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Optimal Tax Routing:
Network Analysis of FDI diversion

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The international corporate tax system is considered as a network and, just like for transportation, 'shortest' paths are computed, minimizing tax payments for multinational enterprises when repatriating profits. We include corporate income tax rates, withholding taxes on dividends, double tax treaties and the double taxation relief methods. We find that treaty shopping leads to an average potential reduction of the tax burden on repatriated dividends of about 6 percentage points. Moreover, an indicator for centrality in the tax network identifies the United Kingdom, Luxembourg and the Netherlands, amongst others, as the most important conduit countries. Tax havens do not have a crucial role in treaty shopping. In the regression analysis we find that the centrality indicators are robustly significant explanatory variables for bilateral FDI stocks. This also holds for our treaty shopping indicator.

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1. Introduction

There is growing international concern over the erosion of corporate income tax bases. Aggressive tax practices of international corporations are brought to the public eye, if not judgment.[1] This concern is addressed by the Base Erosion and Profit Shifting (BEPS) initiative of the G20 and OECD (2013, 2015) and the Anti-Tax Avoidance Directive of the European Union (2016). Multinational enterprises (MNE's) can exploit the differences in the national tax codes of different jurisdictions, with practices as transfer pricing, thin capitalization, hybrid mismatches, and treaty shopping.

Treaty shopping is the practice where MNE's, rather than investing directly in a host country, funnel the investment through a third country to take advantage of treaty provisions not found between the host and the home country of the investment (Davies, 2004). Countries sign treaties on a bilateral basis to avoid double taxation of corporate income to stimulate mutual foreign direct investment (FDI). These treaties are referred to as DTT's: double tax treaties. IMF (2014) considers treaty shopping in a study on spillovers in international corporate taxation and identifies it as a concern for developing countries because of the loss of their tax revenue.

By definition treaty shopping involves the indirect routing, or diversion, of investment. More in general, analysis of available FDI data is being put forward as suggestive of international tax planning (OECD, 2013). Table 1 illustrates the worldwide pattern of FDI positions. Relatively small economies account for large shares in FDI, for example, total inward FDI stocks into the Netherlands in 2013 equaled USD 4263 billion, accounting for 15 percent of worldwide inward FDI stocks. In the same year the Netherlands ranked 17th in terms of GDP (between brackets), with a share of about 1 percent of worldwide GDP. For Luxembourg the discrepancy is even more pronounced, as it is for the British Virgin Islands, ranking 10th in outward FDI stocks.

Table 1: Top 10 of inward and outward FDI stocks in 2013

Country	Inward	FDI	Country	Outward	FDI
	bln US$	%		bln US$	%
World	*27668*	*100.0*	***World***	*27696*	*100.0*
Netherlands (17)	4263	15.4	**Netherlands (17)**	5220	18.8
United States (1)	2755	10.0	**United States (1)**	4693	16.9
Luxembourg (73)	2466	8.9	**Luxembourg (73)**	2990	10.8
China (2)	2331	8.4	**United Kingdom (6)**	1717	6.2
United Kingdom (6)	1536	5.5	**France (5)**	1360	4.9
Hong Kong (41)	1120	4.3	**Germany (4)**	1252	4.5
Germany (4)	907	3.3	**Switzerland (20)**	1179	4.3
Switzerland (20)	809	2.9	**Japan (3)**	1118	4.0
France (5)	796	2.9	**Hong Kong (41)**	1098	4.0
Singapore (37)	751	2.7	**British Virgin Is. (190)**	1074	3.9

Source: IMF Coordinated Direct Investment Survey data, 2013 reporting countries. The totals of inward and outward stocks are not equal due to incomplete reporting and differences in registering stocks by home and host countries. Between brackets: GDP ranking (World Bank data).

[1] For instance the UK Public Accounts Committee, November 2012 and the Panama Papers (ICIJ, 2016).

Little seems to be known quantitatively about treaty shopping; no readily available measure exists for its magnitude, nor on the size of the subsequent reduction of the effective tax burden for MNE's. In this paper we examine the extent to which treaty shopping may lead to FDI diversion and reduced repatriation tax rates. This requires the construction of, if not a measure, then at least of indicators, of treaty shopping. Circumventing the lack of direct data we will construct these from national, publicly available, tax parameters. We examine whether these indicators can contribute to explaining actual bilateral FDI positions.

To develop the indicators we consider the international tax system as a network, just like for transportation, and compute the 'shortest' paths, minimizing tax expenditure for the MNE's when repatriating profits. The network consists of 108 countries, and the tax payments are constructed from the statutory rates of corporate income taxes, withholding taxes on dividends and the double tax relief methods. The bilateral DTT's typically lower, reciprocally, the withholding taxes and provide for more generous relief methods (Avi-Yonah and Panayi, 2011). We compute the potential tax reduction by treaty shopping on repatriated dividends.

In terms of the multilateral dimension our work resembles Barrios et al. (2012) in combining host and home country taxation, including tax treaties and also focusing on dividends. We consider a profit repatriation optimization, given a subsidiary in a host country and the parent company in the home country. Profits could be taxed with the corporate income tax in the host and home country and with a dividend withholding tax in the host country. Double tax relief and tax treaties limit the possible triple taxation of dividend flows already on direct routes. For indirect routes, thus involving FDI diversion, the taxes of all possible conduit countries matter as well, both as a home and a host country. All information is compiled and stored in a 'tax-distance' matrix describing the tax costs for incoming and outgoing dividends between each pair of countries. This matrix is input to a standard algorithm from graph theory which efficiently performs the required minimizations. After a few minor adaptations to the algorithm the computed shortest paths represent optimal tax routes.

Moreover, the network approach enables us to identify countries most likely to perform the role of conduits, countries often accused of being accessories to the tax avoidance by MNE's. A central position in the tax network can be seen as a necessary condition for the role as a conduit. With a next concept from graph theory we compute measures of network centrality.

In the econometric analysis, we first regress bilateral FDI stocks on unilateral tax variables and the bilateral tax rates that contain the information from the DTT's. Next, we introduce bilateral treaty shopping indicators from the network approach. In addition, the (unilateral) network centrality measures for both host and home country are added as explanatory variables. The FDI data are from the IMF CDIS database and the tax parameters from different public sources. All data pertain to the year 2013.

We report three main findings: First, treaty shopping potentially leads to a significant reduction of the tax burden of MNE's of 6 percentage points on average. This reduction by treaty shopping is on top of the 9 percentage points reduction which can already be realized through the DTT's, i.e. without indirect routing of repatriated income. Second, the top 5 in our main measure of network centrality are the United Kingdom, Luxembourg, Estonia, the Netherlands and Hungary. The conduit

role of these countries does however not lead to major tax revenues, if only because they perform that role because they hardly tax incoming and outgoing dividends. Conduit taxation is ultimately only 0.3 percent of worldwide repatriated dividends. Low-tax havens, i.e. those with a low or zero corporate tax rate, are not important conduit countries. Third, the coefficients of the treaty shopping indicator and tax network centrality measures are robustly found to be significant, statistically and in terms of economic impact on bilateral FDI stocks. In addition, the coefficients of other tax variables consistently have the correct sign.

We contribute to the literature with a novel and fundamentally multilateral approach that pairs a rigorous optimization framework with basic tax parameters. It generates quantitative results on treaty shopping in a network of 108 countries. We are not aware of other work where this approach is taken and quantified at this scale.[2] Moreover, we relate these quantitative results to bilateral FDI positions in order to investigate whether treaty shopping has a significant impact on FDI diversion.

An important limitation is the focus on dividends only. The network analysis itself takes the investment decisions as given, i.e. those from a parent company to a subsidiary in another country, and we allow for indirect financing structures involving other countries so as to reduce, especially, the non-resident withholding taxes upon repatriation of dividends. Mintz and Weichenrieder (2010) refer to this as the treaty shopping motive for setting up conduit entities in third countries. We take the profit decision of MNE's as given, focusing on dividends. We do so in recognition of the importance of royalty and interest payments for tax planning structures. These payments are instrumental in stripping corporate earnings in high tax host countries whereas the emphasis in this paper is on treaty shopping, reducing withholding taxes and in some cases the taxation in home countries. Still, the network approach offers a rich multi-country framework to investigate the dividend repatriation tax rates facing MNE's. We do use the withholding tax rates on royalties as explanatory variables in the econometric analysis.[3]

The paper proceeds with a brief discussion of related literature in section 2. The network approach to the international corporate tax system is described in section 3. In section 4 the data of the tax system are presented as well as the effects of double tax relief methods and the DTT's on the double tax rates. The subsequent potential tax reduction by indirect routing is the topic of section 5. Next, in section 6, the results of network centrality are presented, identifying conduit countries. Sections 4, 5 and 6 are both descriptive as well as introducing variables for the regressions described in section 7. The robustness of the regression results is illustrated in section 8, involving alternative measures of centrality. The concluding section summarizes and discusses directions for further research.

[2] Only recently Hong (2014) used a network approach for analyzing international taxation between 15 countries with only withholding taxes on dividends. An early paper of Gerard and Gillard (2004) applies a related approach for only three countries.

[3] Due to the strong correlation between the withholding tax rates for royalties and interest, we only include the former in the regressions.

2. Related literature

Our work is related to Barrios et al. (2012) by following a multilateral approach of international corporate taxation. They investigate the location decision of new foreign subsidiaries and find that taxation of the home country, additional to that of the host country, has a significant negative impact. We also use the basic matrix structure of international corporate taxation for dividend flows, including bilateral tax treaties, albeit for a much larger set of countries. The multilateral approach is also found in the seminal tax competition paper of Devereux et al. (2008) who estimate N x (N-1) tax reaction functions with N the number of countries.

Moreover, Egger et al. (2009) construct effective tax rates between country pairs, reflecting overall host and home country taxation, and find that the bilateral effective tax rate has a negative impact on bilateral FDI stocks. However, they only construct these rates for direct routes, not taking account of treaty shopping, for a sample of OECD country pairs between 1991 and 2002. Because they focus on OECD countries for which marginal and average effective tax rates (EMTR and EATR) are available they are able to calculate effective tax rates for each country pair.

There is an important difference between the papers mentioned above in their use of the term 'effective tax rate'. Devereux et al. (2008) and Egger et al. (2009) use the term to denote the rate determined by the statutory rates and definitions of the tax base, for instance for deductibility of interest on debt. Barrios et al. (2012) also start with statutory rates and then use the term 'combined effective tax rate' to account for the relative difference between the after-tax profit and gross profit in a sequence of combined, subsequent, taxations.[4] As we miss the data on effective tax rates, i.e. the national definitions of the tax base, for most of the non-OECD countries in our sample, we follow Barrios et al. (2012).

Egger et al. (2009) distinguish between regressions with only unilateral effective tax rates and with bilateral effective tax rates. They claim that in the richer tax environment of the latter an indirect effect of an increase in the home country tax rate can be captured; it negatively affects national, competing enterprises thus increasing bilateral FDI. We will further enrich the tax environment with indicators for treaty shopping and conduit countries.

Different from the papers above we are therefore also interested in the combined effective tax rates themselves. In particular, we want to know the effects of treaty shopping on these tax rates. The literature so far mainly considered the FDI effects of treaty shopping. Direct evidence of treaty shopping on FDI is scarce. Treaty shopping may involve treaty abuse and be illegal; the granting of (tax) treaty benefits in inappropriate circumstances (OECD, 2015).[5] With the possibility of treaty shopping being illegal, direct data are not likely to be easily available. Weyzig (2013) makes use of micro data of Dutch Special Purpose Entities (SPE's) from 2007. SPE's, in general, are entities with no or few employees, little or no physical presence in the host country and whose core business consists of group financing or holding activities (OECD, 2013). By relating the FDI flows via SPE's to the direct FDI flows (from the balance of payment statistics) he concludes that the share of bilateral FDI that is passing the Netherlands is 6 percentage points higher with a tax treaty route. This is a large effect because on average 11 percentage points of bilateral FDI stocks has passed the

[4] In separate regressions performed as robustness checks, Barrios et al. (2012) do however use the EATR.
[5] Preventing the Granting of Treaty Benefits in Inappropriate Circumstances, BEPS Action 6 - 2015 Final Report.

Netherlands. Also the low withholding tax rates on dividends have a significant impact on treaty shopping.

Weichenrieder and Mintz (2010) construct for German multinationals the chains of corporate structures across various countries and relate these structures in 2001 to the underlying fiscal motives. The level of withholding taxes is found to be important in determining which countries are used as a platform for investments.

Finally, there are two papers suggesting a network analysis for international taxation. The first is Gerard and Gillard (2004) who illustrate the applicability of network analysis for three EU member states: Belgium, Denmark and the Netherlands. This is too limited for an analysis of treaty shopping and identifying the role of conduit countries. The second paper is Hong (2014) who applies network theory on treaty shopping for a set of 15, mainly major, economies. Hong focuses on the treaty-specific withholding taxes on dividends, but different from our work, double tax relief methods and the corporate income tax are not modelled. His analysis with betweenness centrality measures, similar to those we apply, shows that the UK, Ireland, Hong Kong, Singapore and Luxembourg are most popular as conduit countries, due to the lack of withholding tax on dividends.

3. The network approach to international corporate taxation

The international corporate tax system can be considered a network of countries where distance is defined as the cost of channeling corporate income from one country to another in terms of the taxes to be paid. This section first describes the institutional setting, how the tax burden with repatriation is composed of different international taxes, following Barrios et al. (2012). Next, the costs of tax routes over the network are discussed, involving conduit countries and treaty shopping. Third, it is shown how tax distances can be defined to fit efficient algorithms for computing shortest paths, fully maintaining their tax interpretation (see also annex C1). As our sample contains 108 countries we have more than 10 thousand bilateral tax distances.

Consider a multinational with a subsidiary in a host country S and a parent company in home country P. Both countries may tax the income of the subsidiary. First, there is the corporate income tax (CIT) to be paid in the host country, at a rate t_S. Next, the host country may levy a non-resident withholding tax on the income of the subsidiary, net of the corporate income tax, when it is repatriated to the parent. We only consider the withholding tax on dividends, the income considered refers therefore to profit income, the tax denoted with w_S. However, the host and home country may have signed a tax treaty and a preferential rate $w_{SP} \leq w_S$ may apply. Finally, the home country may tax the foreign-source income at its CIT rate of t_P.

The tax code of the home country may contain provisions to avoid double taxation, for instance it may have a dividend participation exemption: under certain conditions all, or part, of the foreign-source dividend income is exempted from the corporate income tax. These conditions typically require a minimum share in the participation of the subsidiary, and a minimum number of years that the stocks are held. In general we assume that the conditions are satisfied. Some countries do not apply double tax relief methods to profit income from low-tax countries (CFC rules).

Apart from *exemption* two other methods of double tax relief are taken into account: *deduction* and *credits*.[6] Deduction is the most modest relief method where no taxes need to be paid over the taxes already paid. The latter are deducted from the tax base. With the credit system the base is the income of the subsidiary but the taxes paid in the host country are credited against the home corporate income tax.[7] Excess credit is not restituted. The credit method means less generous tax relief than exemption, but more than deduction.

