# Profit Shifting and International Tax Reforms*

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**Abstract**

International taxation rules are widely regarded as outdated, enabling multinational corporations to exploit loopholes and shift profits to tax havens. We study how reforming these rules would affect consumption and welfare across countries. We build a model that distinguishes profits earned through local economic activity from profits moved artificially to tax havens, and introduce *triangle identities* to trace profit-shifting flows between countries. Using macro- and firm-level data, we find that these artificial profit flows are three times more sensitive to tax rates than the broader tax base. Applying the model to the global minimum corporate tax, a reform now being implemented across dozens of countries, we find it improves welfare in two ways: governments collect more revenue to fund public goods, and countries face weaker incentives to undercut each other's tax rates. We identify the optimal minimum tax rate under different assumptions about how taxing rights are divided across countries and show that more fundamental redesigns, such as a destination-based cash flow tax or formulary apportionment, can generate welfare effects an order of magnitude larger.

**Keywords**: Profit Shifting; Tax Avoidance; Tax Havens; International Tax Reforms; Minimum taxation; DBCFT; Multinational firms.

**JEL codes**: F23, H25, H26, H32, H73.

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## 1 Introduction

Multinational enterprises (MNEs) report close to 40% of their profits in a small set of low-tax jurisdictions (Tørsløv et al., 2023). In these jurisdictions, profits booked by foreign affiliates exceed what local activity would justify. The disconnect between where production occurs and where profits are reported has become so pronounced that the U.S. Treasury Secretary warned that the race to the bottom in corporate tax rates, a defining feature of 21st-century globalization, "*impedes national sovereignty by preventing governments from funding urgent fiscal priorities*" (Yellen, 2021). In response, more than 135 countries agreed to introduce a global minimum tax under the OECD/G20 Inclusive Framework (OECD, 2021). The objective is to establish a binding floor for effective taxation, thereby reducing the gains from shifting profits across jurisdictions and limiting tax competition.

The success of such a reform effort fundamentally depends on how multinational corporations adjust the location of their real activities and profit-shifting practices. Evaluating such a policy requires separating shifted profits from the returns to actual economic activity, as well as knowing how these profits would separately respond to changes in the tax system. Empirical studies provide partial answers by documenting the magnitude of profit shifting (Tørsløv et al., 2023) and showing that corporate taxation affects investment and location choices (Suàrez Serrato and Zidar, 2016, Bilicka et al., 2022). Despite its policy relevance, we still lack a comprehensive framework that accounts for firms' endogenous responses to international tax reforms, through their location decisions, the intensity of real production, and the amount of profit shifted, to evaluate the welfare effects of alternative international tax architectures.

In this paper, we develop a general equilibrium model of international taxation to examine how tax reforms affect multinational corporations' optimal production and profit allocation across countries, including tax havens. These choices are shaped by the international tax system, which is summarized by countries' statutory tax rates and the international allocation of taxing rights. Profit shifting is costly and affects production scale, firm entry, and selection into profit shifting. Tax reforms, therefore, influence both the geography of real activity and the geography of tax avoidance.

To quantify these mechanisms, we need three previously unavailable inputs: i) trilateral profit-shifting flows, ii) tax base and profit-shifting elasticities, and iii) profit-shifting frictions. We discuss their identification in turn.

First, we recover the global structure of profit shifting by noting that this is inherently trilateral: profits are generated in a source country $l$, shifted to a tax haven $h$, and accrue to a parent in a residence country $i$. International financial flow data may show that haven $h$ pays income to parents in $i$, and multinational production data may show that parents in $i$ operate affiliates in source country $l$. However, they do not show how much of the income booked in $h$ was generated in a production country $l$. This missing link matters because international tax reforms reallocate taxing rights across these three types of countries. Policy changes can also affect firms' choices of where to locate headquarters ($i$), production facilities ($l$), and book their profits ($h$) and determine the winners and losers of any reform. Their evaluation, therefore, requires trilateral flows rather than bilateral ones. We recover these flows using bilateral FDI income corrected for conduit structures (Blouin & Robinson, 2025; Damgaard et al., 2024) and multinational production data.

In a first step, we obtain excess profits in tax havens through a gravity estimation, in which bilateral income flows depend on economic size and bilateral frictions. We estimate the fraction of FDI income (dividends and reinvested earnings) between $i$ and $h$ that would be absent if $h$ were not a tax haven. This allows us to identify the amount of profits shifted in a tax haven $h$ from firms with parent companies in the residence country $i$ ($h \to i$). Next, we use multinational production data to pin down the real-activity leg from parents in $i$ to production locations $l$ ($i \to l$). Finally, we impose a set of model-implied restrictions, which we refer to as *"triangle identities"*. These require that repatriated profit flows from tax haven to residence ($h \to i$) are consistent with multinational production to all production locations ($i \to l$) and shifted profits to tax havens ($l \to h$). Combining the multinational production link with the estimated flows from tax havens to residence countries ($h \to i$), the triangle identities deliver the missing leg: profits shifted from production country $l$ to tax haven $h$ ($l \to h$). This procedure yields the global matrix of profit shifting for each triplet of residence $i$, source $l$, and haven $h$ ($i \to l \to h$).

We find that in 2017, multinational firms in our sample shifted approximately $359 billion in profits, corresponding to 33% of total multinational profits after correcting for conduit structures. Furthermore, profit shifting follows a clear geographic pattern: conditional on production, firms disproportionately reallocate profits toward nearby tax havens, consistent with bilateral profit-shifting frictions.

Next, we estimate the key elasticities implied by the model. These elasticities are of first-order importance since they determine whether an international tax reform primarily reallocates revenues across countries or also significantly impacts the geographic distribution of economic activity. We find that the elasticity of shifted profits with respect to taxes is approximately three times that of the real tax base. This asymmetry is quantitatively important. It implies that minimum taxation primarily reshapes the allocation of profit shifting, while real production adjusts more gradually through general equilibrium effects on entry and factor markets.

Finally, we recover bilateral profit-shifting frictions. At the median, shifting profits increases effective production costs by about 30%. These frictions vary systematically across source–haven pairs and generate endogenous selection: larger and more efficient firms are more likely to engage in profit shifting. The nature of these frictions matters for the effects of any international tax reform. The selection induced by profit-shifting frictions implies that reforms reducing profit shifting can repatriate substantial tax revenues, as the largest firms are more likely to shift profits. The geographic dimension of these frictions also highlights that the effects of unilateral tax reforms are unequal: closing European tax havens disproportionately impacts European multinationals, while Asian or American firms are only affected through general equilibrium forces.

We use these empirical and structural inputs to evaluate alternative international tax architectures. First, we analyze the OECD's global minimum tax under alternative allocations of taxing rights. This reform imposes a 15% minimum effective tax rate on foreign profits of large multinationals. If profits booked in a jurisdiction are taxed below 15%, a top-up tax may be levied. Under the Income Inclusion Rule (IIR), the parent's residence country ($i$) collects the difference. Under the Undertaxed Profits Rule (UTPR), source countries ($l$) collect it. Under the Qualified Domestic Minimum Top-up Tax (QDMTT), the low-tax jurisdiction ($h$) itself applies the top-up.

In our model, a minimum tax operates through two channels: it reduces firms' incentives to shift profits to tax havens, and it reallocates tax revenues across jurisdictions through the allocation of taxing rights. Residence- and source-based implementations increase revenues in large non-haven economies and dampen tax competition. The welfare impact of the reform for non-haven countries balances increased tax revenues with potential negative effects on private consumption. Higher revenues support public goods consumption, but higher effective tax rates can lead firms to relocate or exit, reducing private consumption.

Welfare gains are heterogeneous across countries, with effects ranging from -0.19% in tax havens to +0.19% in the U.S. when the residence country collects the top-up. When tax havens collect the top-up themselves, they gain +0.42% of welfare. Overall global welfare gains are positive, but modest in this last scenario (+0.02%). We also find that the globally optimal minimum tax rate is 21–22%, associated with a welfare gain of 0.13%. Importantly, a 15% minimum tax rate reduces global profit shifting by 46%. The playing field is more level, but it does not eliminate corporate tax avoidance.

Within the same international tax architecture, we also study alternative policies to the Global Minimum Tax that have been implemented. In 2017, the U.S. introduced its own minimum tax system, the Global Intangible Low-Taxed Income (GILTI, renamed NCTI in 2025), which coexists with the OECD's Global Minimum Tax. Our model allows us to consider this scenario as unilateral or bloc deviations from the minimum tax. Similarly, we also consider the introduction of a Digital Service Tax like the one implemented in France in 2019, or in the U.K. in 2020. We find that these policies generate welfare effects of similar magnitudes to the introduction of the minimum tax.

Finally, we evaluate fundamentally different international tax architectures. Currently, the international tax system is designed around the territorial principle. This gives firms incentives to artificially move profits to low-tax countries to reduce their tax bills. A leading alternative that has received significant attention in policy debates is the destination-based cash flow tax (DBCFT) (Auerbach and Devereux, 2018). Under a DBCFT, taxes are levied on local sales while firms are subsidized for local production. In this scenario, the tax base corresponds to imports and profits from domestic sales, while exports are subsidized (Devereux et al., 2021). Because the tax liability depends solely on the destination of sales, which firms cannot easily relocate, a DBCFT is designed to prevent profit shifting (Auerbach et al., 2017). As domestic firms are taxed only on domestic sales and subsidized for their production, a DBCFT is equivalent to a profit tax on the proceeds of domestic sales, plus a border adjustment component: an import tariff and an export production subsidy.

As a complementary exercise, we also consider Formulary Apportionment (Clausing, 2016), under which a multinational's global profits are consolidated at the group level and taxing rights are allocated according to a predetermined formula — for instance, assigning 50% of taxing rights to the country of production and 50% of taxing rights to the country of consumption. We find that these reforms can induce welfare gains or losses that are an order of magnitude higher than the current reforms under consideration. These architectures yield +0.66% in the U.S. under DBCFT, while formulary apportionment typically generates gains as high as +2.2% in the U.S.

**Related literature.** First, our paper contributes to the literature quantifying the importance of tax avoidance. Tørsløv et al. (2023) provide aggregate estimates of the global magnitude and bilateral distribution of corporate profit shifting.[1] Our first contribution is a novel approach to estimating profit-shifting flows. This improves on existing methods along three key margins. First, our identification relies on internal consistencies of international flows (*triangle identities*) between source, residence, and haven countries. Second, we use structural relations in our model to derive the cross-country allocation of shifted profits. Third, our approach encompasses all modes of profit shifting.[2]

Second, our paper contributes to the literature on firms' responses to corporate taxation. Existing work has focused on real responses, such as investment, employment, and location choices (Suàrez Serrato and Zidar, 2016, Fuest et al., 2018, Bilicka et al., 2022), or on profit shifting across jurisdictions (Egger and Wamser, 2015, de Mooij and Liu, 2020). We account for these two margins in a framework where firms adjust both production and profit shifting, at the intensive and extensive margins, in response to international tax reforms. This allows us to separately estimate the elasticity of real activity and the elasticity of shifted profits. Distinguishing these elasticities is key to understanding whether tax reforms affect the economy beyond tax revenues, by reallocating production and labor demand across countries.

Third, we contribute to the growing literature on international tax reforms (Hanappi and Cabral, 2020). Existing work has mostly evaluated Pillar II, *i.e.*, minimum taxation, through its effects on tax revenues (OECD, 2020, Baraké et al., 2021). We study these reforms in a framework in which firms endogenously adjust production and profit shifting, which allows us to quantify their effects on output and welfare, not only on revenues. Our approach is also related to recent tax competition models of minimum taxation (Janeba and Schjelderup, 2022, Johannesen, 2022, Hebous and Keen, 2023). In line with this work, we allow tax havens to respond to the global minimum tax and find that the reform is welfare-improving for most non-haven countries. More broadly, we also compare minimum taxation

[1] A large literature focuses on the profit shifting of U.S. multinational firms (Hines and Rice, 1994, Clausing, 2020, Wright and Zucman, 2018, Laffitte and Toubal, 2022, Guvenen et al., 2022, Blouin and Robinson, 2025), or provides estimates at a global scale (Janský and Palanský, 2019, Garcia-Bernardo and Janskỳ, 2024). Guvenen et al. (2022) estimates bilateral profit shifting to several tax havens, but only when the U.S. is the source country.

[2] Profit shifting can occur through various channels, including IP-related mechanisms (Santacreu, 2023, Deng et al., 2023), internal debt (Buettner and Wamser, 2013), mispricing of goods (Davies et al., 2018), or services (Hebous and Johannesen, 2021). We discuss profit shifting and its estimation in more detail in Appendix D.

to alternative international tax architectures. To the best of our knowledge, our paper is the first to benchmark the current reform against a destination-based cash flow tax. A DBCFT includes a border adjustment, an import tariff combined with an export subsidy. In the pure border-adjusted case, such a reform would be neutral in standard trade models by Lerner symmetry, the equivalence between import tariffs and export taxes. We find instead that it generates substantial welfare effects, pointing to quantitatively important violations of Lerner symmetry driven by multinationals (Costinot and Werning, 2019, Barbiero et al., 2019).

We make progress in the evaluation of international tax reforms by borrowing technical tools from the quantitative trade and economic geography literature. We build our model from a multi-country Krugman-type model à la Head and Mayer (2004) augmented with multinational firms and profit shifting.[3] Methodologically, however, the calibration of our model requires an estimation of worldwide trilateral profit-shifting flows and the elasticity of paper profits. The main contribution of our paper in this regard is to provide a model-consistent estimation of these profit-shifting flows as well as an estimate of paper-profit elasticity that we find to be three times as large as the elasticity of the reported tax base.

## 2 Conceptual and empirical approaches: an overview

Under the territorial principle, taxing rights should be allocated to the country of production (source country). The international tax system applies this principle by tying taxing rights to the country where profits are reported. While international tax rules seek to align reported profits with real activity, multinationals exploit loopholes and shift profits to low-tax affiliates using transfer pricing of goods and services, and intra-group debt, without relocating labor, capital, or sales. Several well-documented cases illustrate how this structure arises in practice. Levin (2013) shows how Apple Inc. shifted most of its profits to Irish and Singaporean affiliates through service transactions, even though production occurred in China, saving \$12.5bn in taxes in 2011-2012, according to the firm's officials. Levin (2014) documents that Caterpillar designated a Swiss entity as the buyer of parts manufactured in the United States, France, and Belgium, booking the profits in Switzerland without relocating production activities. Laffitte and Toubal (2022) describe a similar case for Google, whose Irish affiliate books advertising revenues generated by French workers, or Kering, where Swiss affiliates record profits on luxury goods produced in Italy. The wedge between where value is created and where profits are booked generates the excess profitability in tax havens documented by Tørsløv et al. (2023).

These examples, while diverse in their organizational details, share a common structure. In each case, a jurisdiction plays one of three roles: it is the place where the parent firm resides and ultimately repatriates profits, where production (broadly defined as creating value) takes place, or where profits are booked. Abstracting from the institutional

[3] The patterns of trade and multinational production have received substantial attention (Arkolakis et al., 2018, Head and Mayer, 2019) with applications to corporate tax reforms (Wang, 2020, Santacreu, 2023, Dyrda et al., 2024). The importance of geography for corporate taxation is highlighted in the work of Fajgelbaum et al. (2019) in the domestic context.

complexity of each arrangement, we retain these three roles as the building blocks of our model. A firm headquartered in residence country $i$ produces in source country $l$ and may shift profits to tax haven $h$, as illustrated in Figure 1. The firm then sells in several destination countries $n$, not represented in the figure. Production and profit-shifting decisions are jointly determined. A change in shifting incentives affects the firm's effective tax rate, which feeds back into its real production choices. Conversely, adjustments in real activity affect the gains from shifting profits.

A key aspect of our framework is that it delivers distinct elasticities with respect to the tax rate: one governing real production and the other governing profit shifting. This allows the model to discipline the relative magnitude of profit shifting and real adjustments. Our approach also departs from Hines and Rice (1994)'s seminal work that assumes a simple bilateral relationship between source countries and tax havens, overlooking the potential for profit-shifting arbitrage across multiple havens. This has important implications for quantifying tax reforms that target complex and multi-jurisdictional tax avoidance.

In Section 3, we explicitly model the substitutability between tax havens, which is governed by the elasticity of profit shifting. We model profit-shifting activities as subject to bilateral frictions that act as marginal-cost shifters and affect both selection into profit shifting and its scale. This parsimonious approach has three important advantages. First, the model allows us to estimate these frictions directly (Section 5) and compare them to alternative measures of the cost of shifting profits. Second, while the literature has focused on different profit-shifting channels, our approach allows us to encompass all modes of profit-shifting.[4] Third, alternative profit-shifting methods are substitutable: firms may respond to different reforms by changing their practices but not their total shifted profits. Our modeling approach implicitly accounts for this substitutability and allows us to study the effect of international tax reforms on profit shifting as a whole, rather than, for example, profit shifting through transfer pricing or intangibles only.

With this modeling structure, we consider several reforms of international taxation designed to limit MNEs' tax avoidance. These can affect tax rate differentials with tax havens (e.g., the global minimum tax) and change the rules allocating taxing rights (e.g., Destination-based cash flow taxation). Section 6 provides an analysis of how various reforms affect profit shifting, production, tax revenues, and global welfare.

# 3 Model

This section describes the model that guides the calibration of profit-shifting flows, their response to tax reforms, and the counterfactual analysis.

## 3.1 Set-up

**Structure of the model.** The world economy consists of $n = 1, \ldots, N$ countries, of which $h = 1, \ldots, H$ are designated as "tax havens". Each country is endowed with labor, the

[4] We discuss in Appendix D why accounting for all profit shifting channels is important for macro-level quantification.

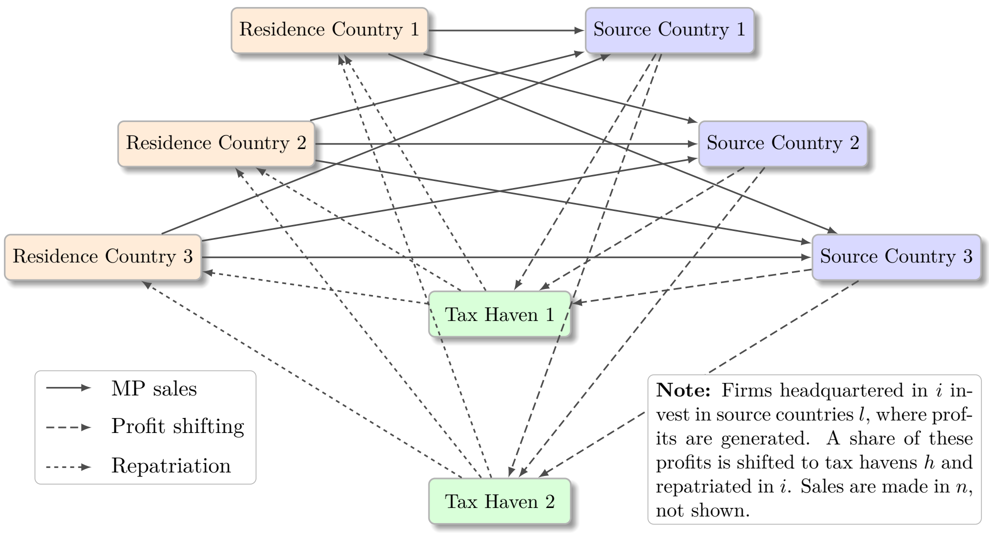



Figure 1: Interactions between residence countries, source countries, and tax havens.

unique factor of production. The $L_n$ workers are immobile across countries. Each worker inelastically supplies one unit of labor paid $w_n$. An endogenous number of corporations $\mathcal{N}_i$ with tax residence in country $i$ operate under monopolistic competition. Each corporation is a collection of $M$ affiliates where $M$ is a random variable and each affiliate $m$ designs and produces a single variety in a source country $l$. This variety can be sold in any country $n$. Profits generated by each affiliate are booked either in the source country under territorial taxation or in a tax haven $h$ through profit shifting.

**Demand and pricing.** The set of varieties supplied in country $n$ is $\Omega_n$. The demand for any variety in $\Omega_n$ at price $p_n$ is given by $d_n(p_n) = Y_n \frac{p_n^{-\sigma}}{P_n^{1-\sigma}}$. The price-elasticity of demand is $\sigma > 1$; $Y_n$ denotes total expenditures; $P_n$ is the price index given by $P_n = \left(\int_{\Omega_n} p_n(\omega)^{1-\sigma} d\omega\right)^{\frac{1}{1-\sigma}}$. Real expenditure is given by $Y_n/P_n$. Monopolistic competition and CES preferences jointly imply that the profit-maximizing markup equals $\frac{\sigma}{\sigma-1}$ and is independent of the destination market. The total expenditure $Y_n$ is purchased by households and the government. A part $C_n$ is purchased by households for consumption purposes, and its complement $B_n$ is purchased by the government through tax revenues and finances a public good, so $Y_n = C_n + B_n$.

**Welfare.** We define the welfare of country $n$ as:

$$U_n = (B_n/P_n)^{\beta_n} C_n/P_n,$$

where $B_n$ are tax revenues that are used to finance a public good and $\beta_n \geq 0$ is a country-specific preference parameter. $C_n/P_n$ represents the household consumption.

**Frictions and taxation.** Consider a plant producing in $l$ belonging to a firm headquartered in $i$. When the source country $l$ and the residence country $i$ differ, the cost to produce abroad involves a friction $\gamma_{il} \geq 1$, which reflects a technology transfer from the headquarters. Serving foreign destination markets $n \neq l$ comes with trade frictions $\tau_{ln} \geq 1$ for iceberg transport costs. Neither producing nor serving the destination market

$n$ requires the payment of a fixed cost. Therefore, plants serve all markets and $\Omega_n \equiv \Omega$. The geography of a source country $l$, its economic size, and that of its trade partners adjusted by trade frictions are summarized by the endogenous market potential of country $l$, $\Xi_l^{1-\sigma} = \sum_n \Xi_{ln}^{1-\sigma} = \sum_n \tau_{ln}^{1-\sigma} Y_n P_n^{\sigma-1}$ (Head & Mayer, 2004), which summarizes the attractiveness of location $l$ as an export platform. Corporations producing in a non-haven country $l$ can choose to book their profits in a tax haven $h$. A tax haven can host and tax profits of foreign firms at the rate $t_{lh} < t_{ll}$ without requiring their physical presence, i.e., a production site. When shifting their profits, we assume that firms incur a bilateral cost $\alpha_{lh}$. The bilateral structure of these frictions is deliberate. On the production side, these costs can subsume heterogeneity across countries $l$ — e.g., different sector composition and sectoral differences in profit-shifting abilities, which we do not model. On the haven side, they capture differences across $h$: tax havens differ in characteristics that facilitate profit shifting, like communications infrastructures or the legal technologies they offer to foreign firms (e.g., reduced incorporation time and costs, opacity and secrecy, accounting rules, and treaty network; see Tørsløv et al. (2023) and Laffitte (2024) who show that tax havens differ from other jurisdictions). Our reduced-form friction $\alpha_{lh}$ goes further by allowing these determinants to be bilateral, so the cost of shifting profits to a tax haven differs depending on whether they stem from production that is sourced in the U.S. or, for instance, in France. This approach is consistent with evidence on the sectoral and geographical specialization of tax havens (Garcia-Bernardo et al., 2017, Bilicka et al., 2020, and Laffitte and Toubal, 2022).

**Profits.** The idiosyncratic profitability of an affiliate $m$ is subsumed in $\varphi_m$: this variable encompasses both the affiliate's idiosyncratic physical productivity as well as its tax avoidance ability. The global post-tax profits of an affiliate $m$ that belongs to a corporation domiciled in $i$, produces in $l$ and books its profits in $h$ are given by

$$\pi_{ilh}(\varphi_m) = (1 - t_{ilh}) \frac{\iota_l}{\sigma} \left( \frac{\sigma}{\sigma - 1} \frac{\gamma_{il}\alpha_{lh}}{\varphi_m} w_l \Xi_l \right)^{1-\sigma}. \quad (1)$$

The term $\left( \frac{\sigma}{\sigma-1} \frac{\gamma_{il}\alpha_{lh}}{\varphi_m} w_l \Xi_l \right)^{1-\sigma}$ denotes the global revenues of an affiliate in the triplet $ilh$. These revenues turn into pre-tax profits with the standard relationship that the sales-to-profit ratio is governed by the elasticity of demand $\sigma$. This parameter simultaneously governs profitability and the curvature of demand. Anticipating our calibration, we disentangle them by introducing a production-country-specific wedge $\iota_l \leq \sigma$ between sales and profits so that firms producing in $l$ have a sales-to-profit ratio equal to $\iota_l/\sigma$.

We allow the tax rate $t_{ilh}$ to be trilateral. For instance, taxing rights at the origin matter when discussing ongoing reforms, e.g., the global minimum tax reform, which gives taxing rights over the tax gap $t^{min} - t_{ilh}$ in tax havens $h$ to residence countries $i$.

The total profits of a firm headquartered in $i$ with $M$ affiliates are given by $\pi_i = \sum_{m=1}^{M} \sum_{l,h} \pi_{ilh}(\varphi_m)$. Importantly, we assume that each affiliate books all its profits in a single tax domicile. This assumption implies that at the micro level, tax-avoiding plants' profits in $l$ bunch at zero, consistent with Bilicka (2019). Aggregate bilateral profit-shifting flows result from aggregating heterogeneous profit-shifting patterns across plants within and across firms.

## 3.2 From micro to macro

**Firm heterogeneity.** We parametrize the distribution of $\varphi$ to relate our model to bilateral macroeconomic flows, e.g., trade shares, multinational production shares, and profit shifting. Despite its simplicity, our model retains gravity patterns for both trade and multinational production flows. We leverage this minimal structure to incorporate profit-shifting flows to tax havens.

We introduce firm heterogeneity as follows. In each residence country, firms decide whether to enter, i.e., to establish a headquarters in $i$ by paying a sunk cost $w_i f_E$. This constitutes the key intangible investment, as firms decide whether to hire workers to create their patented good. Each corporation draws a number of plants $M \sim \mathcal{H}(\mathcal{M})$, $M > 0$ with expected value $\bar{M}$. For each affiliate, the firm determines how profitable it would be by locating its production facility in any country $l$ *and* recording its profits in any country $h$. When $h = l$, the firm does not shift profits abroad. Formally, each firm draws $M$ independent $N \times H$ matrices of productivities $(\varphi_{lh})$. Last, the overall profitability of each plant depends on a deterministic component $T_i$, inherited from the residence country $i$.[5] A plant owned by a corporation resident in $i$, producing in $l$ and booking profits in $h$, earns post-tax profits $\pi_{ilh}(T_i\varphi_{lh})$.

**Parametrization.** To retain tractability, we make a standard assumption in the literature on multinational production. We assume that productivities follow a multivariate $\upsilon_1$-Fréchet distributionwith scale parameters $A_l$ and a homogeneous correlation function $G_i(.)$ so that the $\varphi_{lh}$ draws by country $i$ are distributed according to the following c.d.f.: $\mathbb{P}\left(\varphi_{11} \leq z_{11}; \ldots; \varphi_{lh} \leq z_{lh}; \ldots; \varphi_{NH} \leq z_{NH}\right) = e^{-G_i\left(A_1 z_{11}^{-\upsilon_1}, \ldots, A_l z_{lh}^{-\upsilon_1}, \ldots, A_N z_{NH}^{-\upsilon_1}\right)}$ where

$$G_i(\mathbf{x}) = \sum_{l=1}^{N} x_{ll} + \theta_i^{-\upsilon_1} \left( \sum_{l=1}^{N} \sum_{h=1, h\neq l}^{H} x_{lh}^{\frac{\upsilon_2}{\upsilon_1}} \right)^{\frac{\upsilon_1}{\upsilon_2}},$$

with $\upsilon_2 \geq \upsilon_1$ and $\mathbf{x}$ denoting a matrix with generic entry $x_{lh}$. The function $G_i$ governs substitutability across $lh$ pairs: $\upsilon_1$ controls how easily *production* relocates across countries, while $\upsilon_2$ controls how easily *paper profits* are reallocated across tax havens. The restriction $\upsilon_2 \geq \upsilon_1$ implies that paper profits, i.e., profits booked by tax-avoiding affiliates, are weakly more elastic to corporate taxation. This reflects that relocating physical production is more costly than shifting profits through paper entities. The formulation allows residence countries $i$ to differ in profit-shifting intensity. Since in the data different $i$ countries shift at different rates, we introduce a parameter $\theta_i$ capturing country-specific (inverse) tax aggressiveness, reflecting heterogeneity in the ability of headquarters across tax domiciles to engage in profit shifting.

[5] This is equivalent to having $i$-specific sunk entry costs $f_E$.

**Sourcing and profit-shifting decisions.** After observing the $\varphi_{lh}$ draws for each of the $M$ affiliates, firms from $i$ select a unique pair $lh$ that maximizes their profits for each plant, as given by (1).

Denote by $\mathbf{t}_i = (t_{ilh})_{1\leq l\leq N, 1\leq h\leq H}$ the matrix of corporate income tax rates and collect all other determinants of affiliates' location choices in $\tilde{A}_{ilh} := A_l \left(\gamma_{il}\alpha_{lh}\iota_l^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{-\upsilon_1}$. We denote by $G_{i,lh}$ the partial derivative of $G_i$ with respect to the $lh$ term and, with a slight abuse of notation, we denote by $G_i(\tilde{\mathbf{A}}_i, \mathbf{t_i})$ the correlation function evaluated at $\left(\tilde{A}_{ilh}(1-t_{ilh})^{\frac{\upsilon_1}{\sigma-1}}\right)_{l\leq N, h\leq H}$.

Then, the probability for an affiliate of a firm from country $i$ to locate its production in $l$ and book its profits in $h$ is:

$$\mathbb{P}_{ilh} = \frac{\tilde{A}_{ilh} G_{i,lh}(\tilde{\mathbf{A}}_i, \mathbf{t}_i)}{G_i(\tilde{\mathbf{A}}_i, \mathbf{t}_i)} (1-t_{ilh})^{\frac{\upsilon_1}{\sigma-1}}, \tag{2}$$

Expression (2) results directly from McFadden (1978)'s discrete choice framework using Generalized Extreme Value distributions (GEV).[6] Importantly, larger firms, for example those with more plants, are more likely to be engaged in profit shifting. A schematic representation of the choices faced by MNCs in our model is provided in Appendix A.

## 3.3 Equilibrium

Using the properties of the GEV, expected post-tax profits $\bar{\pi}_i$ of an affiliate headquartered in $i$, taken over all pairs $lh$, are given by

$$\bar{\pi}_i = \frac{1}{\sigma T_i^{1-\sigma}} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} G_i(\tilde{\mathbf{A}}_i, \mathbf{t}_i)^{\frac{\sigma-1}{\upsilon_1}} \Gamma\left(1 - \frac{\sigma-1}{\upsilon_1}\right). \tag{3}$$

Given profits, government $k$'s tax revenue is denoted $B_k$. Let $\mathcal{M}_i = \mathcal{N}_i \times \bar{M}$ denote the number of affiliates owned by firms headquartered in $i$. Aggregate post-tax profits of firms from $i$ equal $\mathcal{M}_i\bar{\pi}_i$. Pre-tax profits per affiliate are $\frac{\bar{\pi}_i}{1-t_{ilh}}$. Therefore, tax revenues are

$$B_k = \sum_{i,l,h} t_{ilh}^{g_k} \mathcal{M}_i \mathbb{P}_{ilh} \frac{\bar{\pi}_i}{1-t_{ilh}}, \tag{4}$$

where $t_{ilh}^{g_k}$ is the tax rate relevant for country $k$'s tax authority under the prevailing regime, e.g., territorial, worldwide, or a worldwide minimum tax. As an illustration, consider a minimum tax regime that reallocates taxing rights to country $k$, allowing it to tax worldwide profits that are (i) generated by firms headquartered in $k$, (ii) shifted to tax havens, and (iii) taxed below $t_k^{min}$. Country $k$ then collects revenues from firms producing in $k$ and from firms headquartered in $k$ that book profits in a tax haven with a rate below $t_k^{min}$. In this case, $B_k = \sum_i t_k \mathcal{M}_i \mathbb{P}_{ikk} \frac{\bar{\pi}_i}{1-t_{ikk}} + \sum_{l\neq h,h} \max\{t_k^{min} - t_{lh}, 0\} \mathcal{M}_k \mathbb{P}_{klh} \frac{\bar{\pi}_k}{1-t_{klh}}$, where the first term describes the tax revenues generated by firms producing in $k$ and the second term by firms headquartered in $k$ booking profits in a tax haven for which the minimum

[6] To obtain the above formula, note that using (1), profits $\pi_{ilh}$ from a residence country $i$ follow a multivariate $\frac{\upsilon_1}{\sigma-1}$-Fréchet distribution with scale parameters $\tilde{A}_{ilh}(1-t_{lh})^{\frac{\upsilon_1}{\sigma-1}}$ and the same correlation function $G_i(.)$.

tax rate binds.

Production in country $l$ aggregates multinational production from all origin countries. Noting that production $Q_l$ is proportional to profits with a factor $\sigma/\iota_l$ we get:

$$Q_l = \frac{\sigma}{\iota_l}\sum_{i,h}\mathcal{M}_i\frac{\mathbb{P}_{ilh}\bar{\pi}_i}{(1-t_{ilh})}. \tag{5}$$

Setting up a headquarter in country $i$ involves an investment in intangibles to create the patented good $f_E w_i$ paid in labor. In our static model, this forward-looking intangible investment is the same as the entry or innovation investment. The only factor of production $L_i$ is used both for firm entry and production, so that factor-market clearing reads

$$w_i L_i = \mathcal{N}_i f_E w_i + \frac{\sigma-1}{\sigma}Q_i. \tag{6}$$

The price index in country $n$ can be simplified as follows:

$$P_n = \left(\sum_l \frac{\tau_{ln}^{1-\sigma}Q_l}{\Xi_l^{1-\sigma}}\right)^{\frac{1}{1-\sigma}}. \tag{7}$$

Finally, aggregate expenditure in country $i$ results from labor income, corporate income tax revenues, and profits:

$$Y_l = w_l L_l + \mathcal{N}_l(\bar{M}\bar{\pi}_l - f_E w_l) + B_l + \Delta_l, \tag{8}$$

where $\bar{M}\bar{\pi}_i - f_E w_i$ are the profits net of entry/investment costs, and the residual imbalances are captured by $\Delta_l$.[7] The system of equations (4)-(8) determines $Q_l$, $Y_n$, $w_i$, $P_n$ with a numeraire condition such that $P_1 = 1$. The long-run monopolistically competitive equilibrium determines $\mathcal{N}_i$ through a free-entry condition imposing that $\bar{M}\bar{\pi}_i = f_E w_i$, $\forall i$.

Before describing alternative policy regimes, a discussion is warranted on how profit shifting and tax reforms affect firms' choices. First, since profit shifting frictions enter as marginal cost shifters, they affect both the optimal scale of operation (intensive margin) of individual plants and the size of the firm at the extensive margin. Stronger profit shifting frictions reduce the size of each plant. Similarly, any reform that changes the tax rate or its incidence affects the optimal investment policy of the firm. Firms facing higher effective tax rates may optimally choose not to invest in the fixed cost of operation and, therefore, leave the market. In the aggregate, both the intensive and extensive margin adjustments underlie the reaction of sales, profits, and investment into entry. Our model, therefore, reproduces the important finding of the profit-shifting literature that the level of profit-shifting frictions determines the real responses of firms to economic and policy shocks (Hines and Rice, 1994, Suárez Serrato, 2018).

[7] Whether imbalances are considered to remain constant in absolute terms instead of relative terms does not make a difference for our quantification exercises.

## 3.4 Tax-base and profit-shifting elasticities

Denote $X_{ilh}$ the total sales of firms from $i$ whose production has been sourced in $l$ and taxed in $h$. Combining the $G_i$ function and eq. (2), and (3), we obtain the following:

**Proposition 1** (Gravity structure of multinational production and profit shifting)**.** *The fraction of profits that remains taxable in each source country $l$ is given by:*

$$\frac{X_{ill}}{X_i} = \frac{\tilde{A}_{ill}(1-t_{ill})^{\frac{\upsilon_1}{\sigma-1}-1}\iota_l^{-1}}{\sum_{jk}\tilde{A}_{ijk}(1-t_{ijk})^{\frac{\upsilon_1}{\sigma-1}-1}\iota_j^{-1}G_{i,jk}(\tilde{\mathbf{A}}_i,\mathbf{t})}, \tag{9}$$

*where $X_i := \sum_{l,h} X_{ilh}$. Moreover, the fraction of shifted income generated by firms from $i$ that is produced in $l$ and reported in tax haven $h$ is given by:*

$$\frac{X_{ilh}}{\sum_{jk,j\neq k} X_{ijk}} = \frac{\tilde{A}_{ilh}^{\frac{\upsilon_2}{\upsilon_1}}(1-t_{ilh})^{\frac{\upsilon_2}{\sigma-1}-1}\iota_l^{-1}}{\sum_{jk,j\neq k}\tilde{A}_{ijk}^{\frac{\upsilon_2}{\upsilon_1}}(1-t_{ijk})^{\frac{\upsilon_2}{\sigma-1}-1}\iota_j^{-1}}. \tag{10}$$

*As a consequence, from (9), the partial elasticity of the tax base in $l$ to $1-t_{ill}$ is $\tilde{\upsilon}_1 := \frac{\upsilon_1}{\sigma-1}-1$. Moreover, from (10), the partial elasticity of profits shifted from $l$ to $h$ w.r.t. $1-t_{ilh}$ is equal to $\tilde{\upsilon}_2 := \frac{\upsilon_2}{\sigma-1}-1$.*

The proof is relegated to Appendix A.2. Proposition 1 shows how the model captures tax competition for paper profits across tax havens. The multilateral resistance terms in the denominator of (10) show that, beyond the characteristics of tax haven $h$, those of the other tax havens also matter for bilateral profit shifting. A decrease in a tax haven's tax rate $t_{ilh}$ triggers two main effects. First, it increases the total share of profits shifted from $l$ toward tax havens (eq. 2). Second, it reshuffles these profits among tax havens (eq. 10). Some affiliates in $l$ start shifting their profits to $h$ and some others producing in $l' \neq l$ move their production site to $l$ and engage in profit shifting. Moreover, some affiliates that were previously shifting their profits to $h' \neq h$ now switch to tax haven $h$.

This gravity-based profit-shifting enriches the reduced-form set-up *à la* Hines and Rice (1994), standard in the corporate tax avoidance literature, in which bilateral profit-shifting abstracts from other tax havens' attributes and reallocation mechanisms across tax havens.[8]

This completes the characterization of the model under territorial taxation. Towards a comprehensive framework of international tax reforms, in the next section, we extend the model to include non-territorial taxation. This is the basis for the counterfactuals that consider alternative tax architectures in Section 6.

## 3.5 Sales-based taxation

We extend the model to incorporate destination-based taxation, moving beyond the conventional allocation of taxing rights to residence, source, and profit-location countries.

[8]In these models, bilateral profit shifting between $l$ and $h$ is proportional to the difference in tax rates between $l$ and $h$. This implies that the elasticity of profit shifting is not constant. In section 4.4, we extend our model to allow for a varying profit-shifting elasticity.

This framework corresponds to reform proposals aimed at curbing profit shifting and tax competition by leveraging the fact that the location of final sales is harder to manipulate than the location of booked profits. We introduce below three instruments that an extension of our model can accommodate: a destination-based cash flow tax (DBCFT), formulary apportionment (FA) with a sales weight, and an idealized sales tax on tax-avoiding firms.

**Destination-based cash flow tax (DBCFT).** A DBCFT is the most theoretically developed version of sales-based taxation and has been widely studied (Auerbach et al., 2017, Auerbach and Devereux, 2018). We adapt the model to analyze its unilateral implementation. The DBCFT replaces the corporate income tax with a border-adjusted tax that neutralizes standard profit-shifting strategies by disregarding reported profit locations. The DBCFT modifies taxation through three channels: (i) introduction of a sales tax $tr_n$ on domestic consumption, (ii) a subsidy $s_l$ to domestic production costs, and (iii) the elimination of the corporate income tax (CIT). Profits remain as in (1), but the tax system now alters market potentials:

$$\Xi_l^{1-\sigma} = (1+s_l)^{\sigma-1} \sum_n \frac{\tau_{ln}^{1-\sigma}}{(1+tr_n)^{\sigma}} \frac{Y_n}{P_n^{1-\sigma}}.$$

We consider a unilateral DBCFT with $s_l = tr_l \equiv tr$, in which case the expression above implies that profits from domestic sales by local producers are subject to an effective tax rate $t_{ilh} = 1 - (1+tr)^{-1}$. Unlike a standard corporate income tax, imports are taxed (only subject to the sales tax), and exports are subsidized (only subject to the production subsidy). The remainder of the model is unchanged, with tax revenues now including consumption tax receipts and production subsidy payments.

**Formulary apportionment (FA).** Under FA, worldwide profits of each multinational group are consolidated and allocated across jurisdictions according to a formula. Profit shifting is eliminated by construction: the profit-booking location $h$ becomes irrelevant. Let $\omega \in [0,1]$ denote the weight on sales location in the formula, with $1-\omega$ on production factors. The effective tax rate faced by a firm producing in $l$ and selling to locations $n$ becomes $t_l^{FA} = \omega \sum_n \mu_{ln}\, t_n + (1-\omega)\, t_l$, where $\mu_{ln}$ is the share of total profits of a firm producing in $l$ that arises from sales in market $n$.[9] At $\omega = 1$, taxing rights are fully allocated to destination countries. Unlike the DBCFT, FA requires multilateral adoption, as it presupposes common rules for profit consolidation and formula design. The remainder of the model is unchanged.

**Idealized sales tax.** We consider an idealized destination-based sales tax that captures the logic of digital service taxes (DSTs). Unlike the DBCFT, this instrument supplements rather than replaces the corporate income tax. Destination countries levy an *ad valorem* tax $\delta_n$ on the sales of profit-shifting firms only. The instrument is *idealized* in that it assumes perfect targeting of tax-avoiding firms while actual DSTs apply uniformly in targeted

[9] Our apportionment formula is non-distortionary because it is based on profit shares. On the contrary, sales or employment shares would distort the pricing and wage decisions of firms with market power.

sectors regardless of firm-level shifting behavior.

## 3.6 Tax reforms, consumption, and welfare: a discussion

Although our model does not yield closed-form welfare formulas for arbitrary tax reforms, its structure isolates a set of channels through which reforms affect consumption and welfare. We discuss these channels in turn and then trace them through the reforms analyzed in Section 6.

**Channels.** Tax reforms affect welfare through three main channels.

*Firm entry and product variety.* The number of active headquarters determines the number of varieties available for consumption. A reform that raises the effective corporate tax rate reduces post-tax profits and discourages headquarters entry. Because each entrant produces varieties that are traded internationally, fewer headquarters means fewer varieties consumed in *all* countries, not only in the country of residence. Starting from positive tax rates, a reduction in the number of firms lowers the efficiency of production of the private consumption bundle (Dixit and Stiglitz, 1977, Dhingra and Morrow, 2019). This implies that corporate taxation in our set-up is always distortionary, with or without profit shifting.

*Spatial allocation of production.* Corporate tax policy also affects welfare through the allocation of production across countries. When tax rates differ, firms weigh tax differentials alongside country fundamentals, market potential, wages, productivity, when choosing where to locate production and book profits. Dispersion in tax rates, therefore, distorts the spatial allocation of activity. Reducing this dispersion brings location decisions closer to the efficient benchmark and increases consumption, as in Fajgelbaum et al. (2019).

*Taxing rights and public good provision.* Taxation finances the provision of a public good that enters welfare directly. Tax reforms affect the collection of revenues in two distinct ways: by reallocating taxing rights across countries or by changing the effective tax rate. First, reforms that increase the amount of tax revenues collected allow countries to produce more public goods and, all else equal, raise welfare. The higher revenues may be driven by decreased profit shifting or by a higher statutory rate. This channel features a fundamental tension with the *entry channel*, since raising revenues requires lowering the post-tax profitability of firms and, therefore, their incentive to enter. This channel has ex-ante ambiguous effects that depend on countries' preferences for public goods, $\beta_n$. Second, reforms that reallocate taxing rights redistribute tax revenues across space. If such a reform does not change firms' effective tax rate, it does not distort the incentives to enter, and the welfare consequences depend entirely on whether a country wins or loses from this reallocation.

**Corporate taxation.** A change in a country's corporate tax rate illustrates how these channels interact. A tax rate increase may lower the number of active firms by reducing post-tax profits (*entry channel*) and reallocating production and shifting across countries as firms respond to the change in tax differentials (*spatial allocation channel*). It also raises tax revenues from the remaining firms, thereby increasing public good provision (*public* *good channel*). The net welfare effect is ambiguous and depends on the elasticities of entry and production to the tax rate, as well as on the preference for public good consumption.

**Minimum taxation.** A global minimum tax raises the effective tax rate faced by multinational firms. The three channels operate as follows. First, the higher effective tax rate discourages entry, reducing product variety and lowering consumption. Second, the minimum tax reduces the dispersion of effective tax rates across countries, which improves the spatial allocation of activity. Third, the minimum tax affects tax revenues in two separate ways. First, it raises them by taxing low-taxed profits and by reducing profit shifting. Second, it changes the allocation of taxing rights, determining which jurisdiction collects the top-up revenue. Because the firm-level effective tax rate is the same regardless of whether the residence country, the source country, or the profit-booking jurisdiction collects the tax, firm decisions are unaffected by this allocation. The welfare consequences across countries, however, can differ substantially depending on the allocation of taxing rights.

*Deviations from the minimum tax framework.* Implementing a coordinated minimum tax requires agreement across many countries with heterogeneous interests. Two deviations from minimum taxation are particularly relevant to study. First, a country may adopt a minimum tax rate different from the global rate, as under the U.S. GILTI/NCTI regime. A unilaterally lower minimum rate implies a smaller increase in effective tax rates: entry is less discouraged, but dispersion is reduced by less, and revenue gains are smaller. The deviating country partially free-rides on the coordination of others. Second, absent full coordination, countries may resort to unilateral instruments such as sales taxes targeting profit-shifting firms, similar to the Digital Service Taxes adopted by several jurisdictions. A destination country $n$ may introduce a sales tax $\delta_n$. Such a tax disconnects the location of taxation from the location where profits are booked, thereby discouraging profit shifting. The welfare effects are driven by reduced shifted incomes, which raise public good provision. Countries with large consumer markets obtain more revenues and, therefore, larger benefits.

**Alternative international tax systems.** The reforms discussed above modify the existing international tax system. They mitigate profit shifting but do not eliminate it. This motivates a more fundamental question: can an alternative architecture eliminate profit shifting without reducing consumption? We examine two reforms that achieve this by changing how multinational profits are taxed.

*Destination-based cash flow tax.* The DBCFT has three important features. First, it eliminates profit shifting under the current system (Auerbach et al., 2017): when taxation is based on the location of sales, revenues accrue where consumption occurs rather than where profits are booked. Second, it can be implemented unilaterally. Third, it connects to Lerner symmetry, which provides a benchmark of neutrality.

A DBCFT affects welfare by removing the spatial distortions associated with profit shifting. However, a DBCFT combines a border-adjusted tax (BAT) with a potentially large reduction in the corporate tax rate. A lower corporate rate encourages entry, increasing product variety, while the border adjustment alters trade patterns and prices. In our setting, the BAT is not neutral due to multinational production under imperfect competition (Costinot & Werning, 2019) and income effects from eliminating profit shifting. If the reduction in the corporate tax rate exceeds the increase in effective taxation from eliminating shifting, consumption rises at the expense of public good provision. The net welfare effect is therefore sensitive to the chosen rate and to a country's trade balance, which determines the sign and magnitude of border-adjustment revenues.

*Formulary apportionment.* FA replaces the arm's-length principle with unitary taxation: worldwide profits of a multinational group are consolidated and allocated across jurisdictions using a formula based on observable factors such as sales, employment, or capital. As with the DBCFT, profit shifting is eliminated by construction since the profit-booking location is not relevant.

Under FA, the effective tax rate becomes a weighted average of statutory rates, with weights determined by the chosen factors. If the profit-booking location becomes irrelevant, formulas based on sales or employment create incentives to relocate these factors to low-tax jurisdictions, introducing new distortions even as they eliminate profit shifting. The key welfare channel specific to FA is the reallocation of taxing rights: countries whose formula-based share of world activity exceeds their share of booked profits under the status quo gain revenue, and vice versa. By design, FA requires multilateral coordination. Countries gain when the formula allocates them more tax revenue than they would lose from the higher effective tax rates implied by eliminating profit shifting alone.

# 4 Profit shifting and profit-shifting frictions

To quantify the effect of international tax reforms, we use the standard *hat algebra* approach in the quantitative trade literature (Dekle et al., 2007). This method requires two types of inputs for the model: i) the elasticities of various economic flows (trade flows, multinational production, profit shifting); and ii) the initial levels of these flows. While both are available for trade and multinational production flows, they are not for shifted profits. In this section, we describe our novel method to estimate trilateral profit-shifting flows ($i \to l \to h$) and their elasticities. In Section 5, we complete the model inversion and back out the parameters that rationalize the data as an equilibrium. We identify these missing inputs using the model's equilibrium relations and the available data.

## 4.1 A new approach to estimating profit shifting

Our goal is to obtain $\mathbb{P}_{ilh}$: the probability that an affiliate of a firm from $i$ produces in $l$ and books profits in $h$. Our identification strategy has two pillars. The first is a model-implied decomposition formalized in Proposition 2. Equation (2) describes the probability that a firm from $i$ selects pair $lh$ to locate production and book profits. Profits can be reported in the source country ($h = l$) or shifted from the source to a tax haven ($h \neq l$). We assume that no profit is shifted out of tax havens, i.e., $\alpha_{lh'} = +\infty$ for $l = h$ and $h' \neq h$, or repatriated to a tax haven from another tax haven, i.e. $\theta_i = +\infty$ for $i = h$.[10] Let $\Pi_{ill}$ denote total post-tax profits declared in $l$ by firms from $i$ producing in $l$, and $PS_{ilh}$ post-tax profits shifted to $h$ by firms headquartered in $i$ and producing in $l$. Total profits of firms from $i$ are $\Pi_i \coloneqq \sum_l \Pi_{ill} + \sum_{lh} PS_{ilh}$. Total shifted profits are $PS_i \coloneqq \sum_{lh} PS_{ilh}$, and $PS_{ih} \coloneqq \sum_l PS_{ilh}$ denotes profits shifted to tax haven $h$ from firms headquartered in country $i$. We use the separability of $\mathbb{P}_{ilh}$ across country pairs to derive a decomposition of profit-shifting flows.

**Proposition 2** (Decomposition of $\mathbb{P}_{ilh}$)**.** *The following decomposition holds*

$$\mathbb{P}_{ilh} = \mathcal{P}_i \times \zeta_{il} \times \chi_{lh} \text{ , for } h \neq l, \tag{11}$$

*where $\mathcal{P}_i = \frac{PS_i}{\Pi_i}$ is the probability that plants of firms headquartered in i shift profits, $\zeta_{il}$ is the probability that a tax-avoiding firm headquartered in $i$ locates production in $l$ and $\chi_{lh}$ is the probability that a tax-avoiding firm producing in $l$ books its profits in $h$.*

The proposition shows that inferring $\mathbb{P}_{ilh}$ requires three simpler, lower-dimensional probabilities: $\mathcal{P}_i$, $\zeta_{il}$, and $\chi_{lh}$.[11] Given this decomposition, we still face the issue that none of them are readily observable in the data. The second pillar of our strategy identifies these probabilities.

**Identifying $\mathcal{P}_i$.** The first element of the decomposition in Proposition 2 is the probability that a firm headquartered in $i$ shifts profits anywhere in the world: $\mathcal{P}_i = \frac{PS_i}{\Pi_i}$. While the denominator can be observed, the numerator cannot. Identifying $PS_i = \sum_h PS_{ih}$ amounts to answering a counterfactual question: *what would the level of profits recorded in country $h$ be if $h$ were not a tax haven?* Estimating profit shifting requires defining a benchmark level of profit due to real activities (Hines and Rice, 1994, Garcia-Bernardo and Janskỳ, 2024, Guvenen et al., 2022, Tørsløv et al., 2023). Our model provides guidance for this benchmark. According to Proposition 1, profits booked in country $l$ by firms from $i$ due to real activities follow a gravity structure (9). This gravity relationship separates profits booked by country $i$'s firms in haven $h$ ($\sum_l \Pi_{ilh}$) due to real activities in country $h$ ($\Pi_{ihh}$) from shifted profits ($\sum_{l\neq h} \Pi_{ilh}$). Since our model assumes profit shifting occurs only in tax havens, we compute the counterfactual profits booked by country $i$'s firms in country $h$ if it were not a tax haven. We therefore regress bilateral FDI income or bilateral profits on tax haven dummy variables and a set of gravity factors, which explain real activity in country $h$.[12] We estimate the following equation:

$$Y_{ikt} \quad = \quad \exp(\beta_1 \text{Haven}_k + \theta' \boldsymbol{X_{ikt}} + \mu_{it} + \mu_{r_{(k)}t}) + u_{ikt}. \tag{12}$$

[10] This assumption is common in the literature, see for instance Tørsløv et al. (2023).

[11] While the probability of shifting from $l$ to $h$ conditional on shifting is independent of $i$, the unconditional probability of shifting is not separable in $i$, $l$, $h$.

[12] In Appendix Table D2, we propose an alternative strategy where we use the elasticity of profits to the effective tax rate to compute bilateral profit shifting, following Beer et al., 2020 and Garcia-Bernardo and Janskỳ, 2024. Both strategies yield similar aggregate values, but defining a consensus counterfactual tax rate is more challenging than muting the tax haven dummy.

$Y_{ikt}$ is the FDI income or pre-tax profit booked by residence country $i$ in country $k$ in year $t$. $Haven_k$ is an indicator variable equal to 1 if country $k$ is a tax haven. $\boldsymbol{X_{ikt}}$ contains gravity variables with coefficient vector $\theta$; $\mu_{it}$ are residence country $\times$ year fixed effects; $\mu_{r_{(k)}t}$ are region $\times$ year fixed effects; and $u_{ikt}$ are residuals.

Profit shifting, $PS_{ih}$, is defined as the difference between predicted and counterfactual income: $PS_{ih} = \widehat{Y_{ih}} - \widehat{Y_{ih}^0}$. $\widehat{Y_{ih}}$ are predicted values for non-haven countries $i$ reporting incomes in tax havens $h$. $\widehat{Y_{ih}^0}$ corresponds to predicted income when the tax haven premium is set to 0 (i.e., $\beta_1 = 0$). From $PS_{ih}$ we obtain $PS_i$ as $\sum_h PS_{ih}$ and $\mathcal{P}_i$ as $PS_i/\Pi_i$.

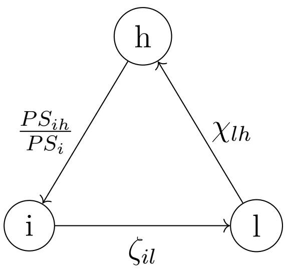
**Identifying $\zeta_{il}$ and $\chi_{lh}$** The two last elements are $\zeta_{il}$ and $\chi_{lh}$. The first term, $\zeta_{il}$, is the probability that a tax-avoiding firm headquartered in $i$ locates production in $l$. Despite the availability of multinational production flows data, $\zeta_{il}$ is not directly observed as it is conditional on the firm shifting profits. The second term is $\chi_{lh}$, the probability that a tax-avoiding firm producing in $l$ books its profits in $h$.

To recover them, we use the following "triangle identities": profits of firms resident in $i$ booked in haven $h$ must equal profits shifted from all source countries $l$ where they operate to $h$. Figure 2 illustrates and Proposition 3 formalizes the triangle identities:

**Proposition 3** (Triangle of Profit Shifting)**.** *The following holds*

$$\frac{PS_{ih}}{PS_i} = \sum_{l \neq h} \zeta_{il} \times \chi_{lh}. \tag{13}$$

Proposition 3 establishes a natural consistency requirement: shifted profits repatriated from $h$ to $i$ ($PS_{ih}$) need to be generated across all destinations $l$ and shifted to $h$ ($\chi_{lh}$) by shifting firms headquartered in $i$ producing in $l$ ($\zeta_{il}$). In Appendix B.2, we show how Equation (13) associated with source-country sales allows us to uniquely *triangulate* $\chi_{lh}$ and $\zeta_{il}$ from $\frac{PS_{ih}}{PS_i}$. In particular they are recovered as a function of observed multinational production flows, aggregate profit shifting in residence countries $i$ and source countries $l$, and elasticities $\tilde{\upsilon}_1$ and $\tilde{\upsilon}_2$. Indeed, profits can be shifted from $l$ only if production occurs in $l$. Because production and paper profits have different elasticities, shifted profits are a distorted representation of real activity, as measured by multinational production data. The model implies that this distortion is governed by elasticities $\tilde{\upsilon}_1$ and $\tilde{\upsilon}_2$ (see Appendix B.2).




$i$: headquarter country, $l$: source country, $h$: tax haven.

$\frac{PS_{ih}}{PS_i}$ is estimated in Section 4.3.
$\zeta_{il}$ and $\chi_{lh}$ are derived in Appendix B.2 using triangle identities.

Figure 2: Triangle of Profit Shifting

**Identifying $\tilde{\upsilon_1}$ and $\tilde{\upsilon_2}$.** To triangulate $\mathbb{P}_{i\ell h}$, we need knowledge of the elasticities of the tax base and profit shifting to tax rates $\tilde{\upsilon_1}$ and $\tilde{\upsilon_2}$. Proposition 1 states that these flows follow a gravity structure in equations 9 and 10. We use firm-level data on where multinationals report their profits to estimate the gravity models in Proposition 1 and obtain the elasticities.

In summary, $\frac{PS_{ih}}{PS_i}$ is estimated using eq. (12) on the FDI income data. The functions $\zeta_{il}$ and $\chi_{lh}$, which depend on $X_{ill}$ (see Appendix C), $PS_i$ (see section 4.3), $\frac{PS_l}{\sum_l PS_l}$ (see Appendix B.2), $\tilde{\upsilon_1}$ and $\tilde{\upsilon_2}$ (see section 4.4), are derived from the algorithm outlined in Appendix B.2. As formalized in Propositions 2 and 3, $\mathbb{P}_{ilh}$ is readily obtained from $\mathcal{P}_i$, $\zeta_{il}$ and $\chi_{lh}$.

## 4.2 Data

Our baseline sample covers 40 countries over 2012-2017, which account for 90% of world GDP in 2017. It includes seven major tax havens: Hong Kong, Ireland, Luxembourg, Netherlands, Singapore, Switzerland, and Offshore Financial Centers, an aggregate of smaller tax havens.

We use FDI income and multinational production data to estimate profit shifting, elasticities, and frictions. Additional sources include tax rates, tax haven policies, trade flows, and other national accounts data. Details are provided in Data Appendix C.

To estimate profit shifting, our primary source is bilateral FDI income from OECD's Balance of Payments statistics, measuring foreign affiliate income returned to the residence country through dividends, interest, or reinvested earnings.[13] Following Wright and Zucman (2018), we construct FDI income by summing reinvested earnings and dividends. We impute missing observations using unilateral rates of return (Appendix C.1), a conservative procedure that tends to underestimate profits in tax havens (see Appendix Figure C2).

FDI income data may involve double counting and misreport the location of multinational earnings (Blouin and Robinson, 2025, Damgaard et al., 2024). Because international statistics follow the immediate investor principle, each entity reports income from its direct investment. Along ownership chains, income is aggregated and can be double counted. We implement two corrections. First, we exclude from our estimation investment flows originating from tax havens, removing common profit-shifting arrangements across multiple havens. Second, we exclude FDI income transiting through Special Purpose Entities (SPEs), shell entities established to obtain tax benefits (International Monetary Fund, 2009). The Netherlands, Ireland, Luxembourg, and the United Kingdom, among the five largest conduit jurisdictions (Garcia-Bernardo et al., 2017), report SPE income separately, allowing us to exclude it. For example, 87% of FDI income sent by Luxembourg in 2017 is excluded, compared with 14% for Denmark. These corrections reduce estimated global profit shifting from \$527 billion to \$359 billion (−32%) in 2017, and from 41% to 33% of total multinational profits, close to the \$310 billion estimate in Blouin and Robinson (2025). Appendix C.1 details the construction and robustness exercises while Figure C1

[13] See Janský and Palanský (2019), and Vicard (2022) for studies of FDI returns in tax havens.

documents the aggregate correction.

The adjusted FDI income series is the most comprehensive bilateral source of multinational profits data, covering more country pairs and years than alternatives. We use it to estimate bilateral profit shifting between residence countries and tax havens. We examine the sensitivity of our estimates using two alternative datasets, Country-by-Country Reporting (CbCR) and Orbis, the latter used to calibrate the tax base and profit-shifting elasticities.[14] For Orbis firm-level data, we followDelis et al. (2022), who match all vintages of BvD Orbis Historical to produce financial and ownership data, including tax haven affiliates, over our sample period. We aggregate the data at the country pair-year level for the profit-shifting estimation.

Turning to multinational production (MP), we construct $X_{ill}$, the sales resulting from the production in the country $l$ by firms headquartered in the country $i$, using the Multinational Revenue, Employment, and Investment Database (MREID) created by Ahmad et al. (2023). The dataset also sources information from Orbis Historic to provide harmonized data on cross-border multinational sales. Trade ($X_{ln}$) is taken from the International Trade and Production Database (Borchert et al., 2022).

The calibration additionally requires $\sigma$ and $\iota_l$. Using French administrative firm-level data (FARE) and the approach of De Loecker and Warzynski (2012), we estimate a median markup of 17%, implying $\sigma = 6.88$.[15] Given $\sigma$, we calibrate $\iota_l$ from the wedge between gross output and profits; $\iota_l$ captures non-labor costs that affect profits but not sales.

## 4.3 Estimation of bilateral profit shifting

**Estimating $PS_{ih}$.** To obtain the profit-shifting premium of havens, we estimate equation (12) using the Poisson pseudo-maximum likelihood (PPML) estimator to account for heteroskedasticity (Santos Silva and Tenreyro, 2006) and work with predictions in levels, avoiding the transformation issue in (log) OLS predictions (Duan, 1983). To capture the geographical specialization of tax havens and increase the accuracy of the predictions (Laffitte and Toubal, 2022), we interact region fixed effects with the tax haven indicator. This allows us to compute region-specific tax-haven premiums, thereby capturing heterogeneity across tax havens in their effectiveness at attracting shifted profits. Appendix Table D3 shows how the estimates change when these regional effects are included.

Table 1 reports the tax haven average marginal effect across different samples and data sources. Following our definition of profit shifting as the difference between predicted and counterfactual income, our preferred estimate, based on adjusted FDI income, puts profit shifting at $359bn, or 33% of all profits in the sample in 2017, consistent with Wier and Zucman (2022), who report 36%. Using unadjusted FDI income yields $527bn, showing

[14]As noted by Fuest et al. (2025), CbCR are a relevant source for observing profits where they are booked. However, CbCR lack bilateral pre-tax profit series for some important pairs, for example the United Kingdom and the Netherlands, and cover only 2016–2021. CbCR data are also subject to double counting that is more difficult to correct at the macro level than FDI income (see OECD's "important disclaimer regarding the limitations of the Country-by-country report statistics", OECD, 2025).

[15]This is in line with estimates in Tintelnot (2017), or De Loecker et al. (2020) who find a median markup of around 20% using Compustat data.

Table 1: Estimation of $PS_{ih}$

| Dep. Variable | FDI Income | | Pre-tax Profits | |
|---|---|---|---|---|
| | Unadjusted | Adjusted ($noSPEs$) | CbCR | ORBIS |
| | (1) | (2) | (3) | (4) |
| $Haven_k$ (average marginal effect) | 1.517*** | 1.572*** | 1.627*** | 0.654*** |
| | (0.177) | (0.192) | (0.228) | (0.198) |
| $\mu_{it}$ | Yes | Yes | Yes | Yes |
| $\mu_{r_{(k)}t}$ | Yes | Yes | Yes | Yes |
| Haven × Region dummies | Yes | Yes | Yes | Yes |
| Controls | Yes | Yes | Yes | Yes |
| # Countries | 146 | 146 | 140 | 57 |
| Observations | 73,447 | 73,120 | 4,354 | 6,725 |
| Pseudo R2 | 0.821 | 0.805 | 0.789 | 0.792 |
| **Profit Shifted (m$, 2017)** | **526946** | **358921** | **572290** | **80976** |
| **Sample's profits (%, 2017)** | **41** | **33** | **32** | **19** |

Note: This table reports the average marginal effect of the tax haven dummy in order to aggregate all tax haven-region interactions in one coefficient. Column (1) uses unadjusted FDI income, column (2) excludes SPE-transiting FDI income, column (3) uses CbCR pre-tax profits, column (4) uses Orbis pre-tax profits. Controls include log GDP, log GDP per capita, log distance, contiguity, colonial ties, and common legal origin. All specifications include region × year, origin × year, and haven × region fixed effects. PPML estimation throughout. Standard errors clustered at the country level in parentheses. ***, **, *: 1%, 5%, 10% significance.

that the conduit correction is quantitatively important. Using CbCR data, 32% of profits are shifted into tax havens. Finally, the Orbis sample is limited in its aggregate coverage of tax havens.

Appendix Table D2 reports additional robustness tests. Removing region fixed effects (column 2) does not affect global profit shifting, only its distribution. The correlation with the baseline estimates remains high (0.92). Estimates are also stable using only non-imputed FDI incomes (column 3), and controlling for statutory (column 4) or effective (column 5) tax rate in the destination. Column (6) uses an alternative identification strategy based on deviations from a 25% benchmark tax rate (Garcia-Bernardo and Janskỳ, 2024), yielding estimates close to our baseline in levels ($356bn vs. $359bn) and allocation (correlation with baseline profit shifting of 0.62). We favor our baseline approach for two reasons. First, the alternative requires introducing tax harmonization as an additional assumption, which is not needed in our framework. Second, it generates profit-shifting estimates for non-haven countries with effective tax rates below the benchmark, inconsistent with our model's assumption that tax avoidance requires both low tax rates and an offshore legal architecture (Laffitte, 2024).

**Profit-shifting flows.** We use Propositions 2 and 3 to compute $PS_{ilh}$. Figure 3 displays estimated profits shifted to tax havens (center) by residence country (left) and source country (right). We display the top 10 countries and aggregate the rest.

Figure 3 shows the predominance of residence countries such as the U.S. and, to a lesser

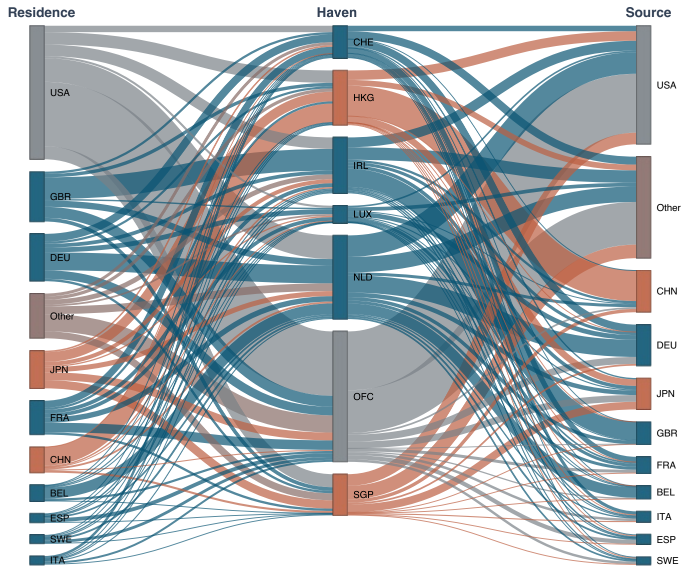



Figure 3: Profit shifting shares from residence-country $i$ to $h$ ($PS_{ih}/PS_i$) and from source-country $l$ to $h$ ($\chi_{lh}$).

extent, the UK, and Germany, in shifting profits to tax havens. It also shows the relative importance of each tax haven in profit shifting, with a predominance of Offshore Financial Centers, mainly in the Caribbean and attracting profits from the U.S. Figure 3 also confirms that gravitational frictions shape profit shifting. European tax havens prominently host profits from non-haven EU countries and the U.S., while China and Japan shift most of their profits to Hong Kong and Singapore.

**Comparisons and robustness.** Several papers estimate profit shifting at the production country or tax haven level (Zucman, 2014, Clausing, 2020, Janský and Palanský, 2019, Garcia-Bernardo and Janskỳ, 2024, Delis et al., 2022 and Tørsløv et al., 2023). Table 2 reports Spearman's rank correlations of our estimates with the literature. Panel A aggregates our bilateral measure by production country and correlates it with unilateral estimates from Tørsløv et al. (2023) (hereafter, TWZ), the Tax Justice Network (Cobham et al., 2020), and the European Commission using the CORTAX model (Alvarez Martinez et al., 2016). The large positive correlations suggest a stable relative position of each source country across methodologies.

Table 2: Spearman's rank correlation

| | Source | Correlation | Obs. |
|---|---|---|---|
| *A. Unilateral profit shifting* $PS_l$ | Tørsløv et al. (2023) | 0.79 | 33 |
| | Cobham et al. (2020) | 0.76 | 33 |
| | Alvarez Martinez et al. (2016) | 0.93 | 21 |
| *B. Bilateral profit shifting* $PS_{lh}$ | Tørsløv et al. (2023) | 0.67 | 111 |

Panel B compares our estimates with TWZ, the first study to propose a measure of bilateral profit shifting. Their methodology allocates bilaterally global profit shifting using excess trade in high-risk services and cross-border interest flows.[16] Restricting the comparison to European tax havens, we find a rank correlation of 0.67 despite using different data and strategies. Additional comparisons are in Appendix D.2 and D.3. In particular, we show our profit-shifting allocation correlates at 0.64 with one based on excess trade in services (Appendix Figure D3), suggesting services trade is an important but not unique determinant of profit shifting.

## 4.4 Tax-base and profit-shifting elasticities

Existing studies find that corporate tax rates have a larger impact on profits in low-tax jurisdictions compared to high-tax jurisdictions, holding real activity constant (e.g., Dowd et al., 2017, Bratta et al., 2021, Fuest et al., 2025, Garcia-Bernardo and Janskỳ, 2024). However, these studies do not differentiate between profits arising from real production activities and those generated through profit shifting. They estimate an elasticity pooling data from tax havens, where a large share of profits is shifted, and high-tax countries, where real production dominates. Instead, our model incorporates two tax elasticities: one for the tax base (governed by $\tilde{v}_1$) and one for profit shifting (governed by $\tilde{v}_2$), with the restriction $\tilde{v}_2 \geq \tilde{v}_1$ (profit shifting is more elastic to taxes than real production).

Our calibration strategy is guided by Proposition 1, which states that shifted and taxable profits shares follow a similar gravitational structure, depending on bilateral frictions, country wages, and market potential. Firm-level variation in Orbis Historical allows us to account for these using controls and the appropriate set of fixed effects. The two elasticities are identified from different tax rates (equations 9 and 10): the fraction of profits *shifted* to tax havens responds to changes in bilateral effective tax rates, while the fraction of taxable profits responds to changes in statutory tax rates. We show below that both reduced-form and structural approaches lead to a profit-shifting elasticity that is approximately three times the tax-base elasticity. Table 4 cross-checks our firm-level estimates using the macro-estimate $PS_{ilh}$ and TWZ data.

**Profit-shifting elasticity.** To calibrate $\tilde{v}_2$, we analyze the sample of firms reporting profits in tax havens from Orbis Historical. Estimating bilateral profit shifting at the firm level requires defining a benchmark level of normal profits. As common in this literature, our "excess profit" methodology benchmarks high profits in tax havens against firm-specific employment and fixed assets (Guvenen et al., 2022, Fuest et al., 2025).

Our model assesses the responsiveness of profits to changes in effective tax rates across tax havens, while also accounting for bilateral gravitational forces. The firm-level regressions therefore include firm-year fixed effects and identify $\tilde{v}_2$ using within-firm variation in excess profits across tax havens. Based on Proposition 1, we estimate the following

[16] In Appendix D.1, we review methods in the current literature and identify three additional sources of profit shifting beyond those TWZ considers: profit shifting in goods, tax-haven deflated imports, and non-"high-risk" services. Appendix D.3 evaluates robustness using TWZ inputs.

equation using PPML:

$$PTI_{f_iht} = \exp\Big(\delta_0 \ln(1 - t_{f_iht}) + \delta_1 \ln(Emp_{f_iht}) + \delta_2 \ln(Assets_{f_iht}) + \mu_{f_it} + \mu_{iht}\Big) \times \epsilon_{f_iht} \quad (14)$$

where $\delta_0 = \tilde{\upsilon}_2$ is our coefficient of interest. $PTI_{f_iht}$ is the pre-tax profit, of firm $f$ from country $i$, reported in tax haven $h$ in year $t$; and $t_{f_iht}$ is the bilateral effective tax rate faced by firm $f$ in $h$, computed from Orbis Historical. Firm-year fixed effects ($\mu_{f_it}$) control for time-varying firm characteristics, such as changes in management practices, business strategies, or other firm-specific shocks, while country-pair and year fixed effects ($\mu_{iht}$) control for time-varying bilateral factors such as tax treaties and historical ties, also mitigating the influence of country-specific accounting practices (Blouin and Robinson, 2025).

**Tax-base elasticity.** Similarly, $\tilde{\upsilon}_1$ is identified from firm-level variation in pre-tax profits across non-haven countries, using statutory tax rates that vary at the source country-year level. Since statutory rates vary only at the country level, collinearity limits the use of fixed effects, we instead include controls for market size, wage level, and bilateral frictions. We estimate the following equation:

$$PTI_{f_ilt} = \exp\Big(\kappa_0 \ln(1 - t_{f_ilt}) + \kappa_1 \ln(GDP_{lt}) + \kappa_2 \ln(GDPPpc_{lt}) + \mu_{f_it} + \mu_{il}\Big) \times u_{f_ilt} \quad (15)$$

where $\kappa_0 = \tilde{\upsilon}_1$ is our coefficient of interest. $PTI_{f_ilt}$ is the pre-tax profit of firm $f$ from country $i$, reported in non-tax haven $l$ in year $t$. GDP and GDP per capita (in logs) control for market size and wage level. Firm-year fixed effects ($\mu_{f_it}$) control for time-varying firm characteristics and country-pair fixed effects ($\mu_{il}$) control for bilateral frictions.

$\epsilon_{f_iht}$ and $u_{f_ilt}$ are error terms. We estimate both equations by PPML, which yields consistent estimates under heteroskedasticity (Santos Silva and Tenreyro, 2006; Fuest et al., 2025), and report OLS results for comparison.

**Result 1.** *The paper profit elasticity is three times larger than the elasticity of the tax base.*

Table 3 reports the estimated elasticities $\tilde{\upsilon}_1$ and $\tilde{\upsilon}_2$. Columns (1) and (2) use statutory tax rates ($t_{lt}$) and columns (3) and (4) use bilateral effective tax rates ($t_{f_iht}$). We report OLS results in columns (1) and (3) and PPML results in columns (2) and (4).

We find a profit-shifting elasticity, $\tilde{\upsilon}_2 = 6.8$, about three times the tax base elasticity, $\tilde{\upsilon}_1 = 2.0$. Our estimate suggests that multinational production, which is governed by both elasticities, is relatively mobile across countries.[17]

[17] For comparison, Wang (2020) estimates an elasticity of MP sales to taxes between 1.8 and 2.1, consistent with our estimates for $\tilde{\upsilon}_1$. Our estimate is at the upper bound of the 0–2 range reported by Agostini et al. (2026) who estimate elasticities in 16 different countries using a unified methodology. We also compute the *semi-elasticity* of the tax base and find a semi-elasticity of the tax base of 1.3 using OLS and 2.7 using PPML (see Appendix Table E4), at the upper bound of the 1–1.2 range reported in the meta-study of Beer et al. (2020). There is no direct comparison for $\tilde{\upsilon}_2$. However, in their estimation of a non-linear elasticity of profit to taxes using micro-level country-by-country reporting data, Fuest et al. (2025) find a semi-elasticity of profits to taxes ranging from -5 at a tax rate of 0.15 to -13 near a zero tax rate, confirming large elasticities for profits (essentially paper profits) located in tax havens. Garcia-Bernardo and Janskỳ (2024) reports a similar finding with aggregated country-by-country reporting data. We assess the sensitivity of our counterfactual experiments to alternative calibrations of $\tilde{\upsilon}_1$ and $\tilde{\upsilon}_2$ in Appendix section I.5.

Table 3: Estimation of elasticities $\tilde{\upsilon}_1$ and $\tilde{\upsilon}_2$

| | Estimation $\tilde{\upsilon}_1$ | | Estimation $\tilde{\upsilon}_2$ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $ln(1-t_{lt})$ | 1.085*** | 2.042** | | |
| | (0.204) | (0.867) | | |
| $ln(1-t_{f_iht})$ | | | 3.844*** | 6.827*** |
| | | | (0.541) | (1.307) |
| Observations | 216,397 | 216,397 | 2,649 | 2,649 |
| Adj. $R^2$ | 0.524 | 0.896 | 0.602 | 0.979 |
| Estimator | OLS | PPML | OLS | PPML |
| Controls | Yes | Yes | Yes | Yes |
| Firm × Year | Yes | Yes | Yes | Yes |
| Origin × Destination | Yes | Yes | No | No |
| Origin × Destination × Year | No | No | Yes | Yes |

Note: Columns (1)-(2) control for log GDP and log GDP per capita; columns (3)–(4) control for log employment and log fixed assets. OLS in columns (1) and (3), PPML in columns (2) and (4). Full table in Table E1. Standard errors clustered at the country level in parentheses. ***, **, *: 1%, 5%, 10% significance.

A potential concern is whether the elasticity estimates are affected by the OECD's Base Erosion and Profit Shifting (BEPS) initiative, which began producing guidelines in 2015. Appendix Table E2 reports separate pre-2015 and post-2015 elasticity estimates. The results show reasonable stability: $\upsilon_1$ estimates are statistically indistinguishable across periods in both specifications, while $\upsilon_2$ shows some increase post-2015 in OLS but remains stable in PPML. We perform robustness checks with these alternative elasticities in our counterfactuals.

**Profit-shifting elasticity: robustness.** So far, our estimation uses firm-level data. To assess the sensitivity of our implied elasticities, Table 4 reports results using two alternative data sources: our macro-estimate $PS_{ilh}$ and TWZ profit-shifting data.

Table 4: Alternative identification of $\tilde{\upsilon}_2$

| Data Source | $PS_{ilh}$ (1) | Tørsløv et al. (2023) (2) |
|---|---|---|
| Implied $\tilde{\upsilon}_2$ | 4.495** | 7.178*** |
| | (1.705) | (2.108) |
| Observations | 2,601 | 589 |
| Gravity Controls | Yes | Yes |

Note: PPML estimations throughout. Full results in Table E3. In column (1), we use the share of profit shifting implied by our model, $\frac{PS_{ilh}}{\sum_{l,h} PS_{ilh}}$. This follows the specification of equation (10). In column (2), we directly use profit-shifting data from Tørsløv et al. (2023) and Wier and Zucman (2022) . It is a panel at the source country-haven level ($lh$). In parentheses, standard errors clustered at the residence country-tax haven ($ih$) level in column (1) and at the source country level in column (2). ***, **, *: 1%, 5%, 10% significance.

Both estimates are statistically significant and consistent with our firm-level results:

column (1) yields $\tilde{\upsilon}_2 = 4.5$ and column (2) yields $\tilde{\upsilon}_2 = 7.2$.

**Extension: a variable profit-shifting elasticity.** Our calibration of $\tilde{\upsilon}_2$ rests on the assumption that the share of profits shifted to tax havens is a constant elasticity function of the corporate tax rate. While this assumption is reasonable for small changes in corporate tax rates, policies like a global minimum tax could generate large variations in effective tax rates and tax rate differentials. We refine our parametrization of the profit-shifting elasticity and allow for an additional variable profit-shifting elasticity that decreases with the tax differential (Bratta et al., 2024). We augment the determinants of firms' location choices with $(t_l - t_{lh})^k$ where $k$ is a shape parameter.

The partial elasticity of profit shifting then becomes a function of taxes in source countries and in tax havens: $\frac{\upsilon_2}{\sigma-1} - 1 + k\frac{\upsilon_2}{\upsilon_1}\frac{1-t_h}{t_l-t_h}$. In this calibration, the shape parameter $k$ and the elasticity $\upsilon_2$ are determined by matching moments of the data. In particular, we calibrate the non-linear elasticity so that it equals the estimated linear elasticity when $t_l$ and $t_h$ are at their average value in the sample, and so that it stays larger than $\tilde{\upsilon_1}$, when the tax differential between non-haven countries and tax havens goes toward 1. $\tilde{\upsilon_1}$ is seen here as a natural upper bound for the elasticity of profit shifting when tax rates are very different. The details of the exercise are provided in Appendix F. In this setting, the non-linear elasticity will be above the linear elasticity for small tax rate differentials, as demonstrated by Figure F1 in the Appendix. This property will have implications for the implementation of the minimum tax rate. We implement this varying profit-shifting elasticity to simulate minimum taxation policy scenarios.

# 5 Profit-shifting frictions

Bilateral profit-shifting frictions are a central feature of our framework. They determine whether firms shift profits and where they produce and report them. In this section, we recover these frictions from observed flows of profits shifted by firms resident in $i$ from source country $l$ to haven $h$. We first describe the procedure and then examine the magnitude and determinants of these frictions in Section 5.2.

## 5.1 Identifying profit-shifting frictions

At the calibrated equilibrium, profit-shifting probabilities $\mathbb{P}_{ilh}$, taxes $t_{ll}$ and $t_{lh}$, and estimated elasticities $\tilde{\upsilon}_1, \tilde{\upsilon}_2$ are observed. The next proposition formalizes the identification of profit-shifting frictions.

**Proposition 4** (Identifying profit-shifting frictions)**.** *At the calibrated equilibrium the following holds*

$$\bar{\theta}\tilde{\theta}_i \alpha_{lh} \left(\frac{1-t_{ll}}{1-t_{ilh}}\right)^{\frac{1}{\sigma-1}} = \left(\frac{\mathbb{P}_{ilh}}{\mathbb{P}_{ill}}\right)^{-\frac{1}{\upsilon_1}} \left(\frac{\mathbb{P}_{ilh}}{\mathcal{P}_i}\right)^{\frac{1}{\upsilon_1}-\frac{1}{\upsilon_2}}, \tag{16}$$

*where $\bar{\theta}$ is a normalizing constant such that $\theta_i = \bar{\theta}\tilde{\theta}_i$. We specify $\bar{\theta}$ in Appendix G.*

On the right-hand side of equation (16), we have observable profit-shifting flows. On the left-hand side, we have the tax differential gains from shifting to tax haven $h$ rather than booking profits domestically in $l$, combined with the associated profit-shifting frictions for firms from $i$ producing in $l$ and shifting in $h$. The term $\bar{\theta}\tilde{\theta}_i\alpha_{lh}$ captures the frictions required to rationalize observed profit-shifting flows given taxes and elasticities. When $\mathbb{P}_{ilh}$ is large relative to $\mathbb{P}_{ill}$, the model implies low profit-shifting frictions.

We note that $\tilde{\theta}_i = \theta_i/\bar{\theta}$ and $\alpha_{lh}$ can be mapped into a marginal cost equivalent $Cost_{ilh} := \tilde{\theta}_i\alpha_{lh}$. This is the marginal cost increment associated with profit shifting from any $l$ to any $h$ by firms from $i$ *if all profit-shifting frictions were such that* $\alpha_{l'h'} = \alpha_{lh}$. In contrast with trade or multinational production frictions, the interaction of the tax base and profit-shifting elasticities implies that bilateral profit-shifting flows do not satisfy the independence of irrelevant alternatives. The cost of shifting profits from $l$ to $h$ depends on the profit-shifting frictions between other $l' - h'$ pairs.

## 5.2 Magnitude and determinants of profit-shifting frictions

We back out the bilateral profit-shifting frictions following Proposition 4 and explore the magnitude and determinants of profit-shifting frictions.

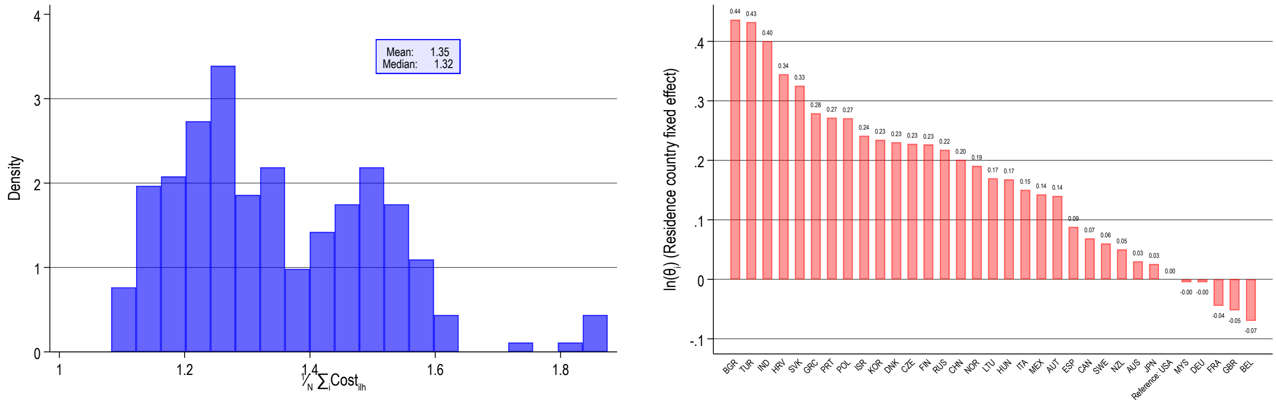
**Average profit-shifting costs.** In our model, profit-shifting costs are assumed to be homogeneous within an $ilh$ triplet, and the endogenous selection into profit shifting occurs through the heterogeneous draws of $\varphi$. Conversely, existing empirical estimates of the cost of profit-shifting include the selection into shifting activities in the costs themselves. Namely, the literature estimates the cost of profit shifting conditional on shifting. Consider the relation implied by equation (16): the tax advantage from shifting from $il$ to $h$, including the frictions, equals the probability of shifting in $ilh$. In the data, this probability is low: few firms shift at all despite a potentially large tax advantage. As a consequence, the model implies that the cost of profit shifting common to all firms is large, to rationalize the strong selection into shifting. This result is in line with previous literature that documents an important concentration of profit shifting (Davies et al., 2018, Wier and Erasmus, 2023).

We plot the distribution of the profit-shifting cost, $Cost_{ilh} := \tilde{\theta}_i\alpha_{lh}$, averaged over (non-haven) residence countries in panel (a) of Figure 4. The median value of profit-shifting costs calculated in our sample is 1.3. A profit-shifting cost of 1.3 means that shifting from a residence country $i$ to a tax haven $h$ through a production affiliate $l$ generates an increase in the cost of production of 30%, all other things being equal. These frictions are large, as most firms facing them choose not to shift at all, and they are *unconditional*.[18]

The friction can also be compared to the variable friction $\gamma_{il}$, which represents the costs of separating the location of production from headquarters. We find a median value of $\gamma_{il}$ of 1.5, somewhat larger than the multinational production costs of 1.31 provided by Head

[18]Related estimates of profit-shifting costs are provided by McClure (2023), Bilicka et al. (2024), and Altshuler et al. (2025), based on different modeling approaches. These studies typically estimate costs *conditional* on firms engaging in profit shifting. In our framework, shifters incur an average profit-shifting friction equivalent to 13% of the gross benefits of tax planning. It is of a similar order of magnitude to Altshuler et al. (2025), who find planning costs equal to 17.4% of tax-planning benefits in the context of hybrid tax planning structures by U.S. MNEs. See Appendix G.2 for details.

and Mayer (2019) for the car industry.




(a) Average cost of profit shifting ($Cost_{lh}$)

(b) Distribution of $ln(\theta_i)$

Figure 4: Profit-shifting frictions

Note: Profit shifting frictions are estimated following Proposition 4. Panel (a): distribution of $Cost_{lh} = \frac{1}{N}\sum_i^N Cost_{ilh}$. Panel (b): distribution of $\theta_i$ (with the U.S. as the reference country), the (inverse) tax aggressiveness of the residence country. $Cost_{ilh}$ is separated into $\theta_i$ and $\alpha_{lh}$ using fixed effects: $ln(Cost_{ilh}) = ln(\tilde{\theta}_i)+ln(\alpha_{lh})$.

**Components of profit-shifting costs: $\tilde{\theta}_i$ and $\alpha_{lh}$.** The profit-shifting cost has two components: the (inverse) tax aggressiveness of the residence country $\tilde{\theta}_i$ and the bilateral friction $\alpha_{lh}$. Following the model, the costs are perfectly separable via fixed effects for $i$ and for $lh$ pairs: $ln(Cost_{ilh}) = ln(\tilde{\theta}_i) + ln(\alpha_{lh})$. Residence country fixed effects capture $ln(\tilde{\theta}_i)$ and source-tax haven dyadic fixed effects ($lh$) capture bilateral profit-shifting frictions $ln(\alpha_{lh})$. About 40% of the variation in profit-shifting costs is explained by this last component.[19]

Figure 4b plots the cross-country distribution of $\ln(\theta_i)$. We estimate U.S. multinationals to be among the most aggressive profit shifters alongside those from Belgium, the United Kingdom, France, and Germany, as lower values of $\theta_i$ represent lower costs of profit shifting. Other countries incur cost penalties relative to U.S. MNEs, consistent with Klassen and Laplante (2012) and Delis et al. (2022). We find a relatively large dispersion in profit-shifting costs. The differences in tax aggressiveness across residence countries in panel (b) of Figure 4 show the key role of headquarters in firms' profit-shifting practices.

Finally, we study the determinants of $\alpha_{lh}$ in Appendix Table G1. We show that gravity variables play an important role. Distance is a strong determinant of profit-shifting frictions: the coefficient on $\ln(\text{distance}_{lh})$ is positive and significant, and the concave term indicates that distance matters most at short ranges. Second, language proximity matters, while historical and institutional ties, such as former colonial relationships, are less relevant in this sample. In other words, profit-shifting frictions shape the geographic impact of international tax reforms.

[19]The different abilities of residence countries to reduce shifting costs should be interpreted as deviations from the U.S. as reference country.

# 6 Policy simulations

We now proceed to the evaluation of different international tax reforms. This section quantifies the effects of different types of reforms on tax revenues, GDP, profit shifting, consumption, and welfare. We study minimum taxation, its optimal design and potential deviations, and alternative international tax systems such as Destination-Based Cash Flow Taxation or Formulary Apportionment.

We compute counterfactual equilibria for 40 countries using 2015–2017 data, focusing on the United States.[20] The calibration is summarized in Table I1 and validated in Figure I1. We compute counterfactuals using exact hat algebra, which expresses equilibrium changes relative to the baseline (Appendix H). Technology and frictions are held constant throughout the analysis.

Welfare depends on preferences for the public good, $\beta_n^\star$, which are not directly observable. Assuming that the observed policy configuration constitutes a Nash equilibrium, we can recover countries' preferences for tax revenues. Our approach follows the *inverse optimum weights* method used in optimal taxation to infer welfare weights (e.g. Bourguignon and Spadaro, 2012; Hendren, 2020). This is a revealed-preference approach: at the initial equilibrium, we assume countries have no incentive to change their statutory tax rate. Formally, we recover $\beta_n^\star$ such that $\frac{\partial U_n(\beta_n^\star)}{\partial t_n} = 0$, $\forall n$, where $t_n$ is the tax rate in source country $n$. This is equivalent to assuming that the observed tax rates constitute a Nash equilibrium where governments choose their CIT rates $t_n$. Appendix Figure I2 shows that $\beta_n^\star$ is strongly correlated with the statutory tax rate. We hold the vector $\beta_n^\star$ fixed in all counterfactuals.

## 6.1 Illustrative counterfactual tax reforms

To illustrate the model's mechanisms and benchmark the quantitative results, Appendix Table I2 reports three simple reforms for the U.S. economy.

*Unilateral tax change: mechanical versus endogenous tax base response.* A 5% reduction in the U.S. tax rate illustrates the central trade-off in corporate taxation: the increase in consumption (+0.4%) comes at the expense of a decline in tax revenues (-4.2%). The revenue decline is smaller than the mechanical prediction (-5%) as the lower rate increases real activity (real GDP rises by 0.3%), and profit shifting declines (-7.3%), both broadening the domestic tax base. By construction of the welfare function, any deviation from the initial statutory rate reduces welfare (-0.03%). This counterfactual highlights the importance of accounting for the mobility of both real activity and profit shifting.

*Closing a tax haven: the role of geography.* Turning Singapore into a non-haven has limited effects on U.S. profit shifting (-3.9%) and tax revenues (+0.3%), as shifting reallocates toward other tax havens, notably Hong Kong. This effect is substantially different in countries with lower profit-shifting frictions with Singapore, such as Malaysia, where profit shifting declines more (-52%) and tax revenues increase (+1.6%); see Appendix Figure

[20] Appendix Tables I6 to I8 report results on other countries, including coalitions like the EU, India, and China.

I3. This experiment underscores the role of geography, bilateral frictions, and tax haven substitutability in shaping the spatial reallocation of profits after a reform.

*Eliminating profit shifting: private versus public good consumption.* Eliminating profit shifting increases U.S. corporate tax revenues by 6.6% but reduces consumption by 0.5%. Welfare rises by 0.2% as the welfare gain from higher public good provision outweighs the loss in private consumption. This experiment highlights a central tension: profit shifting erodes the tax base but lowers effective tax rates, supporting entry and production. Eliminating it increases public good provision at the cost of private consumption.

## 6.2 Minimum taxation

**Policy context.** Minimum taxation ensures that no foreign affiliate can face an effective tax rate below $t^{min}$ by locating profits in low-tax countries. Its implementation raises practical challenges regarding the allocation of taxing rights: which jurisdiction has priority to collect the minimum tax revenues? Taxing rights over profits $\pi_{ilh}$ may be assigned to the residence country ($i$), the source country ($l$), or the profit-booking location ($h$). In the initial negotiations on the OECD/G20 Inclusive Framework on BEPS, priority was given to residence countries $i$. If residence countries do not collect the tax, source countries $l$ may do so based on their share of group activity.[21] Subsequently, the *Qualified Domestic Minimum Top-up Tax* (QDMTT) granted priority to the profit-booking jurisdiction $h$, potentially a tax haven. We therefore evaluate these alternative allocations under the 15% global minimum tax established by the BEPS.

In all counterfactuals, real activity is fully deductible from the minimum tax base, so the minimum tax applies only to shifted profits $PS_{ilh}$. This reflects the OECD objective of curbing base erosion through profit shifting rather than restricting competition for real activity. It mirrors the substance-based carve-out, which excludes profits linked to real activity from the minimum tax base (see Schjelderup and Stähler, 2024).

Table 5 reports the results for the U.S., distinguishing unilateral from multilateral implementation. Appendix Figure I4 presents counterfactuals using alternative pre- and post-BEPS elasticity estimates. The qualitative results and main conclusions are unchanged.

**Unilateral minimum taxation.** Under a residence-based minimum tax $t^{min}$, the U.S. taxes *U.S.-headquartered* MNEs that continue to shift profits to tax havens at the top-up rate $t^{min} - t_{ilh}$, regardless of the source country. The reform also endogenously broadens the U.S. tax base, as some firms operating in the U.S. no longer find profit shifting profitable. Corporate tax revenues consequently rise by 3.8%, driven by both the decline in profit shifting (-37.3%) and the collection of the minimum tax revenues.

Ex ante, the production effect is ambiguous because two forces operate in opposite directions. First, firms place more weight on U.S. fundamentals ($A_{U.S.}$) and less on tax differentials when choosing where to book profits and locate production, which reallocates activity toward the relatively productive U.S. economy (*spatial allocation channel*). Second,

[21] This corresponds to the *Income Inclusion Rule* (IIR) for residence countries and the *Undertaxed Profits Rule* (UTPR) for source countries.

Table 5: Impact of a 15% minimum tax rate for the U.S.

| Minimum Taxation | % change in U.S.'s ... Tax revenues | Profit Shifting | Real Production | Consumption | Welfare |
|---|---|---|---|---|---|
| Unilateral | | | | | |
| – Residence | 3.77 | -37.3 | -0.14 | -0.25 | 0.15 |
| – Source | 3.67 | -37.9 | -0.14 | -0.22 | 0.17 |
| Multilateral | | | | | |
| – Residence | 3.77 | -37.3 | -0.14 | -0.22 | 0.19 |
| – Source | 3.64 | -37.3 | -0.14 | -0.22 | 0.17 |
| – Tax havens' adjustment | 2.44 | -37.3 | -0.14 | -0.22 | 0.045 |

the higher effective tax rate for tax-avoiding firms deters entry (*firm entry channel*). This entry effect reduces production and offsets part of the reallocation toward fundamentals. Quantitatively, the lower entry dominates: production declines by 0.14% and consumption by 0.25%. Welfare increases by 0.15%, reflecting higher public good provision.[22]

If the taxing rights were instead allocated to source countries, the effects would differ. The effective tax rate rises for all profit-shifting firms *producing* in the U.S., reducing production by 0.14%. Consumption declines by 0.22%. This slightly smaller consumption loss arises because the top-up tax applies to firms operating in the U.S., including foreign-owned firms, while U.S. firms abroad are unaffected. Because the decline in consumption is smaller, welfare increases more than under residence-based taxation, by 0.17%.

**A global minimum tax.** A multilateral implementation of the minimum tax reduces the dispersion of effective tax rates across countries and raises them for all tax-avoiding firms, regardless of headquarters location. Because firms face the same minimum tax under residence- and source-based rules, the distribution of corporate tax rates is identical across the two scenarios. The direct effects on profit shifting and production are therefore the same. Outcomes may, however, differ because tax revenues are allocated differently across countries. For the U.S., residence-based minimum taxation brings slightly more revenues than source-based minimum taxation, illustrating the cost-advantage of U.S. firms in profit shifting.

From a global allocation perspective, the reform has mixed effects. It raises effective tax rates while reducing their dispersion, affecting welfare through opposing channels. Higher tax rates increase public good provision but reduce firm entry, lowering the mass of varieties and thus private consumption. Lower dispersion reduces the weight of tax considerations in firms' decisions, shifting activity toward economic fundamentals and improving spatial allocation.

Quantitatively, the efficiency gains from lower dispersion are dominated by firm exit,

[22]Note that the status quo that pins down preferences for public-good provision is a Nash equilibrium in unilateral statutory rates. The minimum tax operates through a different instrument, by changing effective tax rates on shifted profits $t_{ilh}$ for $h \neq l$, not statutory rates. Unilateral deviations from the status quo under minimum taxation can therefore raise welfare.

resulting in a 0.14% decline in U.S. production under all multilateral scenarios. Welfare increases in all cases, as higher public good provision more than offsets lower private consumption.

Panel (a) of Figure 5 shows welfare changes under a 15% residence-based multilateral minimum tax. Most countries, especially non-havens, experience net welfare gains, while only a few non-havens face consumption losses not compensated by public goods. Tax havens generally lose as multinational firms reduce profit shifting. Some tax havens, including OFCs and Singapore, offset these losses through gains in consumption from activity reallocation. Because profits cannot be shifted out of tax havens, effective tax rates rise worldwide except in tax havens, inducing some relocation of real activity toward them. Overall, a residence-based multilateral minimum tax generates welfare gains for most countries. It also reduces world profit shifting by 46% (Appendix Table I7).

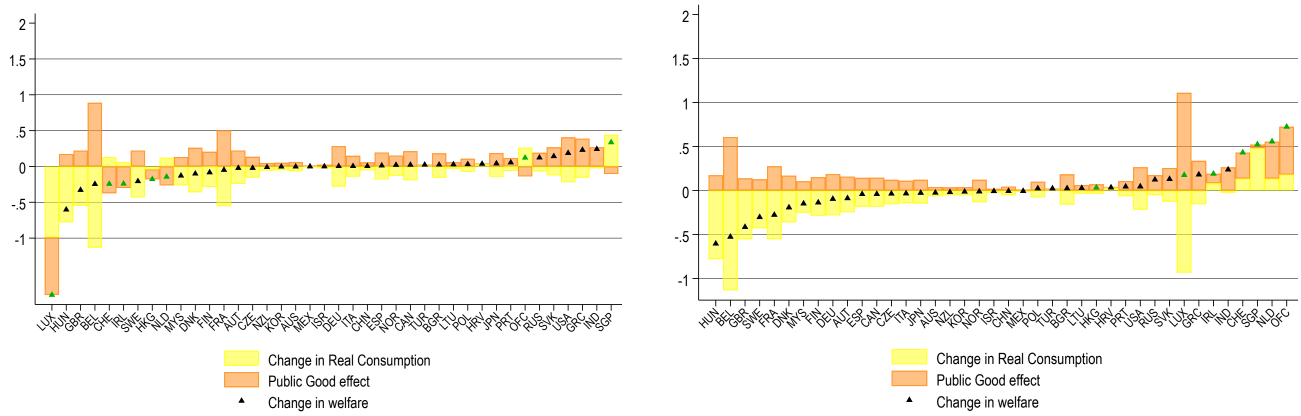
**Tax havens' response to the minimum tax.** Implementing minimum taxation requires accounting for tax havens' incentives to adjust their corporate tax regimes. In our model, tax havens can respond by setting their tax rate to the minimum tax rate, $t_{lh} = t^{min}$, to capture revenues that would otherwise accrue to source or residence countries. This corresponds to OECD's QDMTT mechanism, which gives profit-booking jurisdictions priority to collect the top-up.[23]

At the firm level, the effective tax rate is unaffected by the allocation of taxing rights, so the effects on profit shifting, real production, and consumption are identical regardless of the collecting jurisdiction. At the country level, however, tax revenues are reallocated from non-havens to havens. Despite this reallocation, the gains from a global minimum tax remain, as the overall reduction in profit shifting broadens the tax base of non-haven countries. For the U.S., tax revenues increase by 2.4%, implying small welfare gains of 0.045%.

Appendix I.4 decomposes the reform into mechanical effects and endogenous firm responses in general equilibrium. A residence-based multilateral minimum tax raises revenues mechanically by 2.2%, but the total increase in general equilibrium reaches 3.8%. The additional gain is driven primarily by reduced profit shifting, which expands the CIT base by 2.6% (120% of the mechanical effect), while reducing the minimum tax base (-0.83%). The relocation of production further lowers revenues by 0.16%. When tax havens adjust, the minimum tax base in non-haven countries becomes zero, and the reduction in profit shifting remains the only channel through which tax revenues increase in non-haven countries. These results underscore the importance of accounting for firms' endogenous profit-shifting responses and general equilibrium effects when evaluating tax reforms.

Panel (b) of Figure 5 shows the distribution of welfare effects when tax havens respond to the reform. This response only shifts the allocation of tax revenues across space. This reallocation significantly changes the winners and losers of the reform by affecting countries' consumption of public goods. Tax havens benefit substantially from the reform

[23] This behavior is consistent with the results in Johannesen (2022). See also Janeba and Schjelderup (2022) and Hebous and Keen (2023) for theoretical analyses.




(a) Taxing rights allocated to residence countries

(b) When tax havens adjust

Figure 5: Effect of a 15% multilateral minimum tax on welfare.

Note: This figure shows country-by-country welfare changes following the introduction of a 15% multilateral minimum tax. Panel (a) shows the results when taxing rights are allocated to the residence country (IIR). Panel (b) shows the results when tax havens adjust their tax rate to 15% (QDMTT). Consumption of country $n$ is defined as $C_n/P_n$. Welfare of country $n$ is defined as $U_n = (B_n/P_n)^{\beta^\star_n} C_n/P_n$. The public good effect denotes the change in $(B_n/P_n)^{\beta^\star_n}$. Green triangles denote tax havens.

in both tax revenues and consumption. The intuition is the following. Before the introduction of the minimum tax, tax havens compete for shifted profits and cannot raise tax rates unilaterally because profit-shifting income is highly elastic to taxation. The global minimum tax reduces this competitive pressure and acts as a *coordination device* among them. Low-tax jurisdictions can then collect higher revenues without being undercut. As we discuss below, this coordination effect extends to non-haven countries: by limiting base erosion, the minimum tax weakens their incentives for tax competition. Appendix Table I6 reports the welfare effect of minimum taxation scenarios for different country coalitions. World welfare increases under all minimum taxation scenarios. In the case of tax havens' adjustment, gains in the U.S., India, China, and tax havens are offset by losses in the E.U. and other developed countries.

Finally, a common concern is that firms may relocate headquarters to countries that do not enforce the minimum rate. We address this by distinguishing short-run effects, with fixed headquarters, from long-run effects, where headquarters location and entry adjust endogenously. In the short run, firms can reallocate production but not headquarters. Real production responds less, leading to smaller declines in consumption and larger welfare gains in the U.S. (Appendix Table I3).

**The optimal minimum tax rate.** Is the 15% minimum tax rate chosen by OECD countries optimal? Our framework is designed to address this question through various scenarios of taxing rights allocation. The objective function is global welfare, defined as the sum of country-level welfare: $\max_t \mathcal{W}(t) = \sum_i U_i(t)$.

**Result 2.** *The distribution of taxing rights critically shapes the welfare impact of the global minimum tax. Source-based and residence-based scenarios yield higher welfare at an* *optimal tax rate of 21-22%. The tax havens' response through Qualified Domestic Minimum Top-up Tax (QDMTT) and the non-haven response through Corporate Income Tax (CIT) adjustments result in lower welfare gains.*

Next, we analyze the effects of these different tax designs on welfare in detail. The results are shown in Figure 6.

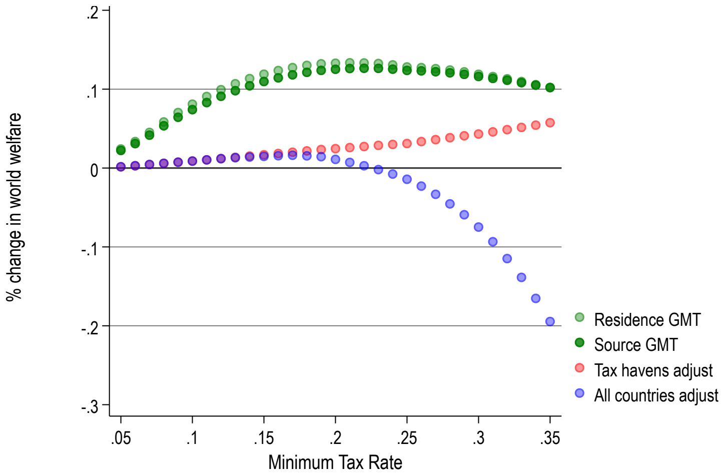



Figure 6: Optimal minimum tax rate.

Note: Changes in world welfare under different minimum taxation scenarios. The residence GMT optimum is 21%; the source GMT optimum is 22%. When tax havens adjust, welfare is maximized at 40% (not shown here), eliminating all profit shifting. When all countries adjust, welfare is maximized at 17%. At these optimal rates, profit shifting declines by 72%, 69%, 100%, and 54%, respectively. We provide a sensitivity analysis based on the calibration of the statutory tax rate in Appendix I5

Early policy proposals centered on two allocations of minimum taxing rights: to residence or to source countries. In our model, the global welfare difference between the two is small. This reflects similar aggregate size and revenue preferences across countries affected by profit shifting and those engaging in it. When tax havens do not adjust, the optimal rate is 21% under residence- and 22% under source-based taxation, increasing global welfare by about 0.13% in both cases (green dots in Figure 6). These reforms reduce global profit shifting by 72% and 69%, respectively.

These policies likely trigger responses from tax havens. Holding the minimum rate fixed, such responses reallocate tax revenues toward havens, which capture the gains from the reform. Under this scenario (red line), global welfare is lower as gains accrue primarily to tax havens, which have a lower preference for tax revenues. As the minimum rate rises, profit shifting declines further and gains shift toward non-haven countries. Note that at 40%, the highest statutory tax rate in our database, profit shifting is fully eliminated, and the three scenarios coincide by construction.

All scenarios above assume that countries can distinguish profit shifting from real activity, consistent with the logic of the "substance-based carve-out". Without this carve-out, or if such discrimination fails (blue curve), the minimum tax applies broadly and effectively harmonizes statutory rates. In this scenario, the optimal rate is 17% where welfare increases by 0.02% and profit shifting is reduced by 54%. Higher rates induce welfare losses up to -0.2%. This negative effect is driven by the aggregate loss in varieties as tax rates rise worldwide to match the minimum tax.

**Effects of minimum taxation on tax competition.** The minimum tax reform, by changing the global allocation of taxing rights and tax rates, could influence countries' choices of statutory corporate tax rates. To study this issue, we start from the Nash equilibrium induced by the vector of $\beta_n^*$, implement the minimum tax reform with a rate of 15% when tax havens adjust, and let countries unilaterally change their statutory rate at the margin (0.1 percentage point increase). To identify which countries benefit from such deviation, we compute the change in welfare $\left(\frac{\partial U_n}{\partial t_n}\right)$.[24]

**Result 3.** *A 15% minimum tax reduces tax competition incentives for most countries.*

Figure 7 plots the change in welfare implied by a marginal increase in the statutory rate. Most countries would benefit from a unilateral increase in their statutory rate. Intuitively, they would trade off a loss in consumption with an increase in real tax revenues.

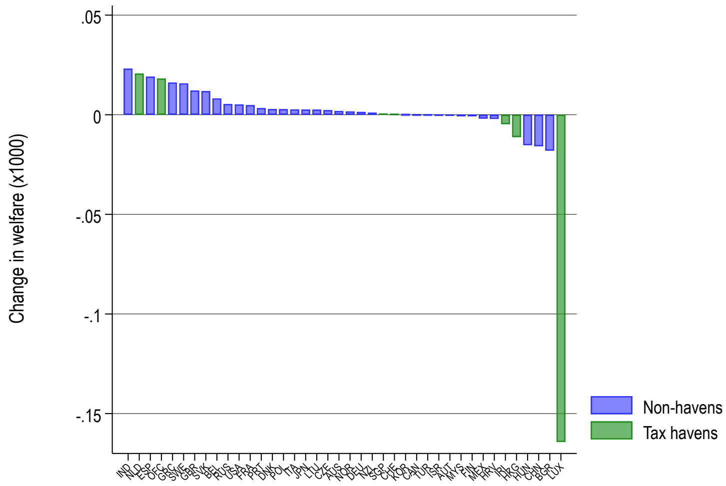



Figure 7: Marginal welfare effect of the statutory tax rate after a 15% global minimum tax.

The global minimum tax lowers the cost of raising statutory rates by limiting tax base erosion through profit shifting in non-havens. This increases their incentives to raise statutory taxes. The reform, therefore, acts as a coordination device for non-havens, mitigating the race to the bottom in statutory rates for most countries.

## 6.3 Deviations from the minimum tax framework

Implementing a coordinated minimum tax requires alignment across many countries and interests. As discussed in Section 3.6, we consider two policy-relevant deviations from the agreed framework. First, some countries deviate from the global minimum rate, reflecting the current situation in which the U.S. has applied its own minimum tax regime since 2017

[24]We leave the resolution of the new Nash equilibrium for future work. Although the general approach of Ossa (2014), Wang (2020), and Ferrari and Ossa (2023) could be adapted to our framework, one would need to consider additional available instruments, from subsidies (e.g., those announced by Switzerland following the global tax deal) to domestic minimum taxes (e.g., the U.K.).

(GILTI). Second, we study a unilateral sales tax on tax-avoiding firms as an alternative to global coordination, capturing the logic of Digital Service Taxes (DSTs) adopted as countermeasures, notably by the E.U.

We focus on the E.U., as it has played a central role in minimum tax reforms (the 2022 Minimum Tax Directive) and the development of alternative instruments. We report results for all coalitions in the Appendix Tables I6 to I8.

**Deviations from the global minimum tax.** The OECD's January 2026 "Side-by-Side" guidelines allow countries to implement alternative minimum tax systems, such as the U.S.'s GILTI, creating scope for deviations from the agreed rate. A country may benefit from deviating downward: by setting a lower residence-based minimum tax, it collects part of the top-up revenue on its own MNEs while limiting the increase in their effective tax rates, thereby preserving competitiveness relative to the coalition. We model this as a unilateral reduction in the minimum-tax rate relative to the rest of the coalition under the regime with havens' response. In our application, the deviating country, the U.S., applies a lower residence-based minimum tax. Appendix Tables I6 to I8 report outcomes for each coalition when one member deviates to a 13% rate while the rest of the world maintains 15%.

The first row of Table 6 reports the effects of the global minimum tax in the E.U., excluding E.U. tax havens. The second row considers the effect in the U.S. of a deviation to a 13% minimum rate by the U.S. The U.S. obtains a larger increase in tax revenues than in the case where tax havens adjust, as it is able to collect the top-up. The increase in tax revenues is lower than in the residence case at 15% since the minimum rate is now lower. The decrease in GDP and consumption is smaller. This results in larger welfare gains than in the most likely scenario where tax havens adjust their tax rates (QDMTT). The third row shows how such deviation affects the E.U. non-haven countries. This deviation negligibly affects E.U. tax revenues since these revenues only come from firms reducing profit shifting. The decline in profit shifting is slightly smaller than in the coordinated scenario, as U.S. firms face a weaker incentive to curb profit shifting. Welfare falls by the same magnitude as in the scenario without deviation. In other words, a deviation from the global minimum tax appears to be a free-riding policy on others' coordination efforts.

**Sales taxes as an alternative to a global minimum tax.** Absent global coordination, a unilateral alternative is a digital service tax (DST), which levies charges on the sales of large digital firms to counter tax avoidance. DSTs have been adopted in more than 15 countries, with commitments to repeal them once the global minimum tax is implemented. A plausible counterfactual to failed coordination is therefore the coexistence of multiple unilateral DSTs.

As discussed in Section 3.6, we model an *idealized* DST under which countries tax only tax-avoiding firms. This differs from actual DSTs, which apply uniformly within targeted sectors, irrespective of firm-level shifting, and cover only selected digital activities. Our idealized instrument therefore provides an *upper bound* on the efficiency of destination-based taxation: it captures the outcome under perfect targeting, with the gap relative to actual DSTs reflecting the welfare cost of imperfect targeting and uniform application across heterogeneous firms.

In this counterfactual, E.U. non-haven countries form a coalition that applies such a tax. We implement a revenue-neutral DST such that it matches the total E.U. revenues under the minimum tax when havens adjust (+3.25%).

The results are in the last row of Table 6. To generate revenues comparable to the benchmark minimum taxation in the E.U., only a 0.75% sales tax is required. The incidence of a sales tax falls directly on prices and is governed by the demand elasticity. By contrast, a corporate tax only affects prices indirectly through the price index via entry. The sales tax reduces profit shifting by one-fourth relative to the global minimum tax. Because the decline in profit shifting is smaller, the instrument is less harmful to real GDP and consumption, yielding large positive welfare gains for the E.U.[25]

Table 6: Impact of deviations from the Global Minimum Tax for the E.U.

| | % change in ... | | | | |
|---|---|---|---|---|---|
| | Tax revenues | Profit Shifting | Real Production | Consumption | Welfare |
| Minimum tax with havens' adjustment (benchmark) | | | | | |
| In the E.U. (excluding tax havens) | 3.25 | -47.95 | -0.115 | -0.346 | -0.154 |
| Deviation by the U.S. at 13% | | | | | |
| In the U.S. | 3.24 | -31.07 | -0.118 | -0.179 | 0.170 |
| In the EU (excluding tax havens) | 3.25 | -47.94 | -0.114 | -0.347 | -0.155 |
| E.U. Sales tax on tax avoiders at 0.75% | | | | | |
| In the EU (excluding tax havens) | 3.25 | -12.5 | -0.04 | -0.07 | 0.17 |

This contrast follows from Section 3.6. Under the global minimum tax, non-haven revenue gains arise mainly from reduced profit shifting, which expands the tax base, rather than from top-up revenues. Under the idealized DST, countries gain both from reduced shifting *and* from revenues generated by the new tax, which applies to all sales of tax-avoiding firms rather than only to a top-up component.[26]

**Result 4.** *An idealized sales tax on tax-avoiding firms delivers revenue gains comparable to the global minimum tax but is associated with a lower drop in consumption. For the E.U., a 0.75% tax on shifters' sales replicates the E.U. revenues under the global minimum tax while reducing profit shifting by one-fourth as much, generating positive welfare effects. The efficiency gains arise because destination countries collect revenue directly from sales rather than relying solely on reduced profit shifting to expand the tax base.*

[25] Our welfare analysis abstracts from distributional considerations, in particular the relative incidence on firms versus consumers, which typically weighs against sales-based instruments such as DSTs.

[26] The case of France illustrates well this mechanism. In 2025, the global minimum tax generated limited additional top-up revenues due to incomplete QDMTT implementation (+0.5 billion euros), whereas the DST, targeting 30 firms, raised up to 1 billion euros.

## 6.4 Alternative international tax systems

The reforms analyzed above operate within the existing international tax system. They constrain tax competition but preserve territorial taxation. As noted in Section 3.6, they reduce profit shifting but do not eliminate it.

This raises a natural question: can an alternative system eliminate profit shifting and yield higher welfare gains? We examine two structural reforms that fundamentally change how multinational profits are taxed. The first is a destination-based cash flow tax (DBCFT), which can be implemented unilaterally and rests on well-established theoretical foundations. The second is formulary apportionment (FA), a multilateral system that replaces territorial taxation with formula-based allocation of taxing rights.

**Destination-based cash flow tax.** As discussed in Section 3.6, the DBCFT replaces the corporate income tax with a sales tax and a production subsidy. In practice, domestic firms selling domestically are subject to both, such that the net tax liability is the difference between their sales tax and production subsidy. Conversely, foreign firms are subject only to the sales tax, which operates like an import tariff, while domestic firms selling abroad are subject only to the production subsidy, which operates like an export subsidy. These latter two elements represent a border-adjusted tax (BAT).

Table 7 reports the effects of different DBCFT rates in the United States. We express these rates in CIT-equivalent terms, