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The indirect costs of corporate tax avoidance exacerbate cross-country inequality

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Abstract: Corporate tax avoidance hampers domestic revenue mobilization and, with it, the development of lower- and middle-income countries. While a wide range of studies has shed light on the magnitude of profit shifting by multinational corporations, the indirect costs of this behaviour is underexplored. These indirect costs are likely to be skewed based on a country's level of income. We hypothesize that developed countries tend to recover a larger part of corporate tax revenue losses (primary effects or direct costs) via capital gains and dividend taxes on corporate investors (secondary effects). Furthermore, developed countries can offset tax losses by borrowing in financial markets at very low interest rates (tertiary effect or, together with secondary effects, indirect costs). In this paper, we introduce a dynamical model that includes not only corporate tax revenue losses but also tax revenue collected from capital gains and dividend taxes, as well as government borrowing costs. We use country-by-country reporting data on the operations of multinational corporations to estimate profit shifting, alternative operationalizations of the location of investors to proxy the tax revenues from capital gains and dividend taxes, and yields on government bonds to measure the cost of borrowing. Our results show that when these indirect costs are included, the total cost of profit shifting for developing countries increases significantly, while some developed countries can often offset or recover the majority of the direct costs of profit shifting. The ability of the latter to do this is, however, uneven with, for example, most European countries losing revenues from profit shifting even after indirect effects are taken into account. Only a handful of other countries actually appear to profit from profit shifting—and by an amount that is far smaller, in relation to gross domestic product, than the losses suffered by others.

Key words: profit shifting, corporate tax avoidance, tax havens, multinational corporations, indirect costs, inequality

JEL classification: F36, F65, G28, H26, H87

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1 Introduction

The literature on corporate tax avoidance has established that profit shifting to tax havens is a widespread phenomenon: between US$500 billion and US$1 trillion of corporate profits are estimated to be shifted annually to low-tax jurisdictions (Tørsløv et al. 2020; Garcia-Bernardo and Janský 2021). Although the evidence is still mixed, developing countries seem to be affected more (Johannesen et al. 2020; Garcia-Bernardo and Janský 2021; Hearson 2018; Janský and Palanský 2019). Johannesen et al. (2020) argue that countries at lower levels of economic development are more exposed to cross-border profit shifting at both the extensive margin, with companies' reported profits being more likely to be close to zero, and the intensive margin, with companies' profits being more sensitive to foreign tax rates. Evidence has indicated that intra-firm financing, in particular, tends to be more sensitive to tax rates in developing countries (Fuest et al. 2011), with negative implications for their fiscal capacity.

Crucially, this body of existing research only covers the flow of corporate profits into tax havens, which we call direct costs or primary effects. However, corporate profits shifted into tax havens do not remain there indefinitely but rather trickle up to investors via dividends, interest on corporate bonds, and capital gains (secondary effects). Consequently, the governments of countries where these investors are tax residents can collect capital gains and dividend taxes on the proceeds of shifted corporate profits and thereby partly offset the primary effects of profit shifting. Some governments, moreover, are able to borrow at much lower interest rates than others (tertiary effects, or, together with secondary effects, indirect costs). What this means is that the effective long-term fiscal cost (total effects or total costs) of the same amount of immediate revenue loss will actually be very different for different countries.

In this paper, we show that these secondary and tertiary effects of profit shifting, which to the best of the authors' knowledge have not been previously explored, have crucial implications for the international distributional impacts of profit shifting. The bulk of investors in multinational corporations (MNCs) are located in developed countries, which implies that taxes collected on dividends and capital gains are concentrated in these countries. Furthermore, what matters is not only the residence or citizenship of corporate investors but also the ability of their respective home governments to track and tax their income and assets. Like the geographic location of corporate investors, the ability of governments to track and tax investor income is skewed in favour of developed countries—and, in particular, the United States via the Foreign Account Tax Compliance Act (FATCA), which requires most major non-US financial institutions worldwide to find and report the assets and identity of clients with a potential connection to the United States. Developed countries can thus potentially offset a significant part of the direct corporate tax revenue losses caused by profit shifting by collecting increased investor-level tax revenues on dividends, interest, and capital gains, which will be directly boosted by higher rates of global corporate tax avoidance. Developing countries, in contrast, are generally unlikely to recover any significant revenues this way.

Developing countries also face an additional disadvantage with respect to the long term, as opposed to just the immediate costs of profit shifting: their cost of borrowing is higher. While developed countries can issue debt to offset tax losses at extremely low or even negative interest rates, developing countries typically pay higher interest rates. This causes the costs of their tax losses to exponentially compound over time after they are incurred. Germany, which loses around US$24 billion in taxes because of profit shifting (3 per cent of their total tax revenue, based on estimates from Garcia-Bernardo and Janský 2021), can issue 20-year bonds with a -0.03 per cent yield to pay for public services. In contrast, Mexico, which loses around US$8 billion because of profit shifting (6 per cent of their total tax revenue), can only issue bonds with a 7.1 per cent yield. We benchmark these borrowing costs in relation to the combination of the rate of inflation and the rate of gross domestic product (GDP) growth (i.e. nominal GDP growth). Ultimately, these uneven costs of government borrowing determine whether or not a given country can simply grow out of any increases in debt issued to offset tax revenue shortfalls. Some

developing countries have been growing faster than their sovereign borrowing interest rates (e.g., China). Other developing countries have not and are thus more likely to be forced to offset tax losses by making socially, developmentally, and politically painful choices regarding taxation and spending. Such painful choices in turn raise the spectre of further negative long-term developmental as well as fiscal multiplier effects because of the potential of austerity programmes to further reduce the rate of GDP growth.

In this paper, we quantify the total costs of corporate profit shifting for different countries by taking into account these various direct and indirect net fiscal costs. We use a system dynamics model that allows us to estimate the total cost of profit shifting for developed and developing countries over time. We find that the geographically unequal distribution and taxation of shareholders, and the unequal cost of sovereign borrowing, produces stark differences in the total impacts of profit shifting on developed as opposed to developing countries. We estimate that developing countries lose on average 36 per cent more than previously estimated, while for most developed countries, the inclusion of indirect profit shifting effects leads to significantly lower estimates of the overall net fiscal cost of profit shifting. Crucially, however, the international distribution of net costs and benefits is also extremely uneven within each group of countries. Some developing countries suffer far more severe losses than others. The large developed country tax havens (particularly the United Kingdom, Switzerland, Singapore, and the Netherlands) appear to extract a net fiscal profit from global corporate tax avoidance, even while the majority of developed countries incur net fiscal losses. Meanwhile, the United States and China appear to be structurally indifferent from a domestic fiscal standpoint to the operation of the tax haven system, notwithstanding the fact that the system itself is above all dominated by the activities of American and Chinese firms.

We contribute to the existing literature on corporate tax avoidance by updating and improving the estimation of profit shifting and its total costs. While recent studies provide sophisticated estimates of profit shifting, the coverage of developing countries is usually extremely poor. Moreover, studies on profit shifting have so far ignored dividend and capital gains taxation (Amatong 1968) and the knock-on costs of government borrowing (Gelos et al. 2011). Accounting for these secondary and tertiary effects of profit shifting is crucial to our our understanding of how developing versus developed countries are differentially affected by profit shifting.

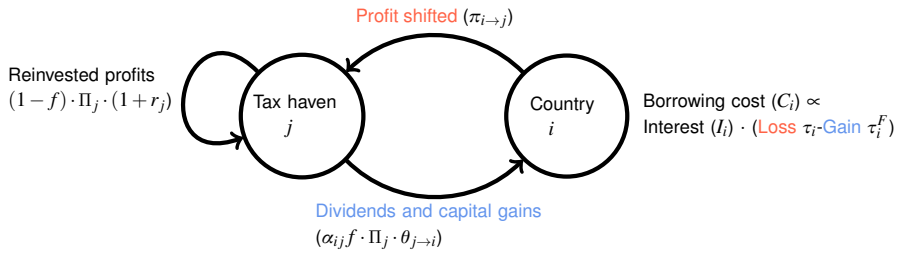
By showing that the indirect cost of profit shifting can be orders of magnitude higher for developing countries than for developed countries, we show that the current international tax system may be hindering the achievement of one of the goals of the 2030 Agenda for Sustainable Development: to 'strengthen domestic resource mobilisation, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection'. If developing countries are systematically disadvantaged at policy negotiations (Christensen et al. 2020) and in leading reform proposals (Picciotto et al. 2021), the documented inequalities are bound to persist. Notably, our results show that the majority of developed countries actually also have clear incentives, on balance, to make a common cause on this issue with developing countries, even if the severity of the net losses they incur is relatively less acute. Moreover, while there are a few countries that appear to reap an overall tax surplus from the current system, most of these only derive fiscal benefits on the order of hundredths to few tenths of a per cent of GDP, which are probably outweighed by the complex national external costs that result from the hampering of development in lower- and middle-income countries.

The remainder of this paper is structured as follows. In Section 2 we introduce the dynamical model that includes indirect costs of profit shifting, describe how we operationalize its parameters and collect the required data, and analytically estimate the long-term (10-year) net costs generated by a single year of present-day profit shifting. Section 3 presents the results, comparing the primary, secondary, and tertiary effects for countries at different levels of economic development. We discuss the distributional implications of this new understanding of the effects of corporate profit shifting to tax havens. Section 4 concludes.

2 Methods and data

2.1 Model

Figure 1: Depiction of the dynamical model



Note: as MNCs shift profits from country i to tax haven j ($\pi_{i\to j}$), this creates a tax revenue loss to country i, equal to the product of profits shifted and the tax rate in the country (τ_i). A fraction $(1-f)$ of the profits accumulated in the tax haven ($f\cdot\Pi_j$) are reinvested and grow with a rate of return r_j. The remaining share of profits, f, are distributed to the investors directly as dividends or interest or indirectly as stock buybacks. The tax revenue collected by country i will depend on the distributed profits ($f\cdot\Pi_j$), the share of investors who are tax residents in country i ($\theta_{j\to i}$), the fraction of those flows taxed by the authorities (α_{ij}), and the tax rate on capital gains and dividends (τ_i^F). If the tax revenue losses are higher than the tax revenue gains, we assume that country i borrows from financial markets to cover this net loss and will pay interest on this increased borrowing.
Source: authors' illustration.

We model the dynamics of the process depicted in Figure 1 with the following coupled equations. First, the payments made by a country at time t, $C_{i,t}$, depend on the interest paid and principal repaid. To be able to compare between countries, we normalize the cost by the GDP of the country.

$$C_{i,t+1} = C_{i,t} + \overbrace{b_{i,t}/GDP_{i,t}}^{\text{interest and principal payments}} . \tag{1}$$

Second, the total debt issued by a country to offset profit shifting, $B_{i,t}$, is determined by the corporate tax loss caused by the profit shifting net of (personal) tax gain caused by profit shifting. We assume the tax revenue gains to be equal to the product of the share f of profits in tax haven j paid to the shareholders, $f\Pi_j$, the fraction of shareholders in country i, $\theta_{j\to i}$, and the tax rate on capital gains, dividends, and interest in country i, τ_i^F. Moreover, we assume that only a certain percentage of those payments, α_{ij}, are actually collected by the authorities—for instance, because of corruption or tax evasion (Alstadsæter et al. 2019).

$$B_{i,t+1} = B_{i,t} + \overbrace{\pi_{i,t}\tau_i}^{\text{tax loss}} - \overbrace{\sum_j \left(\alpha_{ij} f \Pi_j \theta_{j\to i} \tau_i^F\right)}^{\text{tax gain}} + \overbrace{(B_{i,t}\cdot I_{i,t})}^{\text{interest}} - \overbrace{b_{i,t}}^{payment} . \tag{2}$$

The total cost for a country at time t is defined as the sum of the payment costs and the outstanding loans adjusted by GDP growth: $C_{i,t} + {}^{B_{i,t}}/_{GDP_i,t}$.

Finally, part of the profit stashed in tax haven j, Π_j, are reinvested—sometimes in government bonds (Pozsar 2018). The growth of Π_j depends on the profits not paid to shareholders and a rate of return or growth rate $r_{j,t}$.

$$\Pi_{j,t+1} = \underbrace{(1-f)}_{\text{profit not distributed}} \cdot(\Pi_{j,t} + \underbrace{\sum_i \pi_{i\to j,t}}_{\text{profits received}})\cdot \underbrace{(1+r_{j,t})}_{\text{rate of return}} . \tag{3}$$

Our model allows us to simulate the total costs of tax avoidance for any country over time. For this, we first assume that profit shifting takes place in only one year and simulate the subsequent compounding increase of costs over time that this sets in motion. We can then relax this assumption and assume that profit shifting takes place every year. For all other data variables, we use the current values of the data (e.g., interest rates as in 2021). For the total cost of profit shifting, we use the inflation and exchange rate adjusted values.

