The network structure of global tax evasion
Evidence from the Panama Papers

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Abstract

This paper builds on recent insights from network theory and on the rich dataset made available by the Panama Papers in order to investigate the micro-economic dynamics of tax-evasion. We model offshore financial entities documented in the Panama Papers as links between jurisdictions in the global network of tax evasion. A quantitative analysis shows that the resulting network, far from being a random collection of bilateral links, has key features of complex networks such as a core-periphery structure and a fat-tail degree distribution. We argue that these structural features imply that policy must adopt a systemic perspective to mitigate tax evasion. We offer three sets of insights from this perspective. First, we identify through centrality measures tax havens that ought to be priority policy targets. Second, we show that efficient tax treaties must contain exchange information clauses and link tax-havens to non-haven jurisdictions. Third, we show that the optimal deterrence strategies for a social-planner facing a strategic tax-evader in a Stackelberg competition can be characterized using the notion of Bonacich centrality.
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1 Introduction

Curbing tax-evasion has been a permanent issue on the policy agenda ever since the advent of taxation systems. In recent decades, the acceleration and liberalization of financial flows has led to a globalization of the issue whereby tax-evaded wealth circulates through complex chains of jurisdictions and legal entities before finding shelter in tax havens (see e.g. Garcia-Bernardo et al. (2017)). According to Johannesen and Zucman (2014), 8% of the global household financial wealth is hence held offshore. This eventually led to a "crackdown on tax havens": in April 2009, G20 countries urged each tax haven to sign at least 12 tax information exchange treaties under the threat of economic sanctions. More than 300 treaties were signed before the end of 2009 (Johannesen & Zucman, 2014). The efficiency of the crackdown has however been questioned. In particular, Johannesen and Zucman (2014) give evidence, using BIS data on cross-border deposits, that the crackdown has led to a mere reallocation of tax-evaded funds.

In order to design more efficient tax evasion mitigation policies, a detailed understanding of the circulation of tax evaded wealth is required. However, the lack of data and the complex nature of tax evasion schemes have prevented the use of standard micro-economic and micro-econometric methods in this perspective. In this paper, we build on recent insights from network theory and on the rich dataset made available by the Panama Papers in order to bridge part of this gap. The Panama Papers, a leaked dataset that has been made publicly available by the International Consortium of Investigative Journalists (ICIJ) in early 2016, provides information on a set of 213,634 offshore financial entities created by Mossack-Fonseca, one of the leading providers of offshore financial services. Offshore financial entities allow to conceal wealth from a source country, the one of the owner of the entity, to a host country, the one where the entity is registered, in such a way that the identity of the owner is concealed. They can thus be seen as tax-evasion links in a network of countries. Adopting this perspective, we provide a quantitative analysis of the resulting network. This analysis highlights that the network, far from being a random collection of bilateral links, has a hierarchical organization characterized by a core-periphery structure and a fat-tail degree distribution. We argue that policy ought to account for these structural features in the design of tax evasion mitigation policies. The paper provides three set of insights in this perspective.

First, we characterize the most central actors in the global tax-evasion network. This characterization can be used to identify tax havens that ought to be priority targets of evasion deterrence policy (e.g. building on Albert et al. (2000)). Second, we provide an econometric analysis of the determinants of network formation and of the impact of tax treaties thereupon. Our results are consistent with those of Johannesen and Zucman (2014) and Omartian (2017). In particular, we show that efficient treaties are those that contain an information exchange clause and that link tax-havens to "non-haven" countries. This calls for further refinements of the type of "treaty policy" implemented during the G20 crackdown.

Finally, we develop a theoretical model to deliver normative insights on optimal deterrence strategies for a social-planner facing a strategic tax-evader in a Stackelberg competition. The objective of the social planner is to maximize the detection probability of tax evasion across the worldwide network. He can enforce a number of tax treaties in this perspective. The tax evader aims to minimize the probability of detection. He faces a concealment cost that is proportional to the complexity of the tax evasion scheme. Our main analytical result in this setting is that the social planner ought to choose the global structure of tax-treaties in such a way that the linked countries form a sub-network for which the sum of Bonacich centralities is maximal. At the formal level, this result highlights the need to adopt a systemic perspective on tax evasion as the Bonacich centrality of the network does not depend on local properties of the network but on its global structure. From a more applied perspective, the result implies that the social planner should first form a “barrier” of tax treaties surrounding the most central tax havens (i.e. form a quasi-star network of treaties) and then systematically extend the set of treaties to eventually cover the whole set of countries (i.e. form a quasi-complete network). These results are well-aligned with recent policy measures such as the development of the Common Reporting Standard (CRS) by the OECD. This multilateral agreement on automatic exchange of information involves 108 jurisdictions worldwide and accounts for over 4,000 additional bilateral tax information exchange agreements. Although, the CRS is still far from universal and has thus led to reallocation of tax-evaded wealth (Casi et al. (2020)), it provides a framework for global cooperation through which the network of tax treaties can be sequentially completed. In this perspective, our results suggest to target jurisdictions according to a priority order determined by their Bonacich centrality in the network of international tax evasion.

The remaining of the paper is organized as follows. Section 2 reviews the related literature. Section 3 provides an empirical analysis of the global tax-evasion network on the basis of the Panama Papers. Section 4 investigates the determinants of network formation and, notably, the impact of treaties. Section 5 provides a formal model of the Stackelberg competition between a representative tax-evader and a social-planner aiming at deterring evasion. Section 6 concludes.

2 Literature Review

The features of tax havens have been extensively studied in the recent literature. In an early contribution, Hines Jr. (2007) puts forward a first set of stylized facts. Studying 45 major offshore financial centers, the author mentions that tax havens tend to be small (commonly below 1 million inhabitants), affluent and well-governed. Moreover, such fiscal paradises tend to incentive economic activity in neighboring non-haven countries. Dharmapala (2008) extends this set of stylized facts, noticing that tax havens are more prone to be island countries, poorly endowed with natural resources, and relatively close to major financial capital exporters. Moreover, most tax havens seem to bear a British legal origin and to account for a highly advanced telecommunication infrastructure. Dharmapala and Hines Jr. (2009) perform an econometric study over more than twenty different covariates to define which characteristics make a jurisdiction more or less prone to become a tax haven. The authors find, using probit models, that tax havens tend to have a small population and a large GDP per capita as compared to the world average. Moreover, governance has a large and statistical significant impact on the probability of a jurisdiction becoming a tax haven. The authors asseverate that only well-governed countries, which may reasonably be seen as trustworthy, qualify as potential tax havens.

A second strand of literature aims to measure the size of tax havens and thus to evaluate their impact on fiscal policy. Zucman (2013) asserts that at least 50 percent of all deposits held through tax havens belong to households. Hence tax havens are primarily used as a channel of tax evasion (by households) and not simply as a tool for tax avoidance (by firms). Furthermore, Zucman (2013, 2014) estimates that about 8% of the global household financial wealth is held offshore, an amount that surges to about 7.6 trillion USD in 2013. Besides, he mentions these coefficients to be a lower bound, which account only for financial wealth and not all types of assets; other sources estimate the amount to be even higher, between 8.9 and 32 trillion US Dollars (Henry (2012)). Further remarks show an increasing flow of deposits from developing nations, a shrinkage from a large number of small accounts to a reduced amount of affluent 'key-clients' in fiscal paradises and an assumption that about 80% of the wealth held in Switzerland and other havens seems to be evading taxes. Alstadsæter et al. (2018) conclude that around 10% of the world's GDP equivalent is concealed offshore.

Another line of research studies the impact of tax policy on tax havens. Slemrod and Wilson (2009) argue that tax havens are freeloaders for large non-haven economies and do not provide the potential financial incentives other studies (such as Hines Jr. and Rice (1994) and Desai et al. (2006)) had implied. The authors suggest that abolishing some, or all, tax havens would increment the welfare in non-haven nations. Moreover, the nullification of even a few large fiscal paradises would leave all other countries better-off, including any of the still remaining tax havens. As mentioned by Hines Jr. (2010), tax havens are generally pass-through financial locations, where neighboring countries are both the largest sources and destinations of the money flow. Picard and Pieretti (2011) discuss how offshore financial centers can be persuaded to comply with strict supervision of their funds and shareholders' identities whenever the pressure placed on them poses a sufficiently high risk of damaging their business operations. Elsayyad and Konrad (2012) conclude that a 'big-bang' multilateral agreement would be less costly than sequential tax information exchange agreements, and that the order of tax treaties would matter for an efficient sequential deactivation of tax havens. Hanlon et al. (2013) argue that small increments of detection risk may be enough to deter cross-country tax evasive behavior. Moreover, Konrad and Stolper (2016) claim that the success of a policy against offshore financial centers is the outcome of a coordination game between potential investors and tax havens.

The natural experiment induced by the G20 crackdown on tax havens has also generated a substantial literature. Johannesen and Zucman (2014) explore how tax treaties between jurisdictions affected the flow of deposits from sources to host countries. The authors find that whenever a country signed a treaty with a tax haven, there was a reallocation effect, meaning that evaders would shift their deposits to another jurisdiction where no treaty existed. Moreover, the study suggests that tax treaties signed between two tax havens have no statistically significant effects. Potentially, the success of the G20 policy was undermined due to the lack of a coordinated systemic strategy in the bilateral TIEA-type treaty implementations (evidence of this is found in Bilicka and Fuest (2014) and Johannesen and Zucman (2014)). Braun and Weichenrieder (2015) find that, for German affiliates, TIEA's decreased the number of operations with tax havens by 46 percent. Similarly, Andersson et al. (2019) observe a strong announcement effect of TIEA's between Norway and important tax havens for Norwegian tax evaders. Bennedsen and Zeume (2018) evidence how a considerable number of multinational firms actively engage in 'haven hopping'. That is, firms strategically transfer their subsidiaries from offshore financial centers which have signed a TIEA treaty to others who have not. O'Donovan et al. (2019) assess that the occurrence of the Panama Papers leakage erased 135 billion USD in market capitalization among firms directly linked to the Panama Papers. The authors suggest that many offshore financial entities were incorporated for illegal purposes, such as tax evasion or bribe payments, which in turn generated firm value. These results shed light on the importance of secrecy for tax evaders whenever undertaking operations in fiscal paradises.

Besides tax information exchange agreements, diverse inter-jurisdictional fiscal policies have been set in motion to deter international tax evasion. The European Union Savings Directive, enforced in 2005, obliges cooperating jurisdictions to disclose the financial information of entities whose owner is a EU resident. The Foreign Account Tax Compliance Act (FATCA), signed in March 2010, requires all non-US financial institutions to report the assets and identities of all US citizens and residents to the US Department of the Treasury. The OECD introduced the Common Reporting Standard (CRS) in June 2018, a multilateral agreement on automatic exchange of information (AEOI). Today, this initiative comprises over 4,000 additional bilateral tax information exchange agreements involving 108 jurisdictions worldwide. Caruana-Galizia and Caruana-Galizia (2016) examine the effects of the 2005 EU Saving Directives. Employing the information leaked in the Panama Papers, the authors find a substitution effect where EU-resident owned entities migrated to non-cooperating jurisdictions; meanwhile, non-EU owned entities remained stable. Exploiting the Panama Papers, Omartian (2017) uncovers that the FATCA induced US investors to downsize their offshore activity by approximately one-third. Similarly, Johannesen et al. (2018) estimate that the US enforcement initiatives on evasive accounts led to the disclosure of 120 billion USD concealed in offshore financial centers. Casi et al. (2020) study the efficiency of the Common Reporting Standard and find a 11.9% reduction in cross-border deposits, followed by a pronounced relocation effect of funds held by tax evaders seeking secrecy offshore. Albeit the CRS resembles a 'big bang' agreement, in the sense of Elsayyad and Konrad (2012), not all jurisdictions signed[1]. Also, some countries agreed to the CRS, but have not enforced any additional measures to facilitate tax information exchange. In particular, the United States have neither signed nor committed to endorse the CRS. This caveat is far from innocuous, since the US holds two empirically confirmed tax havens (Nevada and Wyoming[2]) plus an anecdotal offshore financial center (Delaware). Potentially, a non-universal multilateral agreement might induce non-cooperative offshore financial centers to reclaim the 'tax haven business' at the expense of cooperative jurisdictions (Elsayyad and Konrad (2012)). Indeed, Casi et al. (2020) estimate that cross-border deposits in the United States increased in the post-CRS era between 10.9% (held by non-haven residents) and 17.7% (held by tax haven residents) from 2014 to 2017. These results shed light on the possibility that the United States have emerged as an attractive destination for cross-country deposits. Consequently, instead of putting an end to international tax evasion, the CRS triggered a relocation effect in the dynamics of wealth concealment similar to that of the G20 2009 crackdown on tax havens. Overall, the existing literature suggests that all previously implemented coordinated fiscal policies have been systematically circumvented by tax evaders (Zucman (2013); Johannesen and Zucman (2014); Caruana-Galizia and Caruana-Galizia (2016); Omartian (2017); Alstadsæter et al. (2018); Casi et al. (2020)). Nonetheless, even if tax information exchange mechanisms are limited and have plenty of room for improvement, they are a useful tool to deter offshore wealth concealment and tax evasion.

Recently, network approaches have been used to model a wide range of financial systems and the interactions between entities. Iori et al. (2005), Vitali et al. (2011), Chinazzi et al. (2013) and Li and Schürhoff (2019) analyze the mechanics of international financial networks, consistently identifying key properties and topological characteristics germane to complex networks. More closely related to our contribution, Garcia-Bernardo et al. (2017) scrutinize corporate tax avoidance networks, through corporate ownership relationships, in order to identify the juris-

[1]The list of countries which did not sign the Common Reporting Standard include several jurisdictions from the EU *black list* of tax havens (American Samoa, Fiji, Guam, Palau, Trinidad and Tobago and US Virgin Islands) and from the EU *grey list* of tax havens (Bosnia and Herzegovina, Botswana, Swaziland, Jordan, Maldives, Mongolia, Namibia and Thailand). Last revised: February 18, 2020.

