Tax Treaties and Foreign Direct Investment: A Network Approach*

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Abstract

Multinational investors often reduce tax on dividends by using indirect investment routes. This paper constructs a tax rate matrix to represent a real-world network of tax treaties between 70 countries and develops network algorithms to study the structure of tax-minimizing (direct or indirect) investment routes in the tax treaty network. The treaty shopping arbitrage rate, defined as the difference between the foreign tax rates of the direct route and a tax-minimizing route, is computed to be about 3.57 percentage points on average. This paper also examines the relationship between FDI and the structure of tax-minimizing routes. Empirical results show that the availability of a tax-minimizing direct route is positively and significantly related to FDI. The inward FDI stock via a tax-minimizing direct route is larger by about 4,260.78 million US dollars (or about 2.48 times larger) than the inward FDI stock via a direct route that is not tax-minimizing. By making a direct route tax-minimizing, countries can encourage FDI via the direct route and reduce treaty shopping.

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Keywords: tax treaty network, tax-minimizing route, treaty shopping arbitrage, foreign direct investment

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1 Introduction

The main purpose of tax treaties is to avoid, or at least to reduce, double taxation on cross-border economic activity, such as foreign direct investment (FDI). By reducing double taxation, tax treaties can help increase the net-of-tax return of investors, such as multinational firms, and encourage FDI.[1] Despite the expected relationship between tax treaties and FDI, empirical studies have found little evidence to support the relationship. For instance, Blonigen and Davies (2004) use an indicator variable for the presence of a tax treaty and find that the average treaty effect on FDI stock is statistically insignificant.[2]

Researchers take two different approaches to resolve the puzzling relationship between tax treaties and FDI. The first approach is to use firm-level data to overcome the aggregate nature of FDI data.[3] The second approach is to use network optimization techniques to understand the network effect of tax treaties on FDI.[4]

By following the "network" approach, in this paper, I examine the structure of tax-minimizing investment routes in a network of tax treaties between 70 countries. This tax treaty network is represented as a tax rate matrix where each entry is defined as the minimum withholding tax (WHT) rate on

[1]Foreign "direct" investment from country i to country j requires that an investor in country i should play an active role by owning a significant proportion (e.g., at least 10 percent) of shares of a company in country j. Generally, FDI is distinguished from foreign "portfolio" investment that requires no minimum threshold on ownership. However, FDI can be made with indirect ownership structures using conduit companies in countries other than i and j. In this paper, the definition of indirect investment routes focuses on such indirect ownership structures.

[2]Louie and Rousslang (2008) also use a treaty dummy variable and find no significant treaty effect on the rate of return from FDI after controlling for the quality of governance in source countries. However, di Giovanni (2005) finds a positive treaty effect on cross-border mergers and acquisitions. For a survey of earlier studies, see Davies (2004).

[3]Weyzig (2013) uses the Dutch data on special purpose entities and finds positive treaty effects on FDI. Blonigen et al. (2014) use the US BEA data on multinational company operations and find that the average treaty effect on foreign affiliate activity is insignificant.

[4]Hong (2014) examines tax-minimizing investment structures in a tax treaty network between 15 selected countries. Also, van't Riet and Lejour (2015) analyze a tax treaty network within a more comprehensive set of countries, but they do not investigate the relationship between FDI and the tax treaty network.

dividends and determined by relevant tax treaties and tax laws.

In this tax treaty network, investors can minimize tax on dividends by choosing direct investment routes (i.e., by investing directly) to 26 countries. These countries impose no WHT on dividends or have an imputation system under which no WHT may be imposed on dividends. However, investors may be able to minimize tax on dividends by choosing indirect investment routes (i.e., by investing indirectly through other countries) to the rest of the 44 countries.

The concept of treaty shopping often refers to the use of indirect investment routes through countries with favorable tax treaties. Multinational investors can shift their profits by remitting dividends through tax-minimizing indirect routes. OECD (2015) highlights that treaty shopping is one of the most important sources of concerns regarding the Base Erosion and Profit Shifting (BEPS) project.

I develop network algorithms to analyze the structure of tax-minimizing (direct or indirect) investment routes to the 44 countries and to assess the reduction in tax rates due to treaty shopping. To limit computational burden, my network algorithms work under a constraint on the number of pass-through countries. I consider four cases depending on the maximum number of pass-through countries and the level of corporate income tax (CIT) rates in pass-through countries. Here I summarize the results in case (1R) when each route passes through at most 1 country and each pass-through country imposes CIT at a reduced rate. The results in the other cases are similar to those in case (1R).

Two network variables are introduced and calculated as follows. For a pair of countries, $TMD1R$ is a dummy variable indicating the existence (i.e., availability) of a tax-minimizing direct (TMD) route in case (1R), and $TSA1R$ is a continuous variable called the treaty shopping arbitrage (TSA) rate in case (1R) and defined as the difference between the foreign tax rates of the direct route and a tax-minimizing route. Thus, an investor can reduce her foreign tax rate by the TSA rate when using a tax-minimizing route.

Notably, in case (1R), the average TSA rate is about 3.57 percentage points, which is substantial when compared with the average WHT rate of 5.35 percent.

Treaty shopping arbitrage is more substantial when the average is taken over the pairs of countries with no tax-minimizing direct route. In case (1R), for 3,033 pairs (62.8%) of countries, the direct route is tax-minimizing.[5] However, for 1,797 pairs (37.2%) of countries, the direct route is not tax-minimizing. Among the pairs of countries with no tax-minimizing direct route, while the average WHT rate is about 12.20 percent, the average TSA rate is about 9.59 percentage points.

In addition I examine the structure of tax-minimizing investment routes to certain source countries.[6] For instance, in case (1R), when China is the source country, there are 31 tax-minimizing direct routes from 31 residence countries to China. Moreover, there are 590 tax-minimizing indirect routes from 38 residence countries to China. For example, there are tax-minimizing indirect routes from the United States (US) to China (CN) that passes through either Hong Kong or the Netherlands. The treaty shopping arbitrage rate among routes between US and CN is calculated to be 4.05 percentage points. Incidentally, it has been known that American multinational firms, such as Starbucks and IBM, indirectly owned and operated Chinese subsidiaries through foreign equity holding companies in Hong Kong and the Netherlands.

Multinational firms can choose investment (ownership) structures that influence FDI between countries at an aggregate level. If such investors consider tax as an important factor when choosing investment structures, the structure of tax-minimizing investment routes, as analyzed in this paper, will be consistent with FDI data. By using bilateral FDI data from the United Nations Conference on Trade and Development (UNCTAD), I find that the average inward FDI stock via a tax-minimizing direct route is larger

[5]Given 70 countries, there are 4,830 ($= 70 \times 69$) pairs of residence and source countries.

[6]The term "source" refers to a place where investors earn income from their investment and "residence" refers to a place where investors originally own their assets for investment.

by about 4,202.59 million US dollars (or about 3.75 times larger) than the average inward FDI stock via a direct route that is not tax-minimizing.

By conducting a regression analysis, I examine whether the two network variables, $TMD1R$ and $TSA1R$, can help explain the patterns of inward FDI stock. Across all relevant regressions, the coefficients on $TMD1R$ are positive and highly significant. In other words, the availability of a tax-minimizing direct route is positively related to inward FDI stock. The estimated coefficients reveal that the inward FDI stock via a tax-minimizing direct route is larger by about 4,260.78 million US dollars (or about 2.48 times larger) than the inward FDI stock via a direct route that is not tax-minimizing. This empirical finding is consistent with a theoretical model.[7] Therefore, by making a direct route tax-minimizing, countries can promote FDI via the direct route and reduce treaty shopping, i.e., the use of indirect routes through conduit countries. However, the coefficients on $TSA1R$ show mixed signs, and are statistically insignificant in some regressions.

From a broader perspective, this paper contributes to the literature on taxation and investment of multinational firms. A cental issue in this literature has been whether and how taxation affects FDI.[8] More recently, researchers focus on how tax systems, together with non-tax motives, influence location decisions and ownership structures of multinational firms. Barrios et al. (2012) examine how tax systems in residence and source countries separately influence location decisions and find that corporate taxation of foreign-source dividends in residence countries may deter entries into potential source countries.[9] Mintz and Weichenrieder (2010) find that German

[7]Hong (2014) develops a game-theoretic model of treaty shopping, where the availability of a tax-minimizing direct route increases the equilibrium probability for an investor to use the direct route, which in turn positively influences FDI.

[8]Mooij and Ederveen (2003) provide a survey of empirical studies. For more recent studies, see Desai et al. (2004), Mutti and Grubert (2004), Becker and Riedel (2012), and Becker et al. (2012). Conversely, Chisik and Davies (2004) study the effects of FDI on tax treaties by using a bargaining model, and show that asymmetry in FDI stocks may result in higher tax treaty rates.

[9]For related studies, see Huizinga and Voget (2009) and Voget (2011). Devereux et al. (2015) examine the efficiency of tax relief rules for foreign-source income. Dischinger and Riedel (2011) examine location decisions for intangible assets.

multinational firms use indirect ownership structures through conduit countries and suggest that treaty shopping is a main reason for indirect structures. Lewellen and Robinson (2013) also discover that US multinational firms use indirect ownership structures for tax motives. Dyreng et al. (2015) find that US multinational firms are more likely to use indirect ownership structures (i.e., foreign equity holding companies) as the WHT rate on dividends paid from a source country to US increases. However, they find no evidence that the existence of a tax treaty between the source country and US affects the use of indirect structures.

The rest of this paper is organized as follows. Section 2 introduces a tax rate matrix to represent a tax treaty network and develops network algorithms to navigate in the network. Section 3 analyzes the structure of tax-minimizing investment routes in the network and calculates network variables such as the treaty shopping arbitrage rate. Section 4 studies the relationship between FDI and the network variables. Section 5 concludes.