2.2 Data

Our model uses the following nine types of data, summarized in Table 1. (i) For the estimates of profit shifting (π), we use the method based on misalignment between profits and economic activity described by Garcia-Bernardo and Janský (2021). In this method, countries where companies report a higher share of profits than real economic activity are assumed to receive shifted profits. Real economic activity is operationalized using the location of employees (50 per cent weight) and wages (50 per cent weight). We compare the estimates of profit shifting with a baseline scenario where we assume that all countries suffer the same level of profit shifting. The baseline scenario allows us to disentangle the costs stemming from different levels of profit shifting, from the costs caused by the unequal distribution of shareholder and borrowing costs. (ii) For corporate income tax rates (τ), we use effective tax rates calculated from country-by-country reporting data, which are more consistent with tax rates from tax returns than other alternatives (Garcia-Bernardo et al. 2021). (iii) For capital gains and dividend tax (τ^F), we use the estimates developed by the OECD (Harding and Marten 2018) for a composition of 30 per cent dividends and 70 per cent capital gains, which is similar to the composition of gains found in the S&P500. Non-OECD countries are added manually from the International Bureau of Fiscal Documentation (IBFD). (iv) For interest rates (I), we average 10-year government bond yields in the period 2010–20 obtained from the Bond Historical Data report provided by World Government Bonds (2022), complemented with the International Financial Statistics published by IMF (2022) and the Rates & Bonds database published by Bloomberg (2022).

Table 1: Summary of the parameters in the model

Parameter	Value	Robustness
(i) $\pi_{i \to j}$: Profit shifting	Misalignment (Garcia-Bernardo and Janský 2021)	Uniform
(ii) τ: Corporate income tax rate	Effective tax rates (CBCR)	
(iii) τ^F: Tax rate on dividend and capital gains	For OECD countries: OECD report. All other countries IBFD 2020	
(iv) I: Interest rate	World Bond Market, IMF, and Bloomberg data on 10-year government bond yields	
(v) $\theta_{j \to i}$: Share of ownership	Calculated as the dot product between the profit→corporate and the corporate→investor matrices	Share of GDP
(vi) α: Share of evasion	Inversely proportional to GNI per capita, with a floor at 20%	Fixed at 0% and 25%
(vii) f: Share of profits distributed to shareholders	30% (dividend payout ratio)	
(viii) b: Share of total debt repaid	0 (but debt devaluates as the country grows)	
(ix) r: Rate of return on offshore wealth	6% (Guyton et al. 2020)	

Source: authors' compilation.

In addition to (v) corporate ownership, discussed in a separate section below, our model depends on the estimation of (vi) the share of tax evasion, α, which we identified with undisclosed offshore wealth.

Because state capacity to track and tax offshore wealth depends, in general, on economic resources, we model $\alpha = \frac{1-1.4GNIpc}{max(GNIpc)} = \frac{1-1.4GNIpc}{178{,}509}$, with a lower bound of 20 per cent. This sets the value of Denmark, Sweden, and Norway around the 25 per cent value found by Alstadsæter et al. (2019). As a robustness test, we also test the effects of a uniform 25 per cent tax evasion for all countries; (vii) the share of profits distributed to shareholder, f, which we set to the average dividend payout ratio of the S&P500 in the last 20 years (35 per cent); (viii) the share of the debt repaid, b, which we set equal to the interest paid + 5 percentage points. This allows debt to be eventually paid and can alternatively be interpreted as the devaluation of debt in relation to economy size as nominal GDP grows; and (ix) the rate of return on offshore wealth, r, which we set to 6 per cent, the empirical value found by Guyton et al. (2020).

2.3 Corporate ownership estimation

Our model depends on the estimation of (v) ownership of profits (θ). Our analysis seeks to determine 1) which countries' firms (at the group nationality level) are responsible for profit shifting in each tax haven and 2) the nationality of the shareholders that own each country's business groups. We estimate both of these on a bilaterally disaggregated basis, thus yielding a two-layered network of direct and indirect corporate and investor claims on the proceeds of profit shifting. This provides a full breakdown of the home countries of companies engaged in profit shifting in each tax haven and of the composition of the shareholder base by nationality (including local) for all firms in each corporate home country.

Constructing both layers of this network is challenging because no publicly available statistics exist on either. In theory, country-by-country reporting data should provide an increasingly effective window into the nationality breakdown of the firms responsible for profit shifting in any particular tax haven. In practice, however, the list of reporting countries is too incomplete for Country-by-Country Reporting data to effectively serve this particular purpose in the present analysis, with these coverage problems being compounded by the fact that, in many cases, most of the tax haven activities of most countries' firms is undertaken by business groups that have inverted to nominal tax haven nationality at the parent level and can thus no longer be traced back to their 'real' nationality in CBCR data (Haberly in press). Consequently, we estimate the nationality breakdown of business groups in each tax haven by making use of a new database of foreign direct investment (FDI) in and through tax havens constructed by Haberly (in press). This provides a breakdown of the ultimate sources of FDI entering nine of the world's largest developed and developing countries via tax haven conduit jurisdictions as of year-end 2015, which together comprise more than half of the world's GDP—namely the US, UK, France, Germany, Italy, Brazil, Russia, India, and China.

The methodology underpinning the construction of this new database is similar to that used in the Damgaard et al. (2019) investigation of 'phantom FDI', insofar as it employs a combination of macro-level bilateral international FDI data from the IMF and OECD (on an immediate and ultimate investor basis) and micro-level Orbis data on corporate structures to estimate a higher dimensional matrix of FDI (taking into account layers of indirect conduit-mediated investment) than is recorded in the IMF or OECD data, which are only disaggregated on a bilateral international basis (see Haberly and Wójcik 2015b, 2015a; Garcia-Bernardo et al. 2017 for additional discussion of the use of either bilateral official FDI or Orbis data for investigating corporate tax haven structures). However, the database generated in Haberly (in press) builds on the approach in Damgaard et al. (2019) by systematically reclassifying the 'true' nationality of all tax-haven-inverted business groups (ca. 6,500 in total) with more than USD$10 million in estimated FDI in each of the nine host countries examined (fully accounting for >90 per cent of Orbis-recorded investment in all of these hosts apart from Russia). It thus provides the first systematic accounting of the role of tax-haven-inverted business groups in tax-haven-mediated FDI. Additionally, it makes use of a Monte Carlo modelling approach that allows for Orbis data to be effectively used and for the level of estimate uncertainty resulting from this use to be quantified, in cases where Orbis provides relatively low coverage completeness for a particular tax haven FDI position.

The end product of the methodology in Haberly (in press) is a '4D' matrix of worldwide inward direct and indirect FDI positions that is cross-disaggregated on a 1) host country, 2) immediate inward investor jurisdiction, 3) tax haven group inversion jurisdiction, and 4) 'real' group ultimate home country basis. For the purposes of this present paper, we make use of this 4D FDI matrix to obtain relatively complete estimates of the breakdown of the nationality of the corporate groups making use of any particular tax haven (based on the assumption that shifted profits can be roughly allocated to firms in proportion to FDI stock). The main limitation of the use of this new FDI database will be a tendency to underestimate the 'round-tripping'-linked profit shifting of business groups from countries other than the US, UK, France, Germany, Italy, Brazil, Russia, India, or China. However, this is outweighed by its other advantages and, in particular, its systematic accounting of the pervasive impact of inversions.

We aggregate the 4D matrix at the immediate inward investor jurisdiction to obtain a 23x216 matrix, *P2C* (profit→corporate). This matrix contains, for each of 23 tax havens,[1] the share of profits attributed to companies with nationality in each of the 199 countries studied in this paper.

Once tax-haven-shifted profits have been proportionally allocated to the 'real' home countries of the business groups estimated to be responsible for this profit shifting, the next stage of analysis is the determination of the nationality breakdown of the shareholders who are the ultimate beneficiaries of profit shifting by any given country's firms. To estimate this, we use a combination of cross-border equity portfolio investment from the IMF Coordinated Portfolio Investment Survey and World Development Indicators (WDI) data on the total market capitalization of all firms in a country—with the assumption being that the total value of local shareholdings in local firms can be estimated to be the difference between total market capitalization and total inward foreign portfolio equity investment. Our analysis indicates that this assumption holds quite well, with the derived estimates of local share ownership of local firms being greater than 90 per cent for numerous economies (including most developing and transition economies) but almost never reaching (impossible) figures of more than 100 per cent (see Supplemental Data). Because of the limitations of available data, we implicitly assume that the nationality breakdown of bondholders and lenders to firms, as well as that of the shareholders of privately held (non-listed) firms, is the same as that of the shareholders of listed companies.

While this approach of estimating the nationality distribution of corporate shareholders in each country functions well in general, it requires overcoming issues of missing or problematic data in some cases. First, while data are available for all jurisdictions worldwide on inward foreign portfolio investment (as the latter is reported at the investing country level), WDI data are not available on the total market capitalization of all jurisdictions—although most major developed, developing, and transition economies are covered by the latter. Apart from the UK, for which we obtain missing market capitalization data directly from London Stock Exchange (2022), we construct estimates of nationality distribution of corporate shareholders, assuming that the percentage of local ownership of local firms takes the regional average value, and distribute the foreign ownership proportionally to inward foreign portfolio equity investment (see Supplemental Data).

Second, while the investor country-reported CPIS provides a breakdown of inward foreign portfolio investment for all countries at the host level, it is limited to coverage of reporting countries at the investor level. This poses a second missing data issue that must be addressed in our construction of corporate shareholder nationality estimates by country. Crucially, the geography of portfolio investment is, in general, substantially more concentrated by source country than by host country, and CPIS-reporting countries appear to account for nearly all of the total global stock of this investment. Consequently, for the purposes of our analysis, we assume that shareholders in CPIS non-reporting countries only

[1] Bahamas, Barbados, Bermuda, British Virgin Islands, Cayman Islands, Curaçao, Cyprus, Gibraltar, Guernsey, Hong Kong, Hungary, Ireland, Isle of Man, Jersey, Luxembourg, Macao, Malta, Mauritius, Netherlands, Puerto Rico, Singapore, Switzerland, the United Arab Emirates, and the United Kingdom.

hold investments in firms locally within their own countries. This omission of cross-border, as opposed to local shareholdings by investors in these countries, appears to result in less than one per cent of worldwide-shifted profits ending up as 'unclaimed' shareholder value that is not attributed to the benefit of any shareholding country—keeping in mind that it may have some implications for estimates of the net impact of profit shifting on some smaller countries at the individual level.

Third, an analytical challenge is presented by the fact that many of the largest sources of portfolio investment, in most countries, are tax havens that in this context primarily serve as domiciles for investment funds whose real beneficiaries lie elsewhere (with Luxembourg, Ireland, and the Cayman Islands generally being the most important such portfolio investment conduits). Consequently, we only attribute to the national shareholders of these tax haven jurisdictions (see Supplemental Data) the proceeds of profit shifting by 'genuinely' local firms [as determined by the inversion 'census' conducted by Haberly (in press)], while reassigning the cross-border portfolio equity holdings of these countries to their estimated 'real' ultimate beneficiaries. This is assumed to be proportional to the amount of inward portfolio equity investment that each of these tax haven jurisdictions receives from countries that are not themselves tax havens (with the latter defined according to a restricted definition constructed for the purposes of this particular analytical step, which omits certain tax havens such as Singapore, Hong Kong, Switzerland, or the UK that have a very substantial amount of 'real' local wealth). Notably, the effective direct estimation of the local share ownership proportion of 'genuinely' local firms in these portfolio investment conduit jurisdictions is also not possible; consequently, we assume that this takes a value based on the average of other large conduit jurisdictions (which notably are subject to greater interpretive uncertainty than the estimates of this for other countries; see Supplemental Data).

The use of CPIS and WDI data allows us to obtain a 216x216 matrix $C2S$ (corporate→shareholder). This matrix contains, for each of 216 countries, the share of ownership attributed to shareholders with nationality in each of the 216 countries. If we define the vector of profits shifted to the 23 tax havens π, the corporate nationality of the claims of those profits is defined as $\pi \cdot P2C$, the dot product of π and $P2C$. The investor nationality of those shifted profits is defined as $\pi \cdot P2C \cdot C2S$. The ownership of profits in each tax haven (θ) is defined by the dot product of $P2C$ (profit→corporate) and $C2S$ (corporate→shareholder).

$$\theta = P2C \cdot C2S \tag{4}$$

This estimation of corporate ownership concludes the discussion of the data sources used as inputs for the model.

2.4 Model analysis

We now turn to exploring the dynamical model analytically. We focus on countries that suffer from profit shifting (i.e. not on tax havens).

Secondary effects: We assume that investors residing in country i own θ_i of the profits in all tax havens. We set the parameters as in Table 1 and calculate the gains after a period of 10 years, of which we allow profit shifting only in the first one. This allows us to carefully quantify the total long-term (primary, secondary, and tertiary) costs of one year of profit shifting. We use a relatively short 10-year reference period to avoid forecasting and compounding debt over long periods of time, while allowing for the 95 per cent of profits to be distributed to shareholders. After 10 years, investors receive a share θ_i of all profits in tax havens $\sum_j (\pi_j)$. We assume that 30 per cent of profits are distributed each year to shareholders, while the remaining 70 per cent grow with a return rate of 6 per cent. Moreover, the value of the profits in tax havens are effectively devalued as the GDP of country i grows (with a growth rate equal to g_i, the geometric mean of the growth rate over the last 20 years).

$$\theta_i \sum_j (\pi_j) \sum_{n=0}^{9} \left(0.3 \cdot \left(0.7 \cdot \frac{1.06}{1+g_i} \right)^n \right) = k_i \cdot \theta_i \sum_j (\pi_j) \tag{5}$$

Because the majority (75 per cent) of profits in tax havens are distributed in the first four years, correcting for GDP growth is relatively unimportant to the estimation of secondary effects. For example, a country such as China, with a growth rate over the last decade of roughly 8 per cent would receive after 10 years 94 per cent of $\sum_j (\pi_j)$, while a country with a 2 per cent growth rate such as the United States would receive 105 per cent of $\sum_j (\pi_j)$. For tractability, we approximate $k_i \simeq 1$.

