%)
TSG=0	175.3 (55.2%)	138.1 (41.1%)	313.5 (93.4%)
TSG	190.9 (56.9%)	144.8 (43.1%)	335.9 (100%)

Source: OECD International payments in services and own calculations.

4.4 Summary statistics of all variables

The average payment between two countries for use of IP rights for the years 2014 to 2019 is 194 million US$. The variation is huge, ranging from 0 US$ to 17.5 billion US$ (in 2019). For flows that could be affected by business and tax motives (BTM), the average is a few million US$ higher than

those only motivated by business reasons (OBM) - see Table 4.5. This is also caused by the number of observations with zero values. Overall, the number of royalty flows with a zero value is underreported, because most reporting countries only report the charges to a limited number of partner countries to the OECD.

Table 4.5 Descriptive statistics between 2014 and 2019 for All, Only Business-Motivated (OBM) and Business- and Tax-Motivated (BTM) flows

Value	Unit	Mean	Mean	Mean	Min	Max
Selection of obs		**All**	**OBM**	**BTM**	**All**	**All**
Royalties	mln $	194.1	191.8	194.7	0	17454
dum_roy	0/1	.94	.90	.96	0	1
gdp_reci	trln $	1.88	2.49	1.71	0.00	21.37
gdp_cap_reci	thd $	35.1	27.0	37.4	1.25	123.7
trade_gdp_reci	ratio	102	67	112	0	426.0
Rule of law_reci		1.02	0.67	1.12	-2.32	2.13
Tax haven_reci	0/1	0.15	0.10	0.16	0	1
gdp_paid	trln $	2.02	3.09	1.71	0.	21.37
gdp_cap_paid	Thd $	37.7	34.9	38.5	1.3	123.7
trade_gdp_paid	ratio	199	78	105	0	426
Rule of law_paid		1.11	0.96	1.14	-1.05	2.13
Tax have_paid	0/1	0.15	0.07	0.18	0	1
Distance (log)	Km	8.03	8.52	7.9-	4.09	9.87
Same border	0/1	0.08	0.06	0.09	0	1
Former similar country	0/1	0.03	0.02	0.03	0	1
Former colony	0/1	0.05	0.05	0.05	0	1
Common language	0/1	0.10	0.12	0.10	0	1
EU pair	0/1	0.33	0.10	0.40	0	1
DPG	%-points	-0.92	-9.75	1.62	-41.2	32.0
WHT	%-points	5.80	12.04	4.01	0	35.0
TSG	%-points	0.88	2.55	0.39	0	33.3
TPG	%-points	-0.14	-7.20	2.01	-37.0	37.0
DPG_rel	Ratio	0.75	0.68	0.77	0	3.08
WHT_rel	Ratio	0.37	0.77	0.25	0	2.24
CIT_paid	%-points	19.51	18.10	19.91	0	46.0
CIT_reci	%-points	19.19	23.69	17.90	0	46.0
Observations	Number	8385	1872	6513	8385	8385

Sources: OECD database, WB Development indicators, CIA Factbook, IBFD data, CEPII (Conte et al., 2022), van 't Riet and Lejour (2018), Tørsløv et al. (2023). _paid is the importing country that pays for the use of the royalties, _reci is the exporting country that receives the royalty payment. The averages are based on a balanced sample between 2014 and 2019.

About 15% of the countries are a tax haven, according to the TWZ list. This is somewhat lower if royalty flows are not motivated by tax reasons (see the OBM column). This result is what we expect because tax havens, as pass-through or ultimate destinations, are important jurisdictions for holding IP rights for tax planning, but not for business, reasons. The average CIT rate is 19%. For paying it is 4.5%-points higher if the payments are only business-motivated.

The average direct tax planning gain is slightly negative, and the variation is large. For OBM flows there are, on average, tax losses of nearly 10%. The average treaty shopping gain is positive, but includes many zero values. In some cases TSG could be 30%. TSG is often related to the tax benefits of avoiding high WHT ratess - these vary between zero and 35%, with an average of 6%.

GDP and trade openness data come from the *World Development Indicators* of the World Bank. We sometimes add data from the *CIA Factbook* (CIA) and the *Penn World Tables* (GGDC, 2023) for some small tax havens. The geographic data come from *CEPII* (Conte et al., 2022). In 10% of the pairs countries have the same language, and in 5% of the pairs the countries had a colonial relationship. The rule of law indicator is from the World Bank, and is one of the Kaufman indicators measuring institutional quality. Because of the high correlation between these indicators, we only use one of them in the regressions. It is a composite indicator based on various characteristics of the rule of law, which could vary between 2.54 and -2.54. A higher value reflects higher institutional quality. Overall, it is higher for BTM flows than for OBM flows, as is also the case for GDP per capita and trade openness. According to economic theory, higher CIT rates correspond to larger and less open economies.[34] This is also what we observe in the data. At the other extreme we find small and open countries with negligible tax rates, which we call tax havens.[35]

5. Regression results and estimating tax-motivated royalty flows

5.1 Regression results of basic specifications

Table 5.1 presents the regression results of the PPML estimator for various specifications. The odd-numbered columns presents the regression results for the OBM royalty flows, and even-numbered columns the BTM flows. Columns (3), (4), (7) and (8) include tax variables - the relative direct planning gain and relative treaty shopping gain. The first four regressions do not include dummies for countries paying and receiving royalties, while the last four regressions do include these dummies. The gravity literature suggests a higher explanatory power with these country dummies. We use the regressions without country dummies as our point of departure, because they allow for a separate robustness analysis with a treatment model.

We compare the results in the uneven and even columns of Table 5.1 that distinguish between *only* business-motivated flows (OBM), and business- *and* tax-motivated flows (BTM). The main reason for doing this is that we think that different motives for royalty payments require different indicators in

[34] E.g. Bucovetsky (1991); Wilson (1991); Kanbur and Keen (1993).
[35] See among others Dharmapala and Hines (2009).

the regression. This distinction was also made in the summary statistics. The starting point is Table 4.1, where the various motives for royalty flows are presented. To isolate royalty payments without tax motives, we select a subset from the ones without direct planning gains. In that case IP shifting is no motivation for the payment. For the observations with treaty shopping gains, there are only business reasons for the flows. However, from Table 4.4 we know that there are only 122 observations in 2018. For the observations with TSG = 0, we know that the size of these flows could be affected by treaty shopping of other country pairs passing this link. However, the network analysis identifies that some of these links are not used at all on the optimal routes. These observations seem only business-motivated, and we add them to the subset OBM flows in the regressions.

The outcomes of the regressions with the subset with OBM flows is presented in column (1). The gravity framework with GDP and distance explains the variation of the flows very well. The pseudo R-squared is 0.65. This is similar for BTM flows in column (2). We see that coefficients of both specifications differ in size, significance and even direction. Interestingly, if the receiving country is a tax haven or has a low GDP per capita this hardly affects OBM flows, but is different for BTM flows. This reflects the fact that tax havens quite often host IP rights in the sample period.

Many other coefficients of the standard variables in the first four columns are similar. The coefficients of GDP are just about one, and statistically significant for both countries. The coefficient for the quality of rule of law is also positive, and significant in the country using IP rights. Tax-haven status of the paying country is also significant and positive, suggesting that there is sub-licensing in tax havens. The other gravity variable, distance between both countries, has the expected negative effect. A former colonial relationship, common border or common language do not have a positive significant impact on bilateral royalty flows in most cases - quite often it is negative.[36] Having been part of the same country in the past has a positive and sometimes significant effect on the flow. The EU dummy is positive and statistically significant with BTM flows.

In columns (3) to (4) we add the tax variables - relative DPG and relative WHT. This shows that a larger direct tax planning gain (DPG) has a significant positive effect on OBM flows (note that the average DPG < 0).[37] This effect weakens for BTM flows. The relative bilateral WHT has a negative significant effect on BTM flows, precisely what we expect MNEs would do for tax reasons.

[36] Dudar et al. (2015) also include R&D in the recipient country where IP rights are located. This has a significant positive impact on the size of royalty flows. This is also the case in our specifications. We do not present these because R&D data are not available for all countries in our sample, and this would substantially restrict the number of observations.

[37] Using a PPML estimator, Dudar et al. (2015) find that a 1%-point higher tax rate differential between the host and home country lowers the direct royalty flow by about 6%. Lejour et al. (2022) also use DPG in their regressions on indirect royalty flows, but only find a significant positive effect on the existence of the flow, but not on its size.