Let home country P have a general double tax relief method (*dtrm*) that it applies. The tax treaties country P has signed may however contain agreements to provide more generous double tax relief to treaty partner S. Thus also the relief methods have a double country dimension: the specific relief method applied by home country P on income from host country S. The combined effective tax rates $t^e_{SP}(dtrm)$ for the multinational can be determined depending on the relief method; all are fully in line with Barrios et al. (2012).

$$
\begin{aligned}
t^e_{SP}(deduction) &= \quad 1-(1-t_S)(1-w_{SP})(1-t_P) \\
t^e_{SP}(credit) &= \quad \max\{1-(1-t_S)(1-w_{SP}), t_P\} \\
t^e_{SP}(exemption) &= \quad 1-(1-t_S)(1-w_{SP})
\end{aligned}
$$

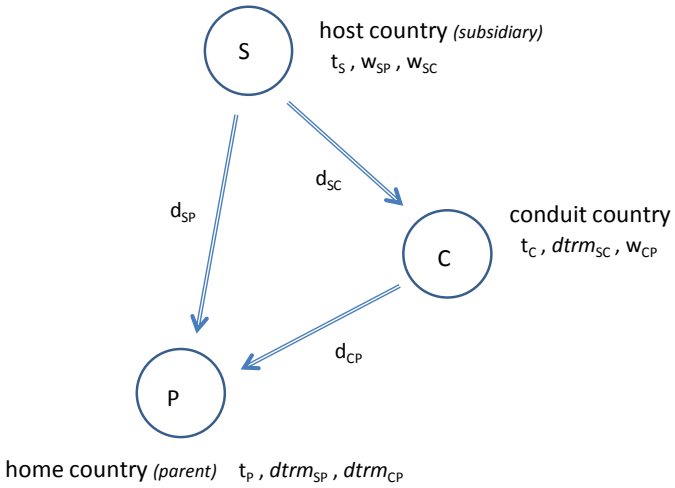
Now consider the possibility of indirect repatriation of dividends, i.e. through a third, or conduit, country C, see figure 1. It is rational for the MNE to choose the indirect route over the direct route, *ceteris paribus*, when its costs in terms of taxes are lower. The conduit country functions both as an intermediate host and as an intermediate home country. In constructing the tax cost of an indirect route it should be avoided to apply the CIT of an intermediate country twice. Define therefore the direct tax distance d_{SP} between host S and home country P based on the relevant withholding tax rate and only the CIT of the parent. The CIT of the host country is excluded from the tax distance definition because this tax is always paid, irrespective of the relief method. Depending on the tax relief method again three possibilities are considered.

$$
\begin{aligned}
d_{SP}(deduction) &= \quad 1-(1-w_{SP})(1-t_P) \\
d_{SP}(credit) &= \quad \max\{w_{SP}, (t_P-t_S)/(1-t_S)\} \\
d_{SP}(exemption) &= \quad w_{SP}
\end{aligned}
$$

By construction holds $t^e_{SP} = 1-(1-t_S)(1-d_{SP})$; the total taxation of the subsidiary's income in host S that is directly repatriated to home country P can be composed of the CIT of host S and the tax distance between S and P. The tax distances can be combined in a multiplication to find the compounded tax of a route, just as distances of road segments can be added for the total distance of a route over a transportation network.

[6] Thus no-relief-at-all, which does occur sparingly, is ignored. See also annex C1.
[7] With an indirect tax credit both the host corporate income tax and the withholding tax are credited. With a direct tax credit only the withholding tax can be credited. We ignore the latter here.

Figure 1: Treaty shopping – one conduit country



Returning to figure 1, observe that indirect routing, i.e. treaty shopping, is rational when total taxes over the indirect route are less than over the direct one, i.e. $1-d_{SP} < (1-d_{SC})(1-d_{CP})$. As the CIT of host S is to be paid in both cases, it does not matter for the (absolute) comparison.

The CIT of an intermediate country is relevant when the next intermediate parent in a tax route applies the credit method. Then it may not be clear which taxes can be credited; all the taxes of the preceding part of the tax route, or just the taxes paid in the previous country? In these conduit situations we take the rate of the world average corporate income tax to be credited. This weighted average excludes the CIT rate of the country involved. The withholding taxes of the previous country are always taken into account and are credited where required.

An alternative approach would be to assume that no taxes at all were paid so that no credits are applied. This would seriously underestimate the potential reduction of the tax burden for MNE's by treaty shopping. On the other hand, taking the statutory CIT of a conduit country as the basis for tax credit would overestimate the potential reduction as this CIT is not likely to be paid in full because of double tax relief.

As an example of an indirect route let the double tax relief of host P be the deduction method and let conduit country C exempt foreign-source dividend income. The treaty shopping condition translates to $w_{SC} + w_{CP} - w_{SC}w_{CP} < w_{SP}$; the combined withholding taxes on the indirect route must be less than on the direct route. This is only possible when the withholding tax to the conduit country is less than the one to the parent, $w_{SC} < w_{SP}$.[8]

The tax distance of an indirect tax route with a single conduit country is the usual combined effective rate of two tax rates. But a shortest path may go beyond the triangles of above. Thus, more in general, for any tax route, with an initial host $k = 1$ and final destination $k = \mathrm{n}$, the total tax distance equals $1-\prod_{k=2}^{\mathrm{n}}(1-d_{k-1,k})$. Clearly, the order of the bilateral tax distances in the computation does not matter. This characteristic allows the use of standard and efficient algorithms

[8] This implies, given that the undiverted investment also would have taken place without the treaty shopping, that the host country loses tax revenue. This is usually the case and has led the OECD to conclude that treaty shopping is a harmful tax practice (OECD, 1998).

to determine the length of the shortest path between all pairs of nodes on the network; or rather the minimum tax costs of repatriating dividends over the network for all country pairs. We use the elegant Floyd-Warshall algorithm[9] for this task. It stepwise builds up the matrix of shortest distances by consecutively adding and evaluating a new node, in arbitrary order, as an intermediate node, or conduit country. Efficiency of the algorithm is important as the number of possible routes over a network is huge.[10]

The algorithm generates the matrix of shortest distances, representing the lowest tax costs in repatriating profits from all host countries to all home countries. The lowest costs for a particular pair may be incurred on the direct route or on an indirect one. The average over all pairs will be taken, double GDP weighted, and, as we consider taxes on top of the CIT of the host countries, we will speak of the world average *double* tax rates. World averages of these rates will be computed, as will be country averages, both as hosts (for outbound profits) and as home countries (for inbound profits). The double GDP weights serve as a proxy for the bilateral dividend flows. Ideally the weights would be based on observations of these flows. However, these data are only very sparsely available and also reflect profit diversion for tax reasons, subject of this paper.

4. Tax data and double tax relief

The selection of 108 jurisdictions for the international network contains all high and upper middle income economies[11] for which sufficient tax data are available. This is augmented with large economies from the lower middle income country category, such as India, Indonesia and the Philippines, covering almost 95 percent of worldwide GDP in 2013. The full list is found in annex A1.

The selection includes also many jurisdictions considered a tax haven, because the latter are usually small and affluent, see for instance Dharmapala and Hines (2009). The importance of including tax havens is evident: they are likely conduit countries if only for their characteristic of low or zero taxes (OECD, 1998). Avoiding precise definitions we refer to the list of Gravelle (2013) as benchmark for tax havens. In the end, we classify 21 countries in our list of 108 countries as tax havens.[12] As a subgroup we identify 10 low-tax havens with a CIT rate of 12.5% or less, so that we can examine the role of the CIT rate. The subgroup includes Bermuda, the Cayman Islands and the British Virgin Islands, see annex A2.

The tax data are mainly obtained from the Worldwide Corporate Tax Guide 2013 from EY. For each country, we have data on the corporate income tax rate, the general rate of the withholding tax on dividends, the general double tax relief method, possibly the more lenient tax relief method for treaty partners and the treaty dividend withholding tax rates. For the dividend tax rates, we choose normally the lowest rate which is often conditional on a substantial participation in the daughter company.[13] Quite often this is 10 to 25 percent of the stocks, but sometimes the lowest tax rate applies only if the parent owns the majority of the stocks.

[9] See for instance Minieka (1978).
[10] For a simple network, that has 10 countries and is complete, meaning that all direct pairwise connections exist, there are almost 10 million simple routes.
[11] World Bank Atlas method, based on 2012 GNI per capita data.
[12] However we exclude Ireland, Jordan, Luxembourg, Switzerland and Singapore, see annex A.2.
[13] We have ignored lowest tax rates which only apply to non-profit organizations, such as pension funds and government institutions.

Although the data have been cross-checked with other information from public sources,[14] still some errors and omissions are expected to remain. In addition, choices and interpretations are unavoidable as tax codes contain different rates and provisions that apply under different conditions, which may involve legal structures, the level of corporate income, the industry, ownership shares, etc. Our choices and best knowledge are found in annex A1 (except for the treaty withholding tax rates).

Statutory rates of corporate income taxation have been used, where applicable including local taxes.[15] We ignore the possibilities to reduce the tax base in the host countries and the lower effective tax rates for three reasons. Frist, as we are mainly interested in the routing decision of repatriating income given the ultimate host and home country, the deduction possibilities of these two countries may apply whatever the route chosen; statutory or effective rates then do not affect comparison. Still that leaves the intermediate jurisdictions on the route and the relief method of the home country. Reduced taxation in the host increases the profit base to be repatriated and hence the scope for further tax reduction. This may be relevant when deduction or the credit method is involved. However, when intermediate or final home countries apply dividend exemption as many countries do, neither effective (as in EATR) nor statutory rates are relevant. The tax minimization will make sure that the chosen routes include as much as possible countries with the dividend participation exemption. A third and practical reason for not using effective tax rates is that these are simply not available for most of the countries in our set.

Table 2: Tax data 2013 - selected countries

Country	CIT	DTRM	THR	CFC	WHT-div	no. trts	tax haven	GDP weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bermuda	0.0	xmp		0	0.0	0	1	0.01
Brazil	34.0	crd		1	15.0	35	0	2.97
Canada	26.3	crd	xmp	0	25.0	75	0	1.88
China	25.0	crd		1	10.0	64	0	15.66
France	34.3	ded	crd	1	30.0	80	0	2.84
Germany	30.2	crd	xmp	1	25.0	71	0	4.04
Hong Kong	16.5	xmp		0	0.0	14	1	0.47
Japan	37.0	xmp		0	20.0	48	0	5.84
Luxembourg	29.2	xmp		0	15.0	56	0	0.05
Malta	35.0	xmp		0	0.0	40	1	0.01
Netherlands	25.0	xmp		0	15.0	72	0	0.89
Switzerland	21.1	xmp		0	35.0	70	0	0.46
United Arab Emirates	0.0	xmp		0	0.0	23	0	0.34
United Kingdom	23.0	xmp		1	0.0	55	0	2.95
United States	39.1	crd		1	30.0	54	0	19.79

Note: crd= credit system, xmp = exemption, ded= deduction system.

[14] For instance, Deloitte (2013) and Loyens & Loeff (2013).
[15] OECD Tax Database and KPMG Tax Tools and Resources.

The CIT rates are listed in annex A1 and in the first column of table 2 for a selected number of countries. When foreign-source income is exempted from corporate taxation (xmp), the tax rate is irrelevant, for the other double tax relief methods it is not. The general tax relief method is indicated in the second column. Countries may provide more generous relief for foreign-source dividends coming from tax treaty partners. Where we have found evidence, this relief method is applied to all treaty partners, although it is treaty specific, see column (3).

The CFC-column indicates when a country applies anti-abuse provisions, or CFC (controlled foreign corporation)-rules to counter tax deferral and avoidance through artificial foreign entities. For these countries we interpret tax relief for dividends from tax havens as deduction, listed in column (7).

Tax havens are often low-tax countries, as is the case for Bermuda and possibly Hong Kong. Malta, listed as a tax haven, has a high corporate income tax of 35 percent.[16] For holding companies, however, this is irrelevant as Malta applies a dividend participation exemption, as does Hong Kong. Tax havens tend to have in common zero withholding taxes. The general rates of this tax are found in the fifth column of table 2 and annex A1. The sixth column indicates the number of bilateral tax treaties a country has with partners within the selection of 108 jurisdictions.

Table 3: Dividend withholding tax matrix 2013 - selected countries

From* \ *To	**Bermuda**	**China**	**Germany**	**Malta**	**NLD**	**Nigeria**	**USA**	**General**
Bermuda	-	0	0	0	0	0	0	0
China	10	-	10	5	10	7.5	10	10
Germany	25	10	-	0	0	25	5	25
Malta	0	0	0	-	0	0	0	0
Netherlands	15	10	0	0	-	12.5	0	15
Nigeria	10	7.5	10	10	7.5	-	10	10
United States	30	10	0	5	0	30	-	30

The bilateral withholding tax rates from the DTT's imply a matrix structure for the tax data, see table 3. An important multilateral tax treaty is the Parent-Subsidiary directive of the EU.[17] This stipulates intra-EU withholding tax rates of zero and dividend participation exemption. The matrix of these dividend withholding taxes ($BWHTD_{ij}$) is a variable in the regression analysis.

With these data the bilateral dividend repatriation tax rates are constructed, combining the withholding tax and taxation in the home country. Next, to compute country and worldwide averages, bilateral weights are required. It should be observed that data on bilateral dividends and FDI are polluted with the phenomenon we are addressing in this paper; the diversion for tax reasons. For this reason we use double GDP-weights, see annex C2, to construct our descriptive statistics on double tax relief and treaty shopping.[18]

[16] However, the larger part of the tax bill can be reclaimed, see Loyens and Loeff (2013).
[17] European Union (1990). Next to the 27 EU member countries in 2013, also Iceland, Norway and Switzerland are included.
[18] In an alternative exercise, in collaboration with the OECD, bilateral weights were used based on sparsely available but actual bilateral dividend flows and FDI stocks, see Van 't Riet, Lejour & Hanappi (2015).

A multinational could face triple taxation when repatriating profits of a foreign subsidiary. With a world average, GDP-weighted, CIT rate of 29 percent for host and home countries and an average dividend withholding tax rate of 17 percent according to our data, this amounts to a compounded rate of about 59 percent, hypothetically. Taking the CIT of the host country as given, there remains in theory about 41 percent additional taxation due to double and triple taxation.[19] In practice double tax relief methods and tax treaties reduce or even eliminate double taxation. As a result, countries often do not levy a withholding tax or corporate tax on incoming dividends. The combined effect of unilateral and bilateral double tax relief is that there remains a world average double taxation of 12%, on top of the CIT of the host country. Thus one can safely conclude that double tax relief methods and tax treaties do what they are supposed to do: they reduce double taxation substantially, with almost 30 percentage points, but not entirely.