2 Network Approach

A complete directed network is a network in which each pair of nodes is connected by two links with opposite directions. Countries i and j can be thought of as nodes i and j in a complete directed network where each link ij is given a weight t_{ij} representing a withholding tax (WHT) rate on dividends. This complete directed network can be thought of as a tax treaty network because tax treaties often determine WHT rates on dividends paid across countries. By constructing a tax rate matrix $T = [t_{ij}]$ to represent a tax treaty network, and by developing network algorithms to navigate in the network, I examine the structure of tax-minimizing investment routes in the tax treaty network.

2.1 Investment routes

An investor plans to invest in country s but lives in country h. From this investment, the investor will earn income m as dividends in country s and repatriate her income to country h. Country s is called the source country while country h is called the residence (or home) country.

The investor chooses an investment route to maximize her net-of-tax income in the residence country, i.e., to minimize tax when she remits her income to country h. Formally, an investment route, or simply a route, is defined as a series of countries, $h, i, \ldots, j, s$, from country h to country s. Let $R(h, s)$ denote the set of all routes from h to s. Let $r \in R(h, s)$ denote a route. Given a route $r = h, i, \ldots, j, s$, countries i through j are called pass-through countries. A route $h, i, \ldots, j, s$ is often written as

$$h \to i \to \cdots \to j \to s$$

when it is necessary to highlight the direction of the route. The investor can choose an indirect route $h, i, \ldots, j, s$ to invest in country s by establishing conduit entities in countries i through j and making her investment indirectly through these entities. She can also choose the direct route h, s to invest in country s. When the investor remits her income from s to h, the remittance route follows the reverse order of the countries in the investment route. The investor leaves no retained earnings in pass-through countries.

The investor's net-of-tax income depends on tax relief rules in the home country. I assume that the home country has a deduction or an exemption system. The foreign tax rate $f(r)$ of a route r is defined as follows:

$$f(r) = \begin{cases} t_{sh} & \text{if } r = h, s \\ 1 - (1 - t_{sj})(1 - t_j) \cdots (1 - t_i)(1 - t_{ih}) & \text{if } r = h, i, \ldots, j, s \end{cases}$$

Here t_i denotes the corporate income tax (CIT) rate in country i and t_{ij} denotes the withholding tax (WHT) rate on dividends paid from country i to country j.

If the investor chooses a route r, in the residence country, the investor's net-of-tax income is $m(1 - f(r))(1 - t_h)$. Because the residence country h, the source country s, and the dividend income m are given and fixed, the investor's net-of-tax income is determined by the choice of a route $r \in R(h, s)$. A route $r^* \in R(h, s)$ is called tax-minimizing if for every $r \in R(h, s)$, $f(r^*) \leq f(r)$. The investor can maximize her net-of-tax income by choosing a tax-minimizing route r^*.

Alternatively, if the residence country has a foreign tax credit system, the investor's net-of-tax income is determined by the greater of the foreign tax rate $f(r)$ and the domestic CIT rate t_h. Thus, if the domestic CIT rate is sufficiently high under the credit system, the investor may not have an incentive to use a tax-minimizing indirect route.[10] However, the investor has such an incentive if the residence country has a deduction or an exemption system.

2.2 Tax rate matrix

A tax rate matrix $T = [t_{ij}]$ shows WHT rates on dividends paid across national borders.[11] Each WHT rate t_{ij} is applied for a pair of countries i and j. If an entity in country i remits dividends to an entity in country j, the tax agency in country i imposes WHT on dividends at the rate t_{ij}. Each WHT rate t_{ij} is determined by the tax treaty between countries i and j and by the national tax law of country i. For the sake of running network algorithms, each diagonal entry t_{ii} is assumed to be zero.

Here I construct a tax rate matrix $T = [t_{ij}]$ between 70 countries, as listed in Tables 1 and 2, by using the information on tax treaties and national tax laws from Deloitte International Tax Source and PwC Worldwide Tax

[10] Notably, the United States has a foreign tax credit system. However, it once had a temporary exemption system, known as the "repatriation tax holiday" in 2004. There is also evidence that American multinational firms use indirect structures for tax motives, as suggested by Lewellen and Robinson (2013) and Dyreng et al. (2015).

[11] Barrios et al. (2012, Table 2) provide a tax rate matrix of 33 European countries. Johannesen (2012, Table 1) also presents a matrix of WHT rates on interest paid across 28 OECD countries. However, these studies do not consider indirect investment structures, as I do in this paper.

Summaries.[12] From these websites I also find the information about CIT rates. Tables 1 and 2 summarize notable WHT systems with minimum, median, and maximum WHT rates and CIT rates in the 70 countries.

Each WHT rate t_{ij} is determined as follows:

First, if the European Union Parent-Subsidiary Directive (EU PSD) can be applied for countries i and j, then set $t_{ij} = 0$. The EU PSD requires the exemption of WHT on dividends paid across EU countries, Iceland, Norway, and Switzerland.[13]

Second, if the EU PSD cannot be applied for at least one of countries i and j, then check if there is a tax treaty between countries i and j. If there is no tax treaty between i and j, then set t_{ij} equal to the WHT rate specified by the national tax law of country i.

Third, if the EU PSD cannot be applied for at least one of countries i and j, but if there is a tax treaty between countries i and j, then set t_{ij} equal to the minimum of the rates specified by the tax treaty between countries i and j and by the national tax law of country i.

A tax treaty may specify a system of WHT rates on dividends depending on the percentage of shares. Given a system of WHT rates, I assume that the minimum WHT rate is applied. For example, according to the tax treaty between China (CN) and the United Kingdom (GB), if a Chinese entity pays dividends to a British entity that holds at least 25 percent of its shares, the WHT rate is 5 percent. Otherwise, the WHT rate is 10 percent. In this case, the minimum WHT rate of 5 percent is applied, i.e., for $i = \text{CN}$ and $j = \text{GB}$, $t_{ij} = 5$.

Moreover, a tax treaty may include the limitation on benefits (LOB) clause, specifying additional residency requirements to obtain the benefits of the tax treaty. If the LOB clause specifies that the minimum WHT rate can only be applied to certain pension funds, I take the next lowest WHT rate for the matrix. Otherwise, I assume that the minimum WHT rate is applied. For instance, according to the tax treaty (amended and signed in 2010) between

[12] Accessed at www.dits.deloitte.com and taxsummaries.pwc.com

[13] European Commission, Council Directive 2003/123/EC of 22 December 2003

Table 1. Selected countries and tax systems

Countries	Codes	WHT systems	Min	Med	Max	CIT
Argentina	AR	Single rate 10%	10	10	10	35
Australia	AU	Imputation	0	0	0	30
Austria	AT		0	5	25	25
Belgium	BE		0	0	25	33
Bermuda	BM	No WHT	0	0	0	0
Brazil	BR	No WHT	0	0	0	34
Bulgaria	BG		0	5	5	10
Canada	CA		5	5	25	15
Cayman	KY	No WHT	0	0	0	0
Chile	CL	Imputation	0	0	0	22.5
China	CN		5	10	10	25
Colombia	CO	Imputation	0	0	0	25
Croatia	HR		0	5	12	20
Cyprus	CY	No WHT	0	0	0	12.5
Czech Republic	CZ		0	5	15	19
Denmark	DK		0	0	27	23.5
Ecuador	EC	Imputation	0	0	0	22
Egypt	EG		0	10	10	22.5
Estonia	EE	No WHT	0	0	0	20
Finland	FI		0	5	20	20
France	FR		0	0	30	33.3
Germany	DE		0	5	25	15
Gibraltar	GI	No WHT	0	0	0	10
Greece	GR		0	5	10	29
Guernsey	GG	No WHT	0	0	0	0
Hong Kong	HK	No WHT	0	0	0	16.5
Hungary	HU	No WHT	0	0	0	10
Iceland	IS		0	5	18	20
India	IN	Single rate 15%	15	15	15	30
Indonesia	ID		5	12.5	20	25
Ireland	IE		0	0	20	12.5
Israel	IL		0	10	25	26.5
Italy	IT		0	5	26	27.5
Japan	JP		0	10	20	23.9
Korea	KR		0	7	20	22

Table 2. Selected countries and tax systems

Country	Code	WHT System	Min	Med	Max	CIT
Latvia	LV	No WHT	0	0	0	15
Lithuania	LT		0	5	15	15
Luxembourg	LU		0	0	15	21
Malaysia	MY	No WHT	0	0	0	25
Malta	MT	No WHT	0	0	0	35
Mauritius	MU	No WHT	0	0	0	15
Mexico	MX		0	5	15	30
Netherlands	NL		0	0	15	25
New Zealand	NZ	Imputation	0	0	0	28
Norway	NO		0	5	25	27
Panama	PA		0	10	10	25
Peru	PE		5	6.8	6.8	28
Philippines	PH		5	15	15	30
Poland	PL		0	5	19	19
Portugal	PT		0	5	25	21
Romania	RO		0	5	16	16
Russia	RU		5	10	15	20
Saudi Arabia	SA		0	5	5	20
Singapore	SG	No WHT	0	0	0	17
Slovakia	SK	No WHT	0	0	0	22
Slovenia	SI		0	5	15	17
South Africa	ZA		5	5	15	28
Spain	ES		0	0	20	28
Sweden	SE		0	0	30	22
Switzerland	CH		0	0	35	8.5
Taiwan	TW		5	20	20	17
Thailand	TH		5	10	10	20
Turkey	TR		5	10	15	20
Ukraine	UA		0	5	15	18
Arab Emirates	AE	No WHT	0	0	0	0
United Kingdom	GB	No WHT	0	0	0	20
United States	US		0	5	30	35
Uruguay	UY		5	7	7	25
Venezuela	VE	Imputation	0	0	0	34
Vietnam	VN	No WHT	0	0	0	22

the United States (US) and Hungary (HU), the minimum WHT rate is zero percent, but this rate can only be applied to pension funds qualified by the LOB clause of the tax treaty. The next lowest rate is 5 percent, which can be applied to other corporate entities. So, for $i =$ US and $j =$ HU, it is assumed that $t_{ij} = 5$. However, according to the tax treaty between the United States (US) and Japan (JP), the minimum WHT rate is zero percent, and this rate can be applied to pension funds as well as companies holding more than 50 percent of shares for a period longer than 12 months. So, for $i =$ US and $j =$ JP, it is assumed that $t_{ij} = 0$.