Table 5.1 Royalty flows in a gravity model, balanced sample, 2014 -2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Flows	OBM	BTM	OBM	BTM	OBM	BTM	OBM	BTM
Log gdp_paid	1.233***	1.197***	1.248***	1.180***	0.750**	0.126	0.752**	0.107
	(0.0483)	(0.0312)	(0.0508)	(0.0314)	(0.297)	(0.502)	(0.293)	(0.524)
gdp_cap_paid	-0.0215***	0.0221***	-0.0150**	0.0209***	-0.0327**	-0.00473	-0.0324**	-0.00429
	(0.00720)	(0.00207)	(0.00687)	(0.00212)	(0.0154)	(0.0103)	(0.0154)	(0.0106)
trade_gdp_paid	-0.00403**	0.00167**	-0.00373*	0.00178**	0.0188**	-0.00178	0.0190**	-0.00153
	(0.00184)	(0.000723)	(0.00197)	(0.000715)	(0.00750)	(0.00481)	(0.00754)	(0.00495)
Tax haven_paid	1.847***	0.869***	1.764***	0.817***	-0.427	1.807	-0.526	1.900
Dummy	(0.389)	(0.0850)	(0.405)	(0.0858)	(0.662)	(1.135)	(0.699)	(1.176)
rle_paid	1.500***	0.838***	1.379***	0.784***	-0.0419	-0.663*	-0.0373	-0.610*
	(0.174)	(0.0676)	(0.179)	(0.0632)	(0.441)	(0.355)	(0.439)	(0.352)
Log gdp_recei	0.755***	1.003***	0.770***	0.982***	0.467***	0.742**	0.480***	0.793**
	(0.0410)	(0.0295)	(0.0445)	(0.0273)	(0.0764)	(0.297)	(0.0791)	(0.309)
gdp_cap_recei	0.00779	0.0120***	0.0112	0.0104***	0.0193***	0.00909	0.0207***	0.00740
	(0.00890)	(0.00271)	(0.00818)	(0.00273)	(0.00522)	(0.00914)	(0.00659)	(0.00924)
trade_gdp_recei	0.000485	0.00209***	0.00109	0.00238***	-0.00372	0.00290	-0.00247	0.00240
	(0.00170)	(0.000613)	(0.00192)	(0.000648)	(0.00544)	(0.00389)	(0.00600)	(0.00375)
Tax haven_recei	0.646	1.122***	0.403	1.042***	0.568*	-1.125*	0.462	-1.444**
Dummy	(0.485)	(0.123)	(0.533)	(0.123)	(0.325)	(0.617)	(0.377)	(0.647)
rle_recei	-0.102	-0.0828	-0.0953	-0.109	-0.262	0.0101	-0.288	0.0143
	(0.234)	(0.0696)	(0.213)	(0.0698)	(0.310)	(0.165)	(0.314)	(0.162)
Log distance	-0.425***	-0.153***	-0.347***	-0.144***	-0.296***	-0.158***	-0.294***	-0.174***
Capitals	(0.0476)	(0.0328)	(0.0527)	(0.0366)	(0.0727)	(0.0425)	(0.0727)	(0.0426)
Com. Border	-0.621**	-0.00499	-0.385	0.0407	1.152***	0.208**	1.186***	0.207**
Dummy	(0.317)	(0.0963)	(0.320)	(0.0935)	(0.344)	(0.0923)	(0.351)	(0.0901)
Former similar	0.821***	-0.455***	1.108***	-0.399**	0.369	0.640***	0.377	0.679***
Country dummy	(0.196)	(0.156)	(0.211)	(0.162)	(0.329)	(0.136)	(0.336)	(0.148)
(Former) colony	0.0732	-0.254***	-0.00345	-0.290***	-1.497***	-0.466***	-1.496***	-0.435***
Dummy	(0.198)	(0.0886)	(0.225)	(0.0911)	(0.192)	(0.0838)	(0.190)	(0.0810)
Com. Language	-0.0936	0.135	-0.165	0.194**	1.094***	0.0131	1.097***	-0.00417
Dummy	(0.156)	(0.101)	(0.143)	(0.0990)	(0.202)	(0.0792)	(0.202)	(0.0779)
EU countres	0.122	0.637***	0.284	0.484***	0.178	0.555***	0.186	0.542***
Dummy	(0.252)	(0.0925)	(0.230)	(0.0945)	(0.216)	(0.106)	(0.217)	(0.107)
Dpg_rel			0.380***	0.0693			0.0931	0.0844
			(0.120)	(0.0450)			(0.139)	(0.0520)
Wht_rel			0.147	-0.511***			0.0584	-0.549***
			(0.160)	(0.120)			(0.225)	(0.157)
Constant	-48.62***	-58.73***	-50.79***	-57.39***	-31.67***	-24.78*	-32.42***	-24.96
	(2.002)	(1.451)	(2.263)	(1.331)	(8.318)	(14.81)	(8.292)	(15.49)
Country dummies	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1,872	6,513	1,872	6,513	1,872	6,513	1,872	6,513
R-squared	0.646	0.714	0.655	0.718	0.871	0.879	0.871	0.880

Notes: All regressions are estimated with PPML with the bilateral royalty flows the dependent variable. Data between 2014 and 2019 are pooled. Year dummies for 2015 to 2019 are included, but not reported. Most of them are not significant. Columns (5) to (8) also have country dummies for paid and receiving countries if they have at least 10 observations by year. This is the balanced sample between 2014 and 2019. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

As explained in the gravity literature, country variables do not reflect all country characteristics and country dummies are therefore preferable. So we use time-invariant dummies for the countries paying and receiving charges for the use of IP rights. However, it is problematic that the OECD data is not balanced in terms of countries paying and receiving charges. The reasons are that only OECD

countries report the charges for the use of IP rights, and often report bilateral data to only a limited amount of partner countries - see Section 4. However, the estimated coefficients for country dummies that appear only a few times in the data are not very stable over the various specifications and samples. Moreover, the coefficients of these country dummies also have a huge impact on the predictions. For this reason we only implement dummies for countries that appear at least ten times a year as paying or receiving country. As a result, we have 53 dummies for paying and for receiving countries, nearly all OECD countries, and some other larger economies.[38]

We include these country dummies to the specifications in columns (1) to (4), and the results are presented in columns (5) to (8). A number of coefficients for other country variables are no longer significant. This is not surprising, because some of these variables are time-invariant (dummies for tax havens), or hardly vary over the years (institutional quality and trade openness). For GDP and GDP per capita, it is mainly the size difference between countries rather than development of time that identify the coefficients. The coefficients for GDP per capita are smaller and statistically significant in less specifications. The tax-haven dummy of the paying country is not significant, and the coefficient for institutional quality is hardly significant with country dummies. Neary all the coefficients of the geographic variables are now significant. The explanatory power of all the regressions is much higher. We use the regression results on the OBM royalty flows without tax variables for the predictions in Section 5.2.

We also present various robust analyses in Annex C. First, we use bilateral tax variables DPG and WHT, instead of the relative ones. The differences are minor. The coefficients of the tax variables are not always statistically significant; this is also the case with the relative tax variables. Second, we test whether the outcomes depend on very large royalty flows. For most of these flows there is no direct tax planning gain. We exclude the 1% largest flows from the regression, and this has hardly any impact on the regression outcomes. Third, we use the specifications in Table 5.1 on all observations instead of the balanced sample. The results are presented in table C2. The most remarkable difference between both samples is that the specifications with BTM royalty flows have less explanatory power in the sample with all observations. This is due to a number of large royalty flows to tax havens for which we have only a few observations, as discussed in section 4. All in all, these robustness analysis confirm most of our findings in Table 5.1.

5.2 Estimating tax motivated flows and tax revenue losses

Table 5.1 suggests that a considerable share of the royalty flows could be motivated by tax planning reasons. Only when there is no direct planning gain and the country pair is not used for treaty shopping purposes, we can assume that the charges for the use of IP are only motivated by business reasons (OBM), or at least not by tax planning reasons. We use this subset of observations to predict the size of the flows motivated by business reasons. We thus assume that the OBM flows are representative for the business motivated flows within the set of BTM flows. From Table 4.5 we observe that while the averages of the tax variables differ a lot between OBM and BTM flows, the differences between the economic variables are much smaller. We predict the business motivated flows for the pooled observations in the balanced sample with the years from 2014 to 2019, with and without country dummies. The regression outcomes are already presented in columns (1) and

[38] The note of Annex Table D2 present a complete list of all country dummies.

(5) of Table 5.1. The size of the predicted OBM flows is similar to the flows in the data at the aggregate level.[39] At the country and bilateral level, the deviations between predicted and realized flows can be large.

The regression coefficients are used to predict the business-motivated flows in the BTM flows. By using the predicted flows due to business reasons, we can estimate the impact of tax planning on the size of the royalty flows. Table 5.2 presents the results at the global level. We aggregated all observed bilateral flows and all predicted bilateral flows by year for the balanced sample. According to the data the use of IP-rights amount to 296 billion US dollar in 2019. The larger part these flows could be motivated by business and tax planning (BTM) reasons. This is also the case for the royalty flows in other years. The amount of OBM flows of about 60 billion US$ seems to be quite constant over time, while the amount of BTM flows varies much more - and increases after 2015.