It is informative to average the bilateral dividend repatriation tax rates country-wise, for the country as home or as host of the investments. Low average tax rates for inbound dividends make a country attractive for corporate residence. The Netherlands and Finland head the ranking of countries in this respect, with average rates of 3.4 and 3.7 percent. In sharp contrast, the average rate for the United States is 16.7 percent.[20] This implies that when US corporations would switch their legal residence to one of these European countries they could reduce the tax burden on repatriated dividends from all over the world with more than 10 percentage points. Ireland, often a candidate country for such a tax inversion, has an average repatriation tax rate of 5.6 percent, ranking 11th.[21]

Exemption, as the own unilateral double tax relief method, contributes to a low average inbound rate, certainly compared to countries with only credits for taxes already paid. Also the number of bilateral tax treaties matters for the inbound rates as they stipulate reduced withholding taxes for the host country of the repatriated profits. The low-tax havens in general have no or few double tax treaties and therefore do not rank high.

The bilateral dividend repatriation tax rates, combining the withholding tax and taxation in the home country, are also used to explain the size of the bilateral FDI stocks in the regressions.

5. Treaty shopping potential

So far only direct routes between the host and home countries were considered, but firms also use indirect financing structures and thus indirect routes for dividend repatriation (Mintz and Weichenrieder, 2010). By establishing conduit entities in third countries multinationals can lower their tax bill compared to a direct route. The cheapest tax routes over the network follow from applying the shortest path algorithm discussed in section 3. We find that for 67 percent of all country pairs indirect tax routes are cheaper than the direct ones.

[19] World average taxation on top of the CIT of the host country equals 1 - (1 - .17)(1 - .29) ≅ 0.41.
[20] See column Direct in annex B1.
[21] An example of a tax inversion was the planned 160 billion US dollar merger of the pharmaceutical companies Pfizer and Allergan, announced in November 2015. Pfizer is American but the legal residence of Allergan is in Ireland, which is also where the new company was supposed to reside. New measures from the US Treasury made the tax benefits of the merger uncertain and the merger plan was abandoned.

The calculated tax reductions from treaty shopping involve deliberate diversion of investment, which will not always take place. The use of tax treaties could be bounded by the limitation of benefits articles in the treaties, although it is not very clear whether these limitations are very effective. Therefore we label this as potential reductions. We find that the potential reduction by treaty shopping is 6 percentage points. This lowers the world-wide average additional taxation, i.e. given the corporate taxation of host countries, from 12 to 6 percent. The findings establish that treaty shopping is a relevant mechanism for lowering the remaining double taxation after the application of double relief methods and tax treaties.

Treaty shopping lowers the combined effective tax rates for two reasons. The first is that firms benefit from routes with lower withholding taxes, explaining the major part of the tax reduction. The second reason is that firms choose routes such that they benefit from more generous double tax relief methods in the destination country. This mechanism is reflected in the fall of the average rate for the CIT of the home country; see the third line of table 4.

Table 4 also gives the split of the double tax revenue over the host, conduit and home countries. Only 0.3 percent of worldwide repatriated dividend flows is cashed by the tax authorities of conduit countries when the multinationals use optimal routes. Van 't Riet and Lejour (2014) show that for individual counties the consequences of indirect routing on tax revenues diverge widely.

Table 4: World average remaining combined effective tax rates (percentages) and *the distribution of the double tax revenue*

	Direct	Indirect
CIT host	29.2	29.2
WTH div	7.7	2.1
CIT home	4.4	3.7
Double	11.8	5.8
Host	*7.7*	*2.1*
Conduit		*0.3*
Home	*4.1*	*3.3*

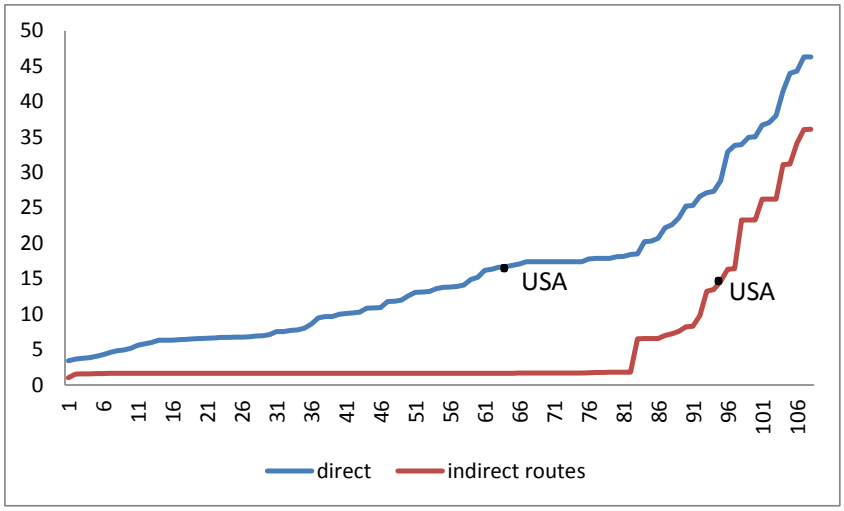
As for the direct tax routes, country average repatriation tax rates can be computed, both for inbound and outbound dividend flows. These country specific results are therefore given in two tables, see annexes B1 and B2. Starting with the tax rates for incoming dividends, figure 2 demonstrates the impact of treaty shopping on the average double tax rates of the home countries. The top line concerns the repatriation tax rates for direct routes, already discussed in section 4. The red line below concerns the rates when optimal use is made of indirect tax routes, i.e. treaty shopping. For both lines the countries have been ordered, from left to right, in ascending rates. As these two country rankings are different, countries have different positions at both lines, as indicated for the USA.

Treaty shopping lowers the floor in the remaining double tax rates; it does not completely eliminate the tax since there are a number of host countries who always levy a withholding tax on dividends irrespective of the host country. There is a distinct group of 82 jurisdictions with a remaining inbound tax rate of 1.8 percent or even lower. The EU members are all in this group as they can

transfer dividends within the EU without any tax cost because of the Parent-Subsidiary directive. The USA, for instance, is not part of this group: it applies the credit method, instead of exemption and levies a high CIT rate, and there are no detours to avoid this, given that repatriation of the foreign-source income is required, i.e. we do not consider deferral of taxation.

A similar pattern can be seen for host countries and the average double tax rates on outbound dividend flows. Here the MNE's face a rate of 5.4 percent or lower when repatriating profits from another group of 82 countries (69 identical to those 82 for inbound flows, explained below). Again treaty shopping is seen to practically equalize the final combined effective tax rates for a large group of countries including again the EU members. Also tax havens are within this cluster as they often levy no withholding taxes. Countries like Canada, China, Japan, and the Russian Federation have higher remaining outward double tax rates, because they always levy a withholding tax rate of at least a 5 percent, even to their most favoured treaty partners.

Figure 2: Rankings of average inbound dividend repatriation tax rates



The country averages with a lower floor in the repatriation tax rates is best understood when the bilateral rates are considered. At bilateral level this floor is rock bottom: final remaining double tax rates of zero. Even without treaty shopping costless repatriation of profits exists, i.e. non-taxed. The initial tax distance matrix contains 2428 cells with value zero; this is 21 percent of all country pairs.[22] Treaty shopping, potentially, increases the number of zero cells to 54 percent of all country pairs. These zero tax rates imply that within the international tax network there is a strongly connected component of 69 countries; for each country profit flows to all the other countries in this component are not taxed at all.

The bilateral tax rates that follow from the shortest path algorithm represent the optimal repatriation strategy for MNE's. They can be compared to the rates on the direct route; no difference means that the direct route is optimal, a positive difference means that there exists a detour with a tax gain. This difference is used in the regression analysis in section 7.

[22] The EU's Parent-Subsidiary directive alone is responsible for (27+3)*(27+3-1) = 870 zero cells.

6. Tax network centrality: identifying conduit countries

For 67 percent of the country pairs there is a cheaper tax route than the direct one. This leads to the question which countries are, potentially, most often used as locations for passing FDI. We identify these conduit countries using a centrality measure from network theory: *betweenness*. Given all shortest paths between all pairs of jurisdictions in the network, betweenness centrality is defined as follows: for a given jurisdiction count the number of times it is on a shortest path from S to P. Divide this number by the total number of shortest paths between S and P. Then sum these fractions over all pairs S and P, excluding those pairs where the given jurisdiction is the initial host or final home country.

We have performed the summation over country pairs with double GDP-weights. With these weights as a proxy for the dividend flows, the betweenness centrality of a country can be interpreted as the share of total worldwide undiverted FDI flows that pass through it (see annex C3). Table 5 presents the top 10 ranking of betweenness centrality and the full country ranking is found in annex B3. We first discuss the main results and next some alternative centrality measures.

Table 5: Top 10 conduit countries

	Country	DIV	no. trts	BTWNS		Country	DIV	no. trts	BTWNS
1	**United Kingdom**	0	51	12.2	6	**Singapore**	0	40	6.0
2	**Luxembourg**	15	57	7.7	7	**Ireland**	20	53	5.5
3	**Estonia**	0	36	6.7	8	**Slovak Republic**	0	42	5.3
4	**Netherlands**	15	74	6.6	9	**Cyprus**	0	35	4.3
5	**Hungary**	0	47	6.1	10	**Malta**	0	38	4.2

The value of the betweenness measure (BTWNS) can also be interpreted as a weighted fraction: the United Kingdom would be on 12.2 percent of the cheapest tax routes of the world average country pair. The UK ranks high because it is an EU member and it levies no non-resident withholding tax on dividends (DIV in table 5). These two characteristics it has in common with Cyprus, Estonia, Hungary, Malta and the Slovak Republic, all in the top 10. But the UK has signed more bilateral tax treaties, and multinationals face on average a lower withholding tax on incoming dividends. The impact on this ranking of a zero rate on the withholding tax is evident. Luxembourg is the first country without a general rate of zero to appear on the list, the Netherlands and Ireland are second and third, but all three countries have signed much DTT's.[23] Singapore is the only non-EU country in the top 10.

Most of the island low-tax havens also do not levy a non-resident withholding tax on dividends. Nevertheless, with the exception of Cyprus, they do not rank high on the centrality measure. This is caused by the fact that they have no or only a few double tax treaties. Low tax havens do not significantly contribute to the conduit function because the other countries apply relatively high withholding taxes on profit flows towards them or apply less generous double tax relief rules (CFC rules) on inward profits flows from low tax havens. If we exclude the top 10 conduit countries from

[23] Luxembourg and the Netherlands are attractive for other tax reasons too. Liquidation of a company in Luxembourg is treated as a capital transaction and is not subject to a dividend withholding tax. The Netherlands has a general rate of zero on royalties and interest. Such characteristics have not been taken into account. To avoid arbitrariness we stick to the bare tax parameters.

table 5 the world average dividend repatriation tax rate is only raised from 5.8 to 6.0 percent. We find that the elimination of a group of countries as conduits has little impact as long as there remains a large group of well-connected countries. This seems to imply that large scale international cooperation would be required to combat treaty shopping.

The ranking of the betweenness centrality measure suggests that there is a close correlation with the FDI stocks in table 1. We explore this below, where centrality in the tax network enters the regression analysis, i.e. with FDI diversion, for both the origin and the destination of the investment.

Centrality measures are calculated using all shortest paths. The total number of shortest paths can be quite larger than the number of country pairs. In fact, multiplicity of shortest paths in the international corporate tax network is abundant.

A potential source of huge multiplicity is direct connections with a zero tax rate; no double taxation at all on repatriation of dividends. The matrix with tax distances contains 2428 zero-cells, which is 21% of all pairs. A consequence of these zeros is that, given a shortest route, there can be costless detours which are also shortest routes. However, in practice firms face costs setting up a holding, even if it is a shell company. The zero-cost detours have been countered by introducing a small penalty for each additional intermediate country on a route. The penalty could represent the cost of setting up a conduit entity in a new country. This reduces the average multiplicity, but it is still about 5.5 paths per country pair.

Another reason for multiplicity is that multinationals may prefer tax routes with slightly higher costs than the strictly cheapest routes because of non-tax characteristics of the conduit countries. These may include the quality of the financial sector and government institutions. We have allowed for a half percent on top of the combined effective range of the strictly shortest paths. Thus paths within this additive range are considered as shortest paths and are included in the computation of the main centrality measures. The average multiplicity per pair increases to 91 different relevant paths.[24] The measure with the range of a half percent and the one without are two alternative centrality measures, respectively *Betweenness* (BTWNS) and *Strict* (STRCT).

Another centrality measure counts whether a jurisdiction is at all on a shortest path of a pair, i.e. *Occurrence* (OCCUR). This is a binary indicator instead of a fraction. By country the indicators are again summed over the pairs. When there would be a unique shortest path for each pair the two measures would coincide; this is however not the case at all as explained above. In addition, an *Unweighted* (UNWTD) betweenness measure for relevant paths within range is created.

It is not obvious which measure of network centrality corresponds best with the conduit function of countries. The main variant which we present is *Betweenness*, for relevant paths within range and double GDP weighted (BTWNS). Besides we use the three extra measures to test whether the assumptions of BTWNS affect the outcomes. Table 6 presents the positions of the main top 10 in the alternative centrality rankings. In annex B3 the full list can be found.

[24] See also annex D.

Table 6: Rank positions for alternative betweenness centrality measures

	Country	OCCUR	STRCT	UNWTD		Country	OCCUR	STRCT	UNWTD
1	**United Kingdom**	3	1	1	6	**Singapore**	6	3	4
2	**Luxembourg**	1	2	10	7	**Ireland**	5	6	14
3	**Estonia**	4	4	7	8	**Slovak Republic**	9	8	11
4	**Netherlands**	7	5	2	9	**Cyprus**	18	10	3
5	**Hungary**	2	7	5	10	**Malta**	16	11	6

The United Kingdom heads three of the four variants of the centrality measures. Luxembourg ranks first in the alternative measure of occurrence. This ranking however, is not very different from the reference ranking of betweenness. Also the ranking with the strict shortest paths does not differ much from that with a range. The same applies for the unweighted measure, which has the UK, the Netherlands and Cyprus as top 3. Thus, with respect to the ranking the results of the centrality measures are robust.[25] This will be shown in the regression analysis as well.

7. The impact of treaty shopping and centrality on FDI stocks

Conduit countries play an important role in diverting FDI stocks between the resident country of the investor and the host country of investment. One would expect that bilateral FDI stocks where a conduit country is the home or host country are relatively larger than those stocks for other country pairs. The total inward and outward stocks of countries like the Netherlands, Luxembourg, and the UK, suggest this is the case, see table 1. In the same way, bilateral FDI stocks between non-conduit countries could be relatively smaller, in particular if the effective profit repatriation tax rate between both countries is high and multinationals have options for rechanneling their investment and profit flows via other countries.

We test the effects of conduit countries and treaty shopping on FDI stocks empirically for the 108 countries in our network, using the IMF/CDIS data for 2013 which include FDI via SPE's.[26] The CDIS database includes the bilateral FDI positions; about 100 countries report inward stocks and 80 countries report outward stocks. We have 6422 observations of the possible 11556 ones, given the set of 108 countries. The other observations are missing, either by non-reporting or reported 'confidential data'. It is likely that the missing values represent mainly smaller FDI stock values. Egger et al. (2009) found that the missing values in their sample are not randomly distributed using a Heckman selection model. We did not find such a result in our sample. Still, as robustness check we also run the regressions in a sample with less missing observations in section 8. This does not alter our main conclusions.

