Profitable Detours:
Network Analysis of Tax Treaty Shopping

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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. This could amount to 75 billion USD, yearly. On average, multinationals pay taxes of about 6 percent on top of the corporate income tax in the host country. Moreover, a network indicator identifies the most important conduit countries such as the United Kingdom, Luxembourg and the Netherlands. Tax havens are found not to be crucial for reducing the withholding tax bill of multinational enterprises.

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1. Introduction

There is growing international concern over the erosion of income tax bases, both personal and corporate. Actions to combat the evasion of the personal income tax seem to amount to a crackdown on bank secrecy laws and aggressive tax practices of international corporations are brought to the public eye, if not judgment.[1] 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.

With a novel approach this paper is able to shed light on 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. The definition of treaty shopping we use is an economic one, emphasizing the indirect investment routing. IMF (2014) considers treaty shopping as a tool of tax planning in a study on spillovers in international corporate taxation and identifies treaty shopping as a concern for developing countries because of the loss of their tax revenue. The OECD (2015) addresses it in its BEPS action plan. This attention is deserved as treaty shopping potentially leads to a significant reduction of the tax burden of MNE's of 6 percentage points. A rough estimate is that this could amount to USD 75 billion, yearly, on repatriating dividends only. This reduction by treaty shopping is on top of the 9 percentage points reduction which can already be realized through the DTT's themselves, i.e. without indirect routing of repatriated income. 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. Our network consists of 108 jurisdictions, 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. We are not aware of other work where this approach is taken and quantified at this scale.[2]

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. Centrality in the tax network could well contribute to explaining the worldwide pattern of FDI stocks, see table 1. Relatively small economies account for large shares in FDI, for example, total inward FDI stocks into the Netherlands in 2011 equaled USD 3327 billion, accounting for 14 percent of worldwide inward FDI stocks. In 2011 the Netherlands ranked 23rd in terms of GDP (between brackets in column 1), with a share of about 1 percent. For Luxembourg the discrepancy is even more pronounced. Large-scale diversion for tax reasons could contribute to explaining this worldwide FDI pattern.

[1] See amongst others Johannesen and Zucman (2014), EU Tax Information Exchange and UK (Parliamentary) Public Accounts Committee, November 2012.

[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.

Table 1: Top 5 of inward and outward FDI stocks in 2011

Country	Inward	FDI	Country	Outward	FDI
	bln US$	%		bln US$	%
World	23816	100.0	**World**	24287	100.0
Netherlands (23)	3327	14.0	**United States (1)**	4156	17.1
Luxembourg (99)	2653	11.1	**Netherlands (23)**	4118	17.0
United States (1)	2548	10.7	**Luxembourg (99)**	2731	11.2
China (2)	1907	8.0	**United Kingdom (8)**	1725	7.1
United Kingdom (8)	1064	4.5	**France (9)**	1597	6.6

Source: IMF Coordinated Direct Investment Survey data, 2011, reporting countries. The totals of inward and outward stocks are not equal due to incomplete reporting and differences in registering stocks by source and host countries. Between brackets: GDP ranking (ppp).

The top 5 in our main measure of network centrality are the United Kingdom, Luxembourg, Estonia, the Netherlands and Hungary. For individual countries a central position in the tax network can be seen as a necessary condition for the role as a conduit. This role 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. Even when we simulate that all tax havens cannot be conduit countries we find that this hardly contributes to the reduction of the world average repatriation tax.

We implement an international tax system as in Barrios et al. (2012), also combining host and home country taxation, including tax treaties and also focusing on dividends. We, however, consider a profit repatriation optimization, given a subsidiary in host country A and the parent company in home country B. In principle profits could be taxed with the corporate income tax in the host and home country and with the dividend withholding tax in the host country. Double tax relief methods and tax treaties limit the possible triple taxation of dividend flows substantially already on direct routes. For indirect routes, passing through other countries, the taxes of all possible conduit countries matter as well, both as a home and a host country. All tax 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, the Floyd-Warshall algorithm, which efficiently performs the required minimizations. After a few minor but crucial adaptations to the algorithm the computed shortest paths represent optimal tax routes.

Our analysis takes the investment decisions as given, i.e. those from a parent company in country B to a subsidiary in country A, 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 also take the profit decision of MNE's as given, focusing on dividends. We do so in full 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. Our main contribution is the application of a network approach, which

offers a rich multi-country framework to further investigate the dividend repatriation tax rates facing MNE's.