Table 5.2 Predicted total royalty flows between 2014 and 2019, balanced sample (billion US$)

		OECD data, balanced sample		Predictions OBM with cty dummies			Predictions OBM without cty dummies		
Year	**Total**	**Total OBM**	**Total BTM**	**pred BM**	**pred TM**	**Ratio TM pred**	**Pred BM**	**pred TM**	**Ratio TM pred**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2014	268.9	59.3	209.7	219.7	49.0	18.2%	248.7	20.3	7.5%
2015	250.5	60.0	190.5	209.1	41.4	16.5%	232.0	18.5	7.4%
2016	251.7	56.5	195.2	212.3	39.4	15.7%	218.4	33.3	13.2%
2017	270.6	59.0	211.7	220.9	49.7	18.4%	216.5	54.1	20.0%
2018	289.7	61.7	228.0	235.2	54.6	18.8%	232.7	57.1	19.7%
2019	296.0	62.9	233.1	236.6	59.4	20.1%	235.6	60.5	20.4%
2014-2019	*271.3*	*59.9*	*211.4*	*222.4*	*48.9*	*18.0%*	*230.6*	*40.6*	*15.0%*

Data sources: OECD and own calculations. Values are in billion US$. Outcomes in column (6) = column (2) – column (5) and outcomes in column (7) equal column (6) / column(2). Similarly, column (9) = column (2) – column (8) and column (10) = column (9) / column (2).

Column (5) in Table 5.2 presents the total predicted size of business-motivated flows by applying the regression results from column (5) in Table 5.1 including country dummies.[40] We estimate the size of flows due to tax planning by subtracting the predicted value of these business flows from total royalty flows in column (2). We conclude that on average 82% of the flows is due to business motives, and the other 18% to tax planning (column (7)). This average is fairly constant between 2014 and 2019.

This is different for the predicted business-motivated flows without country dummies in the regression specification. In 2014 the share of tax-motivated flows is 7.5% and increases monotonically to 20.4% in 2019. On average it is 15%. The reason is that the size of predicted business-motivated flows is higher, in particular in 2014 and 2015, than according to the predictions from the regression with country dummies. Due to the high explanatory power of the regressions with country dummies, the predictions from these regressions are our preferred ones. These results

[39] The aggregated predicted flows motivated only by business reasons deviate at most by 1% from the global value of the OECD data.

[40] The R^2 of the regression in column (5) of Table 5.1 is 0.871 which could be due to overfitting. The predictive power on new observations (BTM) could be much lower. We test this using 10 fold cross-validation. Thus we randomly assign observations to one of ten 'folds' in the data. Then we estimate the model using nine folds and the tenth fold is used to generate out-of-sample predictions. We repeat this ten times, changing the fold that is held out each time. The R^2 is 0.816, somewhat lower than before, but still high, suggesting that overfitting is not a problem for the predictive power of the regression.

suggest that about 18% of the royalty flows in the balanced sample between 2014 and 2019 are tax motivated. The predictions using the regression outcomes with all observations suggest that 18% is at the lower end of the estimates. The prediction outcomes are presented in Annex E. Because this sample includes more royalty flows to tax havens than the balanced sample, it seems reasonable that the estimated 18% of tax-motivated royalty flows is indeed at the lower end, although the estimates without country dummies in the balanced sample suggest that it could be 3%-points lower.

This estimate is an average over inter- and intra-firm flows. Assuming that inter-firm flows are mainly business-motivated, the tax-motivated flows are mainly intra-firm flows. Hebous and Johannesen (2021) conclude that 50% of German royalty flows are intra-firm flows. If this is representative of other countries, and assuming that intra-firm flows are not tax-motivated, at least 36% of all inter-firm flows would be tax-motivated.[41]

The predicted size of the tax-motivated flows varies between 40 billion US$ and 60 billion US$ between 2014 and 2019 in our preferred specification. On average it is nearly 50 billion US$. The modest changes in tax-motivated flows suggests that the amount of tax planning is more or less constant over time, although it seems to increase at the end of our observation period. However, without further analysis it seems somewhat premature to suggest this is indeed the case, but the ratio of predicted tax-motivated flows increases in other specifications as well.

According to the estimations multinationals shift profits of about 50 billion US$ per year from high- to low-tax countries for tax reasons, by relocating IP rights between these countries. It is interesting to estimate the tax revenue losses from IP shifting. We estimate this in several steps for the year 2018.

First, we calculate the tax revenue losses of business- and tax-motivated royalty flows in 2018. To do so, we take all bilateral BTM flows with a positive direct tax planning gain and multiply these flows with their respective bilateral tax planning gains. This global aggregate amounts to 15.8 billion US$ in 2018. We ignore negative direct planning gains, because MNEs will not use these for tax avoidance purposes.

Next we want to focus on tax revenue losses specifically from tax-motivated royalty flows. Clearly business-motivated flows may also incur a tax revenue loss, yet we cannot consider these as tax avoidance because the tax revenue loss follows from a business decision that is not primarily aimed at lowering the tax burden. We know that 18.8% of all flows is tax-motivated in 2018 (see Table 5.2) - 24.0% of all BTM flows. Assuming that all tax-motivated flows have positive DPG, the tax revenue loss is 41.2% of 15.8 billion US$, which is 6.5 billion US$.[42] Here we have assumed that the business- and tax-motivated flows are independently distributed from the size of the tax gain. This assumption is probably not very likely, because MNEs have a larger incentive to restructure their royalty flows if the tax gains are higher.

[41] We divide the amount of predicted tax motivated flows in Table 5.2 by 50% of the total royalty flows.
[42] There are 1,088 observations of BTM flows in 2018. For 456 of these observations DPG<=0, and for 632 observations DPG>0. Note that all OBM flows have a negative DPG. The value of 24.0% of all BTM flows is tax-motivated. If these are evenly distributed over the BTM, these are 261 observations. For tax-motivated flows it is very likely that DPG>0. This is 41.2% of all flows with DPG>0.

Inspecting the tax revenue losses by country pair, we find that about half the 16 billion US$ comes from revenue losses between only ten country pairs. These are the largest losses by pair. The largest 100 revenue losses are responsible for more than 90% of total revenue losses. The total is an aggregate of about 1,088 country pairs. If the largest revenue losses are from tax-motivated flows, most of the revenue loss of 16 billion US$ in 2018 is due to tax-motivated flows. Thus, considering that the size of the flows could be correlated with the tax benefits, we have a range. Tax revenue losses due to tax-motivated flows may vary between 6.5 billion US$ and 16 billion US$.

5.3 Augmenting the estimates for non-reported flows and treaty shopping

Still, the calculations of the share of tax-motivated flows and size of tax revenue losses are a lower bound for two reasons. First, the calculations are only based on observed royalty flows, but we miss many other flows. Annex Table B3 shows that for a number of countries the coverage of bilateral flows as a share of total flows is low. The reason is that these countries only report bilateral flows to a limited number of partner countries. Of countries reporting bilateral flows, 81.5% of the received charges is reported and 67.7% of the paid charges. The share of total charges-paid reported by the Netherlands is only 27.0%, and for Ireland it is 45.4%. For all other reporting countries, the share is far closer to 100%. There are also countries only reporting world totals, such as Luxembourg, Singapore and the UK. Quite often flows are not reported for confidentiality reasons. In these cases, there are only a limited number of firm transactions, or a very large transaction that dominates the total flow. In particular, tax havens as partner countries are missing.

This motivates the following step. Because countries report global paid and received charges for use of IP rights of reporting countries (see Annex Table B3), it is easy to derive the size of non-reported charges. For charges-received, the difference is 64.1 billion US$ in 2018 (353.8 – 289.7). However, for many reporting countries reporting received charges from tax havens holds DPG<0, which could not be tax motivated. The size of flows with DGP>0 amount to 17.2 billion US$ on charges-received which is 26.2% of all non-observed bilateral charges-received in 2018.[43] This is mainly due to Belgium, Ireland, Korea and the US (see Annex Table B3). This suggests that the share of tax-motivated flows in non-reported bilateral charges-received is somewhat higher than the reported bilateral data, but not by much.

For charges-paid this is different. For charges-paid the difference between the world total and reported bilateral flows is 106.5 billion US$ (329.6 - 223.1). For half of it there is a direct tax planning gain. This amounts to 52.7 billon US$ of non-reported bilateral charges-paid. This is nearly all due to the Netherlands, which does not report flows to tax havens, like Bermuda. Thus, the share of tax-motivated flows is substantially higher than for the reported flows. The latter was equal to 18.8% - see Table 5.2.