[2]Nevada and Wyoming were mentioned as recurrent offshore financial centers in the Panama Papers.

dictions that work as conduits or final destinations of shifted profits. Dominguez et al. (2020) make use of the Panama Papers to identify the top offshore financial regions (geographic clusters) and map their intra- and inter-relationships. Kejriwal and Dang (2020) show that the underlying structure of the Panama Papers is significantly different from those commonly found on information and social networks.

The design of efficient policies in such network contexts has also induced a large literature (e.g. Ballester et al. (2006), Bramoullé and Kranton (2007), Allouch (2015) and Elliott and Golub (2019)). In our context, the problem of the social planner amounts to finding a subgraph maximizing the sum of Bonacich centralities. This problem has been addressed in the economic literature, notably by König et al. (2014) and Belhaj et al. (2016) who emphasize its connections with nested-split graphs. The problem is also connected to a well-known problem in graph theory, that of finding the graph with a given number of nodes and vertices that has maximal index (see Corbo et al. (2006), and Chang and Tam (2011)). A long-standing conjecture on that problem is that its solutions are either quasi-complete or quasi-star graphs (see Aouchiche et al. (2008) and Cvetkovic et al. (1997) for solutions in some specific cases).

3 Empirical analysis of the global tax-evasion network

3.1 Data from the Panama Papers

Our analysis of the global network of tax evasion is based on the Panama Papers, a leaked dataset that has been made publicly available by the International Consortium of Investigative Journalists (ICIJ) in early 2016[3]. The dataset documents the activity of Mossack-Fonseca, a Panamian firm that was one of the leading provider of offshore financial services (until the leak). Our working assumption, throughout the paper, is that the activities of Mossack-Fonseca are representative of these of the offshore finance industry. Evidence to support this claim has been given by Omartian (2017) and Alstadsæter et al. (2018). Omartian (2017) finds the Panama Papers to be potentially representative of the global picture by contrasting them against the Bahamas Leaks; which enlist all entities incorporated in the Bahamas regardless of the offshore service provider. Alstadsæter et al. (2018) find strong similarities between how much each country owns in wealth offshore and the use of tax havens as revealed by the Panama Papers. Also, per country, there is a strong correlation between the amount of wealth held offshore and the number of owners of Mossack-Fonseca offshore financial entities. A key part of these activities is the creation of offshore financial entities (shell companies). These entities allow to conceal wealth from a source country, the one of the owner of the company, to a host country, the one where the company is registered and that generally is a tax haven, in such a way that the identity of the owner is (partly) concealed. An offshore financial entity can thus be seen as a tax-evasion link between two countries.

The Panama Papers provide 2.6 Terabytes of information on 213,634 offshore financial entities that had been incorporated in different tax havens by Mossack-Fonseca. More precisely, for each entity, the *Entities* file of the Panama Papers discloses the name of the registered financial body, the country of the beneficial owner, the jurisdiction where the entity was created, the incorporation date, the company type and the status of the account[4]. Even though the Mossack

[3]The data is available under https://offshoreleaks.icij.org/pages/database.

[4]The dataset in fact comprises 4 other files. The *Addresses* file shows the location where the entity was registered. The *Intermediaries* and *Officers* files show, respectively, the broker and shareholder names assigned

law firm began operations in 1977 and joined forces with Fonseca in 1986, the operations leaked in the Panama Papers include information regarding shell companies that date back to 1936[5]. After filtering out for entities for which source country, host country or date of incorporation were missing, we have obtained a consolidated dataset of 212,811 entities ranging from the first entity incorporated in Panama by a Swiss holder in November 1936 to the last offshore account registered for a Chilean resident in Wyoming in December 2015.

In the following, these entities are interpreted as time-stamped links between two countries in the global network of tax evasion. More precisely, we consider networks for which the set of nodes, N, is composed by the 161 jurisdictions which appear at least once as a source or host in the dataset (see Table 9 in the Appendix) while the set of links is defined by considering there is a link from country $i \in N$ to country $j \in N$ if and only if there exists an entity incorporated in country j whose owner is located in country i.

We shall then construct different networks by considering different subsets of links: (i) the cumulative (also referred to as static) network that has all possible links independently of their time stamps, (ii) dynamic sequences of networks where only links formed within a given year are considered. All the networks considered are directed (from source to host country) but we will consider both unweighted and weighted networks, where the weight corresponds to the number of entities incorporated during the period under consideration. Finally, entities where source and host countries happened to be the same country were neglected, which allows us to consider only simple graphs (i.e. without self-loops).

3.2 Global structure of the tax-evasion network

The existing literature hints at the complex nature of tax evasion mechanisms. Garcia-Bernardo et al. (2017) and Dominguez et al. (2020) highlight the elaborate nature of tax evasion circuits implemented by multinational companies and wealthy individuals. The reallocation of funds among offshore centers after the G20 tax haven crackdown, which has been put forward by Johannesen and Zucman (2014), emphasizes the adaptive capacity of the tax evasion system. In this subsection, we investigate whether these complex adaptive features are reflected in the network structure.

The inter-temporal tax-evasion network (containing all links independently of their time stamps) is represented in Figure 1. One of its specific features is that, among the 161 nodes of the network, only 21 have an incoming link (i.e. Mossack-Fonseca incorporated at least one entity). The corresponding countries are listed in Table 1. These host countries correspond, unambiguously, to offshore financial centers. Notably, they have the key features that have been put forward by Dharmapala and Hines Jr. (2009) as characteristic of tax heavens: low population, high GDP per capita and high governance index (see details in Table 1). The global structure of the network is organized around these host countries. Namely, the network has a core-periphery structure. The core consists of the set of host countries that are strongly

to the entity. The *Edges* relate entities, addresses, intermediaries and officers. Moreover, the ICIJ provides three additional datasets on global tax evasion, the *Bahamas Leaks*, the *Offshore Leaks* and the *Paradise Papers* but these do not provide enough information to recover systematically the beneficial owner's country of residence, the jurisdiction where the entity was incorporated and the date of incorporation.

[5]This is due to the fact that registered agents can change over time; so a company may have had a registered agent (a law firm as Mossack-Fonseca) when it was created and years later changed it. We thank the ICIJ and Emilia Diaz Struck for clarifying this question.

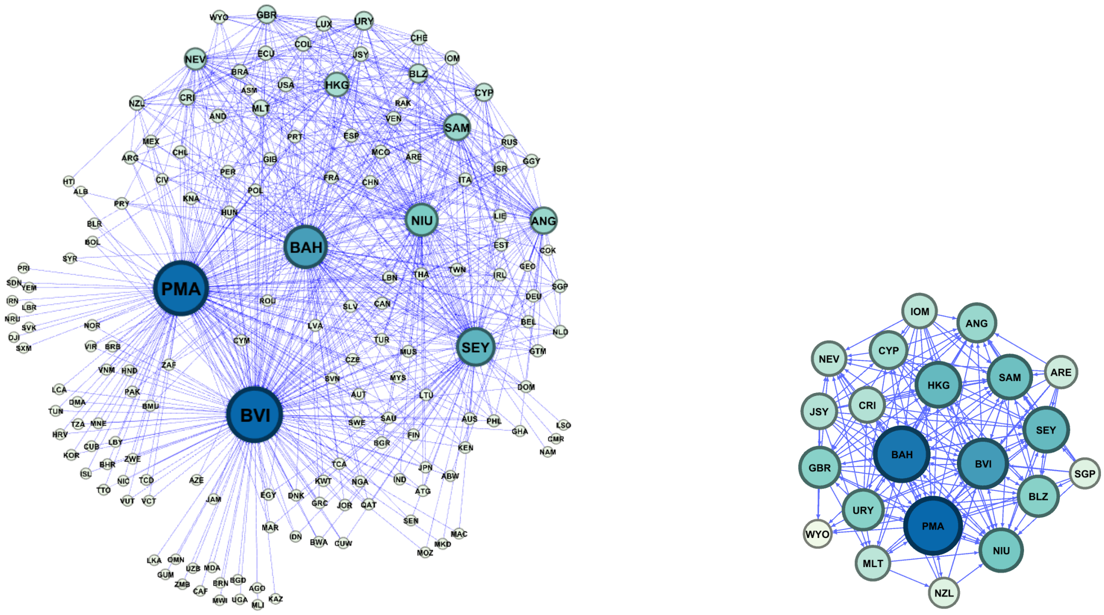


Figure 1: Graphical representation of the network (left panel) and detailed view of the core (right panel). The size and the color intensity of the nodes are proportional to the degree (i.e. to the number of connections).

connected, i.e. each country in the core can be reached via a sequence of directed links from every other country in the core (see right panel of Figure 1). The periphery of the network consists of source countries that have only outgoing links, towards the core.

This hierarchical core-periphery structure is also reflected quantitatively in the degree distribution (Figure 2, left panel) and in the relation between degree and clustering (Figure 2, right panel). The degree distribution exhibits much fatter tails than the random benchmark. A large number of nodes are weakly connected but a significant number of them are highly linked: in particular 5% of the jurisdictions have more than 50 links and 2% have more than 100 links each. As illustrated in the right panel of Figure 2, these high-degree nodes are also privileged connections: the negative slope of the degree-clustering relationships highlights that high degree nodes receive specific links. This is indicative of a hierarchical structure in which nodes receive links according to a priority order highly correlated with the degree (see Li and Schürhoff (2019) as well as the definition of nested split-graphs in Section 5 below). Accordingly, as underlined in Table 2, high degree nodes in the core are also characterized by high levels of centrality.

The core-periphery structure of the network first highlights the partition of countries between sources (the periphery) and hosts (the core) of tax evasion. Moreover, and perhaps more importantly, it emphasizes the complex structure of tax evasion circuits, in line with the findings of Kejriwal and Dang (2020). Indeed, the fact that the core is formed by a set of tax havens evidences the fact that funds incoming in a tax haven are likely to be rerouted towards other tax havens, as suggested by Johannesen and Zucman (2014) and Omartian (2017). Table 3 demonstrates that this rerouting of funds among tax havens constitutes one of the key activities of the network. This rerouting activity closely resembles the inter- and intra-relationship

Code	Jurisdiction	Pop.	GDP pc	Gov. Ind.	Hub Dist.	Haven	Eng.	Brit. Law
ANG	Anguilla	14.61	22,596.89	0.86	3,600	1	1	1
ARE	UAE	9,154.30	39,122.05	0.57	5,240	0	0	1
BAH	Bahamas	386.84	30,483.82	0.86	2,125	1	1	1
BLZ	Belize	359.29	4,950.26	-0.2	3,300	1	1	1
BVI	Brit. Virg. Ilds	30.11	31,697.83	0.93	2,420	1	1	1
CRI	Costa Rica	4,807.85	11,393.02	0.69	3,575	0	0	0
CYP	Cyprus	1,160.98	23,212.22	0.94	3,290	1	0	1
GBR	United Kingdom	65,128.86	44,305.55	1.45	320	0	1	1
HKG	Hong Kong	7,291.30	42,431.89	1.39	2,940	1	1	1
IOM	Isle Of Man	83.17	81,672.02	1.45	320	1	1	1
JSY	Jersey	100.47	73,569.64	1.45	440	1	1	1
MLT	Malta	445.05	23,759.03	1.03	1,740	1	1	0
NEV	Nevada	2,883.06	44,026.00	1.25	140	0	1	1
NIU	Niue	1.63	19,025.57	-0.67	9,280	0	1	1
NZL	New Zealand	4,595.70	38,649.38	1.85	9,280	0	1	1
PMA	Panama	3,969.25	13,684.13	0.15	3,590	1	0	0
SAM	Samoa	193.76	4,149.41	0.68	9,280	0	1	1
SEY	Seychelles	93.42	14,725.10	0.46	8,940	0	1	0
SGP	Singapore	5,535.00	54,940.86	1.46	5,300	1	1	1
URY	Uruguay	3,431.55	15,524.84	0.94	8,560	0	0	0
WYO	Wyoming	586.10	57,182.00	1.25	140	0	1	1
	Sample Average	**8,580.26**	**17,555.85**	**0.06**	**3,689**	**0.23**	**0.37**	**0.34**

Table 1: Characteristics of countries in the core of the tax-evasion network. Pop. refers to population (2015) expressed in thousands. GDP pc refers to GDP per capita in USD (2015). Gov. Ind. refers to governance index (from the World Bank worldwide governance indicators). Hub. Dist refers to the the distance to the closest major trade hub (Rotterdam, New York City or Tokyo), Haven denotes a 1 if the jurisdiction was labeled as a tax haven by Dharmapala and Hines Jr. (2009) and 0 otherwise, Eng. is a dummy variable indicating for English as the main language and Brit. Law a dummy variable for British law origins (from the database of Dharmapala and Hines Jr. (2009)).

mappings proposed by Dominguez et al. (2020). As a matter of fact, some of the countries with the largest number of incoming links, such as Panama or Hong-Kong, also have large number of outgoing links. Hence the network is not a collection of random bilateral links that operate independently. Funds incoming into a tax haven are rerouted towards other tax havens, most likely to reduce tractability of the funds, as suggested by Johannesen and Zucman (2014).

From a conceptual point of view, our results establish that the global network of tax evasion genuinely is a complex network, characterized by a core-periphery structure and a fat-tail degree distribution. This suggests that the process of network formation is not random but rather driven by a process in which network characteristics matter for link formation, as in Barabasi and Albert (1999) and Jackson and Rogers (2007). In other words, tax evasion links (offshore financial entities) are created in a systemic perspective that accounts not only for the individual characteristics of the tax havens but also for their position in the tax-evasion network, e.g. in view of further routing of tax-evaded wealth as emphasized above.