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. Section 4 presents the data of the tax system. Section 5 presents 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 6. Next, in section 7, the results of network centrality are presented. Robustness of these results is illustrated in section 8, involving alternative measures of centrality. The concluding section summarizes and discusses directions for further research.

2. Related literature

Our work is closely 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.[3] 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).

Different from the papers above we are mainly 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 on treaty shopping so far considered only the FDI effects of treaty shopping. Direct evidence of treaty shopping on FDI is scarce. One reason for this may be that the concept of treaty shopping is not exactly defined (Avi-Yonah and Panayi, 2011). We use the economic definition of Davies (2004), emphasizing the tax benefits of indirect investment routes. A more legal definition equates treaty shopping with treaty abuse.

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

[3] In separate regressions performed as robustness checks, Barrios et al. (2009) do however use the EATR.

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. 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 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 how these distances are composed from 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 the distances can be made to fit efficient algorithms for computing shortest paths, fully maintaining their tax interpretation, see 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, denoted with w_S. However, the host and home country may have signed a tax treaty and a reduced 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*.[4] 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.[5] Excess credit is not restituted. The credit method means less generous tax relief than exemption, but more than deduction.

Let rm_P be the general double tax *r*elief *m*ethod applied by home country P. The tax treaties country P has signed may contain agreements to provide more generous double tax relief to treaty partner S. Thus also the relief methods have a double country dimension: rm_{SP}, the relief method applied by home country P on income from host country S. The combined effective tax rates $t^e_{SP}(rm_{SP})$ 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.

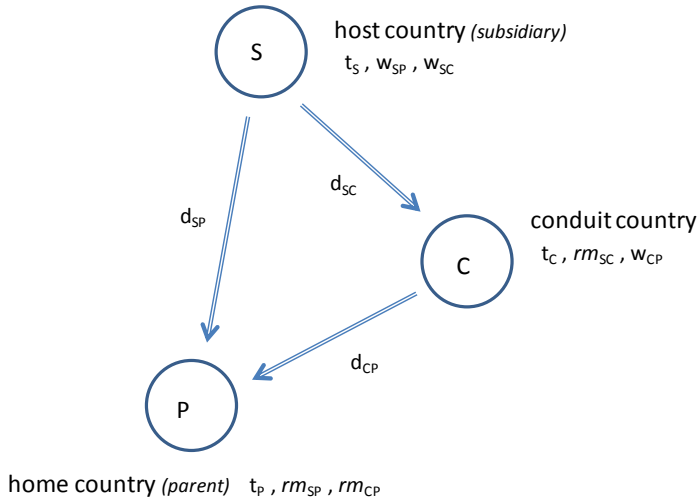
Define the direct tax distance d_{SP} between host S and home country P based only on the relevant withholding tax rate and the CIT of the parent. The CIT of the host country is excluded from the tax distance definition because this tax is always paid, irrespective of the relief method. Depending on the tax relief method again three possibilities are considered.

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

[4] Thus no-relief-at-all, which does occur sparingly, is ignored. See also annex C1.
[5] 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.

By construction holds $t_{SP}^{e} = 1-(1-t_S)(1-d_{SP})$; 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.

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. $1-(1-d_{SC})(1-d_{CP}) < d_{SP}$. 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 nominal 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.[6] 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, $w_{SC} < w_{SP}$.[7]

[6] Two numerical examples are provided in annex C2.

[7] 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).

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 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[8] 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.[9]

The algorithm generates the matrix of shortest distances, representing the lowest tax costs in repatriating profits from all source countries to all residence 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 the diversion for tax reasons subject of this paper. Nevertheless, averages rates will also be computed with alternative weights, discussed in section 4.

4. Tax data

The selection of 108 jurisdictions for the international network contains all high and upper middle income economies[10] 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, thus covering almost 95 percent of worldwide GDP in 2011. The full list is found in annex A1 and as a map in figure 3.

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.[11] 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.

[8] See for instance Minieka (1978).
[9] 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.
[10] World Bank Atlas method, based on 2012 GNI per capita data.
[11] However we exclude Ireland, Jordan, Luxembourg, Switzerland and Singapore, see annex A.2.

The tax data are mainly obtained from the Worldwide Corporate Tax Guide 2013 from EY (formerly Ernst & Young). 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.[12] 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.