We know the size of non-reported bilateral charges-received and paid by reporting country. We can calculate bilateral DPG. So for bilateral flows with DPG>0, we can estimate the tax gain for multinationals and the tax revenue loss for national governments. We simply multiply these

[43] We assume that the value of all non-reported flows are transactions with tax havens with zero rates for CIT and WHT. Combined with the tax parameters of the reporting countries, we can estimate the direct planning gain. For the reporting countries we use their IP-box rate, when applicable.

numbers as presented in columns (7) and (8) of Annex Table B3. This amounts to 5 billion US$ - 1.9 billion US$ for charges-received, and 3.0 billion US$ for charges-paid.

A second reason that the revenue losses are a lower bound is that we only calculate the revenue losses due to the possible direct planning gains for multinationals but ignore the revenue losses due to treaty shopping. The reason is the same as before. We do not have sufficient observations to track complete treaty shopping routes, so we cannot verify whether multinationals exploit these gains with our data. Therefore we do not come up with an estimate of this revenue loss. From earlier work, Lejour et al. (2022), we know that multinationals exploit these gains via the Netherlands and that the treaty shopping gain can amount to 2.7 billion €. Because the Netherlands is a conduit country, this number is not representative for non-conduit countries, as the double Irish-Dutch sandwich suggests. Still, it suggests that worldwide tax revenue losses from treaty shopping can be substantial.

Table 5.3 Predicted tax revenue losses in 2018, balanced sample (billion US$)

Tax avoidance mechanism	Size (bln US$)
Direct planning gain observed data	6.5 – 16
Direct planning gain non observed data	5
Total	*11.5 – 21*

Source: own calculations

Based on our analyses, tax revenue losses due to relocation of IP range from 6.5 billion US$ to 16 billion US$ in 2018, depending on whether business- and tax-motivated royalty flows are independently distributed from the size of the losses by country pair. For the two reasons mentioned above, this still underestimates the size of the revenue losses. Despite the lack of accuracy of these estimates, they give at least some notion of the order of magnitude. Clearly, they would be more accurate with more reporting of bilateral flows to and from tax havens. Because our estimates are not very precise, it is not very meaningful to repeat this exercise for other years of our sample.

Tørsløv et al. (2023) find that multinationals annually shift 600 billion US$ while global profits were 1,700 billion US$ in 2015. This is about 190 billion US$ in lost tax revenue. In 2018 and 2019 the global amount of shifted profits approached 1,000 billion US$ and lowered tax revenue by 250 billion US$ (Wier and Zucman, 2022). Because there are other important tax planning strategies, like transfer pricing and debt shifting, the amount of at least 50 billion US$ due to IP shifting seems to be consistent with this order of magnitude. Lejour et al. (2022) show that the size of the so-called double Irish-Dutch sandwich tax planning strategy is about 25 billion US$. This is probably one of the largest tax planning strategies with IP shifting in the world, and suggests that the estimated switch of royalty flows of 50 billion US$ is a lower bound.

Hebous and Johannesen (2021) conclude that the excess profit margin on remuneration of IP rights of German affiliates in tax havens is below 50%, and that the loss of corporate tax base in Germany is only 300 million US$. However, Germany is not a representative country for IP shifting. Also, in our data the royalty flows between Germany and tax havens are limited, and hardly contribute to the 50 billion US$ shift in the tax base – even though Germany is one of the larger economies in the world.

5.4 Interpreting tax-motivated flows as treatment

As a separate robustness analysis we have also used a treatment model to estimate the impact of tax incentives. We assume that royalty flows could be treated by tax benefits such as direct planning and treaty shopping gains and use treatment models to estimate the impact. Following the classification of BTM and OBM flows, the BTM flows form thus the treatment group. The control group consist of the OBM flows. We use the same two samples of bilateral royalty flows as before: balanced and all observations. That is also the case for the explanatory variables. We use the same variables as in our basic model without country dummies. The main reason for excluding these dummies is that the treatment model does not converge with dozens of country dummies. The specification reads as follows.

$$Flow_{ijt} = \alpha_0 + \alpha_1 G_{it} + \alpha_2 G_{jt} + \alpha_3 G_{ij} + \beta_1 TH_{it} + \beta_2 TH_{jt} + \delta_4 D_{ijt} + \gamma_{1t} YR_t + \varepsilon_{ijt} \qquad (2)$$

Our main variable of interest is $D_{ijt.}$ This is our treatment variable. It equals 1 if *Flow* is a BTM flow and equals 0 if it is an OBM flows. i and j reflect the country dummies and t the year. The other explanatory variables are the same as in equation (1). The only difference is that we exclude the tax variables.

According to these estimates, the average bilateral royalty flow in the control group is 137.4 million US$ in the all-observations sample and 161.5 million US$ in the balanced sample. The difference between these averages implies that the 456 OBM observations that are not reported every year between 2014 and 2019 are on average much smaller than the 1872 observations in the balanced sample.

The coefficient of the treatment variable is positive and statistically significant. If the flows are also tax motivated the flows are 40.6 and 38.6 million US$ higher, respectively. So the flows in the treatment group are on average about 40 million US$ higher than in the control group. The estimation results are presented in Annex D. From the 8385 observations in the balanced sample, 6513 observations are business and tax motivated. This outcome suggests that 18.6%[44] of the size of the royalty flows is tax motivated in the balanced sample. In the sample with all observations this is 22.8%. These numbers are comparable to those we calculated in section 5.2.

Instead of a treatment model we also apply a 1-1 matching model in which the country pairs in the control and treatment group are match with each other. Compared to the treatment model the estimated coefficients are somewhat higher an suggest a somewhat larger share of tax motivated flows than in the treatment model.

[44] This is (6513*38.56)/(8385*161.5).

6. Conclusions

Profit shifting by relocating IP rights, and treaty shopping by sublicensing these rights, is often applied by multinationals in their tax planning strategies, but we do not know the gains in terms of lower taxes and impact on the direction and size of royalty flows. This paper tries to fill this gap in two ways. First, we apply a network analysis (van 't Riet and Lejour, 2018) to measure the tax gains from IP shifting directly, and indirectly by shifting IP rights via other countries. We do this in an international royalty network with the tax parameters of 112 countries. Second, we use the outcomes of the network analysis to explain the size of bilateral royalty flows in an econometric analysis, and predict the magnitude of royalty flows motivated by tax planning.

Although tax planning strategies like the double Irish-Dutch sandwich received a lot of media attention, we show that these strategies are not attractive for many countries. It is essential that IP rights are located in low-tax jurisdictions, and that paying countries do not levy substantial withholding taxes. For most of the country pairs this is not the case. For only 37% of the country pairs we find that there is a direct tax planning gain, and in only 7% of the cases it is beneficial to combine this with treaty shopping. On these routes, the direct planning gain is on average 7.6%, and for treaty shopping it is 9.3%. Russia, Switzerland, Netherlands, Sweden, and Norway are the most attractive countries for sublicensing IP rights. For Russia this is the case because they have a favourable treaty with China, and the others do not levy a withholding tax on royalties. Treaty shopping with royalties is thus much less attractive than with dividends, as we showed in 2018 (van 't Riet and Lejour, 2018). The overall tax benefits are smaller, although between certain country pairs it could still be very attractive.

The network analysis ignores the fact that international royalty payments could also result from other business reasons than tax planning. In the data this is different. Although the largest royalty payments are between countries with a direct planning gain, the magnitude of payments between countries without planning gains is also sizeable. Interestingly, these royalty flows are only sizable if there is not a cheaper alternative, which implies that treaty shopping is not advantageous. Only 6% of the global value of international royalty payments in 2018 is between countries for which there is a more attractive treaty shopping route. However, availability of data on international royalty payments or charges for use of IP rights is limited. The OECD provides only bilateral data for 39 reporting countries in 2018 - these are charges-paid and received. In particular, many flows towards tax havens are missing. This is a limitation of this study, because it is the whole network that determines the attractiveness of particular routes for treaty shopping.

The econometric analysis confirms many outcomes from the descriptive analysis of the data. We have used the PPML method for pooled data between 2014 and 2019, and this analysis confirms that higher withholding taxes on royalties have a negative impact on the size of these flows. The analysis also shows that royalty flows are larger if the receiving country is a tax haven. The gravity model, with GDP of both countries and distance as additional explanatory variables, seems to be well suited to explain the variation in royalty flows.

Using the regression outcomes on the royalty flows only due to business reasons, we predict the flows for the observations that could also be motivated by tax reasons. Then we estimate the size of

these mixed-motivated flows due to business reasons in order to assess the quantitative impact of tax planning. The size of these flows amounts to 50 billion US$ on average between 2014 and 2019, about 18% of all flows. This magnitude is confirmed in a treatment analysis. This number is a lower bound, because many observations towards tax havens are missing, and we have taken a conservative estimate as our preferred one. The loss in tax revenue due to profit shifting is at least 6.5 billion US$, but could amount to 21 billion US$ if revenue losses from treaty shopping and profit shifting involved with non-reported bilateral royalty flows are included. More precise estimates would be possible if more bilateral royalty flows were reported by OECD members and other countries, especially flows to and from tax havens.