Wealth Receivers		
(1) In-Degree	(2) Eigencentrality	(3) Bonacich ($\beta = 0.05$)
BVI	PMA	BVI
PMA	BVI	PMA
BAH	BAH	BAH
SEY	SEY	SEY
NIU	NIU	NIU
ANG	SAM	ANG
SAM	HKG	SAM
NEV	ANG	HKG
HKG	BLZ	NEV
BLZ	URY	BLZ
GBR	GBR	GBR

Table 2: A centrality ranking with aggregate data from 1936 to 2015 features how the tax havens in the core, which attain a high node-degree, are also characterized by high levels of centrality.

Country Pair	Activity %	Host	Activity %	Source	Activity %
BVI-HKG	13.30%	BVI	54.82%	CHE	18.52%
BVI-CHE	9.60%	PMA	20.62%	HKG	18.50%
PMA-CHE	5.66%	BAH	7.56%	JSY	6.98%
BVI-JSY	5.11%	SEY	7.23%	LUX	5.29%
PMA-LUX	2.73%	NIU	4.62%	PMA	4.75%
BVI-GBR	2.65%	SAM	2.52%	GBR	4.67%
BVI-PMA	2.34%	ANG	1.57%	GGY	3.58%
BVI-GGY	2.30%	NEV	0.62%	ARE	3.55%
SEY-HKG	1.83%	HKG	0.20%	URY	2.39%
BVI-SGP	1.77%	BLZ	0.06%	IOM	2.39%
Other 800:	52.70%	Other 11:	0.19%	Other 149:	29.37%

Table 3: Activity rates for the 10 most prominent country pairs, hosts, and sources (measured through the share of offshore entities created). In particular, the first two columns show that more than 13% of the entities were incorporated in the British Virgin Islands (BVI) by a Hong Kong (HKG) beneficiary and that the 10 most prominent links channel almost half of the total offshore registries. The second two columns show that BVI holds more than 50% of the listed offshore accounts and that a group of four countries (BVI, Panama, Bahamas, Seychelles) holds roughly 90%. The third pair of columns exhibit the role of Switzerland (CHE) and Hong Kong (HKG) as major sources of tax–evaded wealth.

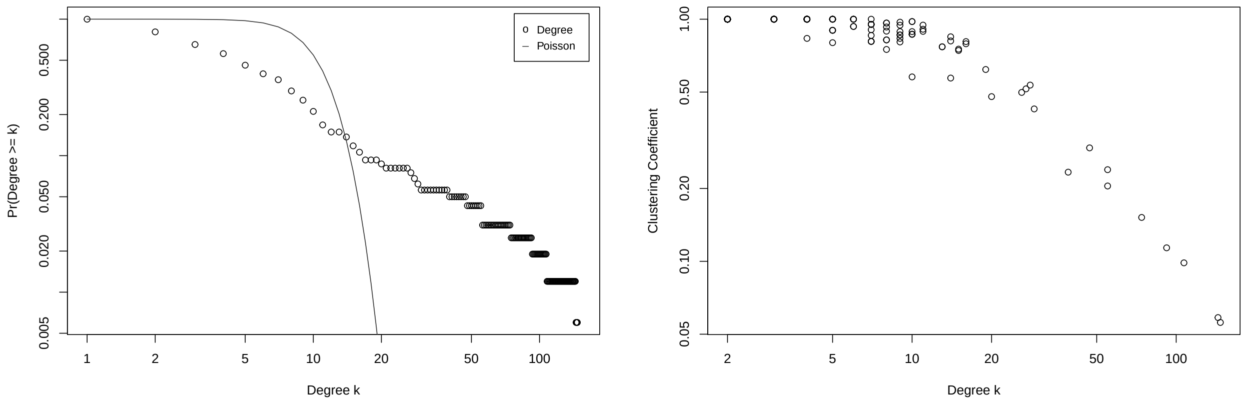


Figure 2: Degree distribution of the network compared to the benchmark Poisson distribution corresponding to a random network (log-log plot, left panel). Relation between degree and clustering coefficient (log-log plot, right panel). The clustering coefficient measures the extent to which the connections of a node are linked among themselves (Li and Schürhoff (2019)). Thus a low clustering coefficient indicates that links are highly specific to a node and the negative slope of the degree-clustering relationship in the right panel indicates that high-degree nodes receive links preferentially as in a nested-split graph.

3.3 Dynamics of network formation

In order to gain a better understanding of the dynamics of network formation, we investigate the properties of the time series of networks obtained by restricting attention to links formed within an annual time-window. In other words, the network of period t contains a link between country i and country j if an offshore entity was created in country j by an agent of country i during period t. It is important to note in this respect that entities can be created by anticipation by a provider of offshore financial services in order to provide to future tax evader offshore entities with some 'historical' legitimacy (these are also known as 'shelf' companies, see Carr and Grow (2011) and Alvarez and Marsal (2017)). Hence, the network actually observed in year t partly accounts for the demand of tax evasion channels anticipated by the provider of offshore financial services.

Our dynamic analysis focuses on the last twenty years of the database, from January 1996 to December 2015, which account for over 80% of the available data. The key features of the network dynamics over this period are displayed in Figure 3. One observes that the number of nodes and links grew steadily until 2009 and then faced a sizeable negative shock, likely caused by the treaty obligations imposed by the G20 on offshore financial centers, as extensively discussed below. The decrease in the number of nodes is larger in magnitude and in duration than that of the number of links, implying that the shock incidentally caused an increase in the density of the network.

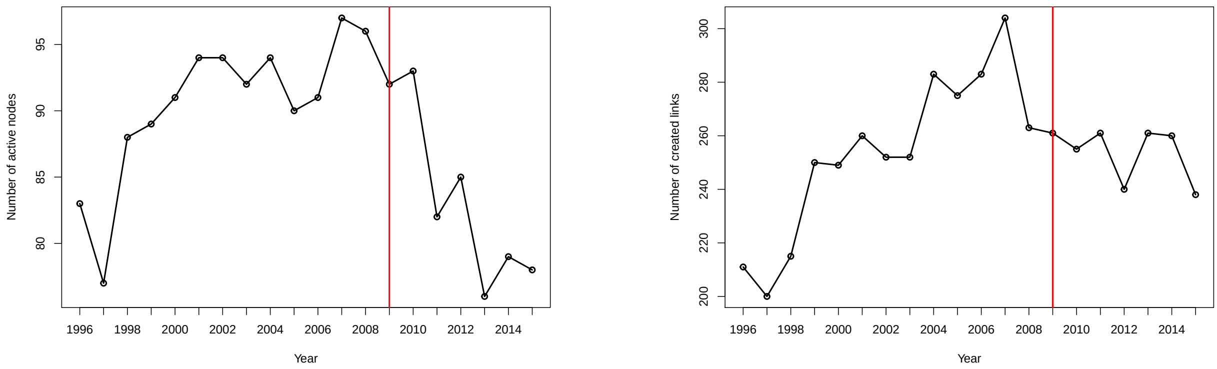


Figure 3: Dynamic evolution of the tax-evasion networks 1996-2015.

From a structural perspective, Figure 4 and Figure 5 reiterate the persistence of a core-periphery structure and of fat-tails. This persistence is explained by the stability of tax-evasion links. Indeed, as detailed in Table 4, 75% of all links and 85% of links between core jurisdictions remain stable on a year-to-year basis.

Remark 1. *Although the structural features of the network remained stable over time, the role of individual jurisdictions has evolved. For example, Niue and Bahamas lost while Seychelles or Anguilla gained centrality over time. Also, Panama and the British Virgin Islands have consistently maintained a very high centrality.*

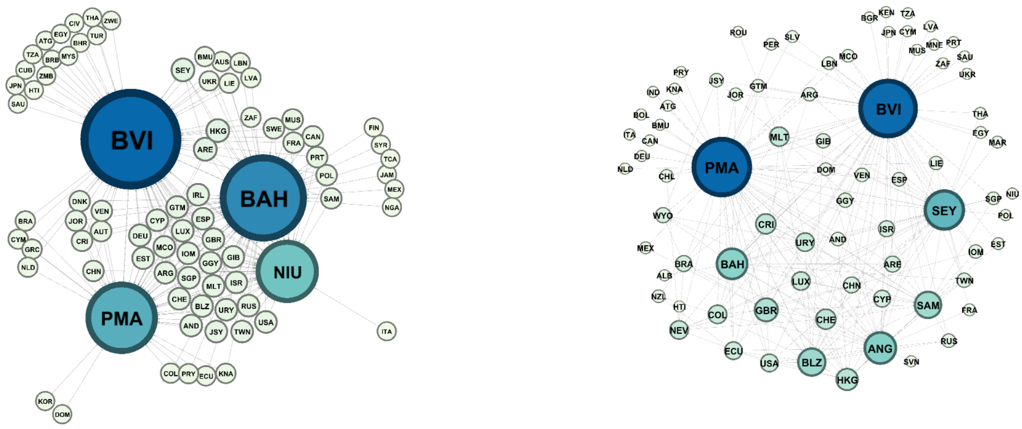


Figure 4: Graphical representation of the network for the years 1996 (left panel) and 2014 (right panel).

The presence of fat tails can further be explained by an analysis of the micro-level dynamics of the network. Indeed, newly formed offshore entities are directed preferentially towards high-degree nodes, as seen in Figure 6. Namely, 47% of offshore entities were created in the British Virgin Islands, 21 % in the Bahamas, 17% in Panama and 10% in Niue. This correlation between degree and linkage probability is consistent with the preferential-attachment process,

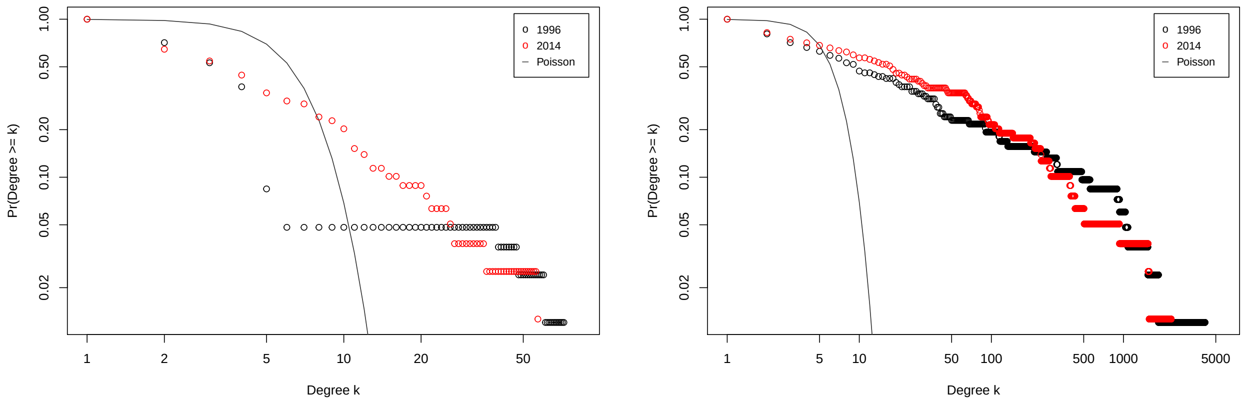
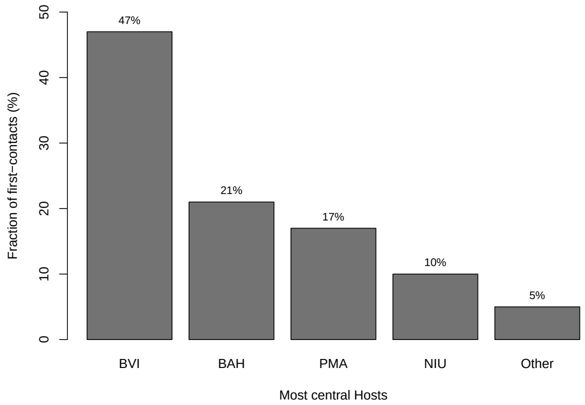


Figure 5: Temporal evolution of the unweighted (left panel) and weighted (right panel) degree distributions of the global tax-evasion network. The left panel shows a persistent fattening of tails in the network from 1996 to 2014.

	Link next year			
	All nodes		Core nodes	
Link this year	=0	=1	=0	=1
=0	88%	12%	87%	13%
=1	25%	75%	15%	85%

Table 4: Stability of node centrality: From 1996 to 2015

which is well-known to lead to scale-free degree distributions, as discussed in detail by Barabasi and Albert (1999). As a matter of fact, for the years 2010 to 2015, the null hypothesis that the degree distribution of the network follows a power-law distribution is not rejected by a goodness-of-fit test following the bootstrap procedure of Clauset et al. (2009).



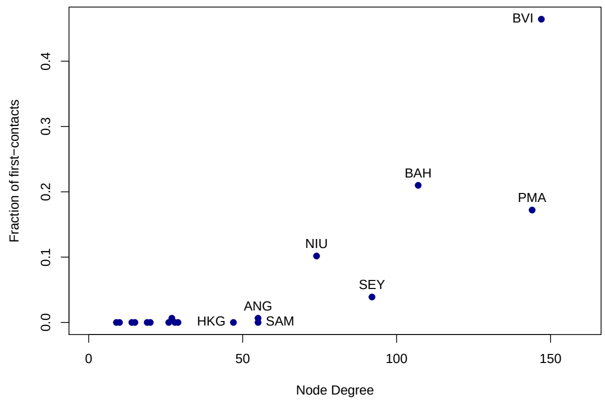


Figure 6: Bar plot showing the hegemony sustained by a few jurisdictions which act as the 'first-ever' destinations for evaded wealth (left panel) and the noticeable correlation between the node degree held by the tax havens with respect to the fraction of first-ever contacts(right panel).

4 Determinants of network formation

In order to gain further insights on the economic drivers of network formation and on the impact of the G20 tax haven crackdown on the structure of the network, we perform an econometric analysis of the determinants of bilateral link formation.