The tax revenue gains of country i from taxing investors is

$$Gains_i = (1-\alpha_i) \cdot \tau_i^F \cdot \theta_i \sum_j (\pi_j), \tag{6}$$

where α_i is tax evasion and τ_i^F the taxation of capital gains and dividends.

Costs: We next track the costs for country i. Country i loses the corporate income taxes that would otherwise be levied on outward-shifted local profits (primary effects). We assume that the country, in the first instance, raises debt to finance such costs and pays interest over 10 years financed via debt (tertiary effects)—this implies that the interest payments compound over time:

$$Cost_i = \pi_i \tau_i \left(\frac{1+I_i}{1+g_i} \right)^{10}, \tag{7}$$

where τ_i is the corporate income tax rate, I_i is the interest rate, and the results are normalized by GDP growth. Countries can thus reduce their debt as a proportion of their economic size by growing their nominal GDP at a rate above the interest rate ($g_i > I_i$).

The total costs for the country are thus:

$$\begin{aligned} Cost_i - Gain_i &= \pi_i \tau_i \left(\frac{1+I_i}{1+g_i} \right)^{10} - (1-\alpha) \cdot \tau_i^F \cdot \theta_i \sum_j (\pi_j) = \\ &= \sum_j \pi_j \left(\frac{\pi_i}{\sum_j \pi_j} \tau_i \left(\frac{1+I_i}{1+g_i} \right)^{10} - (1-\alpha) \cdot \tau_i^F \cdot \theta_i \right). \end{aligned} \tag{8}$$

We define RT_i as the ratio of the share of global investors to the share of global profit shifting:

$$RT_i = \frac{\theta_i}{\pi_i / \sum_j \pi_j}, \tag{9}$$

which plugged into equation 8 yields

$$\begin{aligned} Cost_i - Gain_i &= \sum_j \pi_j \frac{\pi_i}{\sum_j \pi_j} \left(\tau_i \left(\frac{1+I_i}{1+g_i} \right)^{10} - (1-\alpha) \tau_i^F \cdot RT_i \right) = \\ &= \pi_i \left(\tau_i \left(\frac{1+I_i}{1+g_i} \right)^{10} - (1-\alpha) \cdot \tau_i^F \cdot RT_i \right). \end{aligned} \tag{10}$$

This analysis allows us to understand how the total costs for a country depend on the interest and GDP growth rates, RT_i (the proportion of global investors in the country compared with the proportion of

global profit shifting out of the country), the level of tax evasion, and tax rates. The results of this model analysis are included in Section 3.2. Importantly, our analytical assumption that sovereign fiscal losses are financed by debt does not attempt to represent the complexity of real-world responses that any particular government might make to these losses. Rather, quantifying the synthetic long-term cost burden of offsetting tax losses with debt is designed to assess the fiscal pressure that a particular government will be under to respond at all to tax losses, through fiscal tightening—and thus bear all of the negative developmental and social effects that such a tightening likely entails—as opposed to its ability to passively neutralize the long-term costs of sovereign debts, without taking any painful fiscal action at all, simply by growing out of these debts.

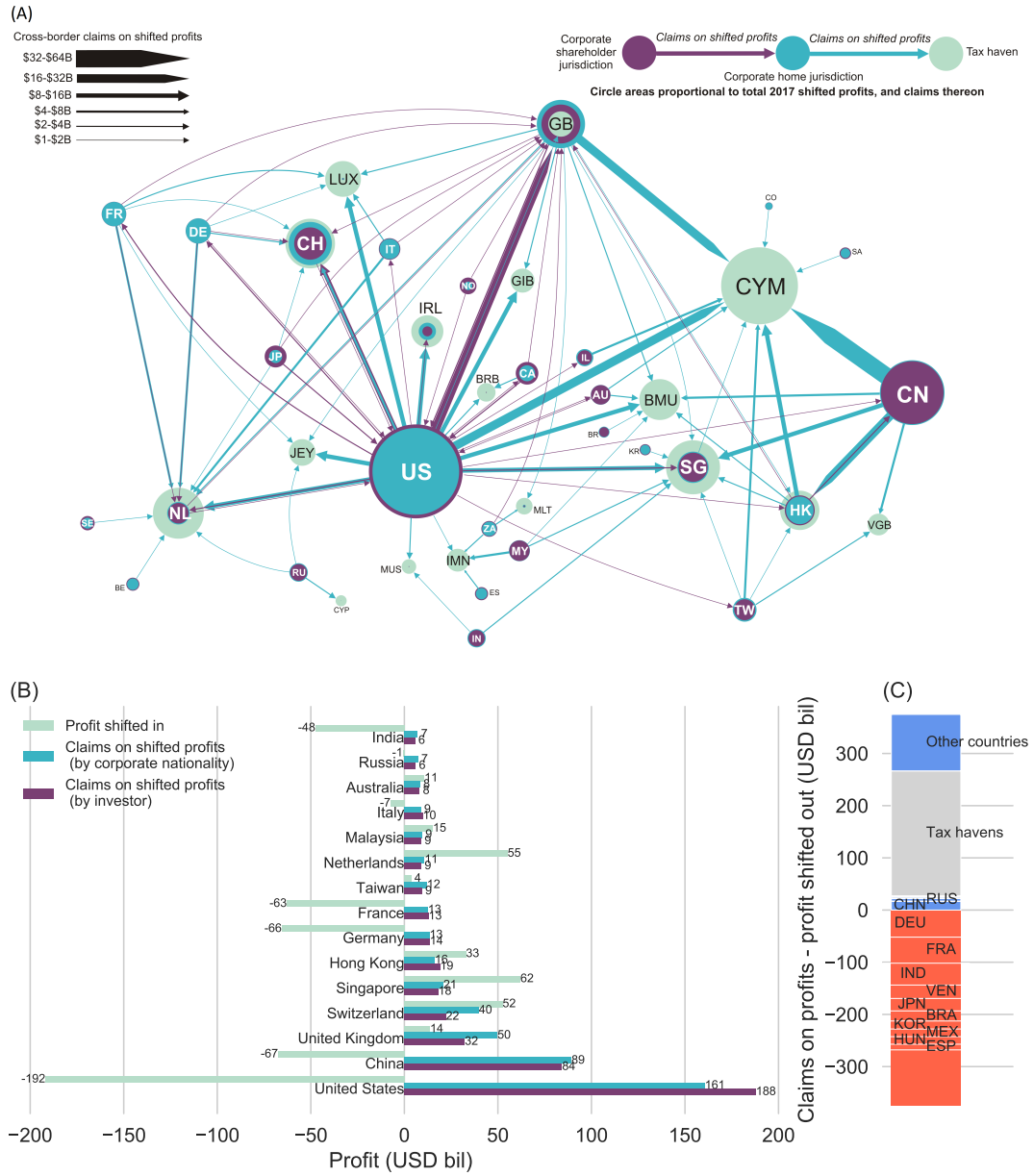
3 Results and discussion

3.1 Geographical distribution of the claims on shifted profits to tax havens

The estimated global breakdown of direct and indirect corporate and shareholder claims on tax haven profit shifting, for 2017, are shown in Figure 2. Figure 2A shows the global network of cross-border direct and indirect claims on tax haven profit shifting, while Figure 2B shows the leading beneficiaries of tax haven profit shifting, by corporate home and shareholder location, ranked by the latter. Shifting of profits to tax havens, and the proceeds thereof, are shown in Figure 2A at the levels of (1) the tax havens in which shifted profits are initially concentrated (light blue-green circles), (2) the ultimate home jurisdictions of the corporations engaged in profit shifting (blue), and (3) the home jurisdictions of the ultimate beneficial owners of these corporations (purple). Circle areas are proportional to total net profits shifted into a jurisdiction for tax havens and to claims on these profits for corporate home and shareholder jurisdictions. Arrows represent the cross-border claims of corporations on the tax havens where they shift their profits (turquoise arrows) and of shareholders on the proceeds of offshore profit shifting that they indirectly obtain via shareholdings in profit-shifting corporations (purple).[2] As discussed in Section 2.2 for tax-haven-inverted corporations, ultimate nationality is attributed to 'real' country of origin and control, rather than the nominal acquired home nationality.

[2] Note that these successive tiers of claims are in many cases contained within jurisdictions, in cases where the native firms of a tax haven make substantial use of local profit-shifting facilities (e.g., as in the case of Swiss and Dutch firms) and where the shareholders of corporations are (as is typically the case) mostly located in the same home jurisdiction as the corporation. Such jurisdictionally self-contained claims are reflected in circle sizes but not represented by network relationships.

Figure 2: **(A)**: Network of estimated claims on profits in tax havens. **(B)**: Value of profits shifted out (light green) and claims on shifted profits by corporate nationality (blue) and investor nationality (purple). **(C)**: Difference between the shifted profits and the claims on profits at the investor level.



Note: we develop the estimated claims on profits in tax havens in two steps. In the first step, we attribute the corporate nationality of the profits shifted to tax havens (light green). These claims on profits are represented with blue circles and edges. In the second step, we attribute the shareholder nationality of the corporations from the previous step, which we represent with purple circles and edges. Only the edges and nodes with values over US$1 billion are visualized. Self-edges are omitted but can be inferred from the relationship between concentric circles—e.g., in China the vast majority of the profits of Chinese companies are owned by Chinese investors and thus the blue and purple circles are indistinguishable in size.

Source: authors' illustrations.

Tracing the corporate nationality of profits shifted

The results suggest that corporate profit shifting worldwide is driven primarily by firms from just a handful of countries. Indeed, it could be largely described as a 'Sino-Anglo-American' phenomenon, with Mainland Chinese, US, British, Hong Kong, and Taiwanese firms accounting for almost two-thirds (63 per cent) of worldwide profit shifting, and US and Mainland Chinese firms alone accounting for nearly half (48 per cent). US firms (including tax haven-inverted firms) are estimated to be responsible for substantially more profit shifting than Mainland Chinese firms alone, accounting for 31 per cent versus

the latter's 17 per cent of the world total. However, the combined share of 'Greater Chinese' (including Hong Kong and Taiwanese) firms, at 23 per cent of world profit shifting, is nearly three-quarters as large as the US total. For US firms, we estimate that the Cayman Islands, Singapore, the Netherlands, Ireland, and Bermuda were the top profit-shifting centers in 2017. Meanwhile, for Mainland China, we estimate that the Cayman Islands, Hong Kong, Bermuda, and the British Virgin Islands were the top profit-shifting centers (Figure 2A).

The United States and Mainland China are also by far the largest sources of outward shifted profits in the world economy, with the US and China estimated to be the source of 27 and 10 per cent of the world total, respectively. To a very large extent, these outward-shifted profits appear to be directly linked to the scale of the tax haven operations of the multinational firms of each country. This is because tax haven operations for each country largely take a 'round-trip' firm, wherein multinational firms and investors make use of tax haven structures largely to hold assets and operations back in their own home country. In the case of China, this round-tripping likely accounts for a majority of the country's total tax haven investment in both the inward and outward direction. We estimate that nearly half of the total claims of Chinese firms on tax haven-shifted profits arise from their operations in the Cayman Islands, which is the jurisdiction most widely used by Mainland business groups for parent company-level offshore incorporations (often undertaken as part of overseas exchange listings). In the case of the US, the role of round-tripping is somewhat less than in China but still quite substantial, with US firms likely either the largest or second-largest sources of tax haven investment in the US. This is primarily due to the large number of US multinational corporate inversions to Ireland and other tax haven jurisdictions, which in turn generates an enormous volume of US round-tripping when these inverted groups hold (and extract profits from) their operations back home (Sharman 2012; Xiao 2004; Buckley et al. 2015; Sharman 2012; Wójcik 2018; Xiao 2004; Haberly in press).

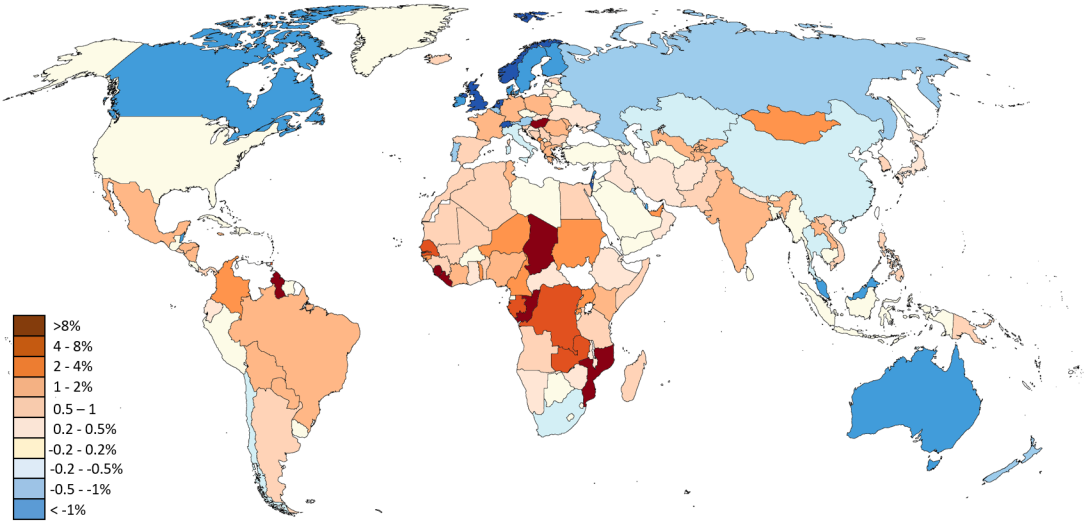
Meanwhile, our results suggest that the country whose firms play the third-largest role in worldwide tax haven profit shifting after the US and China, namely the UK, is itself functioning as a corporate tax haven with net inward as opposed to outward-shifted profits. As of 2017, the UK had a corporate income tax rate of only 19 per cent and an effective rate of 10 per cent, substantially below the average for major developed countries, and was one of the most popular jurisdictions used by US firms for tax inversions prior to the US tax reform in that same year.

Tracing the shareholder nationality of profits shifted

The positioning of countries within the global tax haven system changes substantially when claims on the proceeds of profit shifting are traced back to the shareholder level, as opposed to simply the multinational corporate group level. The discrepancy between these can be seen in the relative sizes of the turquoise (firm-level claims) and purple (investor-level claims) circles for each country in Figure 2A. As can be seen, the tax avoidance activities of firms from most countries are ultimately generating a larger value of proceeds for foreign investors in these firms than investors in each country are deriving from their own shareholdings in foreign tax-avoiding firms (as indicated by countries with a purple-centered circle in Figure 2A). This is because of the disproportionate concentration of share ownership of firms worldwide in the hands of investors based in just a handful of countries. Above all, the proceeds of tax avoidance by firms from countries worldwide tend to flow upwards into the hands of American investors due to their enormous presence within global securities markets—with the US accounting for nearly half (46 per cent) of the net worldwide discrepancy between firm versus investor-level profit-shifting proceeds at the net beneficiary level. We estimate that roughly half of these indirect US investor-level claims on foreign corporate profit shifting are derived from British and Swiss firms because of the combination of the aggressiveness of these countries' firms in shifting profits, and the high proportion of US investors in their shareholder structures. In other words, British and Swiss firms are largely avoiding taxes on behalf of Americans. Reaping the second-largest total net proceeds from worldwide profit-shifting by foreign firms (11 per cent of the world total) are investors based in Japan, whose own firms appear to

engage in little tax haven profit shifting. Also deriving much larger net benefits at the investor level from worldwide tax avoidance by foreign firms than from tax avoidance by national firms is Norway—where the primary beneficiary is likely the government itself, via the global portfolio holdings of its sovereign wealth funds.

Figure 3: Profits shifted out of countries' net of investor's claims on those profits, measured as the share of the country's GDP



Source: authors' illustration.

In Figure 2B–C and Figure 3, we show the net value of outward-shifted profits in relation to investor-level claims on the worldwide multinational corporate profit-shifting process (by both local and foreign firms). Figure 3 shows the net value as a per cent of each country's GDP. Positive (peach-orange) values indicate that the value of profits shifted outward from a country into tax havens is larger than the claims of a country's investors on the tax avoidance activities of firms worldwide, while negative values (blue) indicate that a country's investor-level claims on worldwide corporate tax avoidance are larger than the value of profits shifted out of that country. We find a strong North-South divide in the geographic distribution of countries that are net exporters of, as opposed to net investor-level claimants on, tax-haven-shifted profits—with least developed countries, particularly in sub-Saharan Africa, tending to have a particularly poor position. However, there is also substantial variation in the position of countries within the North and South. Looking at the developed world, we estimate that Canada, Australia, Scandinavia, and the various European tax havens (including the UK) are deriving net investor-level gains within this system, even while most non-tax-haven countries in continental Europe, as well as Japan, are exporting a larger value of profits to tax havens than the value of their investor-level claims on the proceeds of worldwide tax avoidance. The US sits almost exactly at the net break-even point between the two, with the very large volume of profits shifted out of the US being almost perfectly offset by the disproportionate funnelling of the proceeds of worldwide corporate tax avoidance into the hands of US investors.

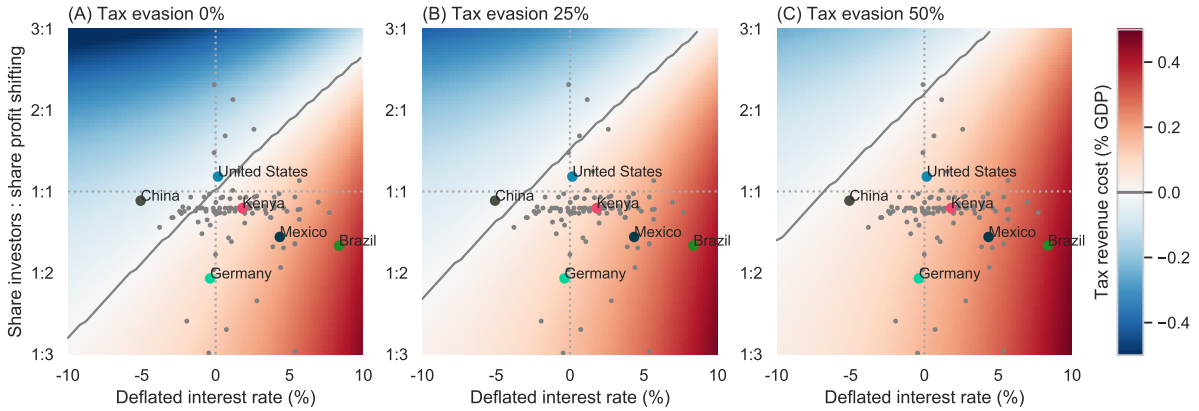
Meanwhile, despite the generally disadvantageous position occupied by developing countries in relation to worldwide profit shifting, we estimate that there are a few middle-income countries such as South Africa and Chile whose investor-level claims on the proceeds of multinational corporate tax avoidance worldwide exceed the value of profits shifted out of these countries—keeping in mind that these private investor-level proceeds do not necessarily translate into public fiscal gains (which is a separate issue examined in the following section). Due largely to the enormous value of their citizens' and firms' offshore investments, some of the larger and more illiberal socialist/post-socialist countries, including both Russia and China, also appear to derive larger investor-level claims on worldwide corporate profit shifting than the value of profits shifted out of these countries. This stands in contrast to more economically liberal post-socialist states in Europe, which nearly all export a much larger value of profits into the tax haven system than what they are able to reclaim at the investor level.

3.2 Including dynamical effects

Results of model analysis

We now turn into the net cost dynamics that result from accounting for debt and investment effects. We start by measuring the total cost of corporate tax avoidance using the analytical model detailed in equation 10 (Section 2.4), which we show in Figure 4. To ease the interpretation of the results, we use a representative 'model' country with corporate and capital gains tax rates τ_i and τ_i^F of 20 per cent and profits shifted out (π_i) amounting to 1 per cent of the GDP (the median profit shifting in the sample). Because countries can only offset profit shifting by taxing investors (with a tax rate of τ^F), reducing τ^F enlarges the area where countries lose revenue (see Figure A1). Figure 4 shows that even in the absence of tax evasion, most countries suffer from tax avoidance. However, not all countries are equally affected by profit shifting. Countries with a high growth rate compared to interest rates (e.g., China, in dark grey) or countries with a high share of investors who can recover tax losses at the level of capital income and gains taxation (e.g., United States, in blue) are affected much less than countries with a high interest (e.g., Brazil, in green) or countries with high primary net tax revenue losses (e.g., Germany, in turquoise).

Figure 4: Tax revenue costs (measured as a per cent of GDP) as a function of the deflated interest rate ($(1+I_i)/(1+g_i)$) and the ratio between the share of investors (θ_i) and share of profit shifted ($\pi_i/\sum_j \pi_j$) for different levels of tax evasion: (A) 0%, (B) 25%, (C) 50%



Note: the position in the space of all countries is shown in grey, and selected countries are annotated. The actual tax revenue cost for a country depends on the specific tax rate (τ and τ^F) and profit shifting (π_i). To calculate the cost, we set the tax rate to a representative value of $\tau = \tau^F = 0.2$ and the profit shifting to the median value in the sample $\pi_i = 1\%$ of GDP.

Source: authors' illustrations.

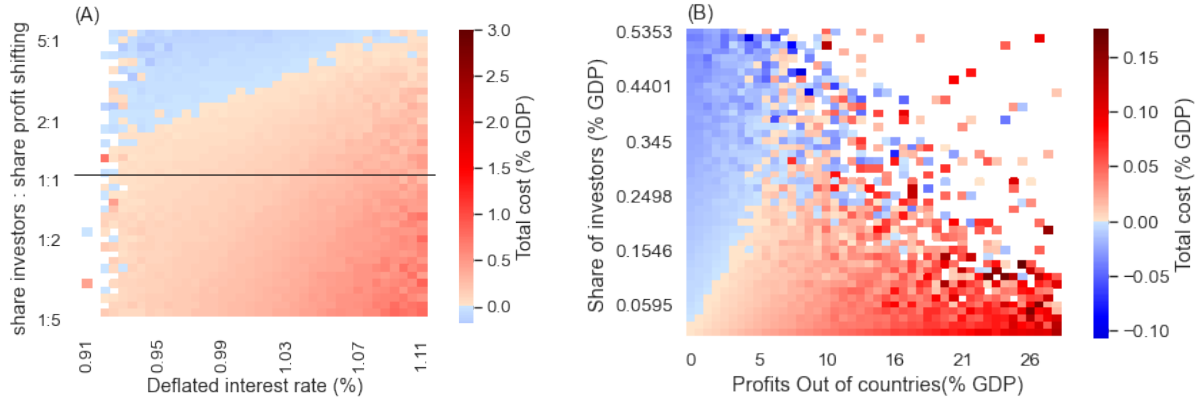
Simulation analysis on synthetic countries

Next, we analyse the total cost of profit shifting by multinational corporations using simulations with our dynamical model (Section 2.1). We set the parameters as in Table 1 and run the simulations for 10 years, of which we allow profit shifting only in the first year. This allows us to quantify the total long-term (direct and indirect) net fiscal costs generated by one year of profit shifting. Our estimates of these long-term country net fiscal gains and losses are predicated on the estimation of a number of different model parameters. Given that each of these parameters is characterized by a certain level of uncertainty, it is important to understand the potential impact (or lack thereof) that variation in different combinations of these parameters have on final estimate results. Given that we only have 216 countries in the sample, we estimate the relationship between profit shifting, the share of investors, and the interest cost, using synthetic countries, created to mimic the relationships between variables present in the original data (see full details in the Appendix). As in the previous section, we visualize the net fiscal gains of countries using heatmaps (Figure 5).

We focus on three key parameters: the intensity of profit shifting, the share of global investors in a country, and sovereign interest rate. Our results of the simulation analysis are consistent with the analytical results from Section 3.2. As expected, the net costs of profit shifting increase with increases in the intensity of profit shifting, with decreases in the share of global investors, and with increases in the interest rate. The results obtained through this method are a further confirmation of the results obtained through the analytical approach. In particular, notice the matching between Figures 5A and A1B (both having tax evasion fixed at the level of 25 per cent).

Our analysis yields two key results. First, countries accounting for large shares of global investors typically have lower outflows of profits (diagonal boundary in Figure 5B, showing a lack of countries in the top right corner). Second, countries with a large enough share of investors can obtain gains (Figures 5A and B). Conversely, the costs in countries whose citizens account for a low share of worldwide corporate ownership in relation to the value of outward-shifted profits appear to be quite sensitive to sovereign borrowing costs (Figure 5A). Additional explanations and results for this sensitivity analysis can be found in Appendix B.

Figure 5: Total costs of profit shifting estimated using synthetic data as a function of (A) the interest rate (x axis, 0% rate visualized) and the logarithm of the ratio of share of investors and share of profits shifted (y axis, 1:1 line visualized)



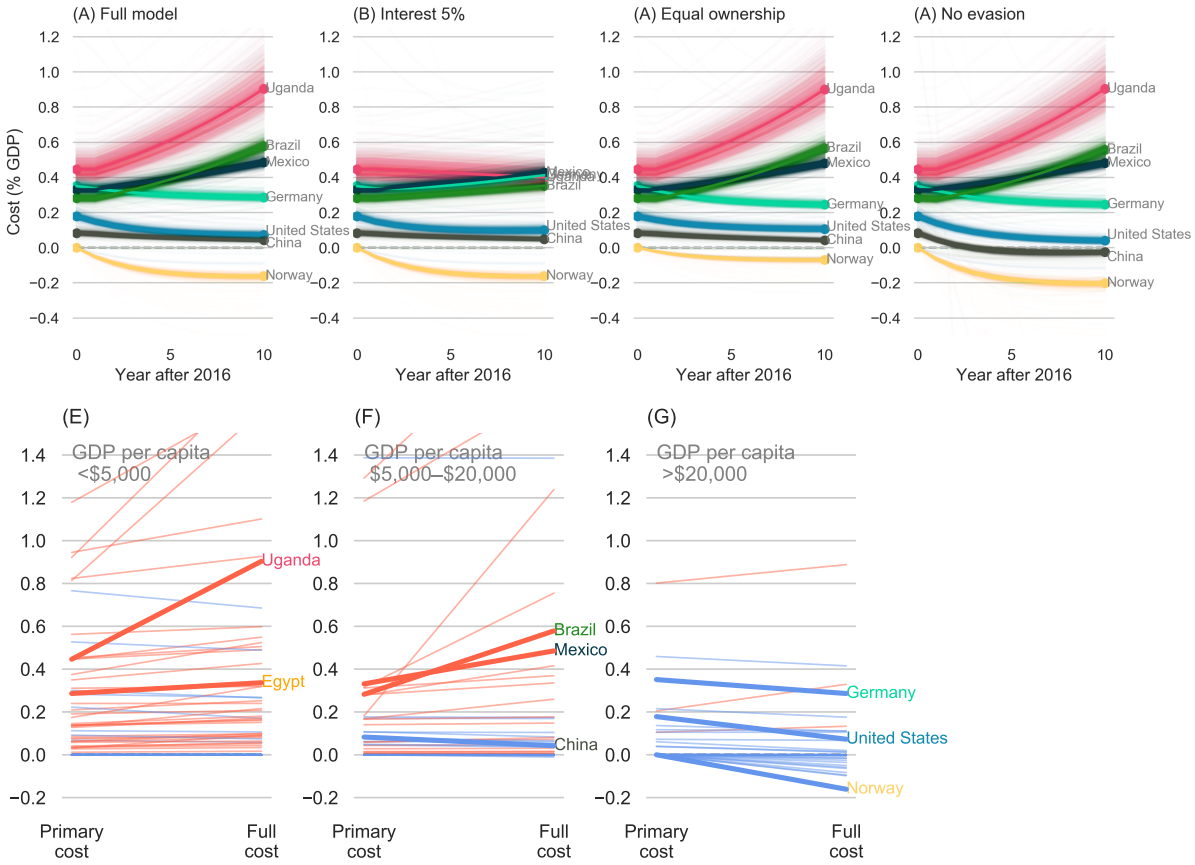
Note: costs are visualized in red and gains are visualized in blue. Only countries with a primary tax revenue loss are included and (B) profits shifted normalized by GDP (x axis) and share of investors normalized by GDP on profits (y axis).

Source: authors' illustrations.

Simulation analysis on real countries

Next, we run our dynamical model (Section 2.1) to understand how the indirect effects affect developing and developed countries differentially. First, we focus on eight different countries, selected because of their data quality and/or economic importance: Uganda, Egypt, Mexico, Brazil, China, Germany, United States, and Norway.

Figure 6: Cost of profit shifting as a function of the country's GDP



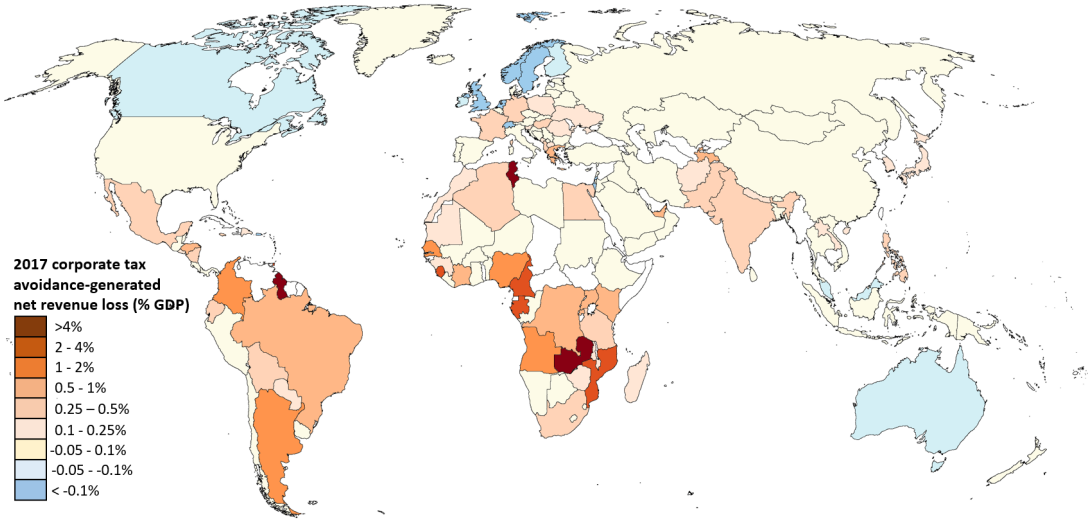
Note: panels (A–D) show results of the simulation for seven selected countries: Uganda (red), Brazil (green), Mexico (navy), China (dark gray), United States (blue), Germany (turquoise), and Norway (yellow). Thin lines show simulation results using different estimations of profit shifting from Garcia-Bernardo and Janský (2021). Median values are highlighted. $\alpha = \{98, 89, 89, 88, 23, 43, 20\%\}$, $I = \{14.9, 10.9, 6.5, 3.5, 2.3, 0.0, 2.0\%\}$.
Panels (E–G) show direct and total costs as a function of each country's GDP. Countries with a GDP per capita (E) less than US$5,000, (F) between US$5,000 and US$20,000, and (G) more than US$20,000. Countries with positive (negative) indirect costs are highlighted in red (blue). Selected countries are annotated. Only countries with a GDP of more than US$10 billion are included. Tax havens are excluded.

Source: authors' illustrations.

The contrast between the cost of profit shifting for developing and developed countries observed in Figure 2 is further amplified once dynamical effects are considered (Figure 6A). Developing countries are forced to issue government bonds at higher interest rates (higher I) and have a lower capacity to track and tax investors (higher α) than developed countries. The bond yield differential is particularly pernicious for developing countries (Figure 6B), as its effects compound over time. The annual cost of corporate tax avoidance for Uganda, Brazil, Mexico, and Egypt, in a world where they were able to borrow at 5 per cent interest—instead of their actual borrowing rates of 14.9, 10.9, 6.5, and 6.3 per cent—would decrease by 0.50, 0.23, 0.06, and 0.03 per cent of their GDP. Conversely, the cost for Germany, which pays an interest rate close to 0 per cent, would increase by 0.13 per cent of their GDP if it was forced to borrow at 5 per cent. Tax evasion, meanwhile, is particularly important for countries that are home to many MNCs or investors (Figure 6C). Norway and China, with their large state-owned investment arms and firms, and the United States, as the home of the largest number of world MNCs, are estimated to be most affected by tax evasion—without tax evasion their annual net cost would be decreased by 0.11 and 0.04 per cent of their respective GDPs (although note that the Norwegian and Chinese governments could not, by definition, evade taxes owed to themselves on their own state investment income, and as such, losses from tax evasion in those countries may be overestimated). While Mexico, Indonesia, or Kenya are likely to suffer proportionally higher tax evasion than developing

countries in relation to wealth or investment income, the lower ratio of global investment income to GDP in these countries (Figure 2) actually reduces the effect of tax evasion (at least with respect to investment income) in relation to GDP.

Figure 7: Total costs of profit shifting, measured as the share of the country's GDP



Note: total costs are measured as the tax revenue loss ($\pi_i \tau$) + the indirect cost (secondary and tertiary effects).
Source: authors' illustration.

Next, we zoom out and look at the consequences of profit shifting in all countries. In the absence of indirect effects, the average cost of profit shifting (weighted by GDP) is 0.33 per cent, 0.12 per cent, and 0.17 per cent for countries with a GDP per capita less than US$5,000, between US$5,000 and US$20,000, and more than US$20,000, respectively (Figure 6D–F). When indirect effects are included, the average annual cost of profit shifting increases by 36 per cent for countries with a GDP per capita of less than US$5,000 (Figure 6D) and by 35 per cent for countries with a GDP per capita between US$5,000 and US$20,000 (Figure 6E). For the median country with a GDP per capita of more than US$20,000, the cost of profit shifting is reduced by 44 per cent (Figure 6F). This average reduction is, however, very unevenly distributed geographically, with only a handful of developed countries actually managing to completely offset the primary costs of corporate tax avoidance, while the majority still suffer positive net losses.

Above all, as shown in Figure 7, any net fiscal benefits of worldwide corporate tax haven use appear to accrue to a handful of major developed economies, most of which are themselves tax havens. Together, Switzerland, the UK, Singapore, the Netherlands, Hong Kong, and Ireland are estimated to reap 45 per cent of total worldwide *total* net fiscal gains (10.7, 8.5, 8.3, 7.9, 5.0, and 4.2, respectively). This is because these countries are not only net recipients of shifted corporate profits (and tax those profits at rates of 5–10 per cent) but also account for a disproportionately large share of the world's private financial wealth (in contrast to most 'small island' tax havens, which levy no corporate income taxes and whose own citizens' wealth holdings are of negligible global importance). Presumably because of the large international claims of its sovereign wealth funds on foreign tax avoiding firms (Babic et al. 2020), Norway also reaps relatively large net fiscal gains on par with the large developed country tax havens.

Notably, the US and China, whose firms play the leading role in profit-shifting activities worldwide, appear to both suffer net fiscal losses from this profit shifting, as the indirect investor-level fiscal proceeds that they derive from it are smaller than each country's direct corporate tax losses from outward profit shifting. The United States claims 74 per cent of global *indirect* fiscal gains (i.e. from taxing investors) from worldwide corporate tax avoidance, which allows it to halve its primary costs, from 0.18 per cent

to 0.07 per cent of its GDP. However, the US is still estimated to suffer the second-largest total net fiscal losses from tax haven profit shifting of any country after India, accounting for roughly 10 per cent of worldwide net fiscal losses.

Crucially, however, because of the enormous sizes of their economies, as well as the very low long-term cost of borrowing that each of their governments enjoys in relation to the combination of inflation and GDP growth rates (i.e. long-term nominal GDP growth), the long-term fiscal net losses suffered by the US and China are quite trivial in importance from the standpoint of each of these countries themselves. In the case of the US, the 10-year net fiscal costs generated by one year of present-day tax revenue losses are estimated to be around 0.07 per cent of GDP, while for China, 10-year net losses are estimated to be 0.04 per cent of GDP. Both the US and China, in other words, can essentially grow out of any additional sovereign debts incurred as a result of corporate tax avoidance, while servicing these debts at a minimal real cost. Central government fiscal deficits, generally speaking, simply do not matter much for these countries, at least within the context of the prevailing global and domestic macroeconomic environment of the past two decades. At presently estimated levels, tax avoidance in these countries is of concern from the standpoint of questions of domestic income and wealth distribution and inequality; however, it has essentially no impact on their ability to fund public expenditure.

In contrast, many least developed countries, particularly in sub-Saharan Africa, are estimated to suffer severe long-term fiscal losses in relation to GDP that are likely to translate into very tangible long-term social costs. This is because these countries tend to have a very high value of net outward-shifted profits in relation to GDP and that these losses are furthermore subsequently amplified by a high cost of sovereign borrowing in relation to inflation and GDP growth. For Zambia, for example, we estimate the 10-year net fiscal cost of corporate profit shifting, assuming that these immediate losses are covered by increased present-day borrowing and long-term interest repayments, at 9 per cent of GDP. This is nearly as high as Zambia's 2017 total final government consumption expenditure of 13 per cent of GDP (based on World Bank WDI data). Meanwhile, for Cameroon and Mozambique, we estimate 10-year net fiscal losses of 3.9 and 2.7 per cent of GDP, compared to 2017 government final consumption expenditures of 11 and 25 per cent of GDP, respectively.

In practice, such a high cost of long-term debt repayment, in relation to the total size of the government budget, has the potential to be fiscally unsustainable. Rather than simply offsetting the fiscal losses through increased long-term borrowing, as we assume here for the purposes of the current simplified net cost estimation analysis, such countries may rather be forced into some combination of draconian budgetary cuts, tax increases (often of a socially regressive kind, such as with a consumption-focused character), and external debt crises and restructuring. It is ultimately in the form of these second-order long-term effects of immediate corporate tax haven profit shifting, which fall outside of the scope of the analysis here, that the most severe developmental and social consequences of corporate tax avoidance will be felt.

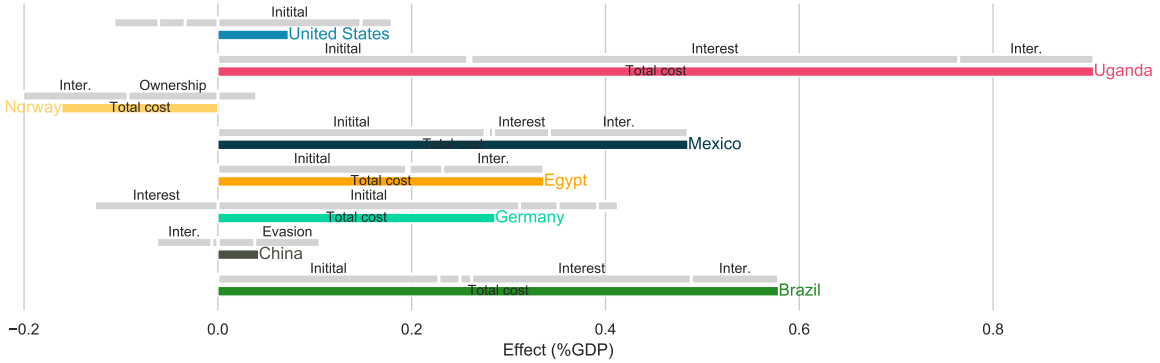
Crucially, for low-income countries, where the need for not only ongoing social spending but also public investment (e.g., in education and infrastructure), is very high, both the immediate social and long-term developmental opportunity (e.g., as resulting from public investment cut-backs) costs of any such immediate efforts to offset tax avoidance losses are also likely to be very high. By directly as well as indirectly reducing the rate of GDP growth, and thus the ability of countries to grow out of their sovereign debts, any upfront austerity programme used to offset fiscal losses from corporate tax avoidance might actually end up ultimately increasing rather than decreasing the real long-term social cost of corporate tax avoidance. Furthermore, the immediate costs of lost corporate tax revenue that would need to be offset by tax increases and spending cuts are very large. For Zambia, Cameroon, and Mozambique, the immediate budget gaps resulting from corporate tax avoidance that would need to be closed (i.e. excluding long-term interest costs) are estimated at 2 per cent, 2.7 per cent, and 2.9 per cent of GDP, which equates to 15, 25, and 12 per cent of total 2017 government final consumption spending, respectively. In this case

of Mozambique, this immediate cost of trying to balance the books to compensate for the costs of tax avoidance is actually even higher than the long-term cost of offsetting tax losses through high-interest borrowing.

Ultimately, what our results show is that the the problem of corporate tax avoidance is not simply of peripheral importance to the question of fiscal and debt sustainability in many developing countries but is rather likely to be one of the issues that is of central importance in this context. Notably, these problems are not entirely limited to developing countries. Greece, in particular, appears to be a prominent outlier among developed countries with estimated net fiscal costs of corporate profit shifting at a level more characteristic of least developed sub-Saharan African countries, but Greece is located between Rwanda and Uganda in the rankings of 10-year net fiscal losses, at 0.7 per cent of GDP. Perhaps most striking is the extreme asymmetry in the international distribution of net fiscal gains and losses, from the standpoints of the governments and broader public in the countries on either side of this divide. For Switzerland, for example, which appears to be the country that derives the largest net fiscal benefit from worldwide corporate tax benefit, we estimate a 10-year net fiscal benefit of somewhere between 1/150th and 1/500th of Swiss GDP (depending on how the immediate net fiscal gain from inward-shifted profits is counted). The paltry nature of such public gains, even concentrated as they are in the hands of a small number of extremely wealthy small economies, is truly remarkable in relation to the level of social harm that our analysis implies, in least developed countries, on the other side of the net profit-shifting equation. Of course, the lion's share of the net gains in this equation is not going to the tax authorities of Switzerland, the Netherlands, or any other country but rather into the hands of private individuals.

Decomposition of the cost

Figure 8: Decomposition of the total cost of profit shifting for selected countries (coloured bar) into five components



Note: the five components are labelled in the figure as follows: direct cost (Initial), interest cost compared with a synthetic tax rate of 5% (Interest), tax evasion cost compared with full disclosure (Evasion), cost of unequal ownership compared with ownership proportional to GDP (Ownership), and the residual (Inter.).

Source: authors' illustration.

Our system dynamics model allows us to systematically and independently assess the parameter space defined by the different contributors to the total costs of profit shifting. Figure 8 shows the results of the systematic decomposition of these costs, where the coloured bar represents total net cost and the five components are displayed on top for each country in gray. These five components are: (i) *Direct cost*, the cost of profit shifting without taking into consideration any indirect effects. This cost is typically higher for developing countries, although some high-income countries such as Germany have high direct costs (see also Figure 6F). (ii) *Interest effect*, the cost of interest, compared with a synthetic world with a 5 per cent interest rate for every country. This effect is highly positive for countries with high interest rates (Uganda, Mexico, Brazil, and Egypt) and highly negative for countries with low interest rates (particularly Germany but also the United States and China). For countries with no costs (Norway), the results are independent of the interest rate. (iii) *Tax evasion cost*, the cost of tax evasion—non-disclosure of capital gains and dividends to the tax authorities—is negligible for developing countries (because few

investors reside in those countries) and relatively small for high-income countries (because tax evasion was already low). (iv) *Ownership effect*, the effect of differences in the location of investors, compared with a synthetic world where ownership is distributed proportionally to GDP. This effect is positive for countries with a share of ownership of profits in tax havens below their share of outward-shifted profits and negative for countries whose shareholders claim a larger proportion of worldwide profit-shifting proceeds than the their share of worldwide outward-shifted profits. This is the main driver of net results for Norway, which is able to profit from the tax avoidance of foreign multinationals because of its large portfolio of global shareholdings. (v) *Interaction effect*, the residual of the total cost minus the four previous components. The interaction effect accounts for non-additive effects between the components. A full decomposition for the top 20 countries is given in Table 2.

Table 2: Decomposition of the annual cost for the 20 countries with highest absolute costs

Country	GDP per capita (US$)	Final cost (US$ bil)	Final cost (% of GDP)	Primary cost (% of GDP)	Evasion cost (% of GDP)	Ownership effect (% of GDP)	Interest effect (% of GDP)	Interaction (% of GDP)
India	1,942	22.7	0.49	0.25	0.02	0.00	0.10	0.12
United States	62,003	17.8	0.07	0.15	0.03	-0.03	-0.03	-0.05
Brazil	8,696	13.0	0.58	0.23	0.02	0.01	0.23	0.09
France	39,380	12.5	0.42	0.40	0.04	0.01	-0.16	0.11
China	9,544	12.2	0.04	0.04	0.07	-0.00	-0.01	-0.06
Germany	45,520	12.2	0.29	0.31	0.04	0.04	-0.13	0.02
Nigeria	2,099	12.1	1.80	0.56	0.00	0.00	0.92	0.31
Argentina	11,478	7.4	1.24	0.15	0.02	0.06	1.00	0.00
Colombia	6,146	7.3	1.70	0.85	0.06	0.00	0.39	0.40
Mexico	9,202	6.8	0.49	0.28	0.00	0.01	0.06	0.14
Japan	39,683	6.0	0.11	0.13	0.02	0.04	-0.06	-0.02
United Arab Emirates	41,432	5.1	0.89	0.56	0.00	0.01	0.03	0.29
South Korea	31,532	4.1	0.18	0.15	0.03	0.05	-0.04	-0.02
Zambia	1,337	3.5	9.06	1.18	0.00	0.00	7.23	0.65
Tunisia	3,457	3.0	5.64	3.02	0.00	0.00	0.96	1.66
Angola	3,119	2.5	1.67	0.74	0.00	0.00	0.53	0.40
Cameroon	1,466	2.1	3.92	1.88	0.00	0.00	1.00	1.03
Kenya	1,669	2.1	1.61	0.54	0.00	0.00	0.77	0.30
Spain	28,314	1.7	0.11	0.10	0.03	0.02	-0.03	-0.01
Philippines	3,246	1.5	0.27	0.18	0.00	0.00	-0.00	0.09

Note: the final cost is decomposed into five components: primary cost, evasion cost, ownership effect, interest effect, and interaction between terms.

Source: authors' compilation.

4 Conclusion

Prior work on the quantification of the cost of profit shifting has typically neglected indirect and long-term cost effects. Here, we disentangle the ownership of profits shifted to tax havens and develop a system dynamics model that accounts for not only corporate tax revenue losses but also tax revenues collected on capital gains and dividend taxes, as well as government borrowing costs. We show that indirect channels magnify the cost of profit shifting for developing countries, even while greatly reducing, and in some cases even inverting, the total cost for developed countries. The cost of profit shifting increases by 36 per cent for developing countries, while it is reduced by 44 per cent for developed countries. Notably, the indirect effects almost completely offset direct costs for the two largest players in worldwide corporate tax avoidance: the United States and China.

Our approach identifies the largest components of the long-term net indirect costs generated by corporate tax avoidance. In developed countries, primary costs (i.e. lost corporate income taxes on outward-shifted profits) and tax evasion are typically the greatest sources of indirect costs. Meanwhile, in developing

countries, the interest cost of the increased sovereign borrowing required to offset tax revenue losses (assuming other taxes and expenditure remain constant—see the discussion in Section 3.2) is typically the highest component. In this paper, we show the cost of tax avoidance normalized by GDP, which allows for a relatively meaningful comparison between countries. However, tax revenue costs and gains are in many respects better contextualized in relation to total tax revenue and/or government spending in a country. Given that developing countries typically have a much lower ratio of government tax revenue to GDP (16, 24, 33, and 39 per cent for low, lower-middle, upper-middle, and high-income countries, respectively), as well as lower levels of public expenditure in relation to GDP, the difference between the effective social cost of corporate tax avoidance for developing versus developed countries is further amplified.

Our results offer insights with implications for international tax policy. Developing countries often argue that they should be represented on an equal footing when international corporate tax system reform is being debated and decided at the OECD or G20 forums and, furthermore, argue that reforms themselves should create a level playing field in the corporate taxation of MNCs. We show that developing countries are in fact impacted disproportionately by the indirect effects explored in this paper. However, the international landscape of net costs and benefits of profit shifting that our analysis reveals are more complex than simply a North versus South divide.

Most importantly, while the developed world as a whole seems to derive something of an aggregate net fiscal benefit from corporate profit shifting, these net fiscal gains are mostly concentrated in a handful of very small wealthy countries—in particular the UK, Netherlands, and Switzerland—that not only account for a disproportionately high percentage of worldwide corporate share ownership (in relation to either their population or GDP) but also serve as tax havens themselves that are net recipients as opposed to sources of shifted profits. Meanwhile, most developed countries appear to suffer net fiscal losses. Just as importantly, our results indicate a critical dimension of global geo-financial and fiscal positionality than transcends traditional questions of the North and South. Within this dimension of geo-financial and fiscal positionality, the governments of the world's two largest economies, the US and China—notwithstanding the fact that the US is a 'developed' whereas China is a 'developing' country—appear to both occupy what could be described as a position of structural fiscal indifference in relation to corporate tax haven use. This structural fiscal indifference stands in sharp contrast to the central role that US and Chinese firms play within the operation of a system whose most acute fiscal effects are primarily felt elsewhere. The most severe of such effects, as we show in our analysis, tend to be felt in the world's least developed countries, particularly in sub-Saharan Africa. However, looking at the middle tiers of long-term fiscal losses in relation to GDP, several large continental European developed economies fall within a range of losses generally more characteristic of much lower-income countries. The 10-year net fiscal losses of France and Germany, for example, at 0.4 and 0.3 per cent of GDP, rank between those of Jamaica and Egypt, and are 4 to 5 times higher than those experienced by the US and 9 to 10 times higher than those experienced by China. Notably, it seems to have been mostly increasing political pressure from and the threat of tax and trade retaliation against tax-avoiding American firms by these relatively affluent developed countries on the losing end of the global tax haven system more than concerns over the much more acute social and developmental effects of this system on poorer countries that has pushed the US out of its stance of longstanding indifference to global corporate tax avoidance and into the Biden administration's strategy of proactively trying to shape and control the global corporate tax reform agenda.

In addition to having important implications for current policy, our results open new avenues for future research. In particular, the flexibility of the model could allow researchers to test the overall effects of potential reforms of the international tax system, such as the Base Erosion and Profit Shifting (BEPS) proposal of the OECD/G20 Inclusive Framework (OECD 2020), as well as the Minimum Effective Tax Rate (METR) proposal (Picciotto et al. 2021).

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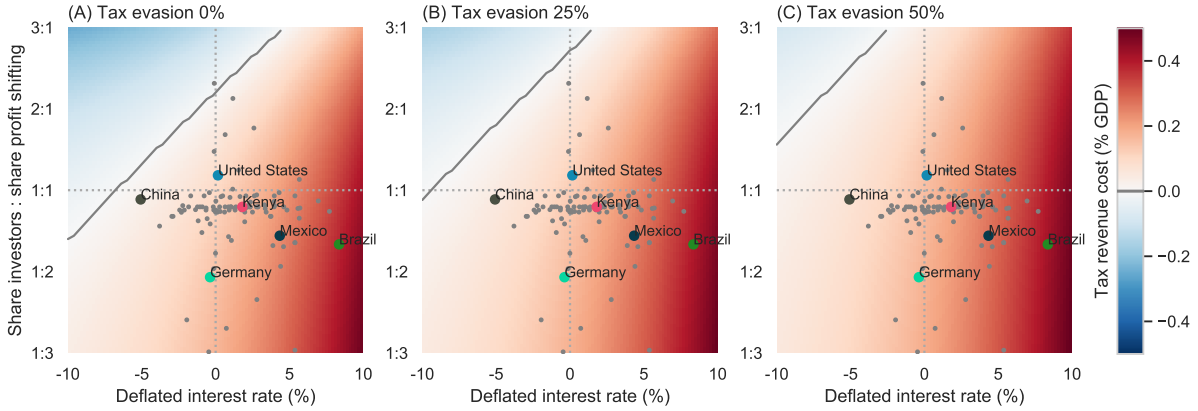
A Supplementary figures

Figure A1: Tax revenue costs (measured as a % of GDP) as a function of the deflated interest rate (interest rate - growth rate) and the ratio between the share of investors (θ_i) and share of profit shifted ($\pi_i / \sum_j \pi_j$) for different levels of tax evasion—(A) 0%; (B) 25%; (C) 50%



Note: selected countries are annotated, all other countries with values within the figure axes are shown in gray. The tax revenue cost depends on the specific tax rate (τ and τ^F) and profit shifting (π_i). We set the tax rate to a representative value of $\tau = 0.2 = 2\tau^F$ and the scale of profit shifting to the median value in the sample $\pi_i = 1\%GDP$.

Source: authors' illustrations.

B Synthetic countries

In this appendix, we use heatmaps to more systematically show how the estimated total costs of profit shifting depend on the value of various specific relevant model parameters. In particular, we take into account the scale of profit shifting (primary effects), percentage of shareholders resident in each country (secondary effects), and government borrowing costs (tertiary effects). We show these heatmaps for real countries and, then, for so-called synthetic or simulated countries, which help us get a better understanding of which factors play the most decisive role, within various contexts, in shaping the international distribution of net fiscal losses and gains from corporate tax avoidance.

B.1 Real countries

First, we construct a heatmap using data on real countries, where we put profit shifting on the horizontal axis and percentage of shareholders on the vertical one (Figure B1). The percentage of shareholders for every country i is calculated from the positive shifted profits vector (that gives us information on profits settled in tax havens) multiplied by the i column of the θ matrix. Then, the percentage of shareholders for every country i will be:

$$s_i = \frac{p \cdot \theta_i}{\sum_j p_j} \tag{11}$$

where s_i is the percentage of shareholders of all tax-avoiding corporations worldwide who reside in country i, p is the vector of positive profits shifted, and θ_i is the column i of the θ matrix.

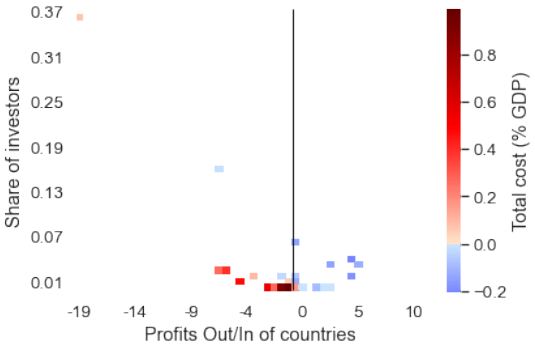
The heatmap can be also seen as a 50×50 matrix, meaning that we divide both profit-shifting and a country's global share ownership percentage into 50 intervals. In each $[k, j]$ element of the matrix lies the mean of the cost faced by countries, with these intervals being defined by the country's percentage of world corporate share ownership as well as total world outward-shifted profits. The net cost is represented by the colour and its intensity:

- Red: countries in the $[k, j]$ box of the heatmap are, on average, loosing net tax revenue from corporate tax avoidance.
- Blue: countries in the $[k, j]$ box of the heatmap are, on average, gaining net tax revenue from corporate tax avoidance.

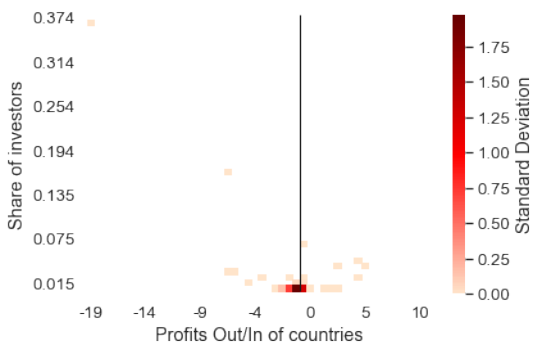
In Figure B1 we can see the obtained graph and the heatmap with associated standard deviations for every mean. As can be seen from the plots, however, the data given from the real 216 countries are not drawn from a wide-enough range of parameters, varying in relation to each other across multiple dimensions, to allow for the clear identification of which factors are of primary importance in driving international variation in net gains and losses. As can be seen, most of the graph is rather empty. To obtain a clearer understanding of the influence of different effects on the total cost of profit shifting, we thus turn to the generation of simulated data for synthetic countries that can more fully flesh out the full multi-dimensional space of parameter variation—as shown in the aforementioned and other heatmaps.

Figure B1: Heatmaps of real data

(a) Heatmap, real data



(b) Standard deviation, real data



Note: x-axis—profits shifted; y-axis—percentage of shareholder; z-axis—mean of total cost per GDP in (a) and relative standard deviation in (b). Positive cost (losing countries) in red, negative cost (gaining countries) in blue. The vertical black line divides tax havens (on the right) from the other countries.

Source: authors' illustrations.

B.2 Synthetic countries

We create the simulated synthetic countries based on the observed statistical distribution of, and relationships between, real country characteristics including the scale of profit shifting, percentage of shareholders with their residence in every country, and government borrowing costs. In this way, the synthetic countries are realistic in the sense of being statistically similar to real countries, even if the main objective of their creation is to more fully fill the parameters' space across regions of this space that are not occupied (or are only sparsely occupied) by these actually-existing countries.

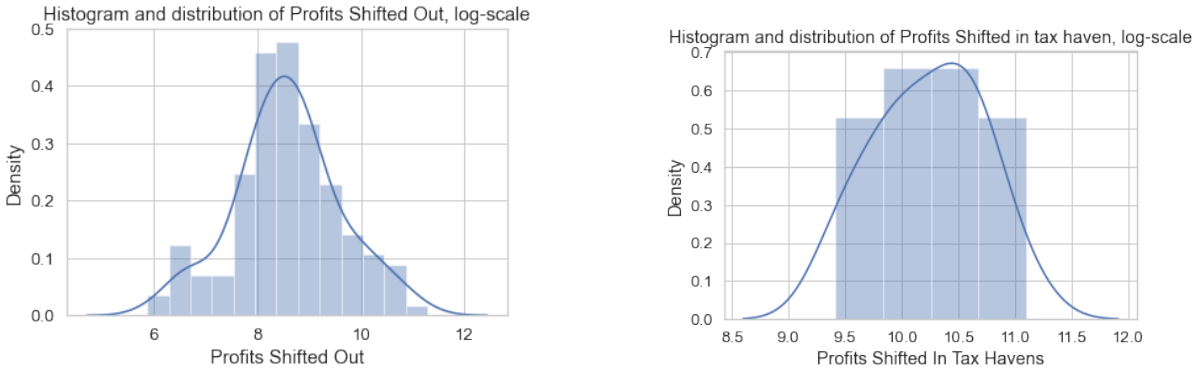
In this section we firstly show how the characteristics of the synthetic countries are created. We then show the sensitivity analysis heatmaps and the results obtained from them.

To create the heatmaps, we put together 50 thousands of sets of synthetic countries, each containing 200 countries. Each set has its net fiscal costs calculated through the dynamical model. They are then added to the synthetic dataset, which contains 10 million countries at the end of the process.

From real to synthetic countries characteristics

- **Profit shifting distribution:** We start by analyzing the distribution (obtained by the corresponding histogram) with which profits are shifted in or out of countries for both negative and positive profits shifted.

Figure B2: Histogram for both negative (on the left) and positive (tax havens, on the right) profits shifted



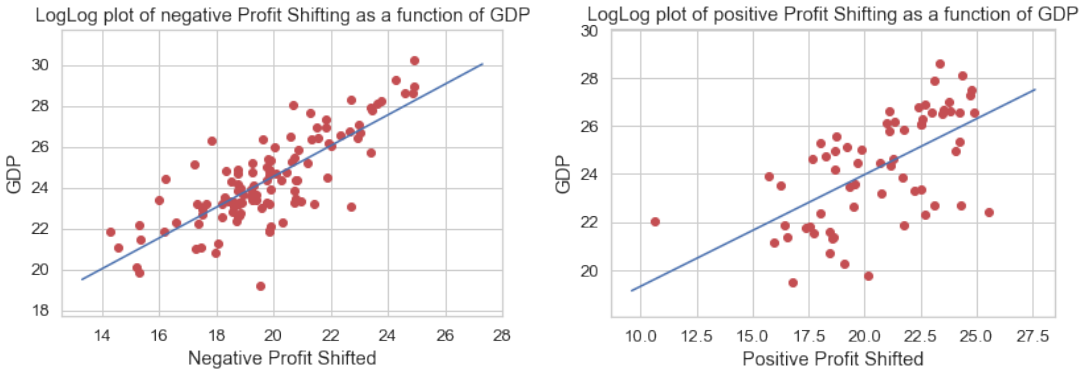
Note: the distribution obtained from them will give us the probability for each synthetic country to have a certain amount of profits shifted.

Source: authors' illustrations.

The probability for each synthetic country to have a certain amount of profits shifted depends on the distributions showed in the histograms.

- **GDP and profit shifting:** the second created characteristic is GDP, the one on which all other characteristics depend. Basing it on the previously created profits shifted (PS) for every country, the assigned GDP follows the real trend pictured in Figure B3.

Figure B3: Plots in log-log scale of the GDP in function of profits shifted of real countries (countries as red point, with linear fit in blue)



Note: this relation will be used to create countries' GDP from the previous created quantity. Profit-losing countries are on the left and tax havens are on the right.

Source: authors' illustrations.

This means that, given the value of profits shifted, GDP value is assigned as the y value of the linear fit, to which is added a negative or positive error.

We start from the linear log-log fit in Figure B3, with parameters a (slope) and b (intercept):

$$\log(GDP_i) = a \cdot log(PS_i) + b \tag{12}$$

Given a certain value of profit shifted PS_i, we assume that every point can lie under a normal distribution $N(\mu,\sigma)$, where μ is the value of the linear function in PS_i ($\mu = a \cdot log(PS) + b$) and σ is the points' average distance with respect to the line ($\sigma = \mathbb{E}(D)$, with D the set of the absolute

values of all distances). If $N_i(0,1)$ is a random number obtained from the standard distribution, for every point i we will then have:

$$\log(GDP_i) = N_i(\mu_i, \sigma) = \mu_i + N_i(0,1) \cdot \sigma = (a \cdot log(PS_i) + b) + N_i(0,1) \cdot \mathbb{E}(D) \tag{13}$$

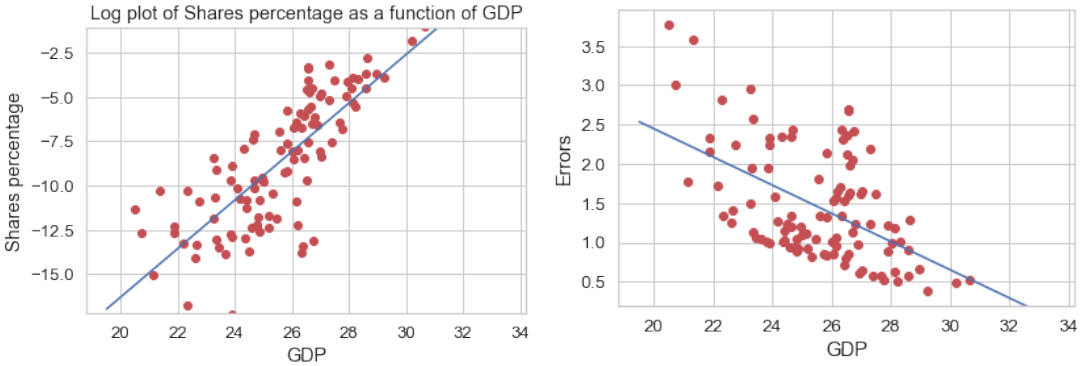
that will become

$$GDP_i = PS_i^a (e^b \cdot e^{N_i(0,1) \cdot \mathbb{E}(D)}) \tag{14}$$

The previous method is used for the creation of all quantities, with some changes to σ in two cases: *GDP* for negative profit shifted countries and shares.

In these two cases, σ is strongly inversely proportional with respect to the x-axis (see Figure B4), so we include this dependence in the following way (and for that reason, we will call it σ_i from now on).

Figure B4: Left—plot in log-log scale of shares in function of GDP of real countries (countries as red point, with linear fit in blue). Right—standard deviation of the points from the line, showing an inversely proportional dependence with the GDP



Source: authors' illustrations.

Accordingly, given a certain value of profit shifted PS_i, we assume that σ_i is the points' average distance with respect to the line, scaled through the value on x-axis. Then the expression of σ_i will be:

$$\sigma_i = \frac{\mathbb{E}(D) \cdot \mathbb{E}(\sum_j \log(PS_j))}{\log(PS_i)} \tag{15}$$

where D is the set of the absolute values of all distances, and $\mathbb{E}(\sum_j \log(PS_j))$ is used to maintain the error of the same order as $\mathbb{E}(D)$.

If $N_i(0,1)$ is a random number obtained from the standard distribution, we will then have:

$$\log(GDP_i) = N_i(\mu, \sigma) = (a \cdot log(PS_i) + b) + N_i(0,1) \cdot \frac{\mathbb{E}(D) \cdot \mathbb{E}(\sum_j \log(PS_j))}{\log(PS_i)} \tag{16}$$

- **Population and share ownership percentage:** The population of every country is simulated with the same method stated before, but starting from country GDP instead of profit shifted. All the other quantities are then created basing their relationship either on GDP, GDP per capita, or

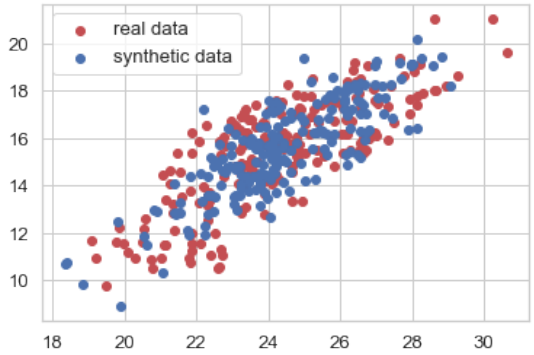
on distribution of the real quantity itself. The choice is based on the correlation of the quantity with one of the aforementioned (at least a high/medium correlation) or none of them (in case of low correlation, the quantity is based on the distribution). Share ownership percentage has been generated following its relationship with country GDP, using σ_i instead of σ, as explained before.

- **Effective tax rates, GDP growth, and interest rates:** To simulate these quantities, we use their relation with GDP per capita and apply the same method.
- **Capital gains tax (CGT):** No significant correlation is found with GDP or GDP per capita. Results are simulated based on the distribution of real data

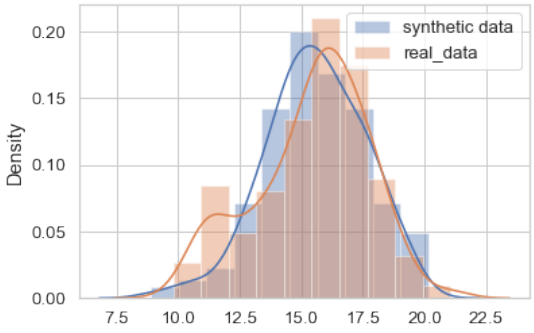
After the simulation, we conducted a qualitative analysis to compare the trends and distributions of real and synthetic data. See, for example, Figure B5.

Figure B5: Comparison of trends in log-log plot of population as a function of GDP (a) and distributions of population (b) of real and synthetic data

(a) Real and synthetic data trends of population



(b) Real and synthetic data distribution of population



Source: authors' illustrations.

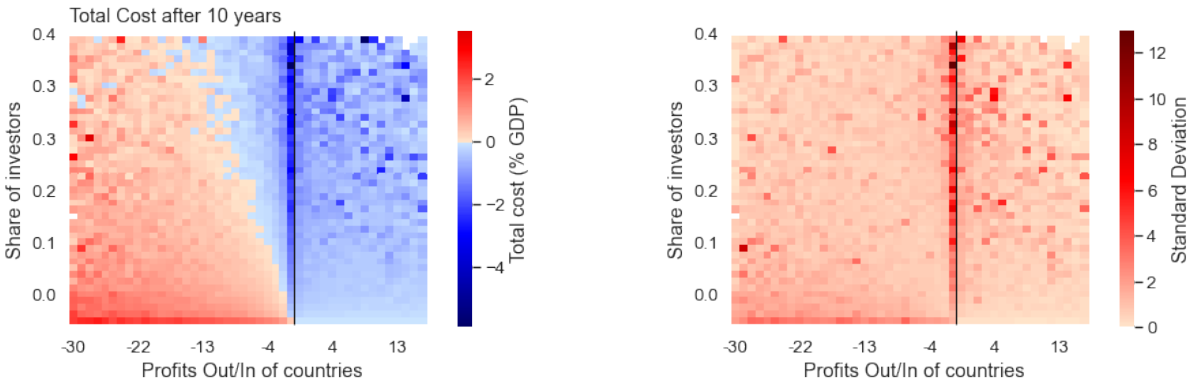
Results

The first plot (Figure B6) is the heatmap showing the same quantities as Figure B1.

Figure B6: Heatmaps of synthetic data

(a) Mean of synthetic data

(b) Standard deviation of synthetic data



Note: x-axis—profits shifted, decreased by a factor of $\frac{10}{10}$; y-axis—percentage of shareholder; z-axis—mean of total cost normalized by GDP in (a) and relative standard deviation in (b). Positive cost (losing countries) in red, negative cost (gaining countries) in blue. The vertical black line divides tax havens (on the right) from the other countries.

Source: authors' illustrations.

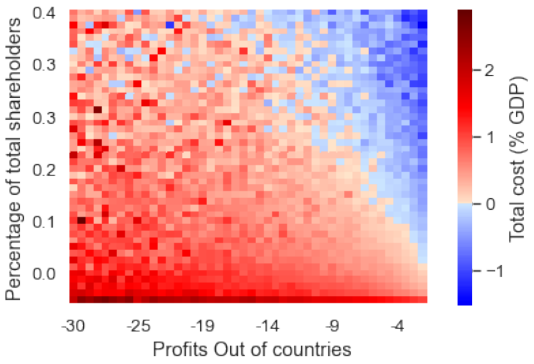
Ten million synthetic countries have been used to create the graph, and we can see how the parameters' space is completely filled. We can also see the clear difference between tax havens and other countries in the plot. Additionally, as expected, for some non-tax haven countries with net outward-shifted profits,

the final fiscal cost is still negative. This means that, despite locally operating MNC profits being shifted in net to tax havens, their governments are able to recoup these tax losses, and derive additional tax gains on top of this, by taxing the increased investor-level proceeds of tax avoidance by both local and foreign multinationals (as is the case for, e.g., Norway).

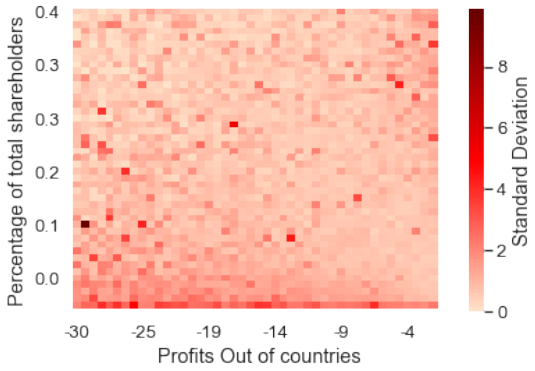
Due to our aim of showing the effects of indirect costs, we concentrate the following heatmaps on the countries suffering net fiscal losses. In Figure B7, we show the same heatmap as that in Figure B6, but with all tax havens removed from the figure.

Figure B7: Heatmaps of synthetic data, losing profits countries only

(a) Mean of synthetic data, losing profits only



(b) Standard deviation of synthetic data, losing profits only



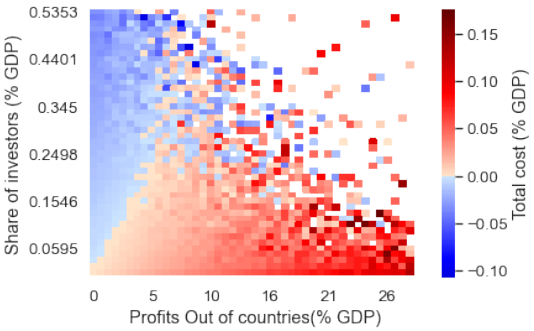
Note: x-axis—profits shifted out, decreased by a factor of $\frac{10}{10}$; y-axis—percentage of shareholder; z-axis—mean of total cost per GDP in (a) and relative standard deviation in (b). Positive cost (losing countries) in red, negative cost (gaining countries) in blue.

Source: authors' illustrations.

We now construct the normalized heatmap (Figure B8). Here we have normalized the scale of all axes (percentage of shareholders, shifted profits, final cost) by country GDP, rather than representing them in total terms.

Figure B8: Heatmaps of synthetic data, losing profits countries only

(a) Mean of synthetic data, losing profits only, normalized



(b) Standard deviation of synthetic data, losing profits only, normalized

Note: x-axis—profits shifted; y-axis—percentage of shareholders (logarithmic scale); z-axis—mean of total cost in (a) and relative standard deviation in (b), all axes normalized by GDP. Positive cost (losing countries) in red, negative cost (gaining countries) in blue.

Source: authors' illustrations.

In this heatmap, the dividing line between countries with net fiscal gains as opposed to losses is relatively clear, and we can see the central role of share ownership concentration, in particular, in defining this dividing line. The figures shows a diagonal division between the blue and red parts regions, with blue becoming more prevalent to the left and upper part of the heatmap , due to the decreasing profits shifted out of countries and increasing concentration of share ownership.

We then incorporate sovereign interest rates as the third parameter to analyze with respect to the final net fiscal cost. To do this, in Figure B9 we construct a heatmap with interest rate on the x-axis, while on the y-axis we have $\frac{percentage\,of\,shares}{percentage\,of\,profits}$, a quantity that we can also write for every country i as $\frac{s_i}{p_i}$. The numerator is the same quantity we introduced and used before. The percentage profits p_i for every country i, meanwhile, is:

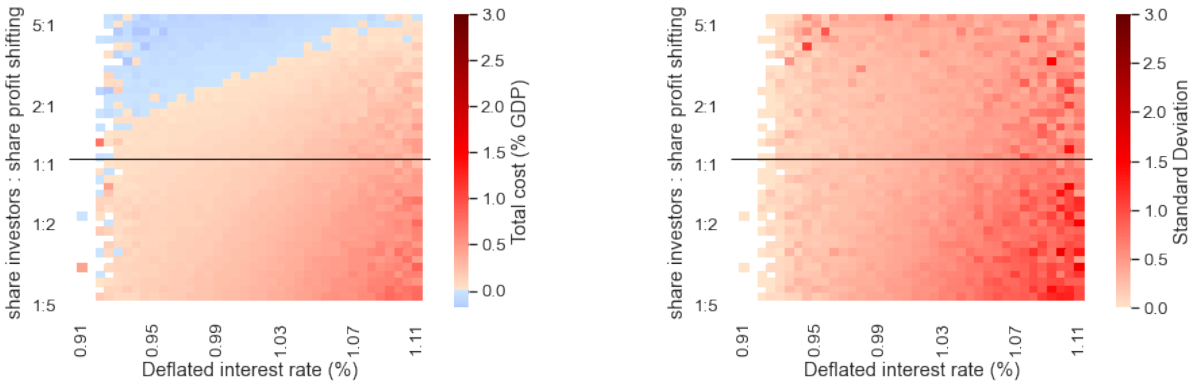
$$p_i = \frac{\pi_i \cdot 100}{\sum_j \pi_j} \tag{17}$$

where π_i is the amount of profits shifted out of country i. The cost is normalized by GDP.

Figure B9: Heatmaps of synthetic data, losing profits countries only

(a) Mean of synthetic data, losing profits only, interests included

(b) Standard deviation of synthetic data, losing profits only, interests included



Note: x-axis—interests; y-axis—$\frac{percentage\,of\,shares}{percentage\,of\,profits}$ (logarithmic scale); z-axis—mean of total cost in (a) and relative standard deviation in (b). Positive cost (losing countries) in red, negative cost (gaining countries) in blue. 30×30 heatmap.

Source: authors' illustrations.

We can clearly see a trend defined by the combination of a country's concentration of worldwide corporate share ownership and its sovereign interest rate. Indeed, we have a darker red in the lower-right boxes and a clear division between gaining and loosing countries with a slope that underlines the effects of all three quantities considered. It is also important how Figures B9a and A1B, even though obtained through two different methods, are matching results.

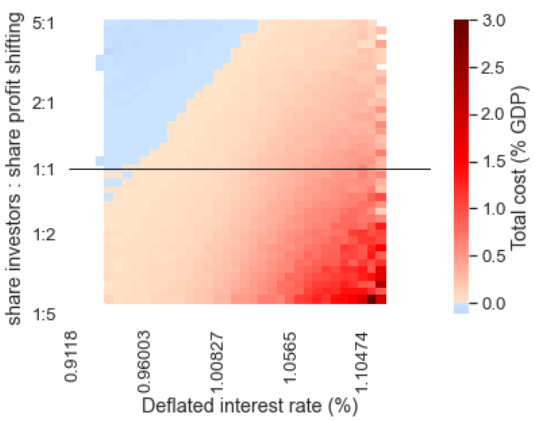
This analogy is even clearer in Figure B10 where the synthetic data have been simulated through a similar process, but with a uniform distribution $U(\mu_i - \sigma, \mu_i + \sigma)$ instead of a normal one. In particular, considering $\mu_i = a \cdot log(PS_i) + b$ as before and $\sigma = U_i(0,1) \cdot \max(D)$, where $U_i(0,1)$ is a random number taken from the interval $[0,1]$, we would have:

$$\log(GDP_i) = U_i(\mu_i, \sigma) = (a \cdot log(PS_i) + b) + U_i(0,1) \cdot \max(D) \tag{18}$$

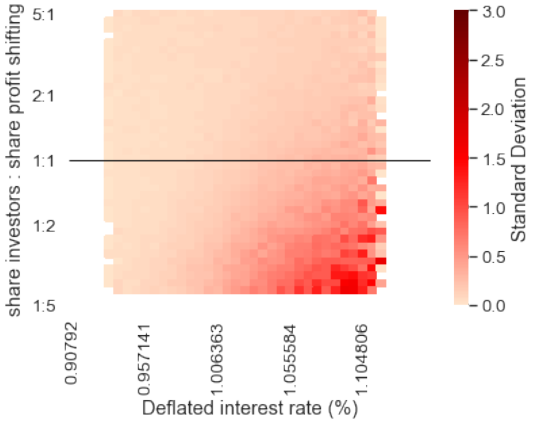
We used again a σ inversely proportional to the x-axis for shares and GDP.

Figure B10: Heatmaps of synthetic data, losing profits countries only

(a) Mean of synthetic data, losing profits only, interests included



(b) Standard deviation of synthetic data, losing profits only, interests included



Note: x-axis—interests; y-axis—$\frac{percentage\,of\,shares}{percentage\,of\,profits}$ (logarithmic scale); z-axis—mean of total cost in (a) and relative standard deviation in (b). Positive cost (losing countries) in red, negative cost (gaining countries) in blue. 30×30 heatmap.

Source: authors' illustrations.