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Annex A: country data on taxation and conduit centrality, 2018

Country	CIT rate (%)	IP box rate (%)	With. tax royalties (%)	Number of treaties	Centrality indicator	Ranking centrality	Tax haven dummy
Albania	15		15	33	0.001992	54	0
Algeria	23		24	25		83	0
Angola	30		10	0		84	0
Argentina	35		35	17		85	0
Aruba	25		0	0	0.000364	58	1
Australia	30		30	39		86	0
Austria	25		20	71	0.194257	15	0
Azerbaijan	20		14	41	0.047118	29	0
Bahamas	0		0	0	0.009612	41	1
Bahrain	46		0	19		87	1
Bangladesh	35		20	27	0.000171	65	0
Barbados	25	2.5	15	26	0.000574	57	1
Belarus	18		15	47		88	0
Belgium	33.99	6.8	30	76	0.138213	18	1
Bermuda	0		0	0	0.009613	40	1
Botswana	30		15	8	0.000171	66	0
Brazil	34		15	15		89	0
Brunei Darussalam	18.5		15	13	0.000263	63	0
Bulgaria	10		10	52	0.00793	42	0
Canada	26.3		25	77	0.049099	28	0
Cayman Islands	0		0	0	0.009613	39	1
Chile	25		15	28		90	0
China	25	15	10	55	0.000359	62	0
Colombia	34	0	15	9		91	0
Costa Rica	30		25	2		92	0
Croatia	18		15	51	0.049591	27	0
Curacao	22		0	0		93	0
Cyprus	12.5		0	34	0.533014	7	1
Czech Republic	19		15	71	0.006336	45	0
Denmark	22		22	65	0.117451	20	0
Dominican Rep.	27		27	2	0.000171	67	0
Ecuador	22		22	15	0.000171	68	0
Egypt	22.5		20	45	0.000107	81	0
Equatorial Guinea	35		10	0		94	0
Estonia	20		10	45	0.019917	35	0
Ethiopia	30		5	14	0.000171	69	0
Finland	20		20	60	0.114043	21	0
France	33.33	15	33.33	85	0.280722	10	0
Gabon	30		20	4	0.000171	70	0
Germany	30.2		15	71	0.136718	19	0
Greece	29		20	49	0.028131	33	0
Guernsey	0		0	4	0.004514	50	1

Hong Kong	16.5		4.95	30	0.004969	49	1
Hungary	9	4.5	0	45	0.531593	8	0
Iceland	20		20	41	0.031901	32	0
India	30	10	10	43	0.005467	47	0
Indonesia	25		20	54	5.84E-05	82	0
Ireland	12.5	6.25	20	64	0.277832	11	1
Isle of Man	0		0	0	0.000364	59	1
Israel	24	10	24	49	0.147853	17	0
Italy	27.9	13.95	26	78	0.025201	34	0
Jamaica	25		33.33	12		95	0
Japan	35.4		20	58	0.07132	24	0
Jersey	0		0	4	0.00243	53	1
Jordan	20		10	14	0.000171	71	0
Kazakhstan	20		15	39		96	0
Korea Republic	22	16.5	20	54		97	0
Kuwait	15		0	33		98	0
Latvia	15		0	37	0.266008	12	0
Lebanon	15		10	19	0.001096	56	1
Libya	20		0	6		99	0
Liechtenstein	12.5		0	8	0.088017	23	1
Lithuania	15		10	43	0.007365	43	0
Luxembourg	27.08	5.84	0	48	0.559166	6	1
Macao	12	0	0	2	0.000364	60	1
Malaysia	24		10	45	0.000219	64	0
Malta	35		0	43	0.2381	13	1
Mauritius	15	3	15	28	0.015669	38	1
Mexico	30		25	56		100	0
Mongolia	25		20	22	0.000171	72	0
Namibia	32		10	9	0.000171	73	0
Netherlands	20.5	5	0	53	0.723099	3	1
New Zealand	28		0	26	0.04461	30	0
Nigeria	30		10	10	0.000171	74	0
Norway	24		0	51	0.585109	5	0
Oman	15		10	21	0.001939	55	0
Pakistan	30		15	43	0.061795	26	0
Panama	25		25	15		101	1
Peru	30		30	7		102	0
Philippines	30		30	40	0.000171	75	0
Poland	19		20	66	0.017948	36	0
Portugal	27.5	15	25	63	0.065595	25	0
Puerto Rico	30		29	0	0.000171	76	1
Qatar	10		5	34		103	0
Romania	16		16	70	0.006065	46	0
Russian Federation	20		20	67	0.901664	1	0
Saudi Arabia	20		15	37		104	0
Serbia and Mont.	15		20	48	0.002499	51	0

Seychelles	30		15	17		105	1
Singapore	17	10	10	64	0.017801	37	1
Slovak Republic	21		19	55	0.005282	48	0
Slovenia	19		15	49	0.006437	44	0
South Africa	28		15	61	0.090249	22	0
Spain	29	12	24	75	0.368977	9	0
Suriname	36		0	1		106	0
Sweden	22		0	54	0.714559	4	0
Switzerland	21.1		0	63	0.873465	2	1
Taiwan Province	17		20	25		107	0
Thailand	20	10	15	34	0.000171	77	0
Trinidad and Tob.	25		15	13	0.000171	78	0
Tunisia	25		15	34		108	0
Turkey	20	0	20	68	0.000127	80	0
Uganda	30		15	9	0.000171	79	0
Ukraine	18		15	57		109	0
Untd Arab Emirates	0		0	45	0.20909	14	0
United Kingdom	20	10	20	87	0.190409	16	0
United States	21		30	57	0.033954	31	0
Uruguay	25	0	12	17		110	0
Venezuela	34		34	29		111	0
Virgin Islands U.S.	38.5		11	0		112	0
Virgin Islands U.K.	0		0	0	0.000364	61	1
Zambia	35		20	20	0.002499	52	0

Sources: IFBD for data on CIT and WHT, TWZ (2023) for tax havens, and outcomes on centrality index are own calculations.

Annex B: Bilateral royalty flows

Table B1: Top 25 on charges paid and received for the use of IP rights in million US$, 2018

Charges-paid			Charges-received		
Reporting country	Receiving country	Value	Reporting country	Paying country	Value
IRL	NLD	27447	JPN	USA	17375
CHE	USA	12017	USA	IRL	16605
USA	JPN	10530	USA	CHE	14335
IRL	USA	10255	USA	CHN	8071
NLD	USA	10186	USA	CAN	7922
JPN	USA	9802	USA	GBR	7587
CAN	USA	7984	CHE	USA	7180
USA	DEU	6962	USA	JPN	6195
KOR	USA	5380	USA	DEU	5745
USA	CHE	5349	DEU	CHN	5651
DEU	IRL	4292	IRL	USA	5646
DEU	USA	3863	JPN	CHN	5381
FRA	DEU	3719	USA	NLD	5296
USA	GBR	3507	USA	KOR	4795
FRA	IRL	3240	FRA	USA	4601
JPN	SGP	3110	USA	HKG	4571
USA	IRL	2980	DEU	USA	4331
NLD	DEU	2812	CHE	IRL	4313
USA	FRA	2683	USA	SGP	3824
SWE	USA	2426	JPN	THA	3692
FRA	USA	2307	CAN	USA	3497
DEU	GBR	2170	USA	MEX	3358
NLD	GBR	2108	NLD	GBR	3303
FRA	GBR	1734	JPN	GBR	3275
USA	CAN	1696	CHE	GBR	3055
WLD	WLD	358933	WLD	WLD	380988