4.1 Link formation probability

As noted by Braun and Weichenrieder (2015), Caruana-Galizia and Caruana-Galizia (2016) and Omartian (2017), the information presented in the Panama Papers does not include the amount of bilateral deposits, nor any other monetary variable. In order to overcome this caveat in the data, we interpret the sequence of annual networks inferred in the preceding sections as a panel dataset of bilateral links. More precisely, we use a linear probability panel-data model to estimate the determinants of the binary link formation variable $L_{i,j,t}$, which assumes a value of 1 if there was at least one offshore financial entity incorporation from source jurisdiction i to host jurisdiction j in period t, and a value of 0 otherwise. The data covers 20 years, from 1996 to 2015, and includes 178,163 incorporated offshore financial entities. Building on the results of the previous section, the set of host jurisdictions is restricted to those that have at least one incoming link, i.e. those that actually were documented as offshore financial centers by the Panama Papers. Following Johannesen and Zucman (2014), we consider the existence of a tax treaty between countries as the key policy determinant of link formation. We thus examine the complete set of endorsed tax agreements as in Johannesen and Zucman (2014). A fundamental remark in this respect is that the authors distinguished among different types of tax treaties: tax information exchange agreements, double taxation conventions, whether treaties followed the OECD standard, and whether treaties included Article 26; which provides for information exchange on request. Our analysis will distinguish the impact of these bilateral tax agreements in two different settings: tax treaties that explicitly include a tax information exchange clause (TIEA's) and tax treaties that do not.

Although "dyadic" models can be used to study link formation, it is likely that a link between two jurisdictions may also depend on the connections with other jurisdictions in the network. In order to explain the complex core-periphery structure of the global tax-evasion network, one must also consider the rerouting possibilities between host j and other host jurisdictions to circumvent the implementation of a tax treaty between source i and host j. De Paula (2020) surveys recent advances on the econometrics of network formation (Graham (2016, 2017); Charbonneau (2017)) and proposes a model specification to study link formation in simple, directed and unweighted networks which considers the lagged dependent variable and a measure of host node-degree as covariates. Since we have repeated observations on a simple, unweighted and directed network, we follow De Paula (2020) to define our regression equation. Hence, we adopt the following linear probability panel data model specification.

$$L_{i,j,t} = \alpha + \beta \text{Treaty}_{i,j,t} + \gamma L_{i,j,t-1} + \delta \sum_{k \neq j} L_{j,k,t-1} + \theta_{i,j} + \xi_t + \epsilon_{i,j,t}. \quad (1)$$

Here, the outcome variable $L_{i,j,t}$ equals 1 if there is a link (at least one offshore financial entity incorporation) from jurisdiction i to jurisdiction j in period t, and 0 otherwise. Analogous binary transformations have been employed and studied in panel data regressions by Braun and Weichenrieder (2015) and Omartian (2017). The dummy variable $\text{Treaty}_{i,j,t}$ indicates the presence or absence of a tax treaty between countries i and j in period t (see details below). The lagged dependent variable $L_{i,j,t-1}$ allows to estimate a dynamic model, while the host node-degree measure $\sum_{k \neq j} L_{j,k,t-1}$ helps keep track of the rerouting channels between host j and other host jurisdictions. The lagged network features $L_{i,j,t-1}$ and $\sum_{k \neq j} L_{j,k,t-1}$ are temporarily restricted by one period to avoid endogeneity and simultaneity issues (De Paula (2020)). Pairwise fixed-effects $\theta_{i,j}$ and time fixed-effects ξ_t are employed to take into account any other external means of influence in the panel data setup, such as distance between jurisdictions, same legal origins, same language, commonalities and time trends (analogous to Johannesen and Zucman (2014); Braun and Weichenrieder (2015); Omartian (2017)). By construction, the lagged dependent variable $L_{i,j,t-1}$ on the right-hand side of Equation 1 is endogenous as it is correlated with the pairwise fixed-effects $\theta_{i,j}$. To obtain a consistent estimator, the Arellano–Bond generalized method of moments (GMM) is employed (Arellano and Bond (1991)). Lastly, $\epsilon_{i,j,t}$ is the error term. As mentioned, we consider two variants for variable $\text{Treaty}_{i,j,t}$ in the regression defined in Equation 1: the existence of a tax information exchange agreement (TIEA) and the existence of a tax treaty without an explicit tax information exchange clause (other). In this context, the main element of interest is the coefficient β, which measures the effect of an existing tax treaty (either *TIEA* or *other*) between source i and host j at time t. Our results are reported in Table 5. All regressions consider annual observations from 1996 to 2015 and are based on the Arellano-Bond GMM two-step procedure with two-way effects at the pairwise and time levels with robust standard errors.

Table 5: Panel regressions of link formation probability on treaty signature

Variables	Hosts: All					
	Source: All jurisdictions		Source: Peripheral jurisd.		Source: Core jurisdictions	
	(1)	(2)	(3)	(4)	(5)	(6)
$Treaty_{i,j,t} = TIEA$	0.0419		0.1474		-0.0865	
	(0.0831)		(0.0955)		(0.0638)	
$Treaty_{i,j,t-1} = TIEA$	-0.1141		-0.2147**		0.0373	
	(0.0832)		(0.0985)		(0.0561)	
$Treaty_{i,j,t} = Other$		0.0342		0.0618		-0.0457
		(0.0836)		(0.0949)		(0.0579)
$Treaty_{i,j,t-1} = Other$		-0.0404		-0.0462		-0.0243
		(0.0860)		(0.1063)		(0.0370)
Lagged Link, 1y: $L_{i,j,t-1}$	0.7006***	0.7041***	0.5438***	0.5379***	0.2781**	0.2599**
	(0.1598)	(0.1608)	(0.1613)	(0.1624)	(0.1166)	(0.1119)
Lagged Link, 2y: $L_{i,j,t-2}$	0.2036*	0.2023*	0.2492**	0.2550**	0.2626***	0.2835***
	(0.1212)	(0.1217)	(0.1258)	(0.1258)	(0.0856)	(0.0969)
Lagged Link, 3y: $L_{i,j,t-3}$	-0.0153	-0.0142	0.0123	0.0144	0.0280	0.0368
	(0.0256)	(0.0258)	(0.0257)	(0.0259)	(0.0409)	0.0403
Host degree: $\sum_{k \neq j} L_{i,k,t-1}$	-0.0006	-0.0006	0.0005	0.0005	0.0036**	0.0026
	(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0017)	(0.0017)
Observations	16,060	16,060	12,880	12,880	3,180	3,180
Number of country pairs	803	803	644	644	159	159
Number of years	20	20	20	20	20	20
Pairwise fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Signif. codes: '***' 0.01 '**' 0.05 '*' 0.10 ' ' 1

Notes: Panel data regressions with linear probability function, where the p-values are based on the Arellano-Bond GMM two-step procedure with two-way effects at the pairwise and time levels with robust standard errors. The dependent dichotomous variable measures the existence or non-existence of a link formation between source i and host j at time t. The sample period considers annual data from 1996 to 2015. The variable of interest is $Treaty_{i,j,t}$, and it is split into two dummy variables: $Treaty_{i,j,t} = TIEA$ if a tax information exchange agreement treaty (as defined by Johannesen and Zucman (2014)) exists between source i and host j at time t, and $Treaty_{i,j,t} = Other$ if a tax treaty without an explicit tax information exchange clause exists between source i and host j at time t.

The efficiency of the G20 approach has also been questioned on the basis of the fact that a large number of TIEA's have been signed among tax havens, raising doubts on their actual enforcement (Johannesen and Zucman (2014); Bilicka and Fuest (2014)). In order to investigate this issue, we have further specialized our econometric analysis by distinguishing three types of jurisdictional sources: all sources; peripheral jurisdictions; and core jurisdictions, explicitly identified as tax havens in the Panama Papers. In our analysis, we estimate separately the regression model introduced in Equation 1 for each treaty-type and source-type combination. Columns 1, 3 and 5 deal with regressions which restrict the independent variable to account for TIEA-type tax treaties only; Columns 2, 4 and 6 consider all other types of tax treaties between country pairs (i.e. non-TIEA). Also, Columns 1 and 2 consider all types of sources, Columns 3 and 4 limit sources to peripheral countries, and Columns 5 and 6 restrict sources to core jurisdictions. The timing of the response to tax treaty signature is also analyzed. We include two dummies in years t and $t-1$ of the tax treaty variable. We find that most of the deterrent effect occurs one year after signature. One plausible explanation is that tax treaties are not enforced immediately after they are signed. For instance, Johannesen and Zucman (2014) suggest there is a time lag of three to five quarters between treaty signature and entry into force. Following, we focus our attention on the deterrent effect of tax treaties in the post-signature period. Columns 1 through 4 indicate that tax treaties may deter the probability of link formation between peripheral and core jurisdictions one year after treaty signature; thus giving support to our working assumption. However, this does not seem to be the case when tax treaties are implemented between two core jurisdictions in Column 5. Columns 1 and 2 show a negative yet not statistically significant coefficient for both specifications ($TIEA$ or $Other$) one year after signature. Likely, these results suggest a high variability among treaty types and among source types. On the one hand, Column 3 offers evidence of a statistically significant deterrence effect of TIEA's on link formation probability whenever one of the parties is a peripheral jurisdiction. On the other hand, Column 5 shows that the latter is not the case when both parties belong to the core of the network.

An advantage of linear probability models is that the coefficients are directly interpretative. Columns 1, 3 and 5 reveal a high variability among source types. For all jurisdictions, a TIEA would reduce the probability of link formation by 11% in the post-signature period, albeit in a non-statistically significant way. This magnitude would increase to 21% at a 5% significance level if the source would be a peripheral jurisdiction. A previous study (Johannesen and Zucman (2014)), using different data, found that TIEA treaties are associated with a roughly 22 percent average drop in tax evaders' deposits. Thereafter, the magnitude, direction and statistical significance of the results presented in Table 5 are in line with the related literature. Furthermore, the lagged dependent variable $L_{i,j,t-1}$ has a very significant impact on the probability of link formation in all specifications. That is, there is an inertial impetus for link formation in already active channels within the network. This relates to the strong year-to-year link stability presented in Table 4 of the previous section. Likewise, Column 5 shows that a higher value of host node-degree $\sum_{k\neq j} L_{j,k,t-1}$ would increase the likelihood of link formation inside the core of the network at a 5% significance level, as in a preferential attachment structure where rich nodes get richer and attract further sources. The significant effects of both lagged network features confirm the complex structure of the global network of tax evasion. Additional robustness checks were performed on the regression results. The coefficients shown in Table 5 consider two-way effects to adjust for unobserved pairwise-specific and time-specific confounders at the same time, are robust to probit and logit link functions, and retain their statistical significance after controlling for source and host specific covariates: GDP, population and Governance Index.

Johannesen and Zucman (2014), Bilicka and Fuest (2014), Braun and Weichenrieder (2015) and O'Donovan et al. (2019) found that economic activity between jurisdictions is not a reliable predictor of treaty signature. Indeed, Braun and Weichenrieder (2015) concluded that there are no endogenous issues between tax treaty signatures and the binomial transformation of the number of incorporated entities, as $L_{i,j,t}$ in our context. Hence, reverse causality is unlikely, and tax treaties may be seen as orthogonal to the dependent variable in our context. Notwithstanding, a test to identify reverse causality between TIEA treaties and offshore entity incorporation is presented in Subsection 4.3 below.

Consequently, we find that tax information exchange agreements (TIEA's) between peripheral and core jurisdictions have a negative and statistically significant impact on link formation, whereas *other* (i.e. non-TIEA) treaties do not have a statistically significant impact. Also, we find that both the magnitude and the statistical significance of the curbing effect of tax treaties on the annual probability of link formation depend on the nature of the source. These two findings suggest that coordinated policies, such as the G20 crackdown on tax havens, might have an impact on tax evasion but that the type and conditions of the enforced treaties are crucial. Moreover, given that not all bilateral transactions are related to tax evasion, and presumably only illegal activities are affected by TIEA's, we may assume the coefficients presented in Table 5 present a lower bound and could be even more pronounced for tax-evaded wealth (Johannesen and Zucman (2014)).

4.2 Link incorporation activity

For robustness, we propose a complementary analysis of link activity levels, i.e. the number of newly incorporated entities on treaty signature. Similar to Omartian (2017), we consider a logarithmic transformation of the total number of incorporated entities[6] between source i and host j at time t:

$$A_{i,j,t} = \ln(1 + Incorporations_{i,j,t}).$$

Thus, we employ the corresponding standard OLS panel data model specification.

$$A_{i,j,t} = \alpha + \beta \text{Treaty}_{i,j,t} + \theta_{i,j} + \xi_t + \epsilon_{i,j,t}, \tag{2}$$

where the dependent variable $A_{i,j,t}$ measures the logarithmic activity level of newly incorporated entities between source i and host j at time t. Analogous to Equation 1, the binary variable $\text{Treaty}_{i,j,t}$ indicates the presence of a tax treaty between countries i and j in period t. Pairwise fixed-effects $\theta_{i,j}$ and time fixed-effects ξ_t are employed to control for external factors of influence, and $\epsilon_{i,j,t}$ is the error term. Once again, separate regressions were estimated by treaty and source types. Two variants for variable $\text{Treaty}_{i,j,t}$ in the regression defined in Equation 2 are considered: (i) the existence of any tax treaty and (ii) the existence of a tax information exchange agreement (TIEA). The complementary results are reported in Table 6. All specifications employ annual observations from 1996 to 2015 and account for double-clustered robust standard errors at the pairwise and time levels.