The advantage of the IMF/CDIS data is the inclusion of the FDI positions via SPE's, which is very important for countries, like Luxembourg and the Netherlands. These data are gathered since 2009. This is a relatively short period for a panel analysis, also considering the correlation between FDI stocks in succeeding years. Moreover, many of the double tax agreements, tax treaties and corporate tax rates often remain the same for a number of years. This questions the value added of

[25] Kendall's (tau) rank correlation coefficients with BTWNS are 0.86 for OCCUR , 0.80 for STRCT and 0.81 for UNWTD.
[26] See the definition in section 2.

a panel analysis. A third factor is that the network analysis is very time consuming. For all these reasons we only conduct an analysis for one year, 2013.

We explain the variation in bilateral FDI stocks (FDI_{ij}) using GDP in the host and home country (*GDP*), the quality of institutions in both countries (*INST*).[27] These data come from the World Bank Development Indicators, sometimes added with GDP data of tax havens from the CIA factbook and Wikipedia. Moreover, we add a number of geographic variables from CEPII. Because our FDI data also include many non-OECD countries, we use not only distance ($DIST_{ij}$) as explanatory variable, but also dummies for a common language ($LANG_{ij}$), former colony (COL_{ij}) and contiguity ($CONT_{ij}$). Except for distance, we expect positive coefficients for these dummies. Our base specification is a typical gravity equation with GDP and distance as the main explanatory variables.

Next, we add dummy variables for tax havens (*TAXH*), for which we expect a positive coefficient. These are based on Gravelle (2013) discussed in Section 4. We include the CIT rates in both countries (*CIT*) and the standard withholding taxes on dividends and royalties (*WTHD, WTHR*). In other specifications we add the bilateral withholding taxes ($BWHTD_{ij}$) agreed upon in tax treaties, instead of the default dividend tax rate in the host countries, and sometimes also the bilateral remaining CIT rate ($RCIT_{ij}$). The tax data come from the sources mentioned in section 4. Our first specification reads[28]

$$\begin{aligned}\log(FDI_{ij}) = {} & \beta_0 + \beta_1 \log(GDP_i) + \beta_2 \log(GDP_j) + \beta_3 INST_i + \beta_4 INST_j + \beta_5 \log(Dist_{ij}) \\ & + \beta_6 LANG_{ij} + \beta_7 COL_{ij} + \beta_8 CONT_{ij} + \beta_9 TAXH_i + \beta_{10} TAXH_j + \beta_{11} CIT_i + \beta_{12} CIT_j \\ & + \beta_{13} WHTD_i + \beta_{14} WHTD_j + \beta_{15} WHTR_i + \beta_{16} WHTR_j + \beta_{17} BWHTD_{ij} + \beta_{18} RCIT_{ij} \\ & + \varepsilon_{ij}\end{aligned} \tag{1}$$

ε_{ij} is the independently and identically distributed disturbance term. One of the well-known problems in estimating gravity equations is the number of zero values for the dependent variable. This problem is extensively discussed in the trade literature (Head and Mayer, 2014) with the many zeros for bilateral trade values in samples with many developing countries. The zero values create missing values with a standard log transformation. This also applies for bilateral FDI stocks, in particular if less developed countries are included. These countries do often not invest in other countries. One of the most common solutions is to use a transformation of *log(1+x)* in which *x* is the bilateral trade value. Then it is important whether the FDI stocks are measured in millions or billions of dollars. This affects the distribution of the log trade values. For that reason Benassy et al. (2007) use a value of 0.3 instead of 1 in the log transformation. This does not solve all problems. Because trade values cannot be negative, the error distribution is truncated and is probably not independent from the explanatory variables. Santos da Silva and Tenreyro (2006) argue for that reason to use a Poisson Maximum Likelihood method. We follow this approach as a robustness analysis, presented in the next section. We do prefer the log transformation because the distribution of FDI values is

[27] We have used the average of the six governance indicators for this purpose.
[28] Note that we do not use all tax variables simultaneously as explanatory variable.

highly skewed; the 1% observations with the highest FDI stock values (representing FDI stock over 100 billion US$) cover 50% of the value of the aggregated bilateral FDI stocks in sample.[29]

Another issue is the potential endogeneity of some of the explanatory variables with bilateral FDI stocks. The literature on the impact of bilateral tax treaties on FDI treats these treaties often as endogenous;[30] increased investment could raise the necessity of a treaty. Many conduit countries indeed signed many treaties. However, since the network centrality of a conduit country is measured as an average over all its 107 partner countries, the impact of a specific bilateral treaty on the network centrality of a country is only limited. This suggests that the potential endogeneity between network centrality and bilateral FDI is very indirect and small and therefore of minor importance in this study.

Table 7: Summary statistics

Variable	Mean	Std .Dev.	Min	Max
Log FDI	3.31	3.43	0.00	13.92
Gravity variables				
Log GDP	12.07	1.98	6.80	16.63
Average institutional quality	0.57	0.83	-1.37	1.86
Log distance	8.55	0.94	4.09	9.89
Contiguity dummy	0.03	0.17	0.00	1.00
Common language dummy	0.11	0.31	0.00	1.00
Colony dummy	0.02	0.15	0.00	1.00
Tax variables				
CIT rate	0.23	0.09	0.00	0.46
Tax haven dummy	0.18	0.39	0.00	1.00
Withholding tax on dividends	0.13	0.11	0.00	0.35
Withholding tax on royalties	0.15	0.10	0.00	0.34
Bilateral withholding tax	0.09	0.09	0.00	0.35
Remaining cit rate in home country	0.06	0.10	0.00	0.40
Bilateral effective tax rate	0.15	0.13	0.00	0.58
Treaty shopping indicators				
Bilateral tax rate after treaty shopping	0.06	0.09	0.00	0.47
Treaty shopping effect	0.09	0.10	0.00	0.50
Betweenness indicator	1.58	2.23	0.00	12.20

Number of observations: 6422

FDI stocks, GDP and distance (in kilometers) are measured in logs. Table 7 presents the summary statistics. The indicator for institutional quality is an average of the Worldwide Governance Indicators (World Bank, 2016), each ranked between -2.5 and 2.5. A higher value implies higher institutional quality. The geographic variables are downloaded from CEPII. Countries are only in 3% of the cases close neighbours. Of the country pairs 11% has a common language and 2% have a colonial relation. The corporate income tax rate varies from zero to 46% and is on average 23%. Of

[29] Many of these bilateral FDI stocks have the US, Luxembourg or the Netherlands as resident or host country. This corresponds to the ordering of aggregated inward and outward FDI stocks in Table 1.
[30] Some references are Blonigen and Davies (2004, 2005) and Egger et al. (2006).

the 108 countries 18% is defined as a tax haven. The default withholding taxes on dividends and royalties more or less vary between 0 and 35% with an average of about 15%.

The bilateral withholding tax rates on dividends are on average 4% points lower than the default withholding tax. The unweighted bilateral effective tax rate is 15% in this sample and is somewhat larger than the double-GDP weighted average tax rate in section 5 for all country pairs. Quite often the effective tax rate is zero, e.g. between the EU member states, but it could also be 58%, suggesting no double tax relief at all. In many cases it is cheaper to divert the FDI stocks via other countries. This makes that the average dividend repatriation tax rate is only 6% instead of 15%. Among the minimizing-tax routes only 37% are direct routes (not in the table).

The outcomes of the OLS regressions with the basic explanatory variables are found in Table 8. GDP in the host and home country have a positive impact on the bilateral FDI stock. This is also the case for institutional quality in both countries. Benassy et al. (2007) and Egger et al. (2009), among others, use GDP per capita instead of institutional quality. Both variables are heavily correlated. We have chosen for institutional quality because the explanatory power is higher in our sample. Distance has the expected negative effect on the size of the bilateral FDI stock; a common language increases bilateral investments, as is also the case for contiguity and a colonial relationship in the past.

Tax havens have larger inward and outward FDI stocks; the coefficients are positive and significant in both home and host countries. Tax havens distinguish themselves from other countries, not only because of low or negligible tariff rates on profits, but also because of characteristics as a lack of transparency, bank secrecy, lack of information sharing, and requiring little or no economic activity for an entity to obtain legal status (Gravelle, 2013). It is easier to hide wealth in bank accounts and holdings than in many other countries. These characteristics suggest that tax haven dummies and corporate tax rates are not strongly correlated.

CIT rates have a negative impact on the outward and inward FDI stocks. Egger et al. (2009) suggest that higher cit rates in the home country pushes multinationals to invest in other countries, at least in a sample of OECD countries. We find the same result if we select only reporting OECD countries as home countries. For our broader sample of home countries this is not the case. The interpretation could be that higher CIT rates discourage investment overall, whether it is invested in the home or host country.

The default withholding taxes on dividends are included in the second regression in Table 8. A higher dividend tax in the host country makes it less attractive distributing profits to the home country and a withholding tax in the home country makes it less attractive for using that country as conduit country. The withholding tax in the host country has indeed a statistically significant negative effect on FDI. In regression (2) this also holds for the one in the home country.

Since repatriated corporate income does not solely consist of dividends we have also added the default withholding tax on royalties for the host and home country in column (3). As mentioned in footnote (4), we do not include the withholding tax on interest due to the high correlation with the one on royalties. The withholding tax on royalties has a negative effect on bilateral FDI stocks for

both countries. Because of the correlation between the withholding taxes on royalties and dividends, the coefficient of the latter tax becomes insignificant in the home country. The coefficient on the CIT rate in the home countries is also much lower; the semi elasticity decreases from 2 to 1. In regressions with bilateral tax variables, see columns (5) and (6) of table 8, we have eliminated the withholding tax of dividends. This does not have any impact on the other coefficients.

A possible problem could be the correlation between the dummies for tax havens and the cit rates or between the tax haven dummies and withholding taxes. As a check we have excluded the tax havens dummies. Comparing the results in column (4) to those in column (2) in table 8 we find that the coefficients on withholding taxes on dividends are somewhat higher without tax havens and those of the CIT rates somewhat lower. The explanatory power is lower, so we include tax haven dummies and withholding taxes in our regressions, except for the dividend tax in the home country.

If we include the bilateral withholding taxes ($BWHTD_{ij}$) agreed upon in tax treaties, instead of the default dividend tax rate in the host country, we find a negative significant effect for this variable. This is shown in column (5) of Table 8. The semi-elasticity of the bilateral taxes is about 4. The explanatory power of the equation is also larger compared to the specification which only includes the standard dividend tax rate in the host country, i.e. column (3). We do not reproduce the result of Egger et al. (2009) where the sign of coefficient of the home country tax rate reverses when the bilateral taxes are added. Apparently, in our sample of 108 countries, the direct negative effect of the tax on the attractiveness for bilateral FDI dominates possible indirect effects via national, competing firms.

The bilateral withholding tax rates do not take count of the remaining CIT that has to be paid in the home country, depending on the tax relief possibilities between the two countries. As discussed in section 4, these double tax relief possibilities could be general or country specific depending on the arrangement in bilateral tax treaties. Therefore we also add the remaining bilateral cit rates corrected for double tax relief ($RCIT_{ij}$) in the sixth column in Table 8. For convenience we have combined the bilateral withholding tax rates and the remaining cit tax rate. This is the effective tax rate defined in section 3. The elasticity of the effective tax rate is smaller than of the bilateral withholding tax rates. Because these remaining CIT rates reflect the burden of the cit rate in the home country, we have excluded the default CIT rate variable from the regression.

Specification [2] represents the level where we examine the role of treaty shopping and conduit countries in explaining the bilateral FDI stocks. So far, we have explained the variation in bilateral FDI stocks by variables related to undiverted investment and hence direct profit repatriation routes. Now, we include the possibilities of indirect routes which divert FDI in order to minimise taxation; the profitable detours. Because the IMF data on FDI stocks includes FDI via SPEs, these are also the appropriate FDI data taking account of diverted FDI.

$$\begin{aligned}\log(FDI_{ij}) = {} & \beta_0 + \beta_1 \log(GDP_i) + \beta_2 \log(GDP_j) + \beta_3 INST_i + \beta_4 INST_j + \beta_5 \log(Dist_{ij}) \\ & + \beta_6 LANG_{ij} + \beta_7 COL_{ij} + \beta_8 CONT_{ij} + \beta_9 TAXH_i + \beta_{10} TAXH_j + \beta_{11} CIT_i + \beta_{12} CIT_j \\ & + \beta_{13} WHTR_i + \beta_{14} WHTR_j + \beta_{15} TRT_{ij} + \beta_{16} SHOP_{ij} + \beta_{17} CENT_i + \beta_{18} CENT_j + \varepsilon_{ij}\end{aligned} \quad (2)$$

The variable $SHOP_{ij}$ reflects the gains of lower taxation by using indirect routes for FDI. If the direct route between countries *i* and *j* is the cheapest one, $SHOP_{ij}$ is equal to zero. If there are cheaper options, $SHOP_{ij}$ has a positive value. We expect a negative sign for the coefficient. Column (2) of Table 9 shows that this is indeed the case; the coefficient is statistically significant. The coefficient suggests that if bilateral taxes can be lowered by 10% points due to treaty shopping, bilateral FDI stocks decrease by about 17%. Treaty shopping thus has a significant impact on bilateral FDI stocks, statistically and economically. The semi elasticity of 1.7 has the same order of magnitude as the semi elasticities of other taxes, although it is somewhat lower than those of the standard CIT rate.

The coefficient for the effective bilateral tax rate is smaller than without treaty shopping. This is probably due to correlation with treaty shopping. In many bilateral relations the bilateral withholding tax is zero and also the remaining cit rate is often zero due to tax exemption. By definition, there is no cheaper tax route, so the treaty shopping variable is zero. Moreover, the higher the withholding tax rate and the remaining cit rate are, the higher is the probability for cheaper tax rates and thus a positive value for the treaty shopping variable.

Next, we switch to the role of conduit countries. The other columns in Table 9 present the regression results including centrality indicators for the home and host countries. Our preferred network centrality indicator, see section 6, is *Betweenness*. A high value of this indicator implies that the country is often used as a conduit country for diverting FDI and profit flows, because the value reflects the share of tax-minimising routes on which the country is present as conduit. We expect that a conduit country receives much FDI and diverts much FDI to other countries. These could be other conduit countries or final host countries. The third regression in Table 9 shows that the centrality indicators, in the host country and in the home country, have a positive and significant impact on FDI. An increase of one standard deviation of the centrality indicator stimulates the bilateral FDI stock by 25% if it is a home country and by 29% if it is a host country. This confirms our intuition; if the home or host country of the bilateral FDI stock is a conduit, FDI stocks are larger.

The attractiveness of a country as conduit depends among others on its withholding taxes. Therefore it is not surprising that this variable is no longer significant. Excluding it hardly changes the coefficients for the other variables, see column (4).

Although a high value of the centrality indicator suggests that both countries are also often used for treaty shopping, we also include $SHOP_{ij}$ and the effective bilateral tax rates in the regression. The reason is that the centrality indicator reflects the relevance of a conduit country in general, but it is not route specific. When a particular route is not the cheapest one, in spite of a conduit country on the route, treaty shopping has still a negative effect on bilateral FDI. This is confirmed with the regression shown in column (5). And, as could be expected, the coefficients of the centrality indicators are somewhat lower now. The centrality coefficients of nearly 0.1 suggest that one standard deviation increase in centrality has an impact of 22% on bilateral FDI stocks.