Although the data have been cross-checked with other information from public sources,[13] 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.[14] We ignore the possibilities to reduce the tax base in the host countries and the lower effective tax rates. The CIT rates of the host countries are therefore an upper bound. There are two reasons why we believe that the difference between statutory and effective rates matters little for our purposes. 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 they are simply not available for most of the countries in our set.

The CIT rates are listed in annex A1 and in the first column of table 2 for a selected number of countries.[15] 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 the 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).

[12] We have ignored lowest tax rates which only apply to non-profit organizations, such as pension funds and government institutions.
[13] For instance, Deloitte (2013) and Loyens & Loeff (2013).
[14] OECD Tax Database and KPMG Tax Tools and Resources.
[15] These include the 6 countries from table 1.

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.

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, see column (7).[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 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.

[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, *de facto,* also Iceland, Norway and Switzerland are included.

With the tax data the bilateral dividend repatriation tax rates are constructed. Next, for country and worldwide averages bilateral weights are required. For the main results we use double GDP-weights, see annex C4.

In an alternative exercise, in collaboration with the OECD, bilateral weights are used which are based on sparsely available but actual bilateral dividend flows and FDI stocks. These data are extracted from the OECD BMD4 database of FDI Statistics. As they do not cover the entire country set a matrix balancing procedure has been applied to complete the set of weights. This procedure incorporates additional aggregate FDI stock data from UNCTAD (2014) and is reported in Van 't Riet, Lejour & Hanappi (2015). 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 present the results based on the GDP-weights as our main outcomes. The alternative weights will be used in two instances; for an estimate of a money measure of the potential tax reduction and as a robustness check.

5. Double tax relief

With the tax data, combined effective tax rates are computed. A multinational could face triple taxation when repatriating profits of a foreign subsidiary. With an 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.[18] 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 the 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.

The bilateral dividend repatriation tax rates can also be averaged country-wise. This can be done for the country as home or as host of the investments; thus for inbound and outbound dividend flows. Lacking full bilateral data on dividend or FDI flows we apply GDP weights. 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; see table 4. In sharp contrast, the average rate for the United States is 16.7 percent.[19] 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.[20]

[18] World average taxation on top of the CIT of the host equals 1 - (1 - .17)(1 - .29) ≅ 0.41.
[19] See column Direct in annex B1.
[20] An example of a tax inversion is the 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 will reside.

Table 4: Top 10 – average direct repatriation tax rates for inbound dividends

	Country	%		Country	%
1	**Netherlands**	3.4	6	**Belgium**	4.3
2	**Finland**	3.7	7	**Denmark**	4.6
3	**United Kingdom**	3.8	8	**Austria**	4.8
4	**Sweden**	3.8	9	**Switzerland**	4.9
5	**Luxembourg**	4.0	10	**Germany**	5.2

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 source country of the repatriated profits. The low-tax havens[21] in general have no or few double tax treaties and therefore do not rank high.

As an example consider repatriating dividends from a subsidiary in the USA to a parent company in China. Full triple taxation would involve the CIT in the USA of 39.1%, the general non-resident withholding tax of the USA on dividends of another 30% and the CIT of China of 25%, see table 2. This amounts to a staggering combined rate of 68%. The double taxation, i.e. on top of the CIT of the USA, would be 47.5%. But China applies the credit method as double tax relief: the full credit leaves a double taxation of 30%. Finally, the bilateral tax treaty stipulates a withholding tax of 10% replacing the general rate of 30%, see table 3. Often the treaty withholding tax is what finally remains as double taxation instead of the full double tax.

6. 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.

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.

[21] Low-tax havens are jurisdictions on the Gravelle (2013) list with a CIT of 12.5% or less: Bahamas, Bermuda, Cayman Islands, Guernsey, Jersey, Isle of Man, British Virgin Islands, Cyprus, Macao and Liechtenstein, see annex A2. In recent years many of these havens have signed bilateral treaties on information exchange, but these treaties do not contain agreements on lower tax rates.

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 5.

Table 5: 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
Source	*7.7*	*2.1*
Conduit		*0.3*
Residence	*4.1*	*3.3*

Table 5 also gives the split of the double tax revenue over the source, conduit and residence 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.

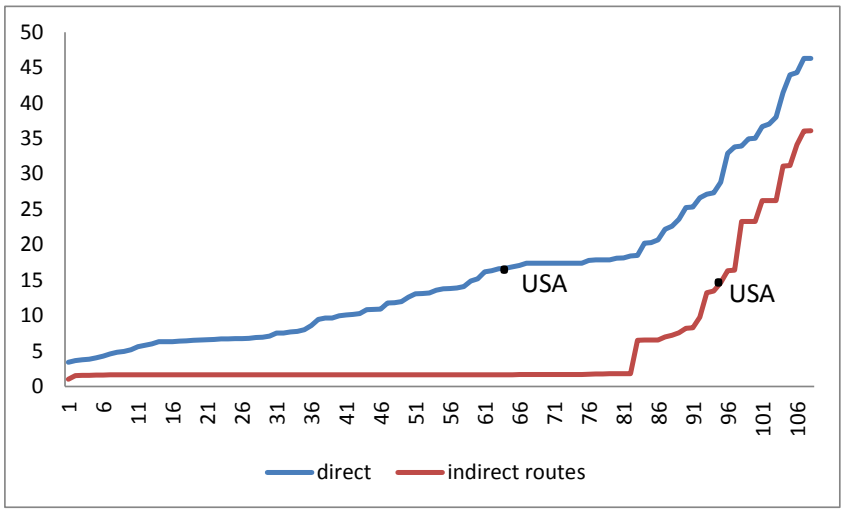
The worldwide averages of table 5 are based on double GDP weights. An alternative set of bilateral weights is generated from sparse but actual dividend flows and combined with FDI positions. These alternative weights result in the following average repatriation tax rates: 11.0 percent for the direct routes and 4.8 percent for the optimal indirect routes. The world average repatriation tax rates are lower for the new weights than for those based on GDP because higher weights are assigned to country pairs with lower repatriation tax rates. This might have been expected as, *ceteris paribus*, lower taxes lead to higher investments.

The reduction of 6 percentage points can be combined with an estimate of the world total of dividend flows of USD 1250 billion (source OECD, 2014). The potential tax reduction by treaty shopping could amount to USD 75 billion, yearly, for dividends.

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. These country results are the rates multinationals face using the countries as hosts for their subsidiaries or as residence of the parent companies.

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 5. 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.

Figure 2: Rankings of average inbound dividend repatriation tax rates



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 source 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.

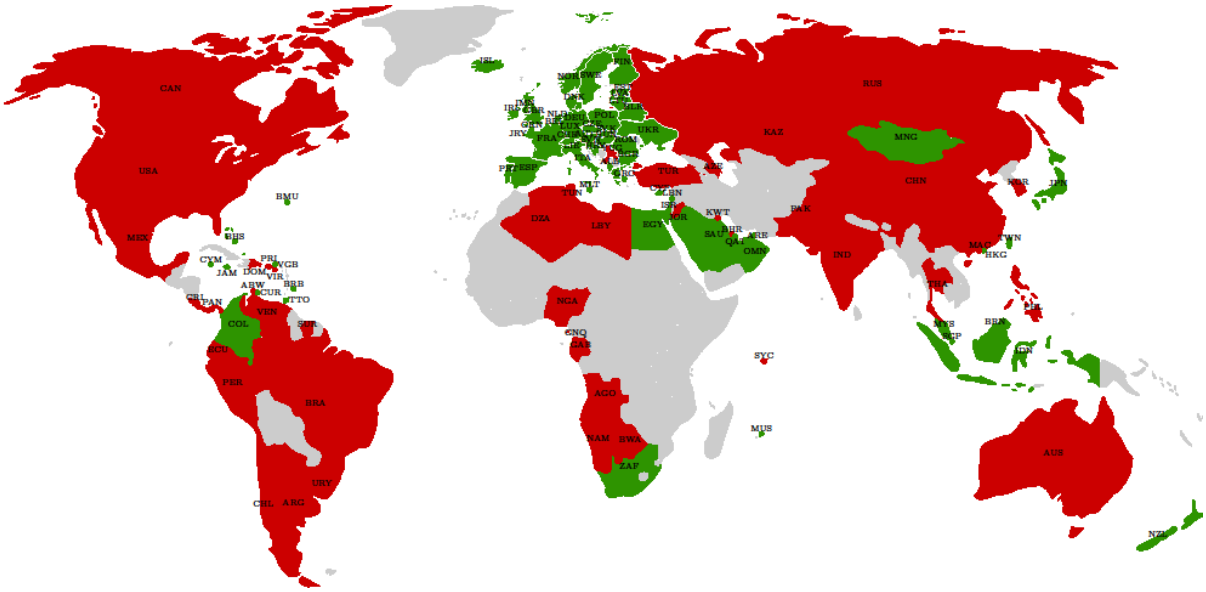
A similar pattern can be seen for host countries and the average double tax rates on outbound dividend flows. Here the MNE's face a rate of 5.4 percent or lower when repatriating profits from another group of 82 countries (69 identical to those 82 for inbound flows, explained below). Again treaty shopping 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 at least a 5 percent withholding tax rate, even to their most favoured treaty partners.

The country averages with a lower floor in the 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 all the other countries in this component can be reached without tax costs. See figure 3 for a map of the countries in the well-connected group; the map also indicates the country coverage. Thirteen countries do well with respect to incoming dividends but are not part of the strongly connected component; China is an example. Thirteen other countries do well in outgoing dividends, such as the USA, but are not strongly connected.

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

Figure 3: Map of country coverage (red and green) and well-connected group (green)



7. 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 determined 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. We take these weights as a proxy for the bilateral dividend flows. With 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.[23] Table 6 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 robustness checks.

[23] See also annex C3.

Table 6: 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 a EU member and it levies no non-resident withholding tax on dividends (DIV in table 6). 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.[24] 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.[25] 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. This is further illustrated with their impact on treaty shopping potential; in a small simulation analysis the possibility of low tax havens being an intermediate station is excluded.[26] This does not raise the world average remaining double tax rate at all. Taking all 26 jurisdictions from the Gravelle-list to be excluded as a conduit raises this world average rate from 5.75 percent to 5.90 percent.

Still, even when we exclude the top 10 conduit countries from table 6 the world average dividend repatriation tax rate is only raised to 6.00 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 suggests that large scale international cooperation is 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 have explored this in a simple cross section regression for all 108 countries. We find that there is indeed a positive correlation between both measures, but can not prove causation due to the limited possibilities of distinguishing direct and diverted FDI stocks and the limitations of a cross section analysis.

[24] Found as avg.DIV in annex B2.

[25] 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.

[26] Exclusion of a jurisdiction as a conduit country is implemented by adding an additional and prohibitive tax.

8. Multiplicity, alternative measures and robustness

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. The first reason is that host countries apply a general rate for their non-resident withholding tax and combined with the same CIT rates of various home countries identical combined rates may follow, depending on the relief methods. CIT rates are clustered around certain values, like 20, 25 and 30 percent.

A second, potential source for the huge multiplicity are 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 about one-fifth 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.

A third 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.

Table 7: 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 table 7. 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, will be shown not to be very different.

One alternative betweenness centrality measure counts whether a jurisdiction is at all on a shortest path of a pair (occurrence), 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 Table 7 has shown.

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 three extra measures to test whether the assumptions of BTWNS affect the outcomes. The first alternative measure is betweenness based on occurrence instead of fractions (OCCUR). The second variant is betweenness for strictly shortest paths, again double GDP weighted (STRCT). In addition the alternative weights, based on dividend flows and FDI positions, create a separate ranking (DIV/FDI) for relevant paths within range. Table 8 presents the positions of the main top 10 in the alternative centrality rankings. In annex B3 the full list can be found.

Table 8: Rank positions for alternative betweenness centrality measures

	Country	OCCUR	STRCT	DIV/FDI		Country	OCCUR	STRCT	DIV/FDI
1	**United Kingdom**	3	1	1	6	**Singapore**	6	3	16
2	**Luxembourg**	1	2	2	7	**Ireland**	5	6	10
3	**Estonia**	4	4	6	8	**Slovak Republic**	9	8	11
4	**Netherlands**	7	5	3	9	**Cyprus**	18	10	5
5	**Hungary**	2	7	4	10	**Malta**	16	11	12

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. And this also applies for the measure with alternative weights, which has the UK, Luxembourg and the Netherlands as top 3. Thus, with respect to the ranking the results of the betweenness centrality measure seem to be robust. [27]

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 first result is that the direct effect of double tax relief and tax treaties lowers the world average rate of 41 percent to 12 percent, given statutory corporate income taxation in host countries. Then 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. The potential reduction of the tax burden for MNE's by treaty shopping could amount to about USD 75 billion, yearly, for dividend repatriation.

[27] Kendall's (tau) rank correlation coefficients with BTWNS are 0.86 for OCCUR , 0.80 for STRCT and 0.88 for DIV/FDI.

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.

Centrality in the network is used to identify candidates for the role of conduit country. 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. A simple model simulation that excludes the possibility that low-tax havens function as a conduit does not raise the world average double tax rate, and exclusion of all tax havens raises this rate only by 0.15 percent.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.

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 analysis yearns for an econometric analysis beyond our cross-sectional regression. The impact of the centrality measure on FDI stocks could be analyzed in an dynamic setting for determining a causal impact. Then time series data on the tax system and FDI stocks should be exploited.

Notwithstanding the limitations we show that with only the main tax parameters we can sketch 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.

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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 are 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, see footnote 11. 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 others countries do not grant a dividend participation exemption to dividend income coming from them. Belgium, for instance, has no CFC-rules as such, but applies these subject-to-tax rules.

Annex B1: Remaining double tax rates for home countries

In	Country	DIV	DTRM	CIT rate	no. trts	Direct	SHOP*
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

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

*: 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	SHOP*
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		FDI&DIV	
		rate	number	%	%	rank	%	rank	%	rank
1	United Kingdom	0	51	12.2	7.4	3	12.9	1	8.4	1
2	Luxembourg	15	57	7.7	7.6	1	7.1	2	6.0	2
3	Estonia	0	36	6.7	7.3	4	3.0	4	4.2	6
4	Netherlands	15	74	6.6	6.7	7	2.8	5	5.6	3
5	Hungary	0	47	6.1	7.5	2	2.2	7	4.3	4
6	Singapore	0	40	6.0	6.8	6	4.4	3	3.3	16
7	Ireland	20	53	5.5	6.8	5	2.7	6	3.9	10
8	Slovak Republic	0	42	5.3	6.5	9	2.1	8	3.8	11
9	Cyprus	0	35	4.3	5.7	18	1.8	10	4.3	5
10	Malta	0	38	4.2	5.8	16	1.6	11	3.7	12
11	Finland	25	59	3.9	6.3	12	1.1	14	4.1	7
12	France	30	80	3.8	5.1	21	1.4	12	3.3	15
13	Malaysia	0	34	3.7	6.4	11	1.0	15	3.4	14
14	Sweden	30	67	3.6	5.8	17	0.8	20	3.5	13
15	Spain	21	71	3.4	4.3	30	1.9	9	3.3	17
16	Denmark	27	61	3.2	5.5	19	0.6	23	4.0	9
17	Belgium	25	70	3.0	5.4	20	0.7	22	4.0	8
18	Switzerland	35	71	2.9	4.9	23	0.8	21	2.9	20
19	Untd Arab Emirates	0	21	2.8	6.5	8	1.0	16	2.1	27
20	Brunei Darussalam	0	1	2.6	6.4	10	1.2	13	1.5	33
21	Germany	25	71	2.4	4.8	24	0.5	25	2.9	19
22	HongKong	0	14	2.3	4.2	32	0.9	17	1.6	32
23	Oman	0	8	2.2	6.2	13	0.5	29	1.5	35
24	Lithuania	15	44	2.1	4.9	22	0.8	18	2.2	24
25	Austria	25	66	1.9	4.5	29	0.4	31	2.9	18
26	Bulgaria	5	50	1.9	4.5	28	0.4	32	2.2	22
27	Norway	25	64	1.9	4.1	33	0.5	28	2.2	25
28	Slovenia	15	46	1.9	4.7	26	0.6	24	2.0	29
29	Colombia	0	4	1.8	5.9	15	0.3	35	0.9	43
30	Iceland	18	38	1.8	4.6	27	0.5	26	2.0	28
31	Latvia	10	45	1.8	4.7	25	0.5	27	2.2	23
32	Curacao	0	0	1.6	6.1	14	0.3	36	1.3	38
33	Romania	16	66	1.6	4.0	35	0.4	34	2.3	21
34	Greece	10	42	1.5	4.3	31	0.4	33	1.9	30
35	Poland	19	64	1.3	3.8	37	0.2	43	2.1	26
36	Czech Republic	35	66	1.2	3.9	36	0.2	40	1.7	31
37	Mauritius	0	15	1.2	3.6	39	0.2	42	1.4	37
38	Italy	20	69	1.1	3.1	49	0.3	37	1.5	34
39	Australia	30	40	1.0	2.4	51	0.1	47	0.7	49
40	Liechtenstein	0	3	1.0	3.6	38	0.2	41	1.1	40
41	Qatar	7	36	1.0	2.2	52	0.8	19	0.6	50
42	Portugal	25	53	0.9	3.5	40	0.1	51	1.5	36

43	Bahamas	0	0	0.7	3.5	41	0.0	59	0.9	41
44	Bermuda	0	0	0.7	3.5	42	0.0	62	0.9	42
45	Cayman Islands	0	0	0.7	3.5	43	0.0	65	0.8	47
46	Guernsey	0	0	0.7	3.5	44	0.0	74	0.9	44
47	Isle of Man	0	0	0.7	3.5	45	0.0	76	0.9	45
48	Jersey	0	0	0.7	3.5	46	0.0	79	0.9	46
49	Virgin Islands U.K.	0	0	0.7	3.5	47	0.0	108	0.8	48
50	Japan	20	47	0.6	3.2	48	0.3	38	1.1	39
51	Turkey	15	59	0.5	2.0	53	0.1	53	0.1	77
52	Croatia	12	44	0.4	2.8	50	0.2	39	0.3	52
53	Egypt	0	23	0.3	4.0	34	0.0	71	0.2	56
54	India	0	40	0.3	0.2	79	0.1	50	0.2	57
55	Ukraine	15	56	0.3	1.9	54	0.2	45	0.3	53
56	Barbados	15	23	0.2	1.5	56	0.1	48	0.2	54
57	Mongolia	20	27	0.2	1.3	60	0.0	88	0.1	67
58	New Zealand	30	36	0.2	1.4	59	0.0	90	0.2	58
59	Albania	10	26	0.1	1.4	58	0.1	46	0.3	51
60	Azerbaijan	10	29	0.1	0.6	67	0.0	58	0.1	59
61	Belarus	12	44	0.1	1.2	61	0.0	61	0.2	55
62	Brazil	15	35	0.1	0.3	78	0.0	64	0.0	84
63	Canada	25	75	0.1	0.6	68	0.1	49	0.1	60
64	Dominican Rep.	10	1	0.1	0.6	69	0.0	69	0.1	62
65	Indonesia	20	52	0.1	0.8	63	0.0	75	0.1	63
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	0.1	65
68	Korea Republic	20	67	0.1	0.7	64	0.0	82	0.1	66
69	Russian Federation	15	59	0.1	0.5	73	0.1	52	0.1	71
70	Saudi Arabia	5	18	0.1	1.8	55	0.5	30	0.1	72
71	Serbia and Mont.	20	42	0.1	0.5	72	0.2	44	0.1	73
72	South Africa	15	55	0.1	1.5	57	0.0	98	0.1	74
73	Trinidad and Tob.	10	16	0.1	0.7	65	0.0	102	0.1	76
74	Algeria	15	23	0.0	0.0	82	0.0	54	0.0	78
75	Angola	10	0	0.0	0.0	83	0.0	55	0.0	79
76	Argentina	35	14	0.0	0.0	84	0.0	56	0.0	80
77	Aruba	10	1	0.0	0.0	85	0.0	57	0.0	81
78	Bahrain	0	10	0.0	0.0	86	0.0	60	0.0	82
79	Botswana	8	8	0.0	0.0	87	0.0	63	0.0	83
80	Chile	35	24	0.0	0.7	66	0.0	66	0.0	85
81	China	10	61	0.0	0.6	71	0.0	67	0.1	61
82	Costa Rica	15	1	0.0	0.0	88	0.0	68	0.0	86
83	Ecuador	0	10	0.0	0.0	89	0.0	70	0.0	87
84	Equatorial Guinea	25	1	0.0	0.0	90	0.0	72	0.0	88
85	Gabon	15	4	0.0	0.0	91	0.0	73	0.0	89
86	Jamaica	33	15	0.0	0.4	75	0.0	78	0.0	90
87	Jordan	0	13	0.0	0.0	92	0.0	80	0.0	91
88	Kuwait	15	40	0.0	0.0	93	0.0	83	0.0	92

89	Lebanon	10	13	0.0	0.0	80	0.0	84	0.0	93
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	0.1	68
95	Pakistan	10	31	0.0	0.0	99	0.0	92	0.0	98
96	Panama	17	14	0.0	0.0	100	0.0	93	0.0	99
97	Peru	4	3	0.0	0.0	101	0.0	94	0.1	69
98	Philippines	15	29	0.0	0.0	102	0.0	95	0.1	70
99	Puerto Rico	10	0	0.0	0.0	103	0.0	96	0.0	100
100	Seychelles	15	12	0.0	0.0	104	0.0	97	0.0	101
101	Suriname	25	1	0.0	0.0	105	0.0	99	0.0	102
102	Taiwan Province	20	19	0.0	0.5	74	0.0	100	0.1	75
103	Thailand	10	34	0.0	0.4	76	0.0	101	0.0	103
104	Tunisia	0	26	0.0	0.0	106	0.0	103	0.0	104
105	United States	30	54	0.0	0.0	81	0.0	104	0.0	105
106	Uruguay	7	6	0.0	0.0	107	0.0	105	0.0	106
107	Venezuela	34	28	0.0	0.3	77	0.0	106	0.0	107
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.[28] 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.

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

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.[29]

[28] See for instance Minieka (1978).
[29] This is the communitative property.

Thus a basic method is defined, with a deduction 'metric'[30], 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[31], 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.

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

[30] Strictly speaking it is not a metric, since, for instance, the property of symmetry is not satisfied.
[31] 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.

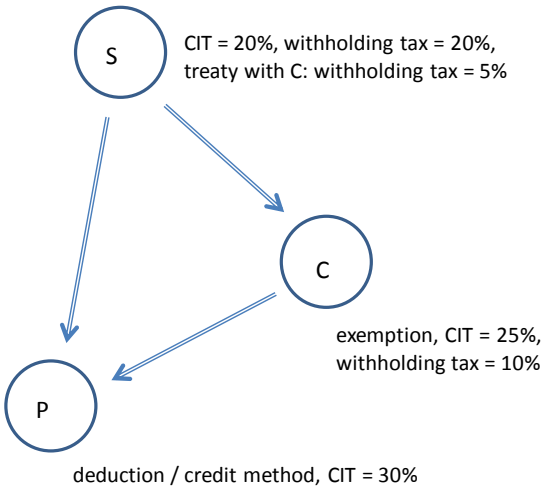
Annex C2: Numerical examples of compounded tax rates and treaty shopping

Host country S levies a corporate income tax (CIT) with a rate of 20%. It also applies this rate on the profits of subsidiaries of foreign companies. When dividends are repatriated to the parent company, host S levies a non-resident dividend withholding tax of again 20%. Home country P has a CIT of 30%. The world average CIT is 25%.

Deduction method

First assume that the home country P applies the deduction method for double tax relief. The compounded taxes due in host S are 36%.[32] And parent P applies another 30% on the after-tax foreign income to yield an overall combined effective tax rate of 55.2%.[33]

Figure C1: A numerical example



The parent company could have diverted the investment through an entity in conduit country C, because countries S and C have signed a bilateral tax treaty, stipulating a withholding tax on flows from S to C of only 5%, instead of the general rate of 20%. Conduit country C has a CIT rate of 25%, but exempts foreign source dividend income to avoid double taxation. It does levy a withholding tax of 10% .This gives a sequence of four compounded taxes yielding a final rate of 52.1%.[34] As this is less than the final rate of the direct route, the rational choice is for the indirect route, i.e. treaty shopping.

Credit method

Now assume that the home country P applies the credit method for double tax relief. The combined taxes due in host S are 36% which exceeds the CIT rate of 30% of the home country. As excess credits are not refunded, the overall compounded tax rate is 36%. If the parent company uses an entity in conduit country C including exemption the compounded effective tax rate is 31.6%.[35] This rate exceeds the CIT rate of P. However, in conduit situations we allow the just world average CIT to

[32] Computed as 1 - (1 - 0.20)(1 - 0.20) = 1 - 0.64 = 0.36.
[33] Computed as 1 - (1 - 0.20)(1 - 0.20)(1 - 0.30) = 1 - 0.448 = 0.552.
[34] Computed as 1 - (1 - 0.20)(1 - 0.05)(1 - 0.10)(1 - 0.30) = 1 - 0.684 = 0.5212.
[35] Computed as 1 - (1 - 0.20)(1 - 0.05)(1 - 0.10) = 1 - 0.684 = 0.316.

be credited, and the relevant withholding tax. These two amount to 32.5%,[36] which also exceeds the CIT of P. The conservative approach would be imposing the direct credit method, which means that only the withholding tax rate can be credited. This results in a combined effective tax rate of 46.8%.[37] In this case treaty shopping is not profitable.

Annex C3: 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, being $1/N_{ij}$, 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*.

[36] Computed as 1 - (1 - 0.25)(1 - 0.10) = 1 - 0.675 = 0.325.
[37] Computed as 1 - (1 - 0.20)(1 - 0.05)(1 - 0.30) = 1 - 0.532 = 0.468.