Row (i) in Table 6 shows the estimated coefficients for unspecified (any) tax treaties, and row (ii) shows the estimated coefficients considering only TIEA-type treaties. For non-specified tax treaties, Columns 1, 3 and 5 do not show any statistically significant coefficients in any of the three regressions. Although TIEA-type tax treaties may deter link activity levels, there are reasons to believe the variability is high among source types. Accordingly, Columns 2 and 4 exhibit the statistically significant deterrent effect of TIEA tax treaties on link activity levels for non-specified and peripheral jurisdictions, respectively. Applying an exponential transformation, one can recover the estimated impact of a TIEA signed between source i and host j conditional on the source's type. For all sources, a TIEA would deter link activity levels by 16% at a 5% significance level. Restricting for peripheral sources, a TIEA would curb link

[6] Number of incorporations plus one, to avoid ln(0).

incorporation activity by 22% at a 1% significance level[7]. While the results presented in Table 5 suggest that TIEA's may inhibit the likelihood of link formation only in the post-signature period, Table 6 shows that TIEA's may deter link incorporation activity between peripheral and core jurisdictions immediately after signature. Notwithstanding, TIEA treaties do not have a statistically significant effect on link activity when implemented between two core jurisdictions. The results presented in Table 6 are in line with those shown in Table 5 and with those of the related literature[8]. Further robustness checks were implemented: the coefficients shown in Table 6 are robust to double-clustering, Newey-West and White standard errors, probit and logit link functions, and retain their statistical significance after controlling for source and host specific covariates: GDP, population and Governance Index. Additionally, there are no incidental parameter problems whenever using an OLS function.

Table 6: Panel regressions of link incorporation activity on treaty signature

Variables	Hosts: All					
	Source: All jurisdictions		Source: Peripheral jurisd.		Source: Core jurisdictions	
	(1)	(2)	(3)	(4)	(5)	(6)
(i) $Treaty_{i,j,t} = Any$	-0.0442		-0.1006		0.1845	
	(0.0798)		(0.0734)		(0.2284)	
(ii) $Treaty_{i,j,t} = TIEA$		-0.1727**		-0.2452***		0.0630
		(0.0807)		(0.0802)		(0.0223)
Observations	16,060	16,060	12,880	12,880	3,180	3,180
Number of country pairs	803	803	644	644	159	159
Number of years	20	20	20	20	20	20
Pairwise fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Signif. codes: '***' 0.01 '**' 0.05 '*' 0.10 ' ' 1

Notes: Panel data regressions with standard OLS function, where the p-values are based on double-clustered robust standard errors. The dependent variable measures entity incorporation activity (as defined by Omartian (2017)) between source i and host j at time t. The sample period considers annual data from 1996 to 2015. The variable of interest is $Treaty_{i,j,t}$, and it is split in two dummy variables: (i) $Treaty_{i,j,t} = Any$ if any tax treaty exists between source i and host j at time t, and (ii) $Treaty_{i,j,t} = TIEA$ if a tax information exchange agreement treaty (as defined by Johannesen and Zucman (2014)) exists between source i and host j at time t.

The persistent effect of TIEA treaties between peripheral and core jurisdictions is reiterated by additional robustness checks. Nonetheless, one particular regression specification suggests that TIEA treaties signed between *peripheral* tax haven sources and core financial offshore

[7] The corresponding transformations are: $e^{-0.1727} - 1 = -0.1586$; $e^{-0.2452} - 1 = -0.2174$.

[8] A previous study by Johannesen and Zucman (2014)), using different data, found that a TIEA would reduce tax evaders' deposits by roughly 16% at a significance level of 10% considering all sources and by approximately 22% at a significance level of 5% once restricted for non-haven sources.

centers do not have a statistically significant deterrence impact on link formation probability. A similar finding was reported by Johannesen and Zucman (2014). Peripheral tax haven sources are jurisdictions that do not belong to the core of the global tax-evasion network in our context, but are identified as tax havens by Dharmapala and Hines Jr. (2009). This category includes jurisdictions such as Switzerland (CHE) and Hong Kong (HKG), which are generally considered as intermediaries in tax evasion circuits and that have, in our network analysis, very large out-degrees both in absolute terms and relatively to their GDP. The flow of funds between these jurisdictions is presumed to unfold as follows. Non-haven peripheral sources may evade directly towards core jurisdictions or to peripheral tax havens. In the latter case, peripheral tax havens rewire a substantial share of funds towards core jurisdictions. In turn, said core jurisdictions may further transfer funds to other nodes in the core. Unfortunately, this type of dynamics are not covered by the information revealed in the Panama Papers, and there is no possibility for us to empirically test the deterrence effect of TIEA's whenever wealth is concealed in this manner. Notwithstanding, even if an intermediate layer of wealth concealment would be applied, the current 'anti-money laundering' (AML) and 'know your customer' (KYC) laws implemented to fight terrorism and illegal activities oblige banks and financial institutions to always know the ultimate beneficiary of each account (Omartian (2017)). That is, if a resident of country i uses an intermediate layer in tax haven k to incorporate an offshore financial entity in host j, the tax evader may be detected if there is a TIEA between countries i and j (Johannesen and Zucman (2014)). Given the KYC and AML policies, this double-layer mechanism is potentially immaterial for the results presented in Table 5 and Table 6, as the (nominal) entity holder located in each core jurisdiction is obliged to know the ultimate beneficiary of the incorporation back at the non-haven country of residence. Following, peripheral tax havens which engage in additional TIEA treaty signatures should also see their wealth concealment activity hampered (as evidenced by Johannesen and Zucman (2014)).

4.3 Tests of identification strategy

Although there are no indications of endogenous issues nor reverse causality between TIEA's and link activity levels reported in the related literature (Johannesen and Zucman (2014); Bilicka and Fuest (2014); Braun and Weichenrieder (2015); Caruana-Galizia and Caruana-Galizia (2016); Omartian (2017)), we present a test of our identification strategy to assess whether or not there is a reverse causality between TIEA treaties and offshore entity incorporation. It is plausible to think that non-haven countries would try to increase their probability of detecting tax evaders by signing tax treaties with key tax havens. Similarly, one could speculate that tax havens might have strategically signed TIEA treaties with jurisdictions that had little entity incorporation activity, or whose level of incorporation activity had been systematically decreasing. If either is the case, then there would be a spurious relationship between the signing of a TIEA treaty and the subsequent link formation probability and activity levels. To test our identification strategy, we follow Johannesen and Zucman (2014) and apply probit panel data models of TIEA treaty implementations as follows

$$\text{TIEA}_{i,j,t} = \alpha + \beta \text{Growth}_{i,j,t} + \gamma W_{i,j,t} + \delta X_{i,j} + \theta Z_{i,t} + \xi_t + \epsilon_{i,j,t}, \quad (3)$$

where the dependent binary variable $\text{TIEA}_{i,j,t}$ indicates the signature of a TIEA treaty between countries i and j in period t, $\text{Growth}_{i,j,t}$ measures the growth rate of the incorporation activity level between countries i and j from period $t-1$ to period t, $W_{i,j,t}$ includes dynamic bilateral factors such as the lagged presence or absence of tax-evasion links and the activity level of newly incorporated entities between source i and host j at time t, $X_{i,j}$ includes time-invariant bilateral factors such as geodesic distance between countries and whether the jurisdictions speak a common language, $Z_{i,t}$ represents source-specific variables, ξ_t are the time fixed effects to control for common time trends and $\epsilon_{i,j,t}$ is the error term.

The models presented in Table 7 estimate the impact of tax evasive behavior on the probability of observing a TIEA-type treaty signature between a peripheral source i and a host j at time t. We consider two metrics which could have an effect on the probability of a TIEA-type treaty to be signed between two jurisdictions, namely the lagged activity growth rate of offshore entity incorporation and the lagged presence or absence of tax-evasion links between source i and host j. Column (1) shows that the probability of signing a TIEA is not affected by the activity growth rate in the preceding year, nor by the one from 3 years to 2 years before the TIEA was signed. However, there is a marginal negative impact of the activity growth rate from 2 years to 1 year before the TIEA signature at a 10% significance level. This result suggests that core jurisdictions may be prone to sign TIEA-type treaties with peripheral jurisdictions with whom their activity levels are decreasing. Nevertheless, the more robust specification in Column (2) shows how this marginally significant effect dissipates once the model accounts for the geodesic distance between jurisdictions and the GDP per capita of the source country. The coefficients in Column (2) suggest that tax havens tend to sign TIEA-type treaties with affluent neighboring jurisdictions. A different set of covariates is employed in Column (3), where the model is fitted on the lagged binary values of link presence. Although the interpretation of such model specification is not straightforward, since one cannot measure the growth rate of this binary variable, these results show that the lagged variable $L_{i,j,t-s}$ does not have any statistically significant impact on the probability of TIEA treaty signatures.

Table 7: Panel regressions of treaty signature on tax evasive behavior

Variables	Treaty type: TIEA				
	Source type: Peripheral jurisdictions				
	Signature of a TIEA treaty			Presence of a TIEA treaty	
	(1)	(2)	(3)	(4)	(5)
Activity growth rate, -1y to 0y	0.0004	0.0003		0.0005	
	(0.0007)	(0.0007)		(0.0015)	
Activity growth rate, -2y to -1y	-0.0023*	-0.0019		-0.0025	
	(0.0012)	(0.0012)		(0.0018)	
Activity growth rate, -3y to -2y	0.0011	0.0008		0.0022	
	(0.0013)	(0.0013)		(0.0017)	
Link activity: $A_{i,j,t}$		-0.0005			
		(0.0006)			
Distance (in thousands of Km.)		-0.0002*			
		(0.0001)			
Source GDP pc (in logs)		0.0021*			
		(0.0012)			
Lagged Link, 1y: $L_{i,j,t-1}$			-0.0021		-0.0051
			(0.0018)		(0.0035)
Lagged Link, 2y: $L_{i,j,t-2}$			0.0007		0.0006
			(0.0012)		(0.0026)
Lagged Link, 3y: $L_{i,j,t-3}$			0.0017		0.0058
			(0.0020)		(0.0038)
Observations	12,880	12,880	12,880	12,880	12,880
Number of country pairs	644	644	644	644	644
Number of years	20	20	20	20	20
Pairwise fixed effects	No	No	No	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes

Signif. codes: '***' 0.01 '**' 0.05 '*' 0.10 ' ' 1

Notes: Panel data regressions with linear probability function, where the p-values are based on robust standard errors. The dependent variable is a dummy equal to 1 if a TIEA-type treaty was signed between source i and host j at time t, and 0 otherwise. The sample period considers annual data from 1996 to 2015. This table investigates whether TIEA-type treaties are motivated either by the entity incorporation activity growth rate or by the lagged presence of tax-evasion links between source i and host j. Link activity levels are considered in logarithmic terms (as defined by Omartian (2017)), *Distance* gives the geodesic distance between capital cities as measured by CEPII, and GDP per capita is considered in logs and retrieved from the World Bank database.

In principle, tax treaties can be canceled and amended as required. For sake of completeness, we also include probit models for the *presence* of a TIEA-type treaty between source i and and host j at time t. Columns (4) and (5) show that the lagged activity growth rates and the lagged tax-evasion links play no role on the presence of TIEA treaties between jurisdictions, respectively. The results presented in Table 7 are analogous for unspecified treaty signatures as the dependent variable (instead of TIEA's), whenever considering all source jurisdictions and also when restricting sources to core jurisdictions.

The results of the baseline and the complementary analysis are consistent with previous findings (Johannesen and Zucman (2014); Braun and Weichenrieder (2015); Omartian (2017)). Likewise, we find robust empirical evidence to support our working assumptions. The signature of a TIEA between peripheral countries and core jurisdictions plays a significant deterrence effect on the probability of link formation, and on the link activity level. From a public policy point of view, the results of this section first show that tax treaties can have an impact on tax evasion. Second, they emphasize the importance of adding information exchange clauses to ensure an effective impact. Third, they question the relevance of treaties signed between tax havens and thus suggest to revisit the definition of the treaty quota imposed by the G20 guidelines.

5 A formal model of tax evasion deterrence

The networked structure of the tax-evasion system highlighted in the preceding sections raises a number of questions for the design of an efficient anti-tax evasion policy. Where is tax evaded wealth likely to be located in the network? How does the structure of the network affects tax-evasion behavior in origin countries? Which are the efficient policies to deter tax evasion given its networked structure? In order to address these issues, we introduce a simple model of the flow of funds in the tax-evasion network and investigate in this setting the strategic behavior of an optimizing tax-evading agent and of a social planner aiming at deterring evasion.

5.1 Notation and definitions

We first recall a set of notions and known results related to networks and, in particular, Bonacich centrality.

Definition 1. *Given a network with adjacency matrix $G \in \mathbb{R}_+^{N\times N}$, and a discount factor $\beta \in [0,1]$, the Bonachich centrality (see Bonacich (1987) as well Ballester et al. (2006)) of a node i is defined as the discounted sum of the weights of all paths in the network leading to i. Namely, the vector of Bonacich centrality is given by:*

$$b(G,\beta) = \sum_{t\in\mathbb{N}} \beta^t G^t \tilde{e} = (I-\beta G)^{-1}\tilde{e}, \tag{4}$$

where $\tilde{e}$ is the vector $(1,\cdots,1) \in \mathbb{R}_+^N$.

This definition can be extended to account for an arbitrary vector of weights on the origins of paths, leading to the definition of the Bonacich centrality of an adjacency matrix G for a discount factor $\beta \in [0,1]$, and a vector of initial weights $x \in \mathbb{R}_+^N$ as

$$b(G,\beta,x) = \sum_{t\in\mathbb{N}} \beta^t G^t x = (I-\beta G)^{-1}x. \tag{5}$$

Remark 2. *The Bonacich centrality is well defined only if $\beta < \mu_1(G)$ where $\mu_1(G)$ is the largest eigenvalue of G (also referred to as the index of G).*

In the following, we shall be concerned with the determination of the network with a given number of links that maximizes the sum of Bonacich centralities. Following *Remark 1* and *Lemma 1* in Belhaj et al. (2016), such networks necessarily are nested-split graphs in the following sense.