The coefficients of the centrality indicators for the home and host country have a positive and significant impact on bilateral FDI stocks. Moreover, we also find that bilateral FDI stocks are larger if the direct profit repatriation route is also the cheapest tax route. And the coefficients of other tax variables are consistently found to have the correct sign.

Table 8: Explaining FDI stocks without indicators for FDI diversion

	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDP_home)	0.795***	0.801***	0.834***	0.719***	0.803***	0.804***
	(0.0192)	(0.0193)	(0.0191)	(0.0186)	(0.0193)	(0.0190)
Log(GDP_host)	0.668***	0.676***	0.680***	0.618***	0.652***	0.659***
	(0.0189)	(0.0188)	(0.0188)	(0.0177)	(0.0190)	(0.0188)
INST_home	1.346***	1.384***	1.310***	1.392***	1.254***	1.216***
	(0.0358)	(0.0384)	(0.0371)	(0.0367)	(0.0351)	(0.0366)
INST_host	0.493***	0.552***	0.526***	0.567***	0.486***	0.479***
	(0.0369)	(0.0391)	(0.0382)	(0.0378)	(0.0357)	(0.0358)
Log(DIST)	-0.967***	-0.964***	-0.927***	-0.821***	-0.817***	-0.832***
	(0.0350)	(0.0348)	(0.0344)	(0.0345)	(0.0366)	(0.0370)
Dummy CONT	0.671***	0.723***	0.761***	0.863***	0.847***	0.794***
	(0.183)	(0.183)	(0.186)	(0.188)	(0.184)	(0.183)
Dummy LANG	1.640***	1.621***	1.731***	1.920***	1.743***	1.781***
	(0.113)	(0.112)	(0.112)	(0.113)	(0.110)	(0.112)
Dummy COL	1.402***	1.343***	1.406***	1.389***	1.364***	1.364***
	(0.203)	(0.202)	(0.196)	(0.190)	(0.194)	(0.195)
Dummy TAXH_home	1.512***	1.451***	1.340***		1.344***	1.405***
	(0.102)	(0.104)	(0.103)		(0.101)	(0.100)
Dummy TAXH_host	0.857***	0.741***	0.681***		0.622***	0.773***
	(0.0970)	(0.0997)	(0.0994)		(0.0975)	(0.0972)
CIT_home	-2.306***	-1.956***	-1.028**	-0.575	-1.011**	
	(0.433)	(0.447)	(0.451)	(0.451)	(0.436)	
CIT_host	-3.153***	-2.527***	-2.349***	-2.027***	-2.006***	-2.857***
	(0.438)	(0.455)	(0.459)	(0.456)	(0.450)	(0.444)
WHTD_home		-0.934***	0.172	-0.767**		
		(0.325)	(0.319)	(0.320)		
WHTD_host		-1.683***	-1.263***	-1.697***		
		(0.331)	(0.337)	(0.336)		
WHTR_home			-4.228***	-4.731***	-4.160***	-4.031***
			(0.339)	(0.336)	(0.334)	(0.327)
WHTR_host			-1.341***	-1.658***	-0.763**	-1.307**
			(0.377)	(0.379)	(0.373)	(0.366)
BWHTD					-3.912***	
					(0.378)	
BWHTD+RCIT						-2.306***
						(0.266)
Constant	-6.447***	-6.518***	-6.851***	-5.233***	-7.010***	-6.969***
	(0.406)	(0.406)	(0.398)	(0.394)	(0.396)	(0.396)
Adjusted R^2	0.514	0.517	0.528	0.5107	0.535	0.532

Notes: The regressions are estimated with OLS. There are 6422 observations.

Robust standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 9: FDI diversion - treaty shopping and centrality

	(1)	(2)	(3)	(4)	(5)
Dummy TAXH_home	1.405***	1.381***	1.411***	1.410***	1.436***
	(0.100)	(0.100)	(0.101)	(0.101)	(0.100)
Dummy TAXH_host	0.773***	0.777***	0.840***	0.846***	0.851***
	(0.097)	(0.097)	(0.100)	(0.097)	(0.097)
CIT_home			-0.969**	-0.970**	
			(0.440)	(0.440)	
CIT_host	-2.857***	-3.090***	-2.588***	-2.608***	-2.963***
	(0.444)	(0.451)	(0.455)	(0.450)	(0.456)
WHTD_host			-0.0820		
			(0.378)		
WHTR_home	-4.031***	-3.959***	-3.812***	-3.813***	-3.707***
	(0.327)	(0.328)	(0.332)	(0.332)	(0.327)
WHTR_host	-1.307**	-1.166**	-1.328***	-1.349***	-0.950*
	(0.366)	(0.395)	(0.372)	(0.357)	(0.361)
BWHTD+RCIT	-2.306***	-1.256***			-0.855**
	(0.266)	(0.364)			(0.364)
SHOP		-1.715***			-1.588***
		(0.432)			(0.429)
CENT_home			0.114***	0.114***	0.099***
			(0.016)	(0.016)	(0.016)
CENT_host			0.130***	0.132***	0.108***
			(0.021)	(0.019)	(0.019)
Constant	-6.969***	-6.954***	-7.992***	-8.001***	-7.885***
	(0.396)	(0.395)	(0.414)	(0.412)	(0.410)
Adjusted R^2	0.532	0.533	0.535	0.535	0.538

Notes: see table 8. The results fort the other variables are available upon request.

8. Robustness analysis

In the previous section we concluded, based on OLS estimators, that conduit countries have larger FDI stocks. We apply the PPML estimator as discussed earlier, to check for the robustness of the outcomes. Moreover, we check whether the results also hold for a limited country sample with less missing and zero values for the FDI stocks and also for other centrality indicators.

Estimation method

An alternative for the OLS estimator is the pseudo Poisson Maximum Likelihood (PPML) estimation method with robust standard errors introduced by Santos Silva and Tenreyro (2006). It delivers consistent estimators under general conditions and the authors show that it behaves well in many specifications, although it is not always efficient. It does not assume a normal distribution of the disturbance terms, like OLS and it therefore less restrictive. The dependent variable is FDI instead of the log and includes all zero values. Unfortunately, the variance of the dependent variable is much larger, due to the very skewed distribution of the FDI values with many zero values and values below 100 mln US dollar, while about 1% of the observations exceeds 100 billion US dollar.

We replicate specification [2] with the PPML estimator for the regressions which include the treaty shopping variable and/or the centrality indicators. The results are presented in the first three columns of Table 10 and should be compared with those in columns (2), (4) and (5) in Table 9. Most of the coefficients have similar signs and are statistically significant irrespective of the estimation

method. The coefficients of our main variables of interest: the centrality indicators and the shop variable have the expected sign and are statistically significant. Conduit countries have on average large FDI stocks as is also the case for direct routes. If there are cheaper options via other countries, FDI stocks are significantly lower (*SHOP>0*).

Sometimes the results of both estimation methods differ. The coefficients for the CIT rate in the host and home country are not significant with PPML.[31] A remarkable difference between both estimation methods is the positive sign on the bilateral effective tax rate, but it is not significant. Further analysis shows that this is mainly due to the US observations as home country with large outward stocks. The US carries out a credit method and due to its high statutory CIT rate, taxes are relatively high. The large bilateral FDI stocks correlate with high tax rates and have more impact in the Poisson regression than in the OLS regression with log transformation.[32]

Many empirical papers on FDI stocks focus on the OECD countries as home and host countries of foreign investment, see Egger et al. (2009) and Benassy et al. (2007) amongst others. These are also the most important outward investing countries in general. The advantages of this selection are that the data contain fewer missing observations and zero values for bilateral stocks. Therefore we restrict our country sample for the home countries to 34 OECD countries and all 108 countries as host countries for investment. Regarding the host countries, we differ from mentioned papers, because an analysis of conduit countries and treaty shopping between only OECD countries does not give much insight. We would miss too many tax havens and minimizing tax routes. Moreover, an OECD country selection would be dominated by EU-country pairs. For these pairs, the withholding tax rates are zero and the exemption method applies, so the direct routes are also the tax-minimising routes.

In the restricted sample of 3672 observations, the number of missing values is indeed much lower (only 20%) and also the number of zero values for bilateral FDI stocks (also about 20%). This is also a check to see whether the large share of missing and zero values in the full sample affect the regression results. The main results are presented in the last three columns of Table 10 and have to be compared with columns (2), (4) and (5) in Table 9. All qualitative results are the same, except for the positive coefficients of the CIT rate in the home country in column (5) and (4) to which we referred before. A second exception is the insignificance of the coefficient on the withholding tax on royalties in the host country. This is also the case for the coefficient of the bilateral effective tax rate. In this subsample the share of the high bilateral FDI stocks is nearly twice as high. If we exclude the observations with the US as home country the coefficient becomes negative.

The impact of centrality in the host country and of treaty shopping seems to be somewhat larger in the restricted sample than in the full sample. The coefficient of treaty shopping is also somewhat larger. These results are very comforting. The inclusion or exclusion of inward stocks of OECD countries does not seem to affect the outcomes.

[31] The coefficients of contiguity and former colony are often not significant with PPML because the standard errors are larger (not shown here).

[32] In reality the effective tax rates for the US are lower, because taxes are only due upon actual repatriation (Zucman, 2014).

Table 10: Robustness analyses: Poisson regressions and data selection

	(1)	(2)	(3)	(4)	(5)	(6)
Dummy TAXH_home	1.282***	1.487***	1.315***	2.194***	2.461***	2.171***
	(0.288)	(0.313)	(0.304)	(0.330)	(0.326)	(0.327)
Dummy TAXH_host	0.691**	0.664**	0.727***	0.811***	0.716***	0.805***
	(0.276)	(0.280)	(0.275)	(0.148)	(0.147)	(0.145)
CIT_home		-0.0616			8.104***	
		(1.711)			(1.019)	
CIT_host	-0.432	-0.310	-1.165	-3.271***	-2.872***	-3.310***
	(1.749)	(1.689)	(1.577)	(0.634)	(0.632)	(0.630)
CENT_home	0.0890***	0.0799***			0.179***	0.156***
	(0.0199)	(0.0197)			(0.0188)	(0.0192)
CENT_host	0.0818***	0.0827***			0.126***	0.112***
	(0.0271)	(0.0267)			(0.0262)	(0.0231)
WHTR_home	-2.441***	-2.401***	-2.636***	-3.702***	-4.140***	-2.959***
	(0.622)	(0.701)	(0.617)	(0.452)	(0.464)	(0.442)
WHTR_host	-4.421***	-4.499***	-4.392***	-0.392	-0.549	-0.185
	(0.947)	(0.964)	(0.944)	(0.491)	(0.481)	(0.478)
BWHTD+RCIT	3.467**		2.242	-0.264		0.0750
	(1.433)		(1.480)	(0.709)		(0.704)
SHOP	-5.185***		-4.967**	-2.210***		-2.023***
	(1.928)		(2.044)	(0.769)		(0.756)
Constant	9.595***	9.128***	10.70***	-12.09***	-13.29***	-14.00***
	(1.442)	(1.576)	(1.286)	(0.608)	(0.635)	(0.634)
Pseudo/Adjusted R^2	0.553	0.546	0.538	0.614	0.633	0.626
Observations	6422	6422	6422	2783	2783	2783
Estimation method	PPML	PPML	PPML	OLS	OLS	OLS

Notes: see Table 9.

Centrality indicators

The *Betweenness* indicator, which is used in the previous sections, is only one of the possible centrality indicators. Section 6 defines other centrality indicators: *Strict*, *Occurrence* and *Unweighted*.[33] With these other centrality indicators, the coefficients for centrality are again positive and significant. Table 11 shows that the coefficients of the various indicators are stable; this result indicates that the impact of a conduit country on the bilateral FDI stocks is very robust. For all indicators we find the same pattern. The impact on the home country is somewhat larger than on the host country. The impact of one standard deviation increase in the centrality indicator for the home country increases the bilateral FDI stock by about 22% (*Betweenness*) to 32% (*Unweighted*). For the host country we find a similar range, it is only 2% to 3% points lower. The coefficient for treaty shopping is also negative and significant.

[33] We use in the main regressions the network centrality indicator *Betweenness* which is double GDP-weighted. The weighting involves all bilateral flows except the incoming and outgoing flows of the country concerned. Therefore own GDP is not part of the measure and there is no endogeneity problem.

Table 11: Robustness analysis with different centrality indicators

	(1)	(2)	(3)	(4)
Indicator	betweenness	occurance	strict	unweighted
CENT_home	0.0989***	0.109***	0.140***	0.131***
	(0.0161)	(0.0162)	(0.0183)	(0.0142)
CENT_host	0.0911***	0.0893***	0.0911***	0.122***
Adjusted R^2	0.540	0.540	0.541	0.545
Average value	1.58	2.80	0.70	1.73
Std dev.	2.23	2.52	1.66	2.43

Notes: see table 9. The results fort the other variables are available upon request.

9. Conclusion

We embark on a novel perspective by applying a network analysis to international corporate taxation. This yields the contribution of the indirect routing of FDI, and the corresponding profit flows, to the reduction of the tax burden of multinational enterprises as well as the insight in the central position of particular countries in the international tax network. We have modeled corporate taxation in host and home countries, double tax relief methods and the withholding tax on dividends for all pairs in a sample of 108 countries. The direct effect of double tax relief and tax treaties lowers the world average repatriation tax rate of a theoretical 41 percent to 12 percent, given corporate income taxation in host countries.

A first important result is that the possibility of treaty shopping allows for a further reduction of 6 percentage points, leaving, on average, a double taxation on repatriated dividends of 6 percent. For about two thirds of the country pairs examined there exists an indirect tax route that is more attractive in terms of lower taxes than the direct route. A large cluster of 69 countries exists that are well interconnected through cheap or even zero tax routes. These results imply that it could be very beneficial for multinational companies to restructure their activities over various countries in such a way that tax payments are minimized.

Centrality in the network is used to identify candidates for the role of conduit country, implying our second result. The United Kingdom heads the ranking of network centrality, followed by Luxembourg, Estonia and the Netherlands. The top 10 has only one non-EU country; Singapore. Tax havens are not crucial conduit countries for the treaty shopping motive. The centrality results are robust with respect to alternative measures of centrality, including allowing for almost cheapest tax routes. In general there is a high degree of multiplicity of cheapest tax routes between the country pairs.

We regress bilateral FDI stocks on the outputs of the network analysis, the bilateral tax rates of tax minimizing tax routes and the (unilateral) network centrality measures for both host and home country. These explanatory variables are robustly found to be significant, statistically and in terms of impact. Coefficients of nearly 0.1 suggest that one standard deviation increase in the centrality measure has an impact of 22% on bilateral FDI stocks. The possibility of treaty shopping raises FDI stocks by 1.7% for each 1%-point that taxes are lowered due to FDI diversion. This is our third important result.