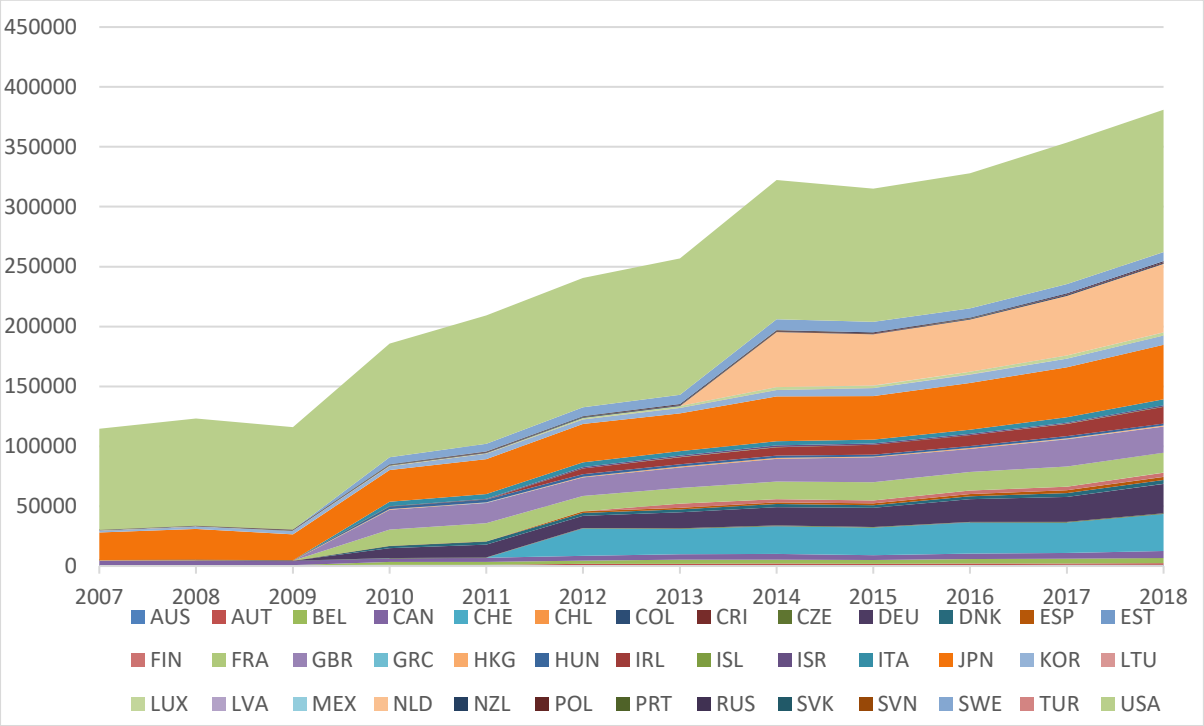
Source: OECD International payments in services, EBOPS Category SH.

Table B2 Overview of the number of bilateral royalty flows by year

Year/ category	SH	SH1	SH2	SH3	SH4	SJ112
2007	328	126	116	116	128	137
2008	331	120	125	114	133	139
2009	504	127	127	121	130	140
2010	1398	314	335	222	226	202
2011	1468	306	320	211	229	273
2012	1597	305	328	225	226	229
2013	1667	480	528	291	308	348
2014	1693	487	483	295	294	300
2015	1664	487	489	314	286	297
2016	1737	455	473	277	279	295
2017	1740	502	494	353	335	282
2018	1754	503	492	375	350	304
2019	1769	505	496	404	348	315

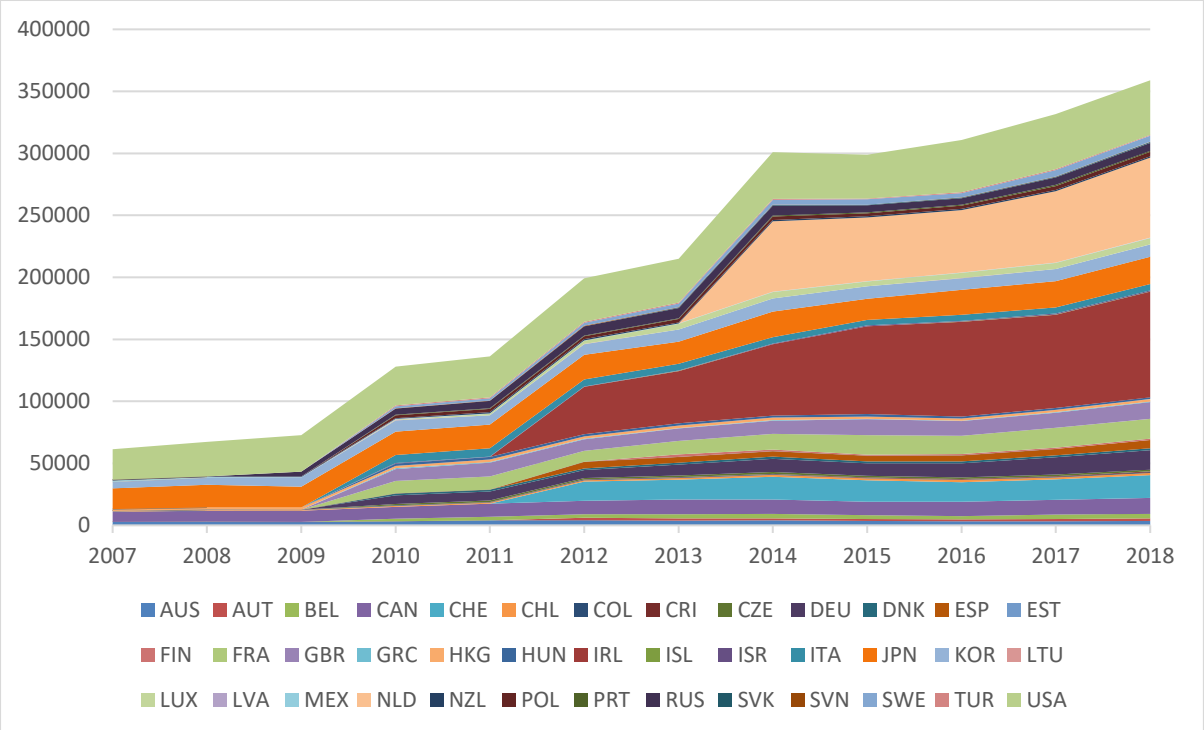
Source: OECD International payments in services.

Figure B1: Charges-received for IP rights in million US$ (SH category)



Source: OECD International payments in services.

Figure B2: Charges-paid for IP rights in million US$ (SH category)



Source: OECD International payments in services.

Table B3: Coverage bilateral royalty flows in million US$ by reporting OECD country in 2018

	Charges-received		Charges-paid		Received	Paid	Received	Paid
2018	Bilateral total	World total	Bilateral total	World total	Ratio	ratio	DPG gain	DPG gain
Column	(1)	(2)	(3)	(4)	(5=1/2)	(6=3/4)	(7)	(8)
AUS	617.6	970.6	3552.5	3628.2	63.6%	97.9%	0.0	0.0
AUT	1351.8	1399.9	1994.8	2003.1	96.6%	99.6%	-2.4	0.4
BEL	2511.9	4387.5	3031.4	3724.1	57.3%	81.4%	435.1	-160.7
CAN	5689.1	5816.4	12649.8	12773.4	97.8%	99.0%	-1.7	1.6
CHE	26917.8	30882.6	16755.2	18403.8	87.2%	91.0%	-158.6	65.9
CZE	484.9	497.7	1491.5	1498.8	97.4%	99.5%	-0.5	0.3
DEU	23658.5	24417.3	15577.5	15619.9	96.9%	99.7%	-115.3	6.4
DNK	2933.8	3341.5	1554.6	1565	87.8%	99.3%	0.0	0.0
EST	13.2	15.8	62.6	64.7	83.5%	96.8%	-0.3	0.2
FIN	3398.5	3463.2	1063.8	1067.1	98.1%	99.7%	0.0	0.0
FRA	16246.7	16798	15796	15919.8	96.7%	99.2%	101.1	-22.7
GRC	90.3	95.8	379.5	383	94.3%	99.1%	-0.5	0.3
HKG	714.3	742.6	1783.9	1993	96.2%	89.5%	-3.3	24.2
HUN	1629.2	1769.8	1462.3	1502.9	92.1%	97.3%	-6.3	1.8
IRL	7399.7	13901.3	38652.5	85199.7	53.2%	45.4%	894.0	-6400.2
ISR	897.3	1098.8	595.8	868.6	81.7%	68.6%	0.0	0.0
ITA	4763.2	4954.8	5120.7	5142.9	96.1%	99.6%	-3.6	0.4
JPN	43709.6	45537.2	18795.5	22008.5	96.0%	85.4%	-281.5	494.8
KOR	3331.5	7752.3	6381.6	9880.9	43.0%	64.6%	154.7	-122.5
LTU	26.1	31.2	53.8	62	83.7%	86.8%	-0.3	0.4
LVA	8.4	9.4	40.3	63.7	89.4%	63.3%	-0.2	3.5
NLD	17642.6	57159.5	17519.5	64719.7	30.9%	27.1%	-1975.8	2360.0
NZL	498.3	754.9	818	912.6	66.0%	89.6%	-71.8	26.5
POL	576.3	616	3623.7	3651.2	93.6%	99.2%	0.4	-0.3
PRT	76.8	116.9	761.5	849.9	65.7%	89.6%	4.0	-8.8
RUS	874.3	876.1	6280.5	6288.2	99.8%	99.9%	0.0	0.0
SVK	55.6	55.8	755.8	751.4	99.6%	100.6%	0.0	-0.1
SVN	63	73.2	261	268.8	86.1%	97.1%	-0.4	0.3
SWE	7244.7	7437.5	4851.1	4862	97.4%	99.8%	-42.4	2.4
USA	115078	118875	41433	43933	96.8%	94.3%	341.7	-225.0
Total	*288503*	*353848*	*223100*	*329610*	*81.5%*	*67.7%*	*-733.8*	*-3950.8*
Total (DPG>0)	*145221*	*162447*	*99617*	*152283*			*1931.0*	*2989.6*

Source: OECD International payments in services. This table presents the aggregated bilateral flows of 30 countries reporting to the OECD secretariat. For some of the reporting countries the aggregated bilateral flows add up to the world total of received and paid charges, but for most countries this is not the case. Nine countries only report world totals, but no bilateral data. These countries are Chile, Colombia, Costa Rica, Iceland, Luxembourg, Mexico, Singapore, Spain and the United Kingdom. These totals are used in Annex Figures B1 and B2. The outcome in column (7) is the non-reported bilateral royalty flow, which is the difference between Column (2) and (1), times the direct tax planning gain. This gain is based on the tax parameters of the reporting country and a tax haven as partner country that does not levy CIT and WHT. A similar calculation is made in column 8, where non-reported bilateral flows follow from the difference of column (4) and (3).

Annex C: Robustness analysis

Table C.1 Robustness analysis with balanced sample, 2014 - 2019

	(1)	(2)	(3)	43)	(5)	(6)	(7)	(8)
Flows	OBM	BTM	OBM	BTM	OBM	BTM	OBM	BTM
With 1% largest flows	Yes	Yes	No	No	Yes	Yes	No	No
Log gdp_paid	1.248***	1.188***	1.036***	0.984***	0.751**	0.116	0.582***	0.114
	(0.0507)	(0.0317)	(0.0466)	(0.0276)	(0.295)	(0.518)	(0.210)	(0.444)
gdp_cap_paid	-0.0152**	0.0200***	-0.0362***	0.0167***	-0.0325**	-0.00477	-0.0185	-0.00329
	(0.00687)	(0.00210)	(0.00939)	(0.00164)	(0.0154)	(0.0106)	(0.0136)	(0.00903)
trade_gdp_paid	-0.00374*	0.00200***	-0.00785***	0.00178**	0.0190**	-0.00159	0.0164**	-0.000478
	(0.00197)	(0.000704)	(0.00181)	(0.000694)	(0.00752)	(0.00499)	(0.00684)	(0.00445)
Tax haven_paid	1.767***	0.864***	2.415***	0.805***	-0.492	2.095*	-0.639	1.544
Dummy	(0.405)	(0.0917)	(0.380)	(0.0756)	(0.692)	(1.236)	(0.550)	(1.021)
rle_paid	1.383***	0.788***	1.667***	0.774***	-0.0372	-0.643*	0.156	-0.342
	(0.179)	(0.0624)	(0.218)	(0.0523)	(0.439)	(0.357)	(0.327)	(0.328)
Log gdp_recei	0.770***	0.981***	0.658***	0.871***	0.478***	0.843***	0.385***	0.690***
	(0.0445)	(0.0259)	(0.0397)	(0.0219)	(0.0795)	(0.319)	(0.0867)	(0.256)
gdp_cap_recei	0.0111	0.00988***	0.0150***	0.00592***	0.0207***	0.00580	0.0100**	-0.00602
	(0.00818)	(0.00273)	(0.00530)	(0.00168)	(0.00661)	(0.00954)	(0.00439)	(0.00872)
trade_gdp_recei	0.00106	0.00232***	0.00211	0.00375***	-0.00278	0.00141	-0.00923**	-0.000513
	(0.00192)	(0.000651)	(0.00160)	(0.000582)	(0.00602)	(0.00398)	(0.00443)	(0.00335)
Tax haven_recei	0.409	1.019***	0.379	0.482***	0.499	-0.372	0.369	-0.611
Dummy	(0.533)	(0.121)	(0.434)	(0.0824)	(0.381)	(0.972)	(0.279)	(0.535)
rle_recei	-0.0945	-0.0905	-0.617***	-0.0821*	-0.281	-0.144	-0.377*	0.101
	(0.212)	(0.0694)	(0.155)	(0.0455)	(0.313)	(0.209)	(0.216)	(0.171)
Log distance	-0.348***	-0.134***	-0.550***	-0.209***	-0.295***	-0.174***	-0.807***	-0.291***
Capitals	(0.0526)	(0.0358)	(0.0791)	(0.0283)	(0.0727)	(0.0425)	(0.0732)	(0.0473)
Com. Border	-0.384	0.0476	-0.565*	0.111	1.176***	0.212**	-0.0895	0.263***
Dummy	(0.320)	(0.0924)	(0.315)	(0.0884)	(0.350)	(0.0910)	(0.357)	(0.0769)
Former similar	1.102***	-0.478***	0.531**	-0.563***	0.378	0.590***	-0.736**	0.333***
Country dummy	(0.210)	(0.164)	(0.250)	(0.130)	(0.335)	(0.136)	(0.322)	(0.118)
(Former) colony	-0.00178	-0.309***	-0.212	0.226***	-1.496***	-0.444***	-1.788***	-0.0696
Dummy	(0.224)	(0.0951)	(0.224)	(0.0726)	(0.190)	(0.0833)	(0.219)	(0.0754)
Com. Language	-0.163	0.201**	0.365**	0.0387	1.095***	0.00894	1.632***	-0.0274
Dummy	(0.142)	(0.101)	(0.150)	(0.0753)	(0.203)	(0.0775)	(0.162)	(0.0667)
EU countres	0.279	0.495***	0.0913	0.544***	0.184	0.500***	-0.814***	0.324***
Dummy	(0.231)	(0.0935)	(0.279)	(0.0769)	(0.217)	(0.108)	(0.250)	(0.114)
dpg	-0.0260***	-0.00287			-0.00375	-0.0268		
	(0.00830)	(0.00304)			(0.0101)	(0.0183)		
wht	0.00906	-0.0327***			0.00399	-0.0406***		
	(0.0102)	(0.00765)			(0.0144)	(0.0105)		
Constant	-50.76***	-57.60***	-38.83***	-48.13***	-32.28***	-26.39*	-20.49***	-21.18
	(2.250)	(1.352)	(2.131)	(1.185)	(8.320)	(15.63)	(6.043)	(13.61)
Country dummies	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1,872	6,513	1,846	6,457	1,872	6,513	1,846	6,457
R-squared	0.655	0.721	0.428	0.613	0.871	0.878	0.884	0.755

Notes: All regressions are estimated with PPML with bilateral royalty flows the dependent variable. Data between 2014 and 2019 are pooled. Year dummies for 2015 to 2019 are included, but not reported. Most of them are not significant. Columns (5) to (8) have also country dummies for paid and receiving countries if these appear at least 10 times a year as paying or receiving country. This is the balanced sample between 2014 and 2019. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table C.2 Robustness analysis with all observations, 2014 - 2019

	(1)	(2)	(3)	43)	(5)	(6)	(7)	(8)
Flows	OBM	BTM	OBM	BTM	OBM	BTM	OBM	BTM
With 1% largest flows	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log gdp_paid	0.764***	1.016***	0.778***	1.008***	0.489***	0.888**	0.499***	0.931***
	(0.0415)	(0.0307)	(0.0456)	(0.0299)	(0.0752)	(0.364)	(0.0768)	(0.355)
gdp_cap_paid	0.00765	0.0177***	0.0111	0.0153***	0.0182***	0.0104	0.0192***	0.00814
	(0.00895)	(0.00341)	(0.00843)	(0.00340)	(0.00507)	(0.0158)	(0.00610)	(0.0139)
trade_gdp_paid	0.000492	0.00304***	0.00123	0.00348***	-0.00498	0.00652	-0.00424	0.00631
	(0.00168)	(0.000677)	(0.00195)	(0.000698)	(0.00530)	(0.00746)	(0.00565)	(0.00604)
gravelle_paid	0.655	1.241***	0.410	1.185***	0.630*	-0.807	0.560	-0.673
dummy	(0.482)	(0.136)	(0.539)	(0.131)	(0.323)	(0.853)	(0.366)	(0.793)
rle_paid	-0.0803	-0.226**	-0.0888	-0.212**	-0.0889	-0.350*	-0.109	-0.415**
	(0.232)	(0.0975)	(0.215)	(0.0853)	(0.299)	(0.211)	(0.302)	(0.189)
Log gdp_recei	-0.426***	-0.115***	-0.354***	-0.0864*	-0.295***	-0.210***	-0.294***	-0.198***
	(0.0464)	(0.0397)	(0.0524)	(0.0446)	(0.0733)	(0.0513)	(0.0733)	(0.0512)
gdp_cap_recei	-0.604*	-0.112	-0.377	-0.0510	0.918***	0.142	0.940***	0.164
	(0.332)	(0.113)	(0.342)	(0.107)	(0.313)	(0.137)	(0.316)	(0.131)
trade_gdp_recei	0.888***	-1.108***	1.170***	-1.233***	0.810**	0.0112	0.822**	-0.378*
	(0.189)	(0.282)	(0.205)	(0.344)	(0.330)	(0.196)	(0.336)	(0.223)
gravelle_recei	0.0690	-0.0868	0.00859	-0.153	-1.342***	-0.224**	-1.339***	-0.277***
Dummy	(0.195)	(0.101)	(0.226)	(0.0961)	(0.193)	(0.106)	(0.191)	(0.0994)
rle_recei	-0.108	0.0521	-0.158	0.101	1.138***	-0.219**	1.142***	-0.129
	(0.152)	(0.0967)	(0.140)	(0.0977)	(0.202)	(0.101)	(0.203)	(0.0782)
Log distance	0.0766	1.062***	0.267	0.984***	0.248	0.787***	0.254	0.496***
Capitals	(0.239)	(0.184)	(0.218)	(0.201)	(0.209)	(0.151)	(0.211)	(0.128)
Com. border	1.209***	1.265***	1.225***	1.264***	0.577**	0.261	0.580**	0.200
Dummy	(0.0493)	(0.0455)	(0.0519)	(0.0498)	(0.243)	(0.644)	(0.241)	(0.596)
Former similar	-0.0197***	0.0173***	-0.0145**	0.0143***	-0.0306**	-0.00444	-0.0304**	-0.00217
Country dummy	(0.00704)	(0.00352)	(0.00665)	(0.00431)	(0.0148)	(0.0117)	(0.0148)	(0.0118)
(Former) colony	-0.00481***	0.00134*	-0.00463**	0.00173**	0.0162**	5.73e-05	0.0163**	0.000813
Dummy	(0.00177)	(0.000734)	(0.00186)	(0.000683)	(0.00676)	(0.00565)	(0.00677)	(0.00602)
Com. Language	1.799***	1.548***	1.755***	1.555***	-0.323	1.886	-0.384	1.832
Dummy	(0.369)	(0.274)	(0.382)	(0.287)	(0.511)	(1.370)	(0.531)	(1.324)
EU countres	1.561***	0.959***	1.498***	0.973***	-0.0757	-1.015**	-0.0759	-0.901**
Dummy	(0.164)	(0.104)	(0.175)	(0.126)	(0.368)	(0.471)	(0.367)	(0.428)
dpg_rel			0.332***	-0.141			0.0642	-0.382***
			(0.115)	(0.100)			(0.138)	(0.0991)
wht_rel			0.177	-0.395**			0.0428	-1.067***
			(0.155)	(0.163)			(0.206)	(0.199)
Constant	-48.31***	-61.73***	-50.47***	-61.32***	-27.46***	-32.11*	-28.03***	-30.23*
	(2.007)	(2.004)	(2.271)	(2.139)	(6.838)	(17.63)	(6.855)	(16.76)
Country dummies	No	No	No	No	Yes	Yes	Yes	Yes
Observations	2,338	7,890	2,338	7,890	2,338	7,890	2,338	7,890
R-squared	0.649	0.518	0.659	0.522	0.871	0.704	0.872	0.764

Notes: All regressions are estimated with PPML with the bilateral royalty flows the dependent variable. Data between 2014 and 2019 are pooled. Year dummies for 2015 to 2019 are included, but not reported. Most of them are not significant. Columns (5) to (8) have also country dummies for paid and receiving countries if these appear at least 10 times a year as paying or receiving country. The sample consist of all observations between 2014 and 2019. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. We have country dummies for ARG, AUS, AUT, BEL, BGR, BRA, CAN, CHE, CHL, CHN, CYP, CZE, DEU, DNK, ESP, EST, FIN. FRA. GBR. GRC. HKG, HRV, HUN, IDN, IND, IRL, ISL, ISR, ITA, JPN, KOR, LTU, LUX, LVA, MEX, MLT, MYS, NLD, NOR, NZL, POL, PRT, ROU, RUS, SGP, SVK, SVN, SWE, THA, TUR, TWN, USA, and ZAF.

Annex D.1 Outcomes of the treatment model

Table D.1 Estimation results from the treatment model with two samples, 2014 - 2019

Column	(1)	(2)	(3)	(4)	(5)	(6)
Method	poisson aipw	poisson aipw	poisson aipw	poisson aipw	psmatch	psmatch
	probit	probit	probit	probit		
Sample	balanced	balanced	all	All	balanced	all
lgdp_c	0.770***	0.982***	0.778***	0.982***		
	(0.0457)	(0.0296)	(0.0457)	(0.0291)		
gravelle_c	0.886	1.175***	0.889	1.273***		
	(0.602)	(0.117)	(0.603)	(0.129)		
lgdpcap_c	-0.0693	0.430***	-0.0623	0.718***		
	(0.102)	(0.107)	(0.103)	(0.159)		
trade_gdp_c	-0.000246	0.00194***	-0.000243	0.00311***		
	(0.00220)	(0.000650)	(0.00220)	(0.000716)		
rle_c	0.153	-0.157*	0.166	-0.384***		
	(0.153)	(0.0913)	(0.147)	(0.134)		
lgdp_p	1.166***	1.153***	1.151***	1.225***		
	(0.0459)	(0.0307)	(0.0463)	(0.0473)		
gravelle_p	1.182***	0.937***	1.216***	1.579***		
	(0.280)	(0.0917)	(0.268)	(0.269)		
lgdpcap_p	-0.267	1.105***	-0.260	0.850***		
	(0.171)	(0.136)	(0.163)	(0.208)		
trade_gdp_p	-0.00232	0.00140*	-0.00337**	0.00112		
	(0.00165)	(0.000736)	(0.00160)	(0.000743)		
rle_p	1.295***	0.498***	1.384***	0.703***		
	(0.190)	(0.0938)	(0.180)	(0.164)		
ldistcap	-0.505***	-0.165***	-0.500***	-0.129***		
	(0.0579)	(0.0331)	(0.0581)	(0.0387)		
contig	-0.680*	-0.0192	-0.661*	-0.103		
	(0.356)	(0.0977)	(0.374)	(0.107)		
comlang_off	-0.195	0.145	-0.201	0.0469		
	(0.195)	(0.103)	(0.191)	(0.0988)		
colony	0.0539	-0.292***	0.0448	-0.119		
	(0.207)	(0.0904)	(0.206)	(0.105)		
smctry	0.733***	-0.463***	0.811***	-1.044***		
	(0.190)	(0.169)	(0.186)	(0.265)		
dum_eu	-0.148	0.467***	-0.161	0.866***		
	(0.237)	(0.0836)	(0.229)	(0.166)		
Treatment effect	38.56*		40.55**		58.61***	58.28***
	(20.22)		(16.98)		(17.09)	(15.39)
Control group	161.5***		137.4***			
	(19.12)		(15.80)			
TME1	0.761***		0.744***			
	(0.0152)		(0.0137)			
Constant	-43.50***	-70.82***	-43.57***	-73.87***		
	(2.903)	(2.158)	(2.840)	(2.344)		
Observations	8,385	8,385	10,228	10,228	8,385	10,228
n0	1872	1872	2338	2338	1872	2338
n1	6513	6513	7890	7890	6513	7890

Annex E Predicted business- and tax-motivated flows for all observations

Table E.1 Predicted total royalty flows between 2014 and 2019, all observations (billion US$)

	OECD data, all observations			Predictions OBM with cty dummies			Predictions OBM without cty dummies		
Year	Total	Total OBM	Total BTM	pred BM	pred TM	Ratio TM pred	Pred BM	pred TM	Ratio TM pred
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2014	280.7	60.0	220.7	225.2	55.5	19.8%	252.2	28.5	10.1%
2015	255.2	60.9	194.3	213.7	41.5	16.3%	233.1	22.1	8.7%
2016	288.1	57.7	230.4	216.4	71.7	24.9%	231.1	57.0	19.8%
2017	307.9	60.4	247.6	223.5	84.4	27.4%	229.0	79.4	25.8%
2018	335.9	63.1	272.7	235.1	100.8	30.0%	244.7	91.2	27.1%
2019	341.2	63.6	277.6	236.0	105.3	30.8%	244.1	97.2	28.5%
2014-2019	*301.5*	*61.0*	*240.6*	*225.0*	*76.5*	*25.4%*	239.0	62.6	20.7%

Data sources: OECD and own calculations. Values are in billion US$. Outcomes in column (6) = column (2) – column (5) and outcomes in column (7) equal column (6) / column(2). Similarly column (9) = column (2) – column (8) and column (10) = column (9) / column (2).