In addition to the general rules explained so far, I consider the following specific cases to construct the tax rate matrix.

Subnational (state, province, etc.) governments may also impose WHT on dividends. However, it is an onerous task to find out the WHT systems of all the subnational governments in 70 countries. Even if a subnational government imposes WHT on dividends, the rate is usually very low. Therefore, I only consider WHT imposed by national (federal) governments.

There is no WHT on dividends in India. However, India imposes a dividend distribution tax at the rate of 15 percent. Hence, it is realistic to assume that the WHT rate is 15 percent in India.

Australia and New Zealand have dividend imputation systems under which no WHT may be imposed on dividends distributed by companies that already pay CIT. Chile, Colombia, Ecuador, and Venezuela also have such systems. I assume that these countries impose no WHT on dividends.

Belgium imposes no WHT on dividends paid to entities resident in a country with a tax treaty. Ireland has a similar rule for WHT exemption. In Denmark the WHT rate is no greater than 15 percent if dividends are paid to shareholders resident in a country with a tax treaty.

In the tax rate matrix as constructed above, even without using a network algorithm, we can find that the investor can minimize tax on dividends by investing directly to 26 countries among all the countries in Tables 1 and 2. In particular, 18 countries impose no WHT on dividends and 6 countries have a dividend imputation system. No WHT may be imposed on dividends under a dividend imputation system. Also, 2 countries have a WHT system with a single rate for all countries.

However, the investor may be able to minimize tax on dividends by investing indirectly to the rest of the 44 countries. With the information about tax rates at hand, the investor needs to develop network algorithms to find tax-minimizing investment routes to these 44 countries.

2.3 Network algorithms

Given a tax rate matrix $T = [t_{ij}]$ and a pair (h, s) of residence and source countries, the investor can find tax-minimizing routes from country h to country s by using a network algorithm. Here I propose network algorithms that work under a constraint on the number of pass-through countries. Each network algorithm repeats the following three steps for all pairs of residence and source countries. Let (h, s) be a pair of countries and let $k \geq 1$ be a positive integer.

Step 1. Build a list of all routes from country h to country s under the constraint that the number of pass-through countries in each route is at most k and compute the net-of-tax income for each route.

Step 2. Find the maximum net-of-tax income among all routes in the list.

Step 3. Find and list all the routes from h to s that achieve the maximum net-of-tax income.

Given 70 countries, there are 4,830 $(= 70 \times 69)$ pairs of residence and source countries. If $k = 1$, there is at most one pass-through country in each route. Thus, the list of all routes includes an indirect route h, j, s with pass-through country j and the direct route h, s. Given 70 countries, there are 69 $(= 68 + 1)$ routes in the list of Step 1.

If $k = 2$, there are at most two pass-through countries in each route. Thus, the list of all routes includes an indirect route h, i, j, s with pass-through countries i and j, an indirect route h, j, s with pass-through country j, and the direct route h, s. Given 70 countries, there are 4,625 ($= 68 \times 67 + 68 + 1$) routes in the list of Step 1.

As k increases, the number of routes in the list of Step 1 grows exponentially.[14] Because the net-of-tax income is computed and compared for each route in the list, as k increases, the computational burden (or running time) of the algorithm increases exponentially. To limit the computational burden, I will use network algorithms with $k = 1$ and $k = 2$.[15]

3 Network Results

For an indirect route, the net-of-tax income depends on corporate income tax (CIT) rates in pass-through countries. I consider two different scenarios about CIT rates. In the first scenario, every pass-through country imposes CIT at a reduced rate of 1 percent. In the second scenario, every pass-through country imposes CIT at the statutory rate. For each scenario, I examine two cases depending on whether $k = 1$ or $k = 2$. Here k denotes the maximum possible number of pass-through countries in a route. I will distinguish between these four cases as follows: (kR) represents the case when there are at most k pass-through countries in a route and each pass-through country imposes CIT at the reduced rate; (kS) represents the case when there are at most k pass-through countries in a route and each pass-through country imposes CIT at the statutory rate.

Now I introduce two groups of network variables. For a pair of countries i and j, if there is a tax-minimizing direct (TMD) route $i \to j$ in case (1R), $TMD1R_{ij} = 1$, and otherwise, $TMD1R_{ij} = 0$. Also, $TMD1S_{ij}$, $TMD2R_{ij}$, and $TMD2S_{ij}$ are defined similarly in cases (1S), (2R), and (2S).

For a pair of countries i and j, the treaty shopping arbitrage (TSA) rate

[14] The number of routes in the list is approximately equal to the number of countries to the power k.

[15] It may not be unrealistic to assume that $k \leq 2$. Mintz and Weichenrieder (2010, Table 4.4) show that only 0.2 percent of German multinational firms use cross-border investment routes (ownership chains) with three or more pass-through countries.

Table 3. Descriptive statistics for network variables

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
$TMD1R_{ij}$	indicator for the existence of	4,830	0.63	0.48	0	1
$TMD1S_{ij}$	a tax-minimizing direct route	4,830	0.75	0.43	0	1
$TMD2R_{ij}$	from i to j	4,830	0.61	0.49	0	1
$TMD2S_{ij}$		4,830	0.75	0.43	0	1
$TSA1R_{ij}$	treaty shopping arbitrage rate	4,830	3.57	6.23	0	34
$TSA1S_{ij}$	among routes from i to j	4,830	2.29	5.03	0	30
$TSA2R_{ij}$		4,830	3.66	6.27	0	34
$TSA2S_{ij}$		4,830	2.29	5.03	0	30
WHT_{ji}	withholding tax rate on dividends paid from j to i	4,830	5.35	7.13	0	35

among routes from i to j in case (1R) is defined as $TSA1R_{ij} = t_{ji} - f(r^*)$, where r^* is a tax-minimizing route from i to j in case (1R). In words, the TSA rate among routes between a pair of residence and source countries is defined as the difference between the foreign tax rates of the direct route and a tax-minimizing route. An investor can reduce her foreign tax rate by the TSA rate by using a tax-minimizing route. If the direct route is tax-minimizing, the TSA rate is zero. Otherwise, the TSA rate is a positive number calculated in percentage points. Also, $TSA1S_{ij}$, $TSA2R_{ij}$, and $TSA2S_{ij}$ are defined similarly in cases (1S), (2R), and (2S).

Table 3 presents descriptive statistics for network variables and withholding tax rates, denoted by $WHT_{ji} = t_{ji}$. Notably, on average, the TSA rate in case (1R) is about 3.57 percentage points, which is substantial when compared with the WHT rate of 5.35 percent.

Treaty shopping arbitrage is more substantial when the average is taken over the pairs of countries with no tax-minimizing direct route. In case (1R), for 3,033 pairs (62.8%) of countries i and j, the direct route $i \to j$ is tax-minimizing. However, for 1,797 pairs (37.2%) of countries i and j, the direct route $i \to j$ is not tax-minimizing. Among these 1,797 pairs with no tax-minimizing direct route, while the average WHT rate is about 12.20 percent, the average TSA rate is about 9.59 percentage points.

In case (2R), for 1,876 pairs (38.8%) of countries i and j, the direct route $i \to j$ is not tax-minimizing. Among these 1,876 pairs, while the average WHT rate is about 11.95 percent, the average TSA rate is about 9.42 percentage points.

In cases (1S) and (2S), for 1,193 pairs (24.7%) of countries i and j, the direct route $i \to j$ is not tax-minimizing. Among these 1,193 pairs, while the average WHT is about 14.95 percent, the average TSA rate is about 9.29 percentage points.

3.1 Reduced rates in pass-through countries

As mentioned in Section 2.2, investors can minimize tax on dividends by investing directly to 26 countries (with no WHT, dividend imputation, or single-rate systems) among the 70 countries. However, investors may be able to minimize tax on dividends by investing indirectly to the rest of the 44 countries.

Table 4 summarizes the result for these 44 countries in case (1R) when each route passes through at most 1 country and each pass-through country imposes CIT at the reduced rate. In Table 4, column “Direct” shows the number of tax-minimizing direct routes to each source country.[16] Because there is only one direct route between a pair of residence and source countries, this number coincides with the number of residence countries with tax-minimizing direct routes to each source country. Column “Indirect” shows the number of tax-minimizing indirect routes and column “Indirect Home” shows the number of residence countries with tax-minimizing indirect routes to each source country. Column “TSA Mean” shows the average of TSA rates for each source country.[17]

As shown in Table 4, when China is the source country, there are 31 tax-minimizing direct routes in case (1R). Moreover, there are 590 tax-minimizing indirect routes from 38 residence countries to China. Precisely, there are 18 tax-minimizing indirect routes from the United States (US) to China (CN)

[16] For country j, the number in column “Direct” is calculated as $\sum_{i \neq j} TMD1R_{ij}$.

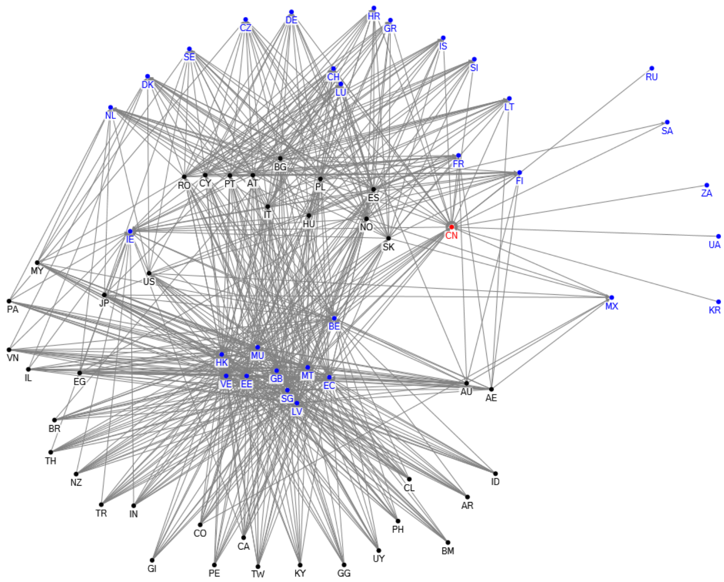
[17] For country j, TSA Mean is calculated as $\sum_{i \neq j} TSA1R_{ij}/(70-1)$.