This brings us to the limitations of the study and directions for further research. We take the profits in the host country as given and focus on dividend flows. More in general, a broader fiscal and juridical environment will affect the holding decisions of multinationals and the size of taxable profit incomes. These activities may involve intra-company financing and the location of intellectual property rights, so that deductibility of interest and royalty payments matter, and the withholding taxes for these categories. We ignore the possibilities to reduce the tax base with interest and royalty payments.

Next, our analysis lacks dynamics and we require profits to be repatriated to the home country. Thus deferral is no option and we miss out on the parking function associated with traditional low-tax havens, as discussed by Mintz and Weichenrieder (2010).

Finally, the econometric analysis could go beyond cross-sectional regressions. The impact of the centrality measure on FDI stocks could be analyzed in a panel setting with country-pair fixed effects. Therefore longer time series data on the bilateral FDI stocks including SPEs should be available. Although on a year-by-year base the differences in the international tax system are not that large, the importance of tax treaty shopping could be different now compared to a decade ago.

Notwithstanding the limitations we show that with only the main tax parameters we can sketch, empirically supported, an entirely plausible and relevant world of international corporate taxation with treaty shopping for about the hundred largest and richest economies in the world including many tax havens and financial centers. We show that treaty shopping is profitable, restructures investment and profit flows and raises FDI stocks in conduit countries.

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Annex A1: Collected tax data 2013 - 108 jurisdictions

Country	CIT	DTRM	THR	CFC	WHT_div	no. trts	tax haven	GDP weight
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Albania	10.0	3	3	0	10.0	26	0	0.03
Algeria	25.0	0	0	0	15.0	23	0	0.34
Angola	35.0	0	0	0	10.0	0	0	0.16
Argentina	35.0	3	3	0	35.0	14	0	0.94
Aruba	28.0	4	4	0	10.0	1	1	0.00
Australia	30.0	3	3	1	30.0	40	0	1.23
Austria	25.0	4	4	0	25.0	66	0	0.45
Azerbaijan	20.0	3	3	0	10.0	29	0	0.12
Bahamas	0.0	4	4	0	0.0	0	1	0.01
Bahrain	46.0	3	3	0	0.0	10	1	0.04
Barbados	25.0	3	3	0	15.0	23	1	0.01
Belarus	18.0	3	3	0	12.0	44	0	0.19
Belgium	34.0	4	4	0	25.0	70	0	0.53
Bermuda	0.0	4	4	0	0.0	0	1	0.01
Botswana	22.0	2	2	0	7.5	8	0	0.04
Brazil	34.0	3	3	1	15.0	35	0	2.97
Brunei Darussalam	20.0	4	4	0	0.0	1	0	0.03
Bulgaria	10.0	3	3	0	5.0	50	0	0.13
Canada	26.3	3	4	0	25.0	75	0	1.88
Cayman Islands	0.0	4	4	0	0.0	0	1	0.00
Chile	20.0	2	3	0	35.0	24	0	0.40
China	25.0	3	3	1	10.0	61	0	15.66
Colombia	25.0	3	3	0	0.0	4	0	0.63
Costa Rica	30.0	2	3	0	15.0	1	1	0.07
Croatia	20.0	3	3	0	12.0	44	0	0.10
Curacao	27.5	4	4	0	0.0	0	0	0.00
Cyprus	12.5	4	4	0	0.0	35	1	0.03
Czech Republic	19.0	2	3	0	35.0	66	0	0.36
Denmark	25.0	3	4	1	27.0	61	0	0.27
Dominican Rep.	29.0	3	3	0	10.0	1	0	0.12
Ecuador	22.0	0	0	0	0.0	10	0	0.19
Egypt	25.0	2	3	0	0.0	23	0	0.68
Equatorial Guinea	35.0	0	0	0	25.0	1	0	0.02
Estonia	21.0	3	4	0	0.0	36	0	0.04
Finland	24.5	3	4	1	24.5	59	0	0.25
France	34.3	2	3	1	30.0	80	0	2.84
Gabon	35.0	2	3	0	15.0	4	0	0.03
Germany	30.2	3	4	1	25.0	71	0	4.04
Greece	26.0	3	3	0	10.0	42	0	0.35
Guernsey	0.0	4	4	0	0.0	0	1	0.00
HongKong	16.5	4	4	0	0.0	14	1	0.47
Hungary	19.0	4	4	1	0.0	47	0	0.25
Iceland	20.0	3	3	0	18.0	38	0	0.02
India	34.0	3	3	0	0.0	40	0	5.91
Indonesia	25.0	3	3	0	20.0	52	0	1.54
Ireland	12.5	3	3	0	20.0	53	0	0.24
Isle of Man	0.0	4	4	0	0.0	0	1	0.01
Israel	25.0	3	3	1	20.0	43	0	0.31
Italy	31.4	3	3	1	20.0	69	0	2.31
Jamaica	25.0	2	3	0	33.3	15	0	0.03
Japan	37.0	4	4	0	20.0	47	0	5.84
Jersey	0.0	4	4	0	0.0	0	1	0.01
Jordan	14.0	2	3	0	0.0	13	0	0.05
Kazakhstan	20.0	3	3	0	15.0	35	0	0.29
Korea Republic	24.2	3	3	0	20.0	67	0	2.04
Kuwait	15.0	2	2	0	15.0	40	0	0.19

Latvia	15.0	3	3	0	10.0	45	0	0.05
Lebanon	15.0	2	3	0	10.0	13	1	0.08
Libya	20.0	0	3	0	0.0	1	0	0.10
Liechtenstein	12.5	4	4	0	0.0	3	1	0.00
Lithuania	15.0	3	4	0	15.0	44	0	0.08
Luxembourg	29.2	4	4	0	15.0	57	0	0.05
Macao	12.0	0	0	0	0.0	0	1	0.06
Malaysia	25.0	4	4	0	0.0	34	0	0.63
Malta	35.0	4	4	0	0.0	38	1	0.01
Mauritius	15.0	3	3	0	0.0	15	1	0.03
Mexico	30.0	2	2	0	0.0	36	0	2.22
Mongolia	25.0	2	3	0	20.0	27	0	0.02
Namibia	34.0	3	3	0	10.0	9	0	0.02
Netherlands	25.0	4	4	0	15.0	74	0	0.89
New Zealand	28.0	3	3	1	30.0	36	0	0.17
Nigeria	30.0	3	3	0	10.0	11	0	0.57
Norway	28.0	3	3	1	25.0	64	0	0.35
Oman	12.0	3	3	0	0.0	8	0	0.11
Pakistan	35.0	3	3	0	10.0	31	0	0.65
Panama	25.0	0	0	0	17.0	14	1	0.07
Peru	30.0	3	3	1	4.1	3	0	0.41
Philippines	30.0	3	3	0	15.0	29	0	0.54
Poland	19.0	3	4	0	19.0	64	0	1.01
Portugal	31.5	3	3	0	25.0	53	0	0.31
Puerto Rico	30.0	3	3	0	10.0	0	0	0.08
Qatar	10.0	2	3	0	7.0	36	0	0.24
Romania	16.0	3	3	0	16.0	66	0	0.35
Russian Federation	20.0	3	3	0	15.0	59	0	3.17
Saudi Arabia	20.0	0	3	0	5.0	18	0	1.14
Serbia and Mont.	15.0	3	3	0	20.0	42	0	0.10
Seychelles	33.0	0	0	0	15.0	12	1	0.00
Singapore	17.0	4	4	0	0.0	40	0	0.41
Slovak Republic	23.0	2	3	0	0.0	42	0	0.17
Slovenia	17.0	3	3	0	15.0	46	0	0.07
South Africa	28.0	3	3	1	15.0	55	0	0.74
Spain	30.0	4	4	1	21.0	71	0	1.78
Suriname	36.0	3	3	0	25.0	1	0	0.01
Sweden	22.0	3	3	1	30.0	67	0	0.50
Switzerland	21.1	4	4	0	35.0	71	0	0.46
Taiwan Province	17.0	3	3	1	20.0	19	0	1.14
Thailand	20.0	2	3	0	10.0	34	0	0.82
Trinidad and Tob.	25.0	3	3	0	10.0	16	0	0.03
Tunisia	30.0	0	0	0	0.0	26	0	0.13
Turkey	20.0	3	3	1	15.0	59	0	1.42
Ukraine	19.0	3	3	0	15.0	56	0	0.42
Untd Arab Emirates	0.0	4	4	0	0.0	21	0	0.34
United Kingdom	23.0	4	4	0	0.0	51	0	2.95
United States	39.1	3	3	1	30.0	54	0	19.79
Uruguay	25.0	2	2	0	7.0	6	0	0.07
Venezuela	34.0	3	3	0	34.0	28	0	0.51
Virgin Islands U.S.	38.5	3	3	0	11.0	0	1	0.00
Virgin Islands U.K.	0.0	4	4	0	0.0	0	1	0.00

Columns (2) and (3): 2 = deduction, 3 = credit, 4 = exemption

Annex A2: Tax havens

Table A1: Tax haven lists in our selection of 108 jurisdictions

Low-tax havens	Other tax havens	Other financial centres	Other low-tax countries
Bahamas	Aruba	Ireland	Albania
Bermuda	Bahrain	Jordan	Bulgaria
Cayman Islands	Barbados	Luxembourg	Oman
Cyprus	Costa Rica	Singapore	Qatar
Guernsey	Hong Kong	Switzerland	United Arab Emirates
Isle of Man	Lebanon		
Jersey	Malta		
Liechtenstein	Mauritius		
Macao	Panama		
Virgin Islands U.K.	Seychelles		
	Virgin Islands U.S.		

The first three columns give the intersection of the Gravelle (2013) list of 50 tax havens with our selection of 108 jurisdictions. The first column presents the low-tax havens, i.e. those with a corporate income tax rate in 2013 of 12.5% or less. Most of them are islands. Malta could have been included in the list of low-tax havens because, although it has a nominal rate of 35%, the effective rate may be reduced to between 0% and 10% by a refund mechanism (Loyens & Loeff, 2013). We have refrained from using such characteristics and have sticked to the bare tax parameters.

The third column indicates the 5 countries from the Gravelle list we have treated differently. The Gravelle list is based on an overview of other papers classifying tax havens. The first four appear only in the list of Dharmapala and Hines (2009) and Hines and Rice (1994) and Singapore is often considered as another financial centre, different from tax havens.

The fourth column contains, for comparison, the other countries in the set with a low tax rate, i.e. a CIT of 12.5% or less. These other low-tax countries could also be of interest because some other countries do not grant a dividend participation exemption to dividend income coming from them.

Annex B1: Remaining double tax rates for home countries*

In	Country	DIV	DTRM	CIT rate	no. trts	Direct	Indirect
1	China	18.8	3	25.0	61	8.6	1.0
2	Russian Federation	17.5	3	20.0	59	6.7	1.5
3	Korea Republic	17.3	3	24.2	67	7.1	1.6
4	Thailand	17.4	2	20.0	34	18.5	1.6
5	Canada	17.2	3	26.3	75	6.4	1.6
6	Turkey	17.4	3	20.0	59	10.9	1.6
7	Chile	17.3	2	20.0	24	26.6	1.6
8	Dominican Rep.	17.4	3	29.0	1	18.1	1.6
9	Kazakhstan	17.4	3	20.0	35	7.7	1.6
10	Azerbaijan	17.4	3	20.0	29	14.1	1.6
11	Serbia and Mont.	17.4	3	15.0	42	13.1	1.6
12	Aruba	17.4	4	28.0	1	17.4	1.6
13	Virgin Islands U.K.	17.4	4	0.0	0	17.4	1.6
14	Bermuda	17.4	4	0.0	0	17.4	1.6
15	Cayman Islands	17.4	4	0.0	0	17.4	1.6
16	Curacao	17.4	4	27.5	0	17.4	1.6
17	Guernsey	17.4	4	0.0	0	17.4	1.6
18	Isle of Man	17.4	4	0.0	0	17.4	1.6
19	Jersey	17.4	4	0.0	0	17.4	1.6
20	Liechtenstein	17.4	4	12.5	3	16.3	1.6
21	Barbados	17.4	3	25.0	23	10.3	1.6
22	Bahamas	17.4	4	0.0	0	17.4	1.6
23	Iceland	17.4	3	20.0	38	6.6	1.6
24	Malta	17.4	4	35.0	38	6.6	1.6
25	Mongolia	17.4	2	25.0	27	23.6	1.6
26	Brunei Darussalam	17.4	4	20.0	1	16.6	1.6
27	Cyprus	17.4	4	12.5	35	7.5	1.6
28	Mauritius	17.4	3	15.0	15	14.9	1.6
29	Albania	17.4	3	10.0	26	13.8	1.6
30	Estonia	17.4	3	21.0	36	6.7	1.6
31	Jamaica	17.4	2	25.0	15	20.3	1.6
32	Trinidad and Tob.	17.4	3	25.0	16	10.0	1.6
33	Latvia	17.4	3	15.0	45	6.3	1.6
34	Luxembourg	17.4	4	29.2	57	4.0	1.6
35	Slovenia	17.4	3	17.0	46	6.5	1.6
36	Lebanon	17.4	2	15.0	13	28.8	1.6
37	Lithuania	17.4	3	15.0	44	6.3	1.6
38	Croatia	17.4	3	20.0	44	11.9	1.6
39	Oman	17.4	3	12.0	8	16.2	1.6
40	Bulgaria	17.4	3	10.0	50	6.7	1.6
41	New Zealand	17.4	3	28.0	36	9.5	1.6
42	Slovak Republic	17.4	2	23.0	42	13.1	1.6
43	Belarus	17.4	3	18.0	44	10.1	1.6
44	Qatar	17.4	2	10.0	36	20.2	1.6
45	Ireland	17.4	3	12.5	53	5.6	1.6
46	Finland	17.4	3	24.5	59	3.7	1.6
47	Hungary	17.4	4	19.0	47	5.8	1.6
48	Denmark	17.4	3	25.0	61	4.6	1.6
49	Portugal	17.4	3	31.5	53	9.7	1.6
50	Israel	17.4	3	25.0	43	10.2	1.6
51	Romania	17.4	3	16.0	66	7.5	1.6
52	Untd Arab Emirates	17.4	4	0.0	21	13.2	1.6
53	Greece	17.4	3	26.0	42	11.8	1.6
54	Norway	17.4	3	28.0	64	7.8	1.6
55	Czech Republic	17.3	2	19.0	66	6.7	1.6
56	Singapore	17.5	4	17.0	40	10.8	1.6
57	Ukraine	17.4	3	19.0	56	6.4	1.6
58	Austria	17.3	4	25.0	66	4.8	1.6
59	Switzerland	17.3	4	21.1	71	4.9	1.6