Definition 2. *An (unweighted) network G is a nested-split graph if*

$$[G_{i,j} = 1 \text{ and } \deg(G,k) \geq \deg(G,j)] \Rightarrow G_{i,k} = 1,$$

where $\deg(G,k)$ *denotes the degree of node k in the network G.*

Such graphs are called nested as it can be shown they are structured by classes of nodes having the same degree and the same set of incoming links. Some notable classes of nested-split graphs are defined as follows:

Definition 3. *The quasi-complete network with n nodes and ν links, denoted by $QC(n,\nu)$ is the graph that contains the complete subgraph K_p with $p(p-1)/2 \leq \nu < p(p+1)/2$ and the remaining $\nu - p(p-1)/2$ links are set between the nodes in K_p and one other node.*

Definition 4. *The quasi-star graph with n nodes and ν links, denoted by $QS(n,\nu)$ is the graph with p central nodes, each having $n-1$ links, and the remaining $\nu - p(n-1)$ links being directed towards a specific node, so as to construct another central node.*

5.2 Centrality and the distribution of tax evaded wealth

We first consider a simple phenomenological model of the dynamics of wealth in a tax-evasion network. The network is represented by a column-stochastic adjacency matrix $(G_{i,j})_{i,j=1,\cdots,N} \in \mathbb{R}_+^{N\times N}$ where N is the number of countries in the network and $g_{i,j}$ measures the share of wealth outgoing from country j that is directed towards country i, i.e. the probability that a unit of tax-evaded wealth, which is outgoing from j, is directed towards i. Tax-evasion behavior is captured by a single parameter $\beta \in [0,1]$, which measures the intensity of tax-evasion, i.e. the share of tax-evaded wealth arriving in i that is rerouted further (while $1-\beta$ is the share that stays in the country).

Remark 3. *Empirically, β likely depends on the host country and on the number of countries through which the funds have transited since the origin country. Considering β is constant renders the process homogeneous in space and in time and thus analytically tractable. From the point of view of a tax evader aiming at avoiding detection, this amounts to consider that the probability of detection is independent of the host country and decreases with each link added to the tax evasion path, independently of the trajectory followed previously.*

In this setting, the dynamics of tax evaded wealth can be characterized by $y(t) \in \mathbb{R}_+^N$ the distribution of idle funds in the network and $x(t) \in \mathbb{R}_+^N$ the distribution of funds in circulation in the network. One has:

$$\begin{cases} x(t+1) = \beta G x(t) \\ y(t+1) = (1-\beta)x(t) + y(t) \end{cases} \tag{6}$$

The first equation represents the flow of funds in circulation in the network. The second equation represents the fact that a share $(1-\beta)$ of funds stops circulating in the network at every step. Combining both equations, one can determine the distribution of funds in the network at time t as a function of the initial distribution of funds $x(0)$ (one assumes $y(0) = 0$). Namely, one has:

$$x(t) = \beta^t G^t x(0) \tag{7}$$

$$y(t) = (1-\beta)\sum_{r=0}^{t-1} \beta^t G^t x(0) \tag{8}$$

As long as $\beta < 1$, Equation 7 implies that asymptotically all funds become idle in the network. In turn, Equation 8 implies that at time t, (idle) funds in the network are distributed according to the discounted sum of paths of length less than t. Accordingly, asymptotically, funds are distributed proportionally to the Bonacich centrality of the network. Namely, one has the following proposition.

Proposition 1. *If tax evaded wealth follows the dynamics given by Equation 6 with $\beta < 1$ one has:*

$$\lim_{t \to +\infty} x(t) = 0$$

$$\lim_{t \to +\infty} y(t) = (I - \beta G)^{-1} x(0)$$

where $(I - \beta G)^{-1} x(0)$ is the Bonacich centrality of the network with adjacency matrix G, corresponding to the discount factor β and the initial weight $x(0)$.

Proposition 1 can then be used to estimate the distribution of tax evaded wealth among tax havens on the basis of the structure of the tax-evasion network, the propensity to evade taxes and the distribution of wealth among origin countries. When applied to the tax-evasion network inferred from the Panama Papers, this implies that the ranking of tax havens by size is given by the Bonacich centrality reported in Table 2 (for a 5% discount factor).

5.3 Policy and behavior in tax-evasion networks

As emphasized in the previous sections, policy makers in source countries have tried to curb the flow of tax evasion by pressuring tax havens to sign information exchange treaties that ought to hamper the circulation of tax evaded money. In other words, they have tried to alter the structure of the network of tax evasion in order to reduce the share of tax-evaded wealth. In order to characterize efficient strategies from this perspective, we analyze the interactions between a tax evader that aims to minimize the probability of being detected by dispersing his funds across a tax-evasion network and a social planner that aims at minimizing tax evasion through the implementation of an efficient set of treaties.

Formally, we represent the strategy spaces of the tax evader and of the social planner as follows. On the one hand, the tax evader chooses the intensity of tax evasion $\beta \in [0, 1]$. On the other hand, the social planner chooses the set of links $(i, j) \in N \times N$ on which a treaty is implemented and tax evasion can thus be detected. We represent this choice by a vector $(h_{i,j})_{i,j \in N} \in \{0, 1\}^{N \times N}$ where $h_{i,j} = 1$ if a treaty is implemented between jurisdiction i and j and $h_{i,j} = 0$ otherwise. These joint choices determine a global probability of detection $\pi(h, \beta)$.

Namely, the probability of detecting tax evaded wealth originating from jurisdiction i is given by:

$$\pi_i(h,\beta) = (1-\beta) + (1-\beta)\beta\sum_{j\in N} h_{j,i}g_{j,i} + (1-\beta)\beta^2 \sum_{j_1,j_2\in N} h_{j_2,j_1}g_{j_2,j_1}h_{j_1,i}g_{j_1,i} + \cdots + (1-\beta)\beta^m \sum_{j_1,\cdots,j_m\in N}\prod_{\mu=1}^{m} h_{j_{\mu+1},j_\mu}g_{j_{\mu+1},j_\mu}h_{j_1,i}g_{j_1,i} + \cdots \quad (9)$$

where the term $(1-\beta)\beta^m$ corresponds to the share of wealth that is stored m steps away from the country of origin and the term $\prod_{\mu=1}^{m} h_{j_{\mu+1},j_\mu}g_{j_{\mu+1},j_\mu}h_{j_1,i}g_{j_1,i}$ corresponds to the probability that the tax evader gets caught along the path $(i, j_1, \cdots, j_m)$.

Denoting by $K(h)$ the matrix with coefficients $(k_{j,i} := g_{j,i}h_{j,i})_{i,j\in N}$, one can write in matrix form the probability of detection of tax-evaded wealth initially distributed according to $x \in \mathbb{R}_+^N$, $\pi_x(h,\beta)$ as:

$$\pi_x(h,\beta) := (1-\beta)\tilde{e}^\top \sum_{m=0}^{+\infty}(\beta K(h))^m x = (1-\beta)\tilde{e}^\top (I-\beta K(h))^{-1}x \quad (10)$$

Hence, the probability for a representative (or aggregate) tax evader with initial distribution of wealth $x \in \mathbb{R}_+^N$ to get detected is proportional to the sum of the Bonacich centralities of the nodes of network $K(h)$ for the discount factor β and the vector of initial weights x.

In this setting, the tax evader has incentives to increase β in order to minimize the probability of detection. However, these incentives can be mitigated by the cost of tax evasion. This cost has many potential drivers: direct financial costs such as payment of tax evasion services, liquidity costs related to the reduced availability of evaded versus non-evaded funds, and reputation and psychological costs in case of detection. We shall denote by $c(\beta)$ the cost of choosing an intensity β of tax evasion and assume throughout that the cost is a smooth (twice differentiable) and increasing function of the intensity of tax evasion. We then assume that the tax evading agent chooses a tax evasion intensity in $[0,\overline{\beta}]$ (where $\overline{\beta} \leq 1$) and arbitrates between the probability of getting detected and the cost of tax evasion. More precisely, we consider that the utility of an agent choosing a tax evasion intensity $\beta \in [0,\overline{\beta}]$ is given by:

$$u(h,\beta) = -\pi_x(h,\beta) - c(\beta).$$

The optimal behavior of the tax evading agent then depends of the properties of the cost function. Yet, one can ensure *à priori* that given a treaty policy h, there exists an optimal level of tax evasion $\phi(h)$. Indeed, $[0,\overline{\beta}]$ is compact and u is continuous, as c and π_x both are continuous. Following, the tax evasion intensity β may be defined as the reaction function of the tax-evading agent to the treaty policy h implemented by the social planner:

$$\beta := \phi(h).$$

As for the social planner, we consider he faces a constraint limiting the actual influence he can exert on the probability of detection, i.e. on the number of treaties he can implement. This constraint of a fixed number of treaties can be justified for two factual reasons. On the one hand, the G20 2009 crackdown on tax havens obliged each tax haven to sign a minimum of 12 tax treaties. Considering that the Panama Papers alone enlist tax evaders from 161 jurisdictions, convincing tax havens to sign only 12 tax treaties appears to be a relatively low number. On the other hand, Bilicka and Fuest (2014) showed that tax havens become reluctant to sign additional TIEA's after reaching their goal of 12 tax treaties. Therefore, this constraint is assumed to be of the form $\sum_{i,j\in N} h_{i,j} = \nu$ with $\nu \in \mathbb{N}$, consistently with the constraint imposed by the G20 on tax havens to sign a given number of TIEA's. Formally, the problem of the social planner, if he takes as given the propensity, β, to tax evade, is:

$$\mathcal{S}_{\nu,\beta} := \begin{cases} \max & \pi_x(h,\beta) \\ s.t & \sum_{i,j\in N} h_{i,j} = \nu \end{cases}$$

In other words, the objective of the social planner is to choose a set of treaties (i.e. detection probabilities) h so that the sum of Bonachich centralities in the network $K(h)$ is maximal.

We shall further consider that the social planner acts as a Stackelberg leader who foresees the strategic reply of the tax evader to his policy and chooses the policy accordingly. Hence, in the following, we focus on the Stackelberg equilibrium of the tax evasion game defined as follows.

Definition 5. *A pair (β^*, h^*) is a Stackelberg equilibrium of the tax evasion game if*

1. *$\beta^* = \phi(h^*)$ is a solution of the problem* $\begin{cases} \max & -c(\beta) - \pi_x(\beta, h^*) \\ s.t & \beta \in [0, \overline{\beta}] \end{cases}$

2. *h^* is a solution to* $\mathcal{S}_\nu := \begin{cases} \max & \pi(h, \phi(h)) \\ s.t & \sum_{i,j\in N} h_{i,j} = \nu \end{cases}$

Remark 4. *In our framework the set of treaties are determined by the social planner, whereas in practice treaties are signed in a decentralized manner. Hence, tax haven countries in our context are seen as somewhat passive agents that are not allowed to determine if it is in their best interest to sign a tax treaty with a peripheral country or not. Nonetheless, our objective in this paper is normative. That is, we are interested in determining the efficient set of treaties.*

5.4 Optimal tax evasion behavior

We first characterize the behavior of a tax evader for a given deterrence policy $h \in \{0,1\}^{N\times N}$, which is considered as fixed throughout this subsection. The impact of tax evasion intensity β on the probability of detection is then given by the following proposition.

Proposition 2. *For every $x \in \mathbb{R}_+^N$ and $h \in [0,1]^{N\times N}$, $\pi_x(h,\cdot)$ is decreasing and concave in β.*

The concavity of π_x implies that agents have, *à priori*, very strong incentives to evade taxes: there are increasing marginal returns to tax evasion in terms of probability of non-detection: as β increases, the probability of detection decreases more and more rapidly. This non-convexity originates from the fact that an increase in the intensity of tax evasion is amplified, non-linearly, by the network. Yet, these incentives can be mitigated by the cost of tax evasion. Hence the optimal behavior of a tax evading agent eventually depends of the properties of the cost function.

One can not characterize analytically the optimal behavior of the tax evader in the general case. In particular, one can not guarantee that the optimum is unique, nor determine whether it is in the interior or on the boundary of the domain. However, one can characterize two polar cases that are of particular interest. First, if the cost of tax evasion is concave, i.e. if the marginal cost of tax-evasion is decreasing, there are only two potentially optimal strategies: either the agent does not tax evade at all or she fully tax evades. Namely, letting $\phi(h) = \text{argmax}_{\beta\in[0,\overline{\beta}]}\ u(h,\beta)$, one has the following proposition.

Proposition 3. *If the cost function c is concave, then the problem* $\max_{\beta\in[0,\overline{\beta}]}\ u(h,\beta)$ *can not have an interior solution and one has:*

- *Either* $u(h,\overline{\beta}) \geq u(h,0)$ *and* $\phi(h) = \overline{\beta}$
- *Or* $u(h,\overline{\beta}) \leq u(h,0)$ *and* $\phi(h) = 0$

The second polar case is the one where the cost of tax evasion is more convex than the probability of detection, i.e. the marginal cost of tax evasion is increasing faster than the probability of tax evasion decreases. Then, there exists a unique optimal level of tax evasion. In particular, if the marginal impact of tax evasion on the probability of detection is large enough, it is optimal to fully tax evade. Namely, one has the following proposition.

Proposition 4. *If c is such that for every* $\beta \in [0,\overline{\beta}]$, $-\pi_x''(h,\beta) < c''(\beta)$ *then there exists a unique solution* $\phi(h)$, *to the problem* $\max_{\beta\in[0,\overline{\beta}]}\ u(h,\beta)$ *and one has:*

- *If* $c'(\overline{\beta}) + \pi_x'(\overline{\beta}) \leq 0$, *then* $\phi(h) = \overline{\beta}$
- *If* $\pi_x'(0) + c'(0) \geq 0$, *then* $\phi(h) = 0$
- *If* $\pi_x'(0) + c'(0) \leq 0$ *and* $c'(\overline{\beta}) + \pi_x'(\overline{\beta}) \geq 0$, *then there exists a unique* $\tilde{\beta} \in [0,\overline{\beta}]$ *such that* $\phi(h) = \tilde{\beta}$

5.5 Strategic deterrence

Tax evaders have an incentive to increase their tax evasion intensity. However, these incentives can be mitigated by the cost of tax evasion. The most intuitive cost function is one that increases with respect to the intensity of tax evasion and that shows decreasing marginal costs of tax evasion. That is, the most plausible form of the cost function given a tax intensity is for the function to be concave. This cost function has many potential drivers, such as direct costs of tax evasion services, liquidity costs related to reduced availability of funds, and psychological and reputation costs in the event of detection. Building on Proposition 3, one can provide a simple characterization of the social planner's equilibrium strategy in the case where c is concave.

Proposition 5. *Assume the cost function c is concave. If* h^* *is a solution to* $\mathcal{S}_{\nu,\overline{\beta}}$ *then* $(\phi(h^*), h^*)$ *is a Stackelberg equilibrium of the tax evasion game.*

Hence, in the case where the cost is concave, it suffices to focus on the behavior of the social planner in a setting where the tax evader fully tax evades. This will be our focus for the remaining of this section.

Remark 5. *For an arbitrary cost function, strategic interactions become more complex and the Stackelberg equilibrium can hardly be characterized analytically. A meaningful proxy of the optimal behavior of the social planner can nevertheless be characterized by taking the propensity to tax evade as given, i.e. by solving the problem $\mathcal{S}_{\nu,\beta}$ as done below.*

In this setting, a fundamental remark is that the problem $\mathcal{S}_{\nu,\beta}$ is equivalent to finding the subgraph of G with ν links for which the sum of Bonachich centralities is maximal. This objective function is clearly supermodular because the number of new paths obtained by the addition of a link to a subgraph is an increasing function of the subgraph. Hence our problem amounts to the maximization of a supermodular function under cardinality constraints, which is known to be NP-hard in general (see e.g Nagano et al. (2011)). Nevertheless, one can characterize analytically the solutions for some particular cases of interest.

- If the intensity of tax evasion β is small enough and the ν links with the largest weight in G can be unambiguously identified, then the social planner can focus on the first order connections in the network and simply target the links of G with the largest weight. Namely, one has:

  Proposition 6. *Assume the ν links with the largest weight in G can be unambiguously identified, i.e. there exists $\mathcal{L}_\nu(G)$ such that $|\mathcal{L}_\nu(G)| = \nu$ and for all $(i,j) \in \mathcal{L}_\nu(G)$ and all $(k,l) \notin \mathcal{L}_\nu(G)$, $g_{i,j} > g_{k,l}$. Then, for β small enough, a solution h^* to $\mathcal{S}_{\nu,\beta}$ is such that*

  $$h^*_{i,j} = \begin{cases} 1 & \text{if } (i,j) \in \mathcal{L}_\nu(G) \\ 0 & \text{otherwise} \end{cases}$$

- If the network G is unweighted and complete, i.e. all tax-evasion paths are equally likely *à priori*, the problem of the social planner amounts to finding from the set of networks with N nodes and ν links, the one for which the sum of Bonachich centralities is maximal. For small β, this problem is investigated in detail by Belhaj et al. (2016), building on Ábrego et al. (2009). Namely, one has:

  Proposition 7. *Assume for all $(i,j) \in N \times N$, $g_{i,j} = 1$. Then, for β small enough a solution h^* to $\mathcal{S}_{\nu,\beta}$ is either a quasi-star or a quasi-complete network. Moreover,*

  – *If $\nu \leq \dfrac{n(n-1)}{2} - \dfrac{n}{2}$, then $h^* = QS(n,\nu)$*

  – *If $\nu \geq \dfrac{n(n-1)}{2} + \dfrac{n}{2}$, then $h^* = QC(n,\nu)$*

- If the network G is unweighted and complete and β is large (i.e. β tends towards $1/\mu_1(G)$), *Lemma 2* in Corbo et al. (2006) shows that maximizing the sum of Bonacich centrality is equivalent to the well-known problem in graph theory of finding the graph with a given number of nodes and vertices that has maximal index (see for example Chang and Tam (2011)). A long-standing conjecture on that problem is that its solutions are either quasi-complete or quasi-star graphs (see Aouchiche et al. (2008) and Cvetkovic et al. (1997) for solutions in some specific cases). In particular, according to *Proposition 1* in Corbo et al. (2006), for n large enough and $n \leq \nu \leq 2n-2$, one has $h^* = QS(n,\nu)$.

This set of results emphasizes that the optimal policy for a social planner who aims at deterring tax evasion depends on the structure of the network and on the level of influence he can exert. If his influence potential is low, i.e. he can impact a limited number of links, he shall aim at forming quasi-star structure, that is, isolate tax havens one after the other. If his level of influence is relatively large, then he shall aim at forming quasi-complete structures, i.e. try to dismantle connections within the core of the network.

Rank	Link	Rank	Link
1	(PMA,BAH)	11	(PMA,GTM)
2	(PMA,BVI)	12	(PMA,USA)
3	(PMA,SEY)	13	(PMA,COL)
4	(SEY,SAM)	14	(PMA,ARE)
5	(NIU,BAH)	15	(PMA,VEN)
6	(SEY,NIU)	16	(ANG,SAM)
7	(BVI,ANG)	17	(BAH,NEV)
8	(PMA,CHE)	18	(BAH,CHE)
9	(PMA,LUX)	19	(PMA,MCO)
10	(PMA,ECU)	20	(PMA,BRA)

Table 8: Top target links for the social planner inferred from a greedy algorithm for the maximization of the global detection probability $\pi_{\tilde{e}}(\beta, :)$ over the inter-temporal weighted network. The weights have been assigned proportionally to the number of months, within the period 1996-2015, in which at least one offshore entity was created on the corresponding link. The results are identical for every value of β in $\{0.05, 0.1, 0.15, 0.25\}$.

In the case of arbitrary networks and propensity to evade β, the problem of the social planner is NP-hard, as stated above. Nevertheless, one can obtain (weak) approximations of the optimal policy through the greedy algorithm, which sequentially adds to the social planner's strategy the links with the largest marginal contribution (see Kempe et al. (2003) for a detailed description of a similar algorithm and Sviridenko et al. (2017) for approximation bounds). Applying this approach to the global (inter-temporal) tax-evasion network inferred in Section 3, one can obtain an approximation of the optimal strategy of the social planner through numerical simulations whose results are reported in Table 8. The simulations first show that the optimal strategy is independent of β in our context. Moreover, the optimal strategy closely approximates a quasi-star centered around Panama (PMA), which is the node with the largest Bonacich and eigenvector centrality in our framework (when accounting for both incoming and outgoing links). The strategy targets in priority: (i) links with core tax havens, notably Bahamas (BAH) and British Virgin Islands (BVI); (ii) links with non-core tax havens, notably Switzerland (CHE), Luxembourg (LUX) and United Arab Emirates (ARE); (iii) links with large tax-evading jurisdictions: USA, Brazil (BRA). These numerical results are consistent with the analytical ones reported above. In particular, they confirm numerically that the optimal strategy from the point of view of the social planner is to first form a quasi-star surrounding the most central tax haven. This key target is Panama according to our results. This finding might however be biased by our usage of the Panama Papers.

6 Conclusions

In this paper, we have built upon the 'Panama Papers' dataset to provide a network analysis of global tax evasion. Our analysis first highlights that the global tax-evasion network, far from being a random collection of bilateral links, has a hierarchical organization characterized by a core-periphery structure and a fat-tail degree distribution. Moreover, the dynamics of network formation are consistent with a preferential-attachment process, which is characteristic of complex networks. Our paper highlights how policy-makers shall account for these structural features for mitigating tax evasion.

First, taking advantage of the natural experiment induced by the G20 2009 crackdown on tax havens, we have investigated the impacts of fiscal treaties on the formation of tax-evasion links. Our results show that efficient treaties are those that contain an information exchange clause and that link tax-havens to "non-haven" countries. Second, we investigate optimal deterrence strategies for a social-planner facing a strategic tax-evader in a Stackelberg competition. The problem turns out to be mathematically equivalent to that of finding the subgraph of a network with maximal Bonacich centrality. This problem has recently received a lot of attention in network and graph theory. We provide both analytical and numerical results that show that an efficient strategy for the social planner is to first from a "barrier" of tax treaties surrounding the most central tax havens (i.e. form a quasi-star network of treaties) and then systematically extend the set of treaties to eventually cover the whole set of countries (i.e. form a quasi-complete network).

The Panama Papers provide a unique opportunity to gain a better understanding of the mechanics of tax evasion. Their usage nevertheless implies some limitations to our analysis. First, we must assume that the activities of Mossack-Fonseca are representative of those of the offshore financial industry. Second, the Panama Papers do not allow to track ownership chains across multiple jurisdictions. Our analysis thus relies on the assumption that tax evasion is "Markovian", i.e. the paths followed by funds leaving a country are independent of their origin.

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Appendix A. Proofs of Propositions

Proof of Proposition 2. We compute the successive derivatives of π_x with respect to β (we omit the variable h to simplify notations)

- Basic calculus shows that the first derivative is given by:

  $$\pi_x'(\beta) = (1-\beta)\tilde{e}^\top (I-\beta K(h))^{-1} K\xi - \tilde{e}^\top \xi$$

  where $\xi := (I-\beta K(h))^{-1}x \geq 0$.

  This yields successively:

  $$\pi_x'(\beta) = \tilde{e}^\top[(1-\beta)(I-\beta K(h))^{-1}K(h) - I]\xi$$
  $$\pi_x'(\beta) = \tilde{e}^\top[(1-\beta)(I-\beta K(h))^{-1}K(h) - I]\xi$$
  $$\pi_x'(\beta) = (1-\beta)(\sum_{m=0}^{+\infty} \beta^m \tilde{e}^\top K(h)^{m+1}\xi) - \tilde{e}^\top\xi$$

  Now, given that G is column-stochastic and for all $i,j \in N$, $h_{i,j} \leq 1$, one clearly has for all $m \in \mathbb{N}$,

  $$\tilde{e}^\top K^{m+1}\xi \leq \tilde{e}^\top\xi.$$

  Thus, one has:

  $$\pi_x'(\beta) \leq (1-\beta)(\sum_{m=0}^{+\infty} \beta^m \tilde{e}^\top\xi) - \tilde{e}^\top\xi = [(1-\beta)\sum_{m=0}^{+\infty}\beta^m - 1]\tilde{e}^\top\xi \leq 0$$

  Hence π_x is decreasing with respect to β.

- Basic calculus then shows that the second derivative of π_x is given by

  $$\pi_x''(\beta) = 2(1-\beta)\tilde{e}^\top(I-tK(h))^{-1}K(h)\zeta - 2\tilde{e}^\top\zeta$$

  where $\zeta := (I-\beta K(h))^{-1}K(h)(I-\beta K(h))^{-1}\cdot x \geq 0$ Hence, similar arguments as above imply that $\pi_x''(\beta) \leq 0$ and thus that π_x is concave.

□

Proof of Proposition 3. The proof is straightforward given the convexity of u. □

Proof of Proposition 4. If c is such that for every $\beta \in [0,\overline{\beta}]$, $-\pi_x''(\beta) < c''(\beta)$ then u is strictly concave and thus $\max_{\beta\in[0,\overline{\beta}]} u(\beta)$ clearly has a unique solution. Then

- If $c'(\overline{\beta}) + \pi_x'(\overline{\beta}) \leq 0$, then $u'(\overline{\beta}) \geq 0$ and given u' is decreasing, one has $u'(\beta) \geq 0$ for all $\beta \in [0,\overline{\beta}]$. Thus u is increasing over $[0,\overline{\beta}]$ and $\overline{\beta} = \hat{E}\text{argmax}_{\beta\in[0,\overline{\beta}]} u(\beta)$.
- If $\pi_x'(0) + c'(0) \geq 0$, then $u'(0) \leq 0$ and given u' is decreasing, one has $u'(\beta) \leq 0$ for all $\beta \in [0,\overline{\beta}]$. Thus u is decreasing over $[0,\overline{\beta}]$ and $0 = \hat{E}\text{argmax}_{\beta\in[0,\overline{\beta}]} u(\beta)$.

- If If $\pi'_x(0) + c'(0) < 0$ and $c'(\overline{\beta}) + \pi'_x(\overline{\beta}) > 0$, then $u'(0) > 0$ and $u'(\overline{\beta}) < 0$, thus the strict concavity of u implies there exists a unique $\tilde{\beta} \in [0, \overline{\beta}]$ such that $u'(\tilde{\beta}) = 0$ and $\tilde{\beta} = \hat{E}\text{argmax}_{\beta \in [0,\overline{\beta}]}\, u(\beta)$.

□

Proof of Proposition 5. Assume h^* is a solution to $\mathcal{S}_{\nu,\overline{\beta}}$. On the one hand, one has $u(0, h) = -1 - c(0)$, which is independent of h. On the other hand, one has $u(\overline{\beta}, h) = -\pi(\overline{\beta}, h) - c(\overline{\beta})$. Thus $u(\overline{\beta}, h)$ is clearly minimal for $h = h^*$.

Recalling $\beta^* := \phi(h^*)$, one then has according to Proposition 3:

- Either $\phi(h^*) = \overline{\beta}$ and $u(\overline{\beta}, h^*) \geq u(0)$. Then, for every $h \neq h^*$, one has has $u(\overline{\beta}, h) \geq u(0)$ and thus $\phi(h) = \overline{\beta}$. The fact that h^* is a solution to $\mathcal{S}_{\nu,\overline{\beta}}$ then implies that h^* is a solution to $\mathcal{S}'_k$ and hence that $(\phi(h^*), h^*)$ is a Stackelberg equilibrium of the tax evasion game.
- Otherwise $\phi(h^*) = 0$ and thus $\pi(\phi(h^*), h^*) = 1$. As for all h, one has by construction $\pi(\phi(h), h) \leq 1$, h^* then is a solution to $\mathcal{S}'_k$ and $(\phi(h^*), h^*)$ is a Stackelberg equilibrium of the tax evasion game.

□

Appendix B. Summary of jurisdictions

Table 9: Summary of jurisdictions

Code	Jurisdiction	Status
ALB	Albania	
ASM	American Samoa	
AND	Andorra	H
AGO	Angola	
ANG	Anguilla	H
ATG	Antigua and Barbuda	H
ARG	Argentina	
ABW	Aruba	
AUS	Australia	
AUT	Austria	
AZE	Azerbaijan	
BAH	Bahamas	H
BHR	Bahrain	H
BGD	Bangladesh	
BRB	Barbados	H
BLR	Belarus	
BEL	Belgium	
BLZ	Belize	H
BMU	Bermuda	H
BOL	Bolivia	
BWA	Botswana	
BRA	Brazil	
BVI	British Virgin Islands	H
BRN	Brunei	
BGR	Bulgaria	
CMR	Cameroon	
CAN	Canada	
CYM	Cayman Islands	H
CAF	Central African Republic	
TCD	Chad	
CHL	Chile	
CHN	China	
COL	Colombia	
COK	Cook Islands	H
CRI	Costa Rica	
CIV	Cote d'Ivoire	
HRV	Croatia	
CUB	Cuba	
CUW	Curacao	H
CYP	Cyprus	H
CZE	Czech Republic	
DNK	Denmark	
DJI	Djibouti	
DMA	Dominica	H
DOM	Dominican Republic	
ECU	Ecuador	
EGY	Egypt	
SLV	El Salvador	
EST	Estonia	
FIN	Finland	
FRA	France	
GEO	Georgia	
DEU	Germany	
GHA	Ghana	
GIB	Gibraltar	H
GRC	Greece	
GUM	Guam	
GTM	Guatemala	
GGY	Guernsey	H
HTI	Haiti	
HND	Honduras	
HKG	Hong Kong	H
HUN	Hungary	
ISL	Iceland	
IND	India	
IDN	Indonesia	
IRN	Iran	
IRL	Ireland	H
IOM	Isle Of Man	H
ISR	Israel	
ITA	Italy	
JAM	Jamaica	
JPN	Japan	
JSY	Jersey	H
JOR	Jordan	H
KAZ	Kazakhstan	

Note 1: Jurisdictions ordered alphabetically by name.
Note 2: The status of 'haven (H)' is defined in the sense of Dharmapala and Hines Jr. (2009).

Code	Jurisdiction	Status
KEN	Kenya	
KWT	Kuwait	
LVA	Latvia	
LBN	Lebanon	H
LSO	Lesotho	
LBY	Libya	
LIE	Liechtenstein	H
LTU	Lithuania	
LUX	Luxembourg	H
MAC	Macao	H
MKD	Macedonia	
MYS	Malaysia	
MLI	Mali	
MLT	Malta	H
MUS	Mauritius	
MEX	Mexico	
MDA	Moldova	
MCO	Monaco	H
MAR	Morocco	
MOZ	Mozambique	
NAM	Namibia	
NLD	Netherlands	
NEV	Nevada	
NZL	New Zealand	
NIC	Nicaragua	
NGA	Nigeria	
NIU	Niue	
NOR	Norway	
OMN	Oman	
PMA	Panama	H
PRY	Paraguay	
PER	Peru	
PHL	Philippines	
POL	Poland	
PRT	Portugal	
PRI	Puerto Rico	
QAT	Qatar	
ROU	Romania	
RUS	Russia	

Code	Jurisdiction	Status
KNA	Saint Kitts and Nevis	H
LCA	Saint Lucia	H
VCT	Saint Vincent & Grenadines	H
SAM	Samoa	
SAU	Saudi Arabia	
SEN	Senegal	
SEY	Seychelles	
SGP	Singapore	H
SXM	Sint Maarten (Dutch part)	H
SVK	Slovakia	
SVN	Slovenia	
ZAF	South Africa	
KOR	South Korea	
ESP	Spain	
LKA	Sri Lanka	
SWE	Sweden	
CHE	Switzerland	H
SYR	Syria	
TWN	Taiwan	
TZA	Tanzania	
THA	Thailand	
TTO	Trinidad and Tobago	
TUN	Tunisia	
TUR	Turkey	
TCA	Turks and Caicos Islands	H
VIR	U.S. Virgin Islands	
UKR	Ukraine	
ARE	United Arab Emirates	
GBR	United Kingdom	
USA	United States	
URY	Uruguay	
UZB	Uzbekistan	
VUT	Vanuatu	H
VEN	Venezuela	
VNM	Viet Nam	
WYO	Wyoming	
YEM	Yemen	
ZMB	Zambia	
ZWE	Zimbabwe	

Note 1: Jurisdictions ordered alphabetically by name.
Note 2: The status of 'haven (H)' is defined in the sense of Dharmapala and Hines Jr. (2009).

Appendix C. Key characteristics of tax havens

Tax havens may be understood as countries or jurisdictions that have either no-tax or very low tax regimes, particularly for corporate revenues and personal income. Moreover, such nations tend not to comply with international authorities regarding the exchange of tax information. Also, they account for a lack of transparency and a heightened sense of protectionism for the financial information of the people registered inside their jurisdiction. Fiscal paradises benefit directly from having companies registered inside their domains even if the tax levied on them is low; fees are collected upon registration, licensing and annual renewals.

An International Business Corporation (IBC) may be considered an offshore legal entity registered as a company in a jurisdiction where it is exempted of paying local corporate taxes and stamp duties (taxes levied on legal documents), not required to appoint local directors, and is allowed to preserve the confidentiality of the beneficial proprietor of the company. Some jurisdictions, as the case for Luxembourg, waive the withholding tax, or retention tax, levied by government to the payer of employment income, dividends and interests.

The purpose of the current subsection is to briefly explore the characteristics of each tax haven employed by Mossack-Fonseca and understand why these jurisdictions are usually considered fiscal paradises, utilizing recent information gathered from Gleeson (2018).

Niue: 1,470 inhabitans, small island in the Pacific, GDP of 15 million USD per year, employs the New Zealand Dollar. This country has a good political stability and a British legal system. International Business Companies located here have no tax duties and do not need to pay for offshore profits. IBC's are not required to file annual reports, require a single director (which may well be overseas) and demand in return a simple yearly fee of 150 USD. Nonetheless, Niue is not a 'credible' fiscal paradise as it is currently a nation that receives aid from New Zealand.

Seychelles: 92,000 inhabitants, GDP of 2.6 billion USD, Indian Ocean island. Seychelles does not tax income nor profits from financial entities. Corporations may be established in less than 24 hours while paying only an annual fee of 100 USD, regardless of the corporation's size. Identities and personal details of the beneficial owners are not recorded publicly and companies are exempt from stamp duties on all transactions.

Costa Rica: It is a Spanish speaking, non-island, country with 4.9 million inhabitants and a 57 billion USD annual GDP and its own currency (Colon). Costa Rica offers a 100% exemption of corporate income tax for eight-years on newly registered companies.

Belize: 387,000 inhabitants, 1.8 billion USD annual GDP, Belize dollar, English-speaking, non-island, British legal origins.A license to operate in Belize without any reporting duties may be registered in matter of hours. Belize does not charge taxes on earning from abroad, including dividends, capital gains, revenues and interests.

Hong Kong: A small country with a 412 billion USD annual GDP and a population of 7.3 million. Hong Kong taxes income source-based and not residential-based, therefore they would only tax income generated in Hong Kong and not the one produced elsewhere. The country itself is then an ideal node for profit shifting and re-wiring financial activities.This property might have placed Hong Kong as the middle-man of a large fraction of financial intermediation.

New Zealand (Cook Islands): Cook Islands are in free association with New Zealand. Fifteen islands with a GDP of 292 million USD and a population of about 13,000 people. Cook Islands are know for generally disregarding international courts, no taxes on offshore profits and very strict laws restricting international authorities to gain access to any type of financial information; moreover, no registry on any company may be obtained by international law enforces without the consent of the company itself (unless there is a criminal offense pending). The requirements to open an account are one director and one shareholder which may have their meetings anywhere in the world, without submitting any reports and simply paying an annual fee of 300 USD.

Luxembourg and Switzerland: Holding companies are worldwide known financial institutions incorporated in Luxembourg and Switzerland with subsidiaries in other jurisdictions. Such corporations are allowed to carry on offshore activities exempted from paying taxes on capital gains and on dividends. Moreover, there are no withholding taxes applied whenever the beneficiary is incorporated inside the European Union. Lastly, the names of these corporate beneficiary owners are not required to be declared.

Bahrain: Arabic-speaking country with 1.4 million persons and 48.5 billion USD annual GDP. This jurisdiction does not have any tax system at all, meaning that there is no legislation, no auditors and no tax reports. Therefore, Bahrain does not tax inheritances, corporate profits, income from renting real estate nor capital gains.

Andorra: Landlocked nation with 77,000 persons and a GDP of 3.3 billion USD; this country does not tax wealth, capital gains, inheritance nor gifts. Prior to 2015, there was no income tax, however a minor levy on income was installed in 2015.

Cyprus: This Mediterranean island of 1.1 million people and a GDP of 30 billion USD commenced to tax corporations at a rate of 2.5% since 2013 and joined the OECD Automatic Exchange of Financial Information in Tax Matters in 2017, which took away the island's tax haven status.

United Arab Emirates (Dubai): With a population of 2.8 million and a GDP of 360 billion USD, this jurisdiction does not account for any type of taxes: corporate, withholding or personal. Income is taxed nominally at a zero percent tax rate.

Barbados: An English-speaking, British legal system, Barbadian dollar user, Caribbean island of 277,821 people and 4.6 billion USD gdp, Barbados is a well regulated tax haven with very low taxes on profits of less than 2.5%; however, capital gains and dividends are exempt from taxes.

Bahamas: This collection of islands with its own currency, Bahamian dollar, are inhabited by 372 thousand people and possess an annual GDP of 7.4 billion USD. The islands does not levies corporate taxes, capital gains, income tax nor wealth tax; however, there are license fees, stamp duties and property taxes.

United Kingdom (Bermuda, Cayman Islands, Gibraltar, Isle of Man, Jersey, Anguilla and British Virgin Islands) All the following are either Crown dependencies or British Overseas Territories or with their own currency, English-speaking, with British legal origins, very small population and a considerably high GDP per capita.

Bermuda: GDP of 5.6 billion USD per year and a population of 65 thousand citizens. This jurisdiction, which employs minimal standards of regulations and business laws, hosts 400 international insurance companies and is a popular tax destination; moreover, there are no income nor corporate taxes in this island.

Cayman Islands: 3.3 billion USD annual GDP with a population of 56 thousand people, yet manages over 36 billion USD on assets. Regarded as one of the most popular tax havens, hosting offices for 40 of the 50 largest banks in the world, the Cayman Islands do not collect taxes on income, capital gains, nor on wealth. Over 10 thousand hedge funds have been registered inside this jurisdiction.

Gibraltar: 32,000 inhabitants and 2 billion USD of annual GDP, Gibraltar is a low tax haven which also benefits from tourism. Irrespectively if the income is domestic or offshore, corporations are taxed at a 10% rate, whereas capital gains, inheritance, wealth, sales and estates are not taxed. Estimates sustain Gibraltar earns more than 100 million pounds each year for concept of corporate taxation. Moreover, Gibraltar is very jealous of its secrecy and places itself as a well-reputed tax destination.

Isle of Man: A self-governing Crown dependency with 85,000 persons and a 4.5 billion USD annual economy, this island has no wealth, capital gains not inheritance tax. Individual income tax is capped and never higher than 20%, there are no stamp duties and there is a zero percent nominal corporate tax rate (except for rental income and domestic banking profits, which are taxed at a 10% rate).

Jersey: A UK Crown dependency with 6 billion USD annual GDP and 100 thousand people, Jersey has zero corporate tax on all non-financial institutions and a 10% tax rate on the former; utilities are taxed a 20% rate. Recently, Jersey agreed to share information about financial activity with the US, UK and the EU.

Anguilla: 311 million USD annual GDP economy and a population shy of 15,000. The island does not tax individual or corporate profits, capital gains nor estate. However, in 2011 they installed a temporary 3% income tax to stabilize the nation's deficit.

British Virgin Islands: 28,000 inhabitants and an annual GDP of 853 million USD follows a nominal tax rate of 0% over income. Moreover, no tax is levied on capital gains, sales, value added, profit, inheritance, estate, gifts nor corporate tax.

Liechtenstein: Recurring to the Swiss franc, this landlocked European country with less than 38,000 inhabitants and a 5.3 billion USD annual GDP is one of the richest countries per capita in the world. Entities incorporated in this jurisdiction pay no income taxes, so long they carry their commercial and economic enterprises elsewhere, limiting the domestic activities of institutions to manage assets and investments. A nominal annual tax of 0.1% is levied on the capital reserves of companies domiciled in the country.

United States (Delaware, Wyoming and Nevada): Delaware has no state taxes on income, corporate or sales profits. Any person, American or not, may operate anonymously through a listing agent in Delaware, paying about 350 USD on annual license and fees, without having to pay taxes on any earnings, inheritance nor capital gains. Nevada does not have an IRS information sharing agreement, does not levy state taxes, accounts for extreme secrecy, and asks for minimal reporting and disclosing, where stockholders' names are not on public record.

Uruguay: Employing the Uruguayan peso, this Latin American country of 3.5 million inhabitants accounts for an annual GDP of 78 billion USD. Although there is 25% corporate tax, it is only levied on income generated inside the country and all the financial flows brought from abroad are not taxed. Moreover, the jurisdiction holds several free trade zones where entities are exempted to pay local taxes as well. Lastly, Uruguay holds a high standard of bank secrecy.

Panama: This Latin American country with 4 million inhabitants and an annual GDP of 63 billion USD, holding its own currency Balboa, jumped to fame after the leak of 11.5 million very sensible financial documents in 2015. Panama has a corporate tax of 25% for local enterprises, while it offers a full tax exemption for offshore entities that carry out the entirety of their economic activities outside Panama. This jurisdiction has a strict financial secrecy, with no limits on currency exchanges and no requirement for corporate shareholders to publicly record their identities.