Table 4. Tax-minimizing routes (1R)

Source	Direct	Indirect	Indirect Home	TSA Mean
AT	33	464	36	6.83
BE	61	162	8	2.78
BG	30	398	39	2.26
CA	40	494	29	4.46
CN	31	590	38	2.11
HR	31	426	38	4.99
CZ	31	387	38	4.81
DK	39	410	30	7.41
EG	5	232	64	7.84
FI	34	415	35	6.01
FR	38	391	31	5.78
DE	31	386	38	6.62
GR	30	398	39	4.51
IS	30	398	39	8.06
ID	1	68	68	8.24
IE	54	245	15	4.13
IL	5	220	64	12.71
IT	31	386	38	7.35
JP	9	318	60	10.62
KR	25	441	44	4.84
LT	32	411	37	6.13
LU	35	438	34	4.14
MX	19	610	50	5.04
NL	40	391	29	4.07
NO	33	433	36	7.59
PA	1	68	68	8.28
PE	31	38	38	0.58
PH	9	107	60	5.03
PL	31	421	38	6.36
PT	30	398	39	8.06
RO	31	421	38	6.41
RU	27	562	42	3.91
SA	16	121	53	3.07
SI	30	398	39	6.29
ZA	40	528	29	3.30
ES	38	457	31	4.75
SE	36	391	33	7.49
CH	36	458	33	6.36
TW	17	218	52	6.60
TH	69	0	0	0.00
TR	15	446	54	5.20
UA	9	340	60	5.98
US	12	393	57	11.97
UY	13	350	56	0.85

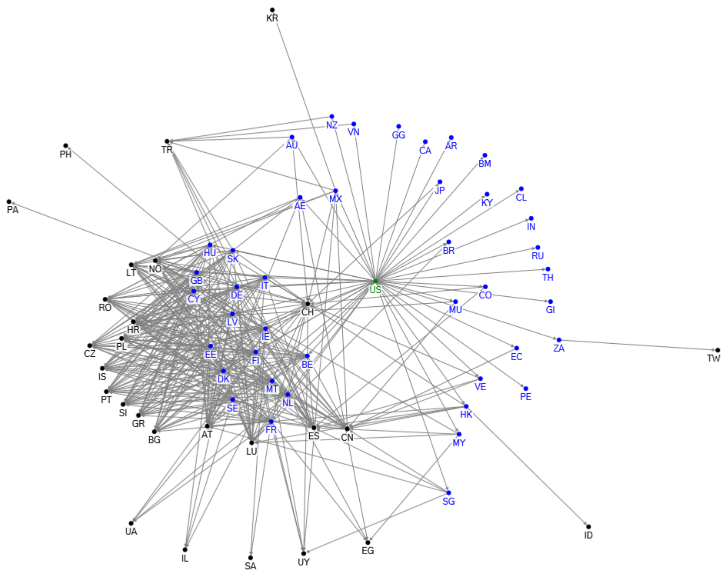
Note: (1R) at most 1 pass-through country and Reduced CIT rates

Figure 1. Tax-minimizing routes (1R) to China



Note: source in red; countries with tax-minimizing direct routes in blue

Figure 2. Tax-minimizing routes (1R) from the United States



Note: residence in green; countries with tax-minimizing direct routes in blue

passing through Hong Kong, the Netherlands, or any one of the following countries: BE, DK, EC, EE, FI, FR, DE, IE, LV, MT, MU, MX, SG, SE, GB, VE. In case (1R) the treaty shopping arbitrage rate among routes between US and CN is 4.05 percentage points.

This finding is consistent with anecdotal evidence that Starbucks Corporation, an American multinational firm, indirectly owned and operated Starbucks (China) Company Ltd., a Chinese subsidiary, through Starbucks Asia Pacific Investment Holding II Ltd., a holding company in Hong Kong. IBM Corporation also indirectly owned and operated IBM China Company Ltd., a Chinese subsidiary, through IBM Holdings B.V., a Dutch holding company.

Figure 1 shows a network diagram of tax-minimizing investment routes to China (CN) in case (1R). In Figure 1, the source country (CN) is marked in red and residence countries with tax-minimizing direct routes to the source country are marked in blue. Residence countries with tax-minimizing indirect routes to the source country are marked in black. Each arrow shows the direction of a route.

The structure of tax-minimizing investment routes can also be examined from the perspective of a residence country. Figure 2 shows a network diagram of tax-minimizing investment routes from the United States (US) in case (1R). In Figure 2, the residence country (US) is marked in green and source countries with tax-minimizing direct routes from the residence country are marked in blue. Source countries with tax-minimizing indirect routes from the residence country are marked in black. Each arrow shows the direction of a route.

In Appendix A, Table A.1 summarizes the result in case (2R) when each route passes through at most 2 countries and each pass-through country imposes CIT at the reduced rate. Interestingly, when KR, PE, PH, SA, or UA is the source country, there are tax-minimizing indirect routes with 2 pass-through countries. However, for the rest of the countries, even if it is possible for a route to pass through 2 countries, every tax-minimizing route passes through at most 1 country.

In Appendix B, Figures B.1 through B.4 show network diagrams of tax-minimizing investment routes to Mexico, Indonesia, Poland, and Saudi Arabia, respectively, in case (1R). These four countries and China are the countries with the largest net inward FDI stock.

Figures B.5 through B.8 show network diagrams of tax-minimizing investment routes from Japan, France, Germany, and the United Kingdom, respectively, in case (1R). These four countries and the United States are the countries with the largest net outward FDI stock.

3.2 Statutory rates in pass-through countries

Table 5 summarizes the result for the 44 countries in case (1S) when each route passes through at most 1 country and each pass-through country imposes CIT at the statutory rate.

As shown in Table 5, when China is the source country, there are 33 tax-minimizing direct routes in case (1S). Moreover, there are 37 tax-minimizing indirect routes from 37 residence countries to China. Precisely, there is only one tax-minimizing indirect route from the United States to China, which passes through the United Arab Emirates (AE). Furthermore, AE is the only pass-through country in the other tax-minimizing indirect routes to CN. In case (1S) the treaty shopping arbitrage rate among routes between US and CN is 3.00 percentage points.

In case (1S) every tax-minimizing indirect route passes through any one of the following 6 countries: BM, KY, GG, HU, CH, AE. All these countries except for HU and CH impose no CIT while HU and CH impose CIT at relatively low statutory rates, 10 and 8.5 percent, respectively.

In Appendix A, Table A.2 summarizes the result in case (2S). Interestingly, the result in case (2S) is essentially the same as the result in case (1S), except for the existence of tax-minimizing indirect routes with 2 pass-through countries. Because BM, KY, GG, and AE impose no CIT and no WHT, by adding one of these countries into a tax-minimizing indirect route with 1

Table 5. Tax-minimizing routes (1S)

Source	Direct	Indirect	Indirect Home	TSA Mean
AT	33	68	68	7.35
BE	61	68	68	2.90
BG	69	152	39	0.00
CA	40	68	68	4.86
CN	33	37	37	1.54
HR	43	28	28	0.88
CZ	46	37	37	2.61
DK	48	27	27	3.80
EG	5	68	68	8.77
FI	34	68	68	6.52
FR	38	68	68	6.23
DE	48	37	37	4.42
GR	38	38	38	2.25
IS	39	32	32	3.59
ID	34	67	67	4.25
IE	54	68	68	4.35
IL	39	30	30	4.07
IT	40	37	37	5.14
JP	21	59	59	7.14
KR	34	67	67	4.16
LT	32	68	68	6.67
LU	52	66	34	2.17
MX	19	68	68	5.77
NL	50	28	28	2.39
NO	47	26	26	3.67
PA	9	66	66	4.35
PE	69	268	68	0.00
PH	20	67	67	3.55
PL	31	68	68	6.91
PT	37	38	38	5.80
RO	31	68	68	6.96
RU	64	61	20	0.14
SA	69	260	66	0.00
SI	39	38	38	4.03
ZA	47	22	22	0.32
ES	46	30	30	2.96
SE	52	24	24	3.91
CH	50	32	32	4.45
TW	21	48	48	1.17
TH	69	268	68	0.00
TR	41	53	53	2.03
UA	38	63	63	3.80
US	44	25	25	4.78
UY	69	220	56	0.00

Note: (1S) at most 1 pass-through country and Statutory CIT rates pass-through country, we can construct a tax-minimizing indirect route with 2 pass-through countries. However, this sort of extension does not change the net-of-tax income. Hence, for each pair of residence and source countries, the direct route is tax-minimizing in case (1S) if and only if it is tax-minimizing in case (2S). Furthermore, the treaty shopping arbitrage rate in case (1S) is equal to that in case (2S).

4 Empirical Application

Multinational firms can choose investment (ownership) structures that influence foreign direct investment (FDI) between countries at an aggregate level. If such investors consider tax as an important factor when choosing investment structures,[18] the results of the network analysis in Section 3 will turn out to be consistent with FDI data. Here I investigate whether two groups of network variables, calculated in Section 3, help explain the patterns of FDI.

4.1 Data and variables

For a pair of countries i and j, the dependent variable FDI_{ij} is defined as the inward FDI stock from i to j in millions of US dollars. These bilateral FDI data are obtained from the UNCTAD.[19] Because network variables are calculated without time-series dimension, I focus on cross-sectional data for year 2012 or the latest year available. Because all the 70 countries except for Gibraltar (GI) and Guernsey (GG) are included in the bilateral FDI data, there are 4,556 ($= 68 \times 67$) pairs of residence and source countries.