60	HongKong	17.5	4	16.5	14	13.8	1.6
61	Sweden	17.3	3	22.0	67	3.8	1.6
62	Belgium	17.3	4	34.0	70	4.3	1.6
63	Malaysia	17.5	4	25.0	34	11.8	1.6
64	Colombia	17.5	3	25.0	4	16.9	1.6
65	Egypt	17.5	2	25.0	23	17.9	1.6
66	South Africa	17.4	3	28.0	55	6.6	1.7
67	Netherlands	17.4	4	25.0	74	3.4	1.7
68	Poland	17.4	3	19.0	64	6.3	1.7
69	Taiwan Province	17.4	3	17.0	19	15.2	1.7
70	Saudi Arabia	17.5	0	20.0	18	22.6	1.7
71	Indonesia	17.3	3	25.0	52	9.6	1.7
72	Spain	17.3	4	30.0	71	6.8	1.7
73	Italy	17.3	3	31.4	69	6.9	1.7
74	France	17.0	2	34.3	80	6.9	1.7
75	United Kingdom	17.9	4	23.0	51	3.8	1.7
76	Germany	17.1	3	30.2	71	5.2	1.7
77	Japan	17.2	4	37.0	47	6.0	1.7
78	Philippines	17.4	3	30.0	29	12.6	1.8
79	Australia	17.2	3	30.0	40	8.0	1.8
80	Nigeria	17.4	3	30.0	11	17.1	1.8
81	Peru	17.4	3	30.0	3	17.8	1.8
82	Puerto Rico	17.4	3	30.0	0	18.4	1.8
83	Venezuela	17.3	3	34.0	28	10.9	6.5
84	Costa Rica	17.4	2	30.0	1	41.5	6.5
85	Jordan	17.4	2	14.0	13	25.3	6.6
86	Libya	17.4	0	20.0	1	33.8	6.6
87	Namibia	17.4	3	34.0	9	18.1	7.0
88	Brazil	17.5	3	34.0	35	17.8	7.2
89	India	18.5	3	34.0	40	13.6	7.6
90	Argentina	17.2	3	35.0	14	17.8	8.2
91	Pakistan	17.4	3	35.0	31	13.9	8.3
92	Suriname	17.4	3	36.0	1	20.7	9.8
93	Virgin Islands U.S.	17.4	3	38.5	0	22.2	13.2
94	Macao	17.4	0	12.0	0	27.3	13.4
95	United States	14.3	3	39.1	54	16.7	14.6
96	Gabon	17.4	2	35.0	4	44.3	16.3
97	Kuwait	17.4	2	15.0	40	25.2	16.4
98	Bahrain	17.4	3	46.0	10	27.1	23.3
99	Botswana	17.4	2	22.0	8	34.9	23.3
100	Ecuador	17.4	0	22.0	10	33.9	23.3
101	Panama	17.4	0	25.0	14	36.7	26.2
102	Uruguay	17.4	2	25.0	6	37.0	26.2
103	Algeria	17.4	0	25.0	23	35.0	26.2
104	Mexico	17.8	2	30.0	36	32.9	31.1
105	Tunisia	17.4	0	30.0	26	38.0	31.1
106	Seychelles	17.4	0	33.0	12	44.0	34.1
107	Angola	17.4	0	35.0	0	46.3	36.1
108	Equatorial Guinea	17.4	0	35.0	1	46.3	36.1

*: The high rankings of China, Russia and South Korea are explained by their relatively high outbound repatriation tax rates. Given the size of their economies, these rates contribute to higher inbound rates for the other countries and thus the three stand out with lower average inbound rates.

Annex B2: Remaining double tax rates for host countries*

Out	Country	DIV	avg.DIV	minDIV	CIT	no. trts	Direct	Indirect
1	United States	30	10.3	0	27.2	54	11.7	2.1
2	Japan	20	7.3	0	29.4	47	9.1	2.5
3	India	0	0.0	0	29.6	40	3.6	2.9
4	France	30	5.2	0	29.7	80	8.0	3.3
5	Venezuela	34	14.1	0	29.8	28	15.8	3.3
6	Belgium	25	6.2	0	29.8	70	9.0	3.4
7	Mexico	0	0.0	0	29.9	36	4.8	3.9
8	Portugal	25	9.3	0	29.9	53	11.9	4.1
9	Italy	20	8.0	0	29.8	69	10.5	4.2
10	Tunisia	0	0.0	0	29.9	26	5.3	4.5
11	Brazil	15	7.0	0	29.7	35	8.5	4.5
12	Spain	21	7.8	0	29.9	71	9.8	4.6
13	Australia	30	10.8	0	29.9	40	15.1	4.6
14	Germany	25	8.1	0	29.9	71	11.1	4.7
15	Luxembourg	15	1.8	0	29.9	57	6.8	4.8
16	Bahrain	0	0.0	0	29.9	10	20.5	4.8
17	Malta	0	0.0	0	29.9	38	16.8	4.8
18	New Zealand	30	12.9	0	29.9	36	17.6	5.1
19	Norway	25	10.6	0	29.9	64	11.8	5.1
20	South Africa	15	6.7	0	29.9	55	10.3	5.1
21	Curacao	0	0.0	0	29.9	0	7.6	5.2
22	Algeria	15	11.7	0	29.9	23	14.0	5.2
23	Ecuador	0	0.0	0	29.9	10	10.1	5.3
24	Kuwait	15	10.1	0	29.9	40	18.0	5.3
25	Panama	17	15.6	0	29.9	14	32.9	5.3
26	Uruguay	7	6.8	0	29.9	6	12.4	5.3
27	Macao	0	0.0	0	29.9	0	24.1	5.3
28	Seychelles	15	13.0	0	29.9	12	30.7	5.3
29	Virgin Islands U.K.	0	0.0	0	29.9	0	26.3	5.3
30	Cayman Islands	0	0.0	0	29.9	0	26.3	5.3
31	Guernsey	0	0.0	0	29.9	0	26.3	5.3
32	Jordan	0	0.0	0	29.9	13	16.5	5.3
33	Liechtenstein	0	0.0	0	29.9	3	24.0	5.3
34	Isle of Man	0	0.0	0	29.9	0	26.3	5.3
35	Libya	0	0.0	0	29.9	1	12.7	5.3
36	Bermuda	0	0.0	0	29.9	0	26.3	5.3
37	Jersey	0	0.0	0	29.9	0	26.3	5.3
38	Barbados	15	9.8	0	29.9	23	28.7	5.3
39	Bahamas	0	0.0	0	29.9	0	26.3	5.3
40	Iceland	18	7.7	0	29.9	38	14.0	5.3
41	Mongolia	20	13.7	0	29.9	27	15.1	5.3
42	Mauritius	0	0.0	0	29.9	15	23.5	5.3
43	Brunei Darussalam	0	0.0	0	29.9	1	12.7	5.3
44	Cyprus	0	0.0	0	29.9	35	19.8	5.3
45	Albania	10	9.0	0	29.9	26	20.6	5.3
46	Jamaica	33.33	20.1	0	29.9	15	23.2	5.3
47	Trinidad and Tob.	10	9.0	0	29.9	16	12.8	5.3
48	Estonia	0	0.0	0	29.9	36	10.0	5.3
49	Latvia	10	5.6	0	29.9	45	15.3	5.3
50	Slovenia	15	6.8	0	29.9	46	14.9	5.3
51	Lebanon	10	9.5	0	29.9	13	29.2	5.3
52	Lithuania	15	6.6	0	29.9	44	16.0	5.3
53	Croatia	12	8.6	0	29.9	44	14.0	5.3
54	Oman	0	0.0	0	29.9	8	18.3	5.3
55	Bulgaria	5	4.0	0	29.9	50	17.4	5.3
56	Slovak Republic	0	0.0	0	29.9	42	8.7	5.3
57	Belarus	12	10.1	0	29.9	44	15.8	5.3

58	Qatar	7	6.1	0	29.9	36	20.6	5.3
59	Ireland	20	2.7	0	29.9	53	16.1	5.3
60	Hungary	0	0.0	0	29.9	47	11.2	5.3
61	Finland	24.5	5.9	0	29.9	59	11.6	5.3
62	Denmark	27	7.2	0	29.9	61	12.6	5.3
63	Israel	20	12.2	0	29.9	43	14.7	5.3
64	Untd Arab Emirates	0	0.0	0	30.0	21	23.9	5.3
65	Romania	16	8.7	0	29.9	66	14.7	5.3
66	Greece	10	6.7	0	29.9	42	9.8	5.3
67	Czech Republic	35	7.5	0	29.9	66	14.3	5.3
68	Singapore	0	0.0	0	29.9	40	13.7	5.3
69	Ukraine	15	7.1	0	29.9	56	14.5	5.3
70	Austria	25	6.8	0	29.9	66	11.2	5.3
71	Switzerland	35	7.3	0	29.9	71	12.9	5.3
72	HongKong	0	0.0	0	29.9	14	23.3	5.3
73	Sweden	30	6.0	0	29.9	67	12.4	5.3
74	Malaysia	0	0.0	0	29.9	34	7.9	5.3
75	Colombia	0	0.0	0	29.9	4	8.8	5.3
76	Egypt	0	0.0	0	29.9	23	8.4	5.3
77	Netherlands	15	4.5	0	29.9	74	9.9	5.3
78	Poland	19	7.8	0	30.0	64	13.7	5.3
79	Taiwan Province	20	17.7	0	30.0	19	21.4	5.3
80	Saudi Arabia	5	4.8	0	30.0	18	13.5	5.3
81	Indonesia	20	11.1	0	29.9	52	14.4	5.4
82	United Kingdom	0	0.0	0	30.1	51	8.8	5.4
83	Pakistan	10	8.1	3.75	29.8	31	10.0	6.7
84	Peru	4.1	4.1	4.1	29.9	3	8.8	7.2
85	Namibia	10	9.5	5	29.9	9	11.0	7.5
86	Canada	25	8.8	5	29.9	75	12.9	9.4
87	Korea Republic	20	8.9	0	30.0	67	12.1	9.8
88	Nigeria	10	9.3	7.5	29.9	11	11.4	9.9
89	Aruba	10	10.0	5	29.9	1	28.4	9.9
90	Botswana	7.5	7.3	5	29.9	8	13.6	10.0
91	Serbia and Mont.	20	13.0	5	29.9	42	19.2	10.0
92	Azerbaijan	10	9.6	5	29.9	29	15.4	10.0
93	Kazakhstan	15	8.6	5	29.9	35	15.3	10.0
94	Chile	35	27.9	0	29.9	24	29.5	10.0
95	Turkey	15	10.3	0	30.0	59	14.9	10.1
96	Russian Federation	15	8.6	5	30.2	59	15.5	10.2
97	China	10	9.4	5	30.9	61	13.6	10.6
98	Angola	10	10.0	10	29.9	0	12.3	10.8
99	Puerto Rico	10	10.0	10	29.9	0	13.0	11.5
100	Dominican Rep.	10	10.0	10	29.9	1	13.3	11.8
101	Suriname	25	24.9	7.5	29.9	1	26.8	12.4
102	Philippines	15	13.0	10	29.9	29	14.3	12.5
103	Thailand	10	10.0	10	29.9	34	15.6	14.6
104	Argentina	35	30.4	10	29.8	14	31.5	14.7
105	Virgin Islands U.S.	11	11.0	11	29.9	0	29.3	15.3
106	Gabon	15	15.0	15	29.9	4	16.4	15.8
107	Costa Rica	15	14.8	5	29.9	1	32.3	19.1
108	Equatorial Guinea	25	25.0	15	29.9	1	26.9	25.7

*: The high rankings of the United States, Japan and India are explained by their relatively high inbound repatriation tax rates. Given the size of their economies, these rates contribute to higher outbound rates for the other countries and thus the three stand out with lower average outbound rates.

Annex B3: Centrality measures

	Country	DIV	DTT	BTWNS	OCCUR		STRCT		UNWTD	
		rate	number	%	%	rank	%	rank	%	rank
1	United Kingdom	0	51	12.2	7.4	3	12.9	1	12.5	1
2	Luxembourg	15	57	7.7	7.6	1	7.1	2	5.0	10
3	Estonia	0	36	6.7	7.3	4	3.0	4	6.3	7
4	Netherlands	15	74	6.6	6.7	7	2.8	5	9.3	2
5	Hungary	0	47	6.1	7.5	2	2.2	7	6.8	5
6	Singapore	0	40	6.0	6.8	6	4.4	3	7.3	4
7	Ireland	20	53	5.5	6.8	5	2.7	6	3.7	14
8	Slovak Republic	0	42	5.3	6.5	9	2.1	8	4.7	11
9	Cyprus	0	35	4.3	5.7	18	1.8	10	7.9	3
10	Malta	0	38	4.2	5.8	16	1.6	11	6.5	6
11	Finland	25	59	3.9	6.3	12	1.1	14	2.1	37
12	France	30	80	3.8	5.1	21	1.4	12	2.6	22
13	Malaysia	0	34	3.7	6.4	11	1.0	15	5.4	8
14	Sweden	30	67	3.6	5.8	17	0.8	20	2.1	26
15	Spain	21	71	3.4	4.3	30	1.9	9	5.2	9
16	Denmark	27	61	3.2	5.5	19	0.6	23	2.1	27
17	Belgium	25	70	3.0	5.4	20	0.7	22	2.9	17
18	Switzerland	35	71	2.9	4.9	23	0.8	21	2.8	19
19	Untd Arab Emirates	0	21	2.8	6.5	8	1.0	16	4.0	13
20	Brunei Darussalam	0	1	2.6	6.4	10	1.2	13	2.7	20
21	Germany	25	71	2.4	4.8	24	0.5	25	1.6	43
22	HongKong	0	14	2.3	4.2	32	0.9	17	4.1	12
23	Oman	0	8	2.2	6.2	13	0.5	29	3.0	16
24	Lithuania	15	44	2.1	4.9	22	0.8	18	1.6	42
25	Austria	25	66	1.9	4.5	29	0.4	31	2.8	18
26	Bulgaria	5	50	1.9	4.5	28	0.4	32	2.1	36
27	Norway	25	64	1.9	4.1	33	0.5	28	1.9	39
28	Slovenia	15	46	1.9	4.7	26	0.6	24	1.4	45
29	Colombia	0	4	1.8	5.9	15	0.3	35	2.2	25
30	Iceland	18	38	1.8	4.6	27	0.5	26	1.4	46
31	Latvia	10	45	1.8	4.7	25	0.5	27	1.6	41
32	Curacao	0	0	1.6	6.1	14	0.3	36	2.6	21
33	Romania	16	66	1.6	4.0	35	0.4	34	2.1	28
34	Greece	10	42	1.5	4.3	31	0.4	33	1.3	48
35	Poland	19	64	1.3	3.8	37	0.2	43	1.8	40
36	Czech Republic	35	66	1.2	3.9	36	0.2	40	1.3	47
37	Mauritius	0	15	1.2	3.6	39	0.2	42	3.3	15
38	Italy	20	69	1.1	3.1	49	0.3	37	1.5	44
39	Australia	30	40	1.0	2.4	51	0.1	47	0.1	58
40	Liechtenstein	0	3	1.0	3.6	38	0.2	41	2.3	24
41	Qatar	7	36	1.0	2.2	52	0.8	19	2.5	23
42	Portugal	25	53	0.9	3.5	40	0.1	51	1.0	50
43	Bahamas	0	0	0.7	3.5	41	0.0	59	2.1	29
44	Bermuda	0	0	0.7	3.5	42	0.0	62	2.1	30
45	Cayman Islands	0	0	0.7	3.5	43	0.0	65	2.1	31
46	Guernsey	0	0	0.7	3.5	44	0.0	74	2.1	32
47	Isle of Man	0	0	0.7	3.5	45	0.0	76	2.1	33
48	Jersey	0	0	0.7	3.5	46	0.0	79	2.1	34
49	Virgin Islands U.K.	0	0	0.7	3.5	47	0.0	108	2.1	35
50	Japan	20	47	0.6	3.2	48	0.3	38	0.4	53
51	Turkey	15	59	0.5	2.0	53	0.1	53	0.0	69
52	Croatia	12	44	0.4	2.8	50	0.2	39	0.6	51
53	Egypt	0	23	0.3	4.0	34	0.0	71	0.4	54
54	India	0	40	0.3	0.2	79	0.1	50	0.3	55
55	Ukraine	15	56	0.3	1.9	54	0.2	45	1.0	49
56	Barbados	15	23	0.2	1.5	56	0.1	48	1.9	38

57	Mongolia	20	27	0.2	1.3	60	0.0	88	0.1	60
58	New Zealand	30	36	0.2	1.4	59	0.0	90	0.1	63
59	Albania	10	26	0.1	1.4	58	0.1	46	0.2	57
60	Azerbaijan	10	29	0.1	0.6	67	0.0	58	0.0	70
61	Belarus	12	44	0.1	1.2	61	0.0	61	0.1	59
62	Brazil	15	35	0.1	0.3	78	0.0	64	0.0	65
63	Canada	25	75	0.1	0.6	68	0.1	49	0.2	56
64	Dominican Rep.	10	1	0.1	0.6	69	0.0	69	0.0	72
65	Indonesia	20	52	0.1	0.8	63	0.0	75	0.0	71
66	Israel	20	43	0.1	0.9	62	0.0	77	0.1	64
67	Kazakhstan	15	35	0.1	0.6	70	0.0	81	0.0	80
68	Korea Republic	20	67	0.1	0.7	64	0.0	82	0.0	67
69	Russian Federation	15	59	0.1	0.5	73	0.1	52	0.0	68
70	Saudi Arabia	5	18	0.1	1.8	55	0.5	30	0.0	66
71	Serbia and Mont.	20	42	0.1	0.5	72	0.2	44	0.0	74
72	South Africa	15	55	0.1	1.5	57	0.0	98	0.1	62
73	Trinidad and Tob.	10	16	0.1	0.7	65	0.0	102	0.4	52
74	Algeria	15	23	0.0	0.0	82	0.0	54	0.0	84
75	Angola	10	0	0.0	0.0	83	0.0	55	0.0	85
76	Argentina	35	14	0.0	0.0	84	0.0	56	0.0	86
77	Aruba	10	1	0.0	0.0	85	0.0	57	0.0	75
78	Bahrain	0	10	0.0	0.0	86	0.0	60	0.0	76
79	Botswana	8	8	0.0	0.0	87	0.0	63	0.0	87
80	Chile	35	24	0.0	0.7	66	0.0	66	0.0	79
81	China	10	61	0.0	0.6	71	0.0	67	0.0	77
82	Costa Rica	15	1	0.0	0.0	88	0.0	68	0.0	88
83	Ecuador	0	10	0.0	0.0	89	0.0	70	0.0	89
84	Equatorial Guinea	25	1	0.0	0.0	90	0.0	72	0.0	90
85	Gabon	15	4	0.0	0.0	91	0.0	73	0.0	91
86	Jamaica	33	15	0.0	0.4	75	0.0	78	0.1	61
87	Jordan	0	13	0.0	0.0	92	0.0	80	0.0	92
88	Kuwait	15	40	0.0	0.0	93	0.0	83	0.0	93
89	Lebanon	10	13	0.0	0.0	80	0.0	84	0.0	82
90	Libya	0	1	0.0	0.0	94	0.0	85	0.0	94
91	Macao	0	0	0.0	0.0	95	0.0	86	0.0	95
92	Mexico	0	36	0.0	0.0	96	0.0	87	0.0	96
93	Namibia	10	9	0.0	0.0	97	0.0	89	0.0	97
94	Nigeria	10	11	0.0	0.0	98	0.0	91	0.0	98
95	Pakistan	10	31	0.0	0.0	99	0.0	92	0.0	99
96	Panama	17	14	0.0	0.0	100	0.0	93	0.0	100
97	Peru	4	3	0.0	0.0	101	0.0	94	0.0	101
98	Philippines	15	29	0.0	0.0	102	0.0	95	0.0	102
99	Puerto Rico	10	0	0.0	0.0	103	0.0	96	0.0	103
100	Seychelles	15	12	0.0	0.0	104	0.0	97	0.0	104
101	Suriname	25	1	0.0	0.0	105	0.0	99	0.0	105
102	Taiwan Province	20	19	0.0	0.5	74	0.0	100	0.0	78
103	Thailand	10	34	0.0	0.4	76	0.0	101	0.0	83
104	Tunisia	0	26	0.0	0.0	106	0.0	103	0.0	106
105	United States	30	54	0.0	0.0	81	0.0	104	0.0	81
106	Uruguay	7	6	0.0	0.0	107	0.0	105	0.0	107
107	Venezuela	34	28	0.0	0.3	77	0.0	106	0.0	73
108	Virgin Islands U.S.	11	0	0.0	0.0	108	0.0	107	0.0	108

Annex C1: The adapted shortest path algorithm

The all-pairs shortest path problem (APSP) is solved with the Floyd-Warshall algorithm.[34] The core of this algorithm is the next comparison, where d_{ij}^{m} is the length of the shortest path from *i* to *j* allowing only the first *m* vertices (countries) as intermediate stations.

$$d_{ij}^{m} = \min\{d_{im}^{m-1} + d_{mj}^{m-1}, d_{ij}^{m-1}\}$$

The algorithm is initialized with the distance matrix, which contains all the relevant information ($D^{0} = D$). By consecutively allowing an additional vertex as intermediate station, the length of the shortest path over the whole network is computed for all possible pairs ($S = D^{\mathrm{N}}$). The elegance and efficiency of the algorithm is that with a fixed and limited number of additions and comparisons, each of the order N^{3} , it completes the job.

The core comparison of the algorithm reflects that in the world of transportation distances simply can be added. This is obviously not the case for tax rates, as the base for taxation with a second rate, are the profits after the first tax. The adaptation corresponds with *deduction* as the method for double taxation relief.

$$d_{ij}^{m} = \min\{d_{im}^{m-1} + d_{mj}^{m-1} - d_{im}^{m-1}d_{mj}^{m-1}, d_{ij}^{m-1}\} \qquad \text{or } d_{ij}^{m} = \min\{1-(1-d_{im}^{m-1})(1-d_{mj}^{m-1}), d_{ij}^{m-1}\}$$

The tax rates include the non-resident withholding taxes, which are given for a pair of jurisdictions, i.e. from *i* to *j*. The country-specific corporate income taxes (CITs) are calculated as part of the compounded distances rates for inward income flows. This is the second adaption.

There is a convenient consequence of including the CIT of a home country in the tax distances applying to its inward flows. For countries with *exemption* as their double tax relief method it amounts to having a CIT of zero. Their actual CIT only matters when these countries are the initial host on a repatriation path, then their CIT must be included in the full combined effective tax rate of the path.

More in general, for any tax route, with an initial host $k = 1$ and final destination $k = \mathrm{n}$, the full combined effective tax rate equals $1-(1-t_1)\left(\prod_{k=2}^{\mathrm{n}}(1-d_{k-1,k})\right)$. Here t_1 denotes the CIT of country 1 and $d_{1,2} = w_{1,2}$ is the bilateral withholding tax rate from 1 to 2. The other tax distances are either the bilateral withholding tax rates, $d_{k-1,k} = w_{k-1,k}$, when country *k* applies *exemption*, or they include the CIT of the intermediate home country *k*, $d_{k-1,k} = 1-(1-w_{k-1,k})(1-t_k)$, when it applies *deduction* as double tax relief. The adapted Floyd-Warshall takes care of the product of the tax distances, in which the order is inconsequential.[35]

[34] See for instance Minieka (1978).

[35] This is the communitative property.

Thus a basic method is defined, with a deduction 'metric'[36], covering both *deduction* and *exemption* as double tax relief methods.

Incorporating the *credit* method introduces a complexity which requires a final adaptation. It s the question which taxes can be credited against the corporate tax in the final or intermediate, home country. Roughly three possibilities can be identified: i) all taxes paid on the preceding tax route are credited, ii) only the taxes actually paid in the last preceding jurisdiction are credited, and iii) the nominal CIT rate of the last preceding jurisdiction is credited as is its the withholding tax[37], whether this CIT is paid or not.

The option of crediting the nominal CIT of the last preceding country has the advantage that nothing needs to be known of the route before that last country visited. Moreover it fits into the method described above, with the definition of tax distance also given in the main text:

$$d_{k-1,k}(credit) = \max\{ w_{k-1,k}, (t_k - t_{k-1}) / (1 - t_{k-1})\}$$

The first option may be most in line with the philosophy of the credit method, i.e. capital export neutrality. In practice it may be difficult, or undesirable, to account for all the accumulated taxes paid on a tax route. These total taxes include the treatment of the CIT of the evaluated jurisdiction. However, it must be realized that the treatment of the CIT in the jurisdiction under consideration is based on the initial distance matrix, so that the credit is based on the *nominal* tax rate of the previous jurisdiction on the path instead of the *actual* total taxes paid. This excludes implementing the first two options.

Acknowledging that the practice of the credit method is complex and that we have no structural information to determine which option best reflects the actual operation of the credit method we decided on the next implementation: we let the world average corporate income tax be credited, in combination with the actual withholding tax of the last conduit jurisdiction preceding the parent jurisdiction with the credit method. It must be observed that the world average tax rate is only applied in those conduit situations where a jurisdiction with the credit method follows a conduit country. When the last preceding jurisdiction is the starting point of a tax route the corporate income tax is paid in the initial host and is credited in the next stop of a tax route.

This gives rise to the final adaptation of the shortest path algorithm. Let d_{ij} denote the usual tax distance between *i* and *j* when *i* is the first node of a path, and let p_{ij} denote the distance between *i* and *j* when *i* is an intermediate node on a path. This second distance incorporates the assumption dealing with the credit method.

$$p_{k-1,k}(credit) = \max\{ w_{k-1,k}, (t_k - \bar{t}) / (1 - \bar{t})\}, \qquad \text{with } \bar{t} \text{ : world average CIT}$$

[36] Strictly speaking it is not a metric, since, for instance, the property of symmetry is not satisfied.
[37] This is the indirect tax credit system, see below.

Let p_{ij}^N be the output of the Floyd-Warshall algorithm with the deduction 'metric' applied to distances for intermediate stations. Thus all shortest distances are known for the inner work of tax routes, i.e. when the first vertex of the route eventually is the second. Then the outer work of initial vertices (jurisdictions) can be added as follows.

$$d_{ij}^N = \min\{d_{ij}, \min_m(d_{im} + p_{mj}^N)\}$$

Instead of allowing both the corporate tax of the host country and the withholding tax to be credited, some countries only allow the withholding tax to be credited against their corporate tax. The latter method is referred to as a direct foreign tax credit whereas the former is the indirect tax credit method. For conduit situations we use the indirect credit method. The direct credit method could also easily have been implemented; it suffices to define the tax distance for *i* as a first node of a tax route, see below. We have however not collected information on countries applying direct rather than indirect credits.

$$d_{ij}(direct\ credit) = \max\{w_{ij}, t_j\}$$

Some countries provide no relief at all for double taxation; the combined effective tax rate for a direct route is as shown below.

$$t_{SP}^e(no\ relief) = t_S + w_{SP} - t_S w_{SP} + t_P$$

In conduit situations problems similar to those with indirect credits occur, although no-relief-at-all is not likely to occur in conduit situations. Nevertheless, we have not covered it.

Generating all shortest paths, and all those within range

The Floyd-Warshall algorithm is an efficient method to compute the value of the strict shortest paths for all pairs of nodes of a network. With a small addition to the algorithm the so-called Penultimate Vertex Matrix (PVM) can be maintained. Upon completion of the Floyd-Warshall algorithm shortest paths for all pairs can be reconstructed from this matrix. The PVM-method generates only a single strict shortest path for a given pair. We however require all shortest paths of a given pair, to be able to compute centrality measures. In addition we are also interested in those paths for a given pair with a length that is within a prespecified admissible range on top of the value of the strictly shortest path. The PVM-method is not suitable for generating all those relevant paths.

Instead we implement a branch and bound method. The branching consisted of a full, depth-first enumeration of all possible combinations. The bounding was accomplished with the values of the strict shortest paths which were computed with the Floyd-Warshall algorithm, executed beforehand. This implementation is a brute-force approach. It is only possible because the relevant paths are not too long, with a sequence of five or six countries as a maximum. Polak (2015) describes a relative efficient implementation of the brute-force method.

Annex C2: The betweenness centrality measure and flows

Country - weights w_i are defined as $w_i = GDP_i / \sum_k GDP_k$. Of course $\sum_i w_i = 1$.

Double GDP - weights on the flows (i, j) are : $w_{ij} = w_i \frac{GDP_j}{\sum_k GDP_k - GDP_i} = w_i w_j \frac{1}{(1-w_i)}$.

By construction $\sum_i \sum_{j \neq i} w_{ij} = 1$. The weights are the flows when 1 euro or dollar is run through the network; they are the shares of the total of the flows.

The measure of *betweenness centrality* for vertex *k*, B_k , is computed from the number of times vertex *k* is on a relevant path from *i* to *j*, excluding *k* as start and end point, n_{kij} , as a share in the total number of relevant paths from *i* to *j*, N_{ij} , and then these fractions are weighted over all pairs *i* and *j*.

$$B_k = \sum_{i \neq k} \sum_{j \neq i,k} w_{ij} \frac{n_{kij}}{N_{ij}}$$

The assumption is that each of the relevant paths between *i* and *j* takes the same share, i.e. $1/N_{ij}$, of the total flow of the pair *ij*, whose share is w_{ij} . Betweenness centrality thus measures the share of total direct flows that run through a vertex, excluding all the flows that start or end at the given vertex *k*.

Annex D: Multiplicity and lengths of shortest paths

Multiplicity and the length of the shortest paths are shown in table D1.

Table D1: Distribution of lengths of shortest paths

	Unit	Total paths	Multi-ciplicity	Length = no. of conduit countries				
				0	1	2	3	4
Strict	Number	63327	5.5	3886	50857	8321	263	0
	%			6.1	80.3	13.1	0.4	0
Range	Number	1052053	91.0	3910	51028	734752	253779	8584
	%			0.4	4.9	69.8	24.1	0.8

The distribution of lengths of strictest shortest paths and those within a range of a half percent is given in the table. Length is denoted in number of intermediate jurisdictions. For 3886 country pairs, about 34 percent of all pairs, the direct connection is among the relevant paths. These 3886 paths are 6.1 percent of all strictly shortest paths. In 80 percent of the paths there is exactly one conduit country in the shortest path. With a range of shortest paths, this is different. The extra shortest paths on top of the strictly shortest paths are not the paths with one conduit jurisdiction, but those with two or three jurisdictions. The maximum number is 4 conduit countries. The two corresponding centrality rankings, i.e. for strictly shortest paths and those within range, are found not to be very different.