Table 6 provides descriptive statistics for the dependent variable FDI_{ij} and for independent variables including the network variables. Note that

[18]For instance, Mintz and Weichenrieder (2010), Lewellen and Robinson (2013), and Dyreng et al. (2015) discover that multinational firms use indirect ownership structures for tax motives.

[19]FDI may take the form of debt as well as equity. FDI with debt instruments may be affected by WHT rates on interest as FDI with equity instruments may be affected by WHT rates on dividends. However, the UNCTAD data do not specify the types of instruments (debt or equity) for FDI at the bilateral level. FDI with equity instruments is usually much larger than FDI with debt instruments at an aggregate level.

Table 6. Descriptive statistics for regression variables

Variable	Obs	Mean	Std. Dev.	Min	Max
FDI_{ij}	4,556	4,146.52	23,234.57	-12,850.94	592,273.20
$TMD1R_{ij}$	4,556	0.62	0.48	0	1
$TMD1S_{ij}$	4,556	0.75	0.43	0	1
$TMD2R_{ij}$	4,556	0.61	0.49	0	1
$TSA1R_{ij}$	4,556	3.49	6.05	0	34
$TSA1S_{ij}$	4,556	2.21	4.85	0	30
$TSA2R_{ij}$	4,556	3.58	6.09	0	34
WHT_{ji}	4,556	5.31	6.97	0	35
$CONTIG_{ij}$	4,556	0.03	0.18	0	1
$COMLANG_{ij}$	4,556	0.09	0.29	0	1
$COMLEG_{ij}$	4,556	0.25	0.43	0	1
$COLONY_{ij}$	4,556	0.03	0.16	0	1
$DIST_{ij}$	4,556	7.45	4.87	0.16	19.65
CIT_i	4,556	21.67	7.86	0	35
GDP_i	4,556	1,028,373.00	2,312,482.00	3,410.10	16,155,254.80

the minimum value of FDI_{ij} is negative and there are 80 observations with negative FDI_{ij} in the data.[20]

As mentioned in Section 3.2, it turns out that the network variables in case (2S) are the same as those in case (1S). Henceforth, I will refrain from reporting the results with the network variables in case (2S).

Two groups of network variables, TMD and TSA, are introduced and calculated in the network analysis. These network variables are defined for a pair of countries i and j.

Firstly, each TMD variable is an indicator variable for the existence of a tax-minimizing direct route. In case (1R), if there is a tax-minimizing direct (TMD) route from i to j, $TMD1R_{ij} = 1$, and otherwise, $TMD1R_{ij} = 0$.

I expect that each TMD variable is positively related to inward FDI stock. When the direct route is tax-minimizing between a pair of residence and source countries, investors will consider the direct route more attractive than indirect routes, and thus, they will use the direct route more frequently. Hong (2014) develops a game-theoretic model of treaty shopping and tax auditing between an investor and a tax agency, where the existence (i.e.,

[20]Negative FDI may indicate reverse investment or disinvestment.

availability) of a tax-minimizing direct route increases the investor's equilibrium probability to use the direct route. This equilibrium behavior leads to increased FDI between residence and source countries at an aggregate level.

Secondly, each TSA variable is a continuous variable specifying the difference between the foreign tax rates of the direct route and a tax-minimizing route. In case (1R), the treaty shopping arbitrage (TSA) rate among routes from i to j is defined as $TSA1R_{ij} = t_{ji} - f(r^*)$, where r^* is a tax-minimizing route from i to j.

I expect that each TSA variable is negatively related to inward FDI stock. When the direct route is not tax-minimizing between a pair of residence and source countries, a TSA variable takes a positive value. Moreover, as the TSA variable increases, by definition, the difference becomes larger between the foreign tax rates of the direct route and a tax-minimizing route. Thus, investors will consider the direct route less attractive than tax-minimizing indirect routes. This can reduce FDI between residence and source countries at an aggregate level.

However, it is also possible that a TSA variable is not significantly related to inward FDI stock. In the game-theoretic model of Hong (2014), the TSA variable (i.e., the difference between the foreign tax rates of the direct route and a tax-minimizing route) does not affect the investor's equilibrium probability, but affects the tax agency's equilibrium audit probability. In this model, when the TSA variable changes, the tax agency adjusts the equilibrium audit probability, and the investor stays indifferent between the direct route and tax-minimizing indirect routes.

The withholding tax rate on dividends paid from j to i is denoted by WHT_{ji}. Each WHT rate is in percentage and from the tax rate matrix constructed in Section 2.2.

In addition there are five bilateral (pair-specific) variables to describe the relationship between a pair of countries i and j. $CONTIG_{ij}$, $COMLANG_{ij}$, $COMLEG_{ij}$, and $COLONY_{ij}$ are indicator variables for a shared border, a common official language, a common legal origin, and a colonial relationship,

Table 7. FDI instock conditional on TMD variables

FDI instock	Conditional on	Obs	Mean	Std. Dev.
FDI_{ij}	$TMD1R_{ij} = 0$	1,715 (37.6%)	1,525.89	10,300.17
	$TMD1R_{ij} = 1$	2,841 (62.4%)	5,728.48	28,198.64
FDI_{ij}	$TMD1S_{ij} = 0$	1,118 (24.5%)	961.11	5,016.57
	$TMD1S_{ij} = 1$	3,438 (75.5%)	5,182.38	26,512.18
FDI_{ij}	$TMD2R_{ij} = 0$	1,790 (39.3%)	1,481.87	10,087.54
	$TMD2R_{ij} = 1$	2,766 (60.7%)	5,870.92	28,564.29

respectively. $DIST_{ij}$ is defined as the population-weighted distance between countries i and j in thousands of kilometers. Head et al. (2010) use these bilateral variables to examine the patterns of international trade. I obtain the data for these variables from the CEPII.[21]

Corporate income tax rates and gross domestic product are variables specific to a country, depending on whether it is a residence country or a source country. CIT_i and CIT_j denote corporate income tax rates in residence country i and source country j, respectively. Each CIT rate is in percentage and from Deloitte International Tax Source and PwC Worldwide Tax Summaries. GDP_i and GDP_j denote gross domestic product at current prices in millions of US dollars in residence country i and source country j, respectively. Because I focus on a cross-sectional analysis, I use GDP data for year 2012 from the United Nations Statistics Division.[22] For my regression analysis I will use the natural logarithm of GDP.[23]

Note that these home-specific and source-specific variables can be replaced with home and source dummy variables.

Before proceeding to regression results, it is worthwhile to examine patterns in the data. Table 7 provides descriptive statistics for inward FDI stock FDI_{ij} conditional on the existence of a tax-minimizing direct route from country i to country j.

For 1,715 pairs (37.6%) of countries i and j, the direct route $i \to j$ is not

[21] Accessed at www.cepii.fr/CEPII/en/bdd_modele/bdd.asp

[22] Accessed at unstats.un.org/unsd/snaama/dnlList.asp

[23] For residence country i, $\ln GDP_i$ is calculated as $\ln(GDP_i + 1)$, and similarly, for source country j.

tax-minimizing in case (1R). The average inward FDI stock via a direct route that is not tax-minimizing is about 1,525.89 million US dollars. In contrast, for 2,841 pairs (62.4%) of countries i and j, there is a tax-minimizing direct route $i \to j$ in case (1R). The average inward FDI stock via a tax-minimizing direct route is about 5,728.48 million US dollars, which is larger by 4,202.59 million US dollars (or 3.75 times larger) than the average via a direct route that is not tax-minimizing.

4.2 Results

Now I present the results of regressions with network variables $TMD1R_{ij}$ and $TSA1R_{ij}$. The dependent variable is FDI_{ij} in the regressions of Table 8 and $\ln FDI_{ij}$ in the regressions of Table 9.[24] Each regression includes the bilateral variables $CONTIG_{ij}$, $COMLANG_{ij}$, $COMLEG_{ij}$, $COLONY_{ij}$, and $DIST_{ij}$ of Head et al. (2010) to control for the relationship between countries i and j. Each regression also includes home-specific and source-specific variables. Columns (1) and (2) include CIT and log-scaled GDP in home country i and source country j. Columns (3) and (4) include dummy variables for home and source countries.

In Table 8, columns (1) and (3) are benchmark regressions without the network variables. In these columns, the independent variable of interest is WHT_{ji} and the coefficients on WHT_{ji} are negative and significant at the 1 percent level. Because the WHT at source can decrease the net-of-tax income of investors, an increase in the WHT rate can discourage inward investment.[25]

Columns (2) and (4) show regression results with the network variables. As expected, the coefficients on $TMD1R_{ij}$ are positive and significant. Column (2) reveals that the inward FDI stock via a tax-minimizing direct route

[24] To keep the observations with zero FDI_{ij}, $\ln FDI_{ij}$ is calculated as $\ln(FDI_{ij} + 1)$. Because 80 observations with negative FDI_{ij} are dropped when the natural logarithm is taken, there remain 4,476 observations in Table 9.

[25] Dyreng et al. (2015) also find that, as the WHT rate increases, US multinational firms are more likely to use indirect ownership structures. The use of indirect structures can reduce FDI via a direct route.

is larger by 4,260.78 million US dollars than the inward FDI stock via a direct route that is not tax-minimizing. Column (4) indicates that the increment can be estimated to be 2,404.87 million US dollars.

However, in column (2), the coefficient on $TSA1R_{ij}$ is insignificant. In column (4), the coefficient on $TSA1R_{ij}$ is negative and significant at the 10 percent level.

Moreover, in columns (1) and (2), the coefficients on CIT_i, the CIT rate in home country i, are negative and significant at the 10 percent level.[26] However, the coefficients on CIT_j, the CIT rate in source country j, are insignificant.

In Table 9, the dependent variable is $\ln FDI_{ij}$, the natural logarithm of inward FDI stock. Overall, Table 9 shows similar results as Table 8.

Columns (1) and (3) are benchmark regressions without the network variables. In these columns, the coefficients on WHT_{ji} are negative and significant at the 1 percent level.

Columns (2) and (4) show regression results with the network variables. As expected, the coefficients on $TMD1R_{ij}$ are positive and significant at the 1 percent level. Column (2) shows that the inward FDI stock via a tax-minimizing direct route is 2.48 (= exp(0.91)) times larger than the inward FDI stock via a direct route that is not tax-minimizing. Column (4) suggests that the ratio can be estimated to be 1.55 (= exp(0.44)) times.

However, in column (2), the coefficient on $TSA1R_{ij}$ is insignificant. In column (4), the coefficient on $TSA1R_{ij}$ is negative and significant.

The following remark summarizes the empirical results about the relationship between FDI and network variable $TMD1R_{ij}$.

Remark. The availability of a tax-minimizing direct route is positively and significantly related to inward FDI stock. Across all relevant regressions in Tables 8 and 9, the coefficients on $TMD1R_{ij}$ are positive and significant.

[26]Barrios et al. (2012) also find that corporate taxation of foreign-source dividends in home countries is negatively related to the probability of foreign subsidiary location in potential source countries.

Table 8. FDI instock and network variables (1R)

	(1) FDI_{ij}	(2) FDI_{ij}	(3) FDI_{ij}	(4) FDI_{ij}
WHT_{ji}	-288.93***		-249.55***	
	(39.37)		(79.88)	
$TMD1R_{ij}$		4,260.78***		2,404.87*
		(780.63)		(1,349.36)
$TSA1R_{ij}$		19.09		-147.69*
		(38.19)		(87.47)
$CONTIG_{ij}$	18,319.51***	18,197.34***	21,589.47***	21,468.16***
	(6,012.87)	(6,006.98)	(5,869.95)	(5,848.30)
$COMLANG_{ij}$	12,467.08***	12,102.39***	9,069.03***	9,043.91***
	(2,690.99)	(2,673.26)	(2,378.92)	(2,376.31)
$COMLEG_{ij}$	-1,150.64	-1,122.35	-952.75	-978.1
	(1,064.60)	(1,064.42)	(1,140.46)	(1,147.54)
$COLONY_{ij}$	4,258.57	4,546.35	570.25	650.75
	(5,748.19)	(5,762.62)	(4,746.48)	(4,750.46)
$DIST_{ij}$	-235.81***	-263.65***	-181.28**	-166.47*
	(45.48)	(45.66)	(87.21)	(86.12)
CIT_i	-67.64*	-66.96*		
	(37.46)	(37.44)		
$\ln GDP_i$	2,008.34***	2,120.30***		
	(266.28)	(277.06)		
CIT_j	-28.33	-33.19		
	(46.13)	(45.81)		
$\ln GDP_j$	2,385.33***	2,296.25***		
	(316.81)	(308.08)		
Home Dummy	No	No	Yes	Yes
Source Dummy	No	No	Yes	Yes
Constant	-47,225.86***	-51,451.42***	4,293.14**	-1,493.87
	(5,781.47)	(6,255.03)	(2,176.20)	(2,200.33)
Observations	4,556	4,556	4,556	4,556
R-squared	0.12	0.12	0.24	0.24

Note: Robust standard errors in parentheses; * significant at 10%; ** at 5%; *** at 1%

Table 9. FDI instock in log scale and network variables (1R)

	(1) $\ln FDI_{ij}$	(2) $\ln FDI_{ij}$	(3) $\ln FDI_{ij}$	(4) $\ln FDI_{ij}$
WHT_{ji}	-0.05***		-0.04***	
	(0.01)		(0.01)	
$TMD1R_{ij}$		0.91***		0.44***
		(0.13)		(0.13)
$TSA1R_{ij}$		-0.01		-0.02**
		(0.01)		(0.01)
$CONTIG_{ij}$	1.33***	1.28***	1.44***	1.41***
	(0.26)	(0.26)	(0.21)	(0.21)
$COMLANG_{ij}$	2.17***	2.08***	1.20***	1.19***
	(0.20)	(0.20)	(0.18)	(0.18)
$COMLEG_{ij}$	0.34***	0.34***	0.57***	0.57***
	(0.11)	(0.11)	(0.09)	(0.09)
$COLONY_{ij}$	0.66*	0.70**	0.53*	0.54**
	(0.35)	(0.34)	(0.28)	(0.28)
$DIST_{ij}$	-0.19***	-0.19***	-0.21***	-0.21***
	(0.01)	(0.01)	(0.01)	(0.01)
CIT_i	-0.05***	-0.05***		
	(0.01)	(0.01)		
$\ln GDP_i$	0.82***	0.84***		
	(0.03)	(0.03)		
CIT_j	0.02***	0.02***		
	(0.01)	(0.01)		
$\ln GDP_j$	0.57***	0.57***		
	(0.03)	(0.03)		
Home Dummy	No	No	Yes	Yes
Source Dummy	No	No	Yes	Yes
Constant	-12.43***	-13.37***	8.65***	8.29***
	(0.49)	(0.50)	(0.38)	(0.40)
Observations	4,476	4,476	4,476	4,476
R-squared	0.34	0.35	0.66	0.66

Note: Robust standard errors in parentheses; * significant at 10%; ** at 5%; *** at 1%

In Appendix A, I present regression results with the other network variables. Table A.3 shows regression results with $TMD1S_{ij}$ and $TSA1S_{ij}$. Mostly, the coefficients on $TMD1S_{ij}$ are positive and significant. However, the coefficients on $TSA1S_{ij}$ show mixed signs and become insignificant in some specifications. Table A.4 shows regression results with $TMD2R_{ij}$ and $TSA2R_{ij}$. In all specifications, the coefficients on $TMD2R_{ij}$ are positive and highly significant. However, the coefficients on $TSA2R_{ij}$ are insignificant.

Overall, I find that the availability of a tax-minimizing direct route is positively and significantly related to inward FDI stock.[27]

This observation is consistent with a game-theoretic model of treaty shopping (Hong, 2014). Therefore, by making a direct route tax-minimizing, countries can encourage foreign investment via the direct route and reduce treaty shopping, i.e., the use of indirect routes through conduit countries.

However, I find no clear relationship between FDI and treaty shopping arbitrage. A possible explanation for this observation is that tax authorities may adjust audit rules against multinational investors according to the magnitude of treaty shopping arbitrage while these investors stay indifferent between direct routes and tax-minimizing indirect routes (Hong, 2014).

5 Conclusion

In this paper, I construct a tax rate matrix to represent a tax treaty network and develop network algorithms to examine the structure of tax-minimizing investment routes. I find that the use of a tax-minimizing indirect route can substantially reduce tax on dividends incurred by a multinational investor. I also find that the availability of a tax-minimizing direct route is positively

[27] I admit the possibility that an unobserved factor can affect both FDI and the structure of tax-minimizing routes. For instance, if there is a cost of treaty negotiation for low tax rates, countries may incur the cost only when they expect large FDI. This can also explain the positive relationship between FDI and the existence of a tax-minimizing direct route. However, in this paper, I used the bilateral variables of Head et al. (2010) that describe the relationship between countries to control for unobserved factors, such as treaty negotiation process and cost. In this context, I believe that a potential endogeneity problem (due to unobserved factors) is minimized.

related to foreign investment via the direct route.

When a direct route is not tax-minimizing, to prevent the use of a tax-minimizing indirect route, i.e., to prevent treaty shopping, countries need to consider negotiating a new tax treaty to make the direct route tax-minimizing. These countries may not necessarily experience tax revenue loss, as the new treaty makes the direct route tax-minimizing and attracts more foreign investment.

For future studies, it will be interesting to study the relationship between tax treaties and ownership structures of multinational firms. In this paper, I focused on FDI data to see the plausibility of the treaty network analysis. However, the aggregate FDI data do not reveal the actual ownership structures (i.e., investment routes) of multinational firms. Hence, to check the plausibility of the network analysis, it is important to examine whether and how multinational firms organize indirect ownership structures when direct ownership structures are not tax-minimizing.

It will also be interesting to study the network effect of LOB (limitation on benefits) provisions in tax treaties on the structure of tax-minimizing investment routes. In this paper, when constructing the tax rate matrix, I considered a restrictive version of LOB provisions that only allow certain pension funds to obtain the benefit of the lowest withholding tax rate. However, in real-world tax treaties, LOB provisions can impose various residency requirements. Therefore, it is important to examine how LOB provisions with various residency requirements affect the structure of tax-minimizing investment routes in tax treaty networks.

Appendix A. Tables

Table A.1 summarizes the result in case (2R) when each route passes through at most 2 countries and each pass-through country imposes CIT at the reduced rate. Table A.2 summarizes the result in case (2S) when each route passes through at most 2 countries and each pass-through country imposes CIT at the statutory rate. In Tables A.1 and A.2, column "Direct" shows the number of tax-minimizing direct routes to each source country. Column "1 Indirect" shows the number of tax-minimizing indirect routes with 1 pass-through country and column "1 Indirect H" shows the number of residence countries with such routes. Column "2 Indirect" shows the number of tax-minimizing indirect routes with 2 pass-through countries and column "2 Indirect H" shows the number of residence countries with such routes. Column "TSA Mean" shows the average of treaty shopping arbitrage (TSA) rates for each source country.

Table A.3 shows regression results with network variables $TMD1S$ and $TSA1S$. Table A.4 shows regression results with $TMD2R$ and $TSA2R$. Because the network variables in case (2S) are the same as those in case (1S), regression results with $TMD2S$ and $TSA2S$ are omitted.

Table A.1. Tax-minimizing routes (2R)

Source	Direct	1 Indirect	1 Indirect H	2 Indirect	2 Indirect H	TSA Mean
AT	33	464	36	0	0	6.83
BE	61	162	8	0	0	2.78
BG	30	398	39	0	0	2.26
CA	40	494	29	0	0	4.46
CN	31	590	38	0	0	2.11
HR	31	426	38	0	0	4.99
CZ	31	387	38	0	0	4.81
DK	39	410	30	0	0	7.41
EG	5	232	64	0	0	7.84
FI	34	415	35	0	0	6.01
FR	38	391	31	0	0	5.78
DE	31	386	38	0	0	6.62
GR	30	398	39	0	0	4.51
IS	30	398	39	0	0	8.06
ID	1	68	68	0	0	8.24
IE	54	245	15	0	0	4.13
IL	5	220	64	0	0	12.71
IT	31	386	38	0	0	7.35
JP	9	318	60	0	0	10.62
KR	1	18	18	610	50	7.38
LT	32	411	37	0	0	6.13
LU	35	438	34	0	0	4.14
MX	19	610	50	0	0	5.04
NL	40	391	29	0	0	4.07
NO	33	433	36	0	0	7.59
PA	1	68	68	0	0	8.28
PE	1	38	38	445	30	0.63
PH	1	31	31	378	37	7.04
PL	31	421	38	0	0	6.36
PT	30	398	39	0	0	8.06
RO	31	421	38	0	0	6.41
RU	27	562	42	0	0	3.91
SA	3	121	53	514	13	3.64
SI	30	398	39	0	0	6.29
ZA	40	528	29	0	0	3.30
ES	38	457	31	0	0	4.75
SE	36	391	33	0	0	7.49
CH	36	458	33	0	0	6.36
TW	17	218	52	0	0	6.60
TH	69	0	0	0	0	0.00
TR	15	446	54	0	0	5.20
UA	5	160	42	1241	22	7.19
US	12	393	57	0	0	11.97
UY	13	350	56	0	0	0.85

Note: (2R) at most 2 pass-through countries and Reduced CIT rates

Table A.2. Tax-minimizing routes (2S)

Source	Direct	1 Indirect	1 Indirect H	2 Indirect	2 Indirect H	TSA Mean
AT	33	68	68	201	68	7.35
BE	61	68	68	201	68	2.90
BG	69	152	39	444	39	0.00
CA	40	68	68	201	68	4.86
CN	33	37	37	108	37	1.54
HR	43	28	28	84	22	0.88
CZ	46	37	37	108	37	2.61
DK	48	27	27	88	23	3.80
EG	5	68	68	201	68	8.77
FI	34	68	68	201	68	6.52
FR	38	68	68	201	68	6.23
DE	48	37	37	108	37	4.42
GR	38	38	38	111	38	2.25
IS	39	32	32	104	27	3.59
ID	34	67	67	201	68	4.25
IE	54	68	68	201	68	4.35
IL	39	30	30	72	19	4.07
IT	40	37	37	108	37	5.14
JP	21	59	59	177	60	7.14
KR	34	67	67	198	67	4.16
LT	32	68	68	201	68	6.67
LU	52	66	34	192	34	2.17
MX	19	68	68	201	68	5.77
NL	50	28	28	81	28	2.39
NO	47	26	26	92	24	3.67
PA	9	66	66	195	66	4.35
PE	69	268	68	792	68	0.00
PH	20	67	67	198	67	3.55
PL	31	68	68	201	68	6.91
PT	37	38	38	111	38	5.80
RO	31	68	68	201	68	6.96
RU	64	61	20	156	15	0.14
SA	69	260	66	768	66	0.00
SI	39	38	38	111	38	4.03
ZA	47	22	22	52	14	0.32
ES	46	30	30	90	31	2.96
SE	52	24	24	80	21	3.91
CH	50	32	32	96	33	4.45
TW	21	48	48	92	24	1.17
TH	69	268	68	792	68	0.00
TR	41	53	53	159	54	2.03
UA	38	63	63	189	64	3.80
US	44	25	25	76	20	4.78
UY	69	220	56	648	56	0.00

Note: (2S) at most 2 pass-through countries and Statutory CIT rates

Table A.3. FDI instock and network variables (1S)

	(1) FDI_{ij}	(2) FDI_{ij}	(3) $\ln FDI_{ij}$	(4) $\ln FDI_{ij}$
$TMD1S_{ij}$	4,096.11***	1,492.56	1.02***	0.25*
	(685.02)	(1,336.65)	(0.16)	(0.15)
$TSA1S_{ij}$	69.46*	-70.51	0.01	-0.03***
	(39.45)	(88.86)	(0.01)	(0.01)
$CONTIG_{ij}$	18,435.68***	21,675.93***	1.33***	1.44***
	(6,016.29)	(5,868.56)	(0.26)	(0.21)
$COMLANG_{ij}$	12,332.26***	9,108.70***	2.12***	1.19***
	(2,689.11)	(2,389.66)	(0.20)	(0.18)
$COMLEG_{ij}$	-1,108.79	-943.71	0.35***	0.58***
	(1,065.80)	(1,143.98)	(0.11)	(0.09)
$COLONY_{ij}$	4,648.89	638.63	0.73**	0.54*
	(5,781.14)	(4,757.68)	(0.34)	(0.28)
$DIST_{ij}$	-272.59***	-212.25**	-0.19***	-0.21***
	(46.26)	(83.03)	(0.01)	(0.01)
CIT_i	-59.55		-0.05***	
	(37.42)		(0.01)	
$\ln GDP_i$	2,059.39***		0.83***	
	(273.09)		(0.03)	
CIT_j	-32.64		0.02***	
	(45.91)		(0.01)	
$\ln GDP_j$	2,211.86***		0.55***	
	(301.45)		(0.03)	
Home Dummy	No	Yes	No	Yes
Source Dummy	No	Yes	No	Yes
Constant	-50,288.39***	-1,651.85	-13.28***	8.36***
	(6,198.66)	(2,761.13)	(0.51)	(0.41)
Observations	4,556	4,556	4,476	4,476
R-squared	0.11	0.24	0.34	0.66

Note: Robust standard errors in parentheses; * significant at 10%; ** at 5%; *** at 1%

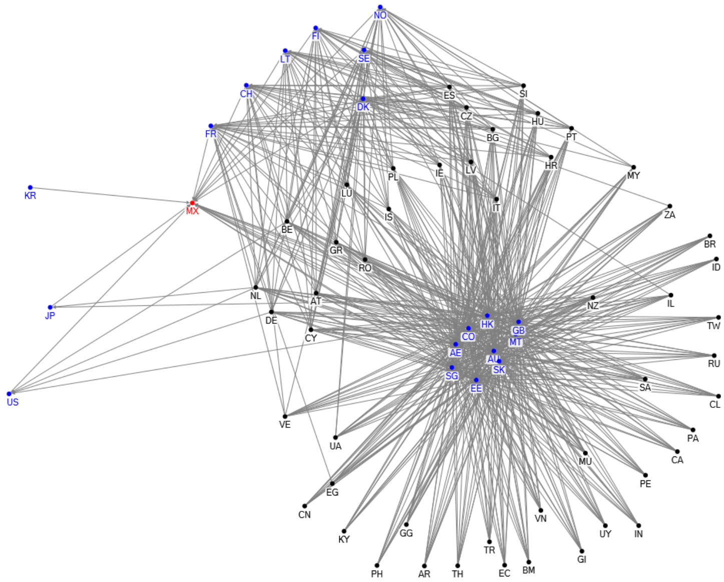
Table A.4. FDI instock and network variables (2R)

	(1) FDI_{ij}	(2) FDI_{ij}	(3) $\ln FDI_{ij}$	(4) $\ln FDI_{ij}$
$TMD2R_{ij}$	4,620.89***	3,098.21*	0.99***	0.69***
	(775.98)	(1,601.82)	(0.13)	(0.15)
$TSA2R_{ij}$	28.43	-126.14	-0.01	-0.02
	(36.56)	(88.82)	(0.01)	(0.01)
$CONTIG_{ij}$	18,263.37***	21,459.30***	1.30***	1.41***
	(6,001.88)	(5,845.58)	(0.26)	(0.21)
$COMLANG_{ij}$	12,060.51***	9,018.31***	2.07***	1.18***
	(2,668.60)	(2,371.30)	(0.20)	(0.18)
$COMLEG_{ij}$	-1,123.07	-997.15	0.34***	0.56***
	(1,063.89)	(1,149.46)	(0.11)	(0.09)
$COLONY_{ij}$	4,502.80	681.92	0.69**	0.55**
	(5,756.39)	(4,750.49)	(0.34)	(0.28)
$DIST_{ij}$	-253.09***	-162.26*	-0.19***	-0.21***
	(45.54)	(85.98)	(0.01)	(0.01)
CIT_i	-68.19*		-0.05***	
	(37.42)		(0.01)	
$\ln GDP_i$	2,129.30***		0.84***	
	(277.41)		(0.03)	
CIT_j	-30.45		0.02***	
	(45.79)		(0.01)	
$\ln GDP_j$	2,312.38***		0.57***	
	(309.37)		(0.03)	
Home Dummy	No	Yes	No	Yes
Source Dummy	No	Yes	No	Yes
Constant	-52,059.14***	-1,799.87	-13.51***	8.04***
	(6,298.08)	(2,219.33)	(0.50)	(0.37)
Observations	4,556	4,556	4,476	4,476
R-squared	0.12	0.24	0.35	0.66

Note: Robust standard errors in parentheses; * significant at 10%; ** at 5%; *** at 1%

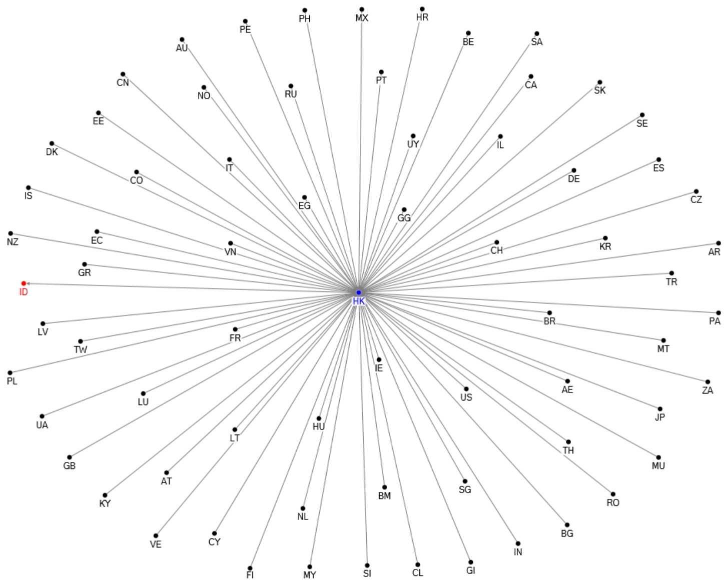
Appendix B. Network Diagrams

Figure B.1. Tax-minimizing routes (1R) to Mexico



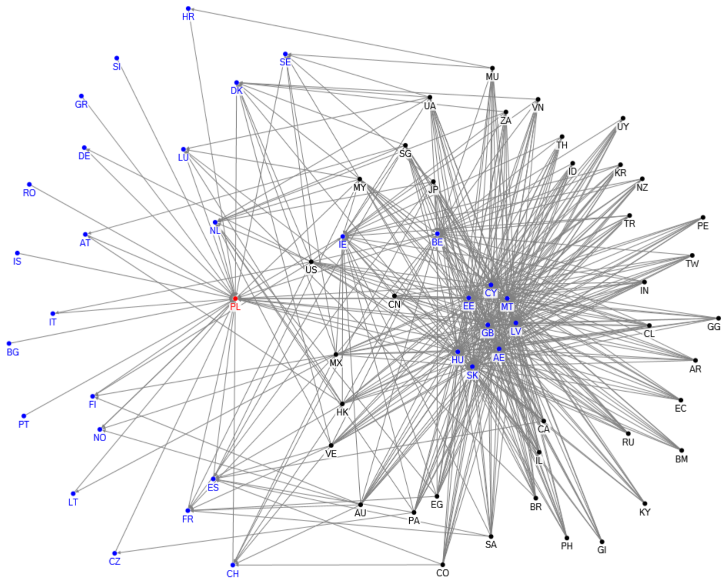
Note: source in red; countries with tax-minimizing direct routes in blue

Figure B.2. Tax-minimizing routes (1R) to Indonesia



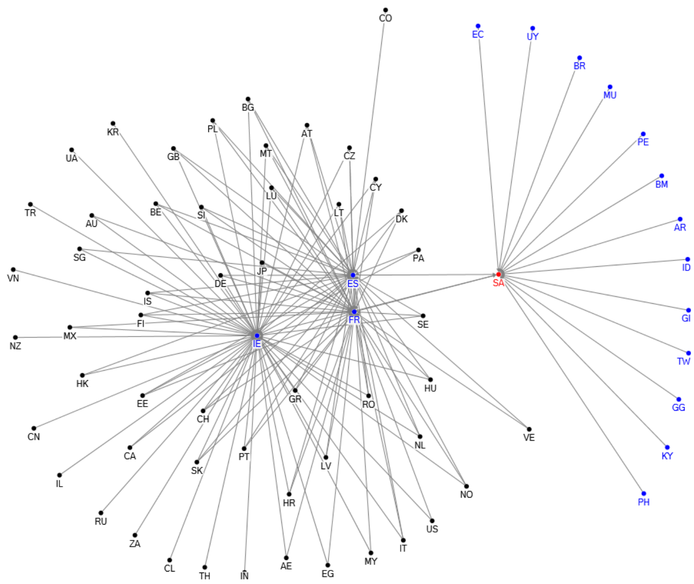
Note: source in red; countries with tax-minimizing direct routes in blue

Figure B.3. Tax-minimizing routes (1R) to Poland



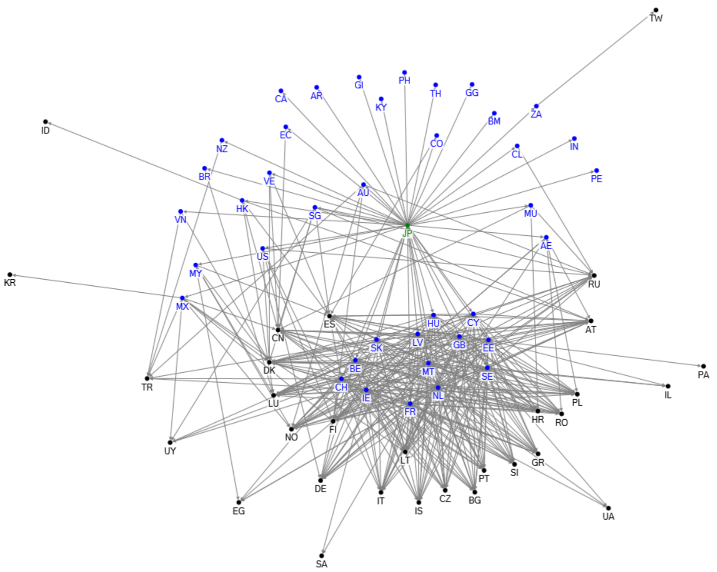
Note: source in red; countries with tax-minimizing direct routes in blue

Figure B.4. Tax-minimizing routes (1R) to Saudi Arabia



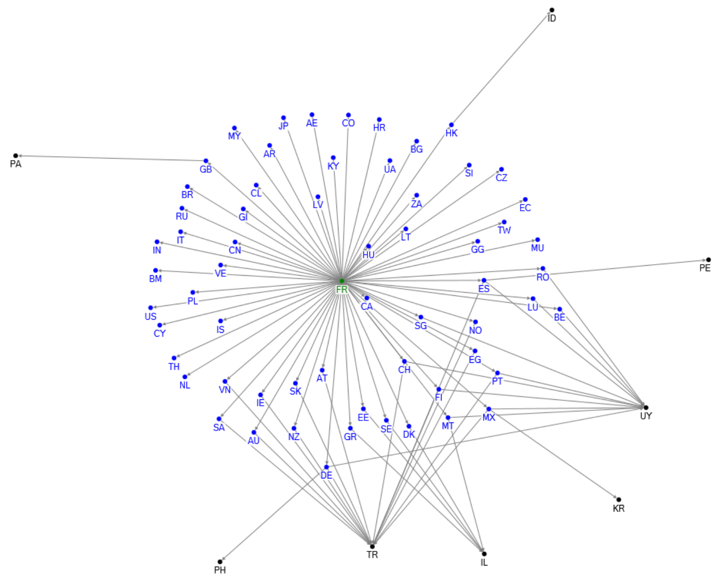
Note: source in red; countries with tax-minimizing direct routes in blue

Figure B.5. Tax-minimizing routes (1R) from Japan



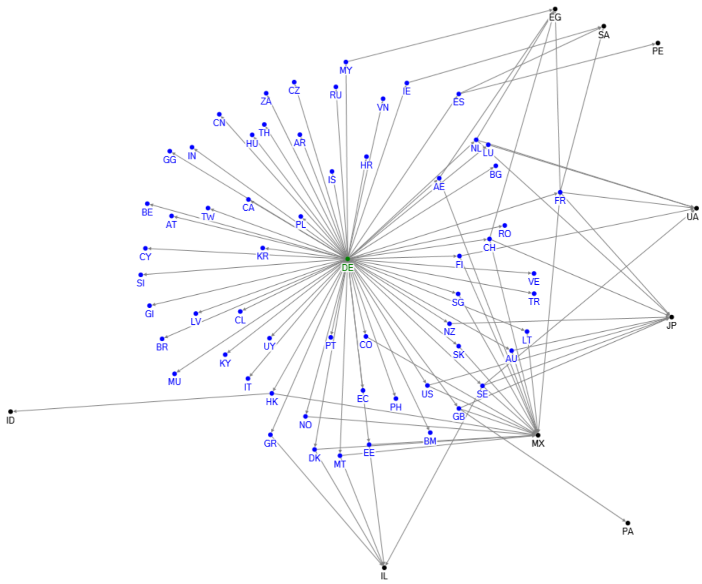
Note: residence in green; countries with tax-minimizing direct routes in blue

Figure B.6. Tax-minimizing routes (1R) from France



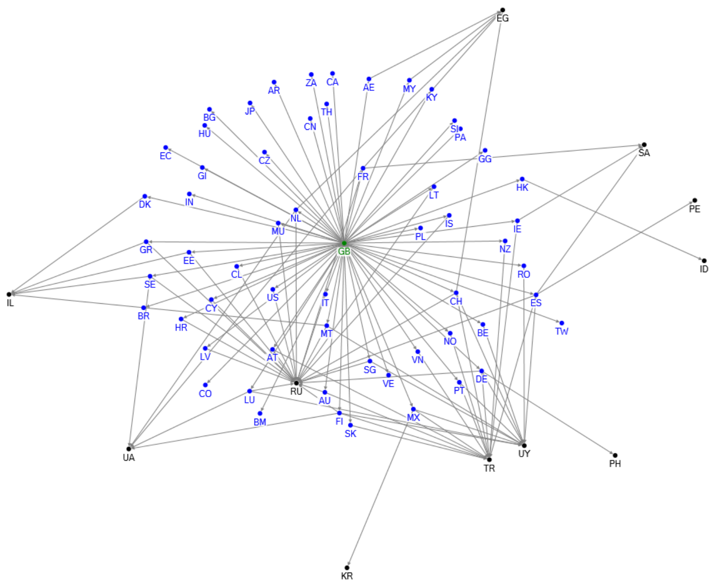
Note: residence in green; countries with tax-minimizing direct routes in blue

Figure B.7. Tax-minimizing routes (1R) from Germany



Note: residence in green; countries with tax-minimizing direct routes in blue

Figure B.8. Tax-minimizing routes (1R) from the United Kingdom



Note: residence in green; countries with tax-minimizing direct routes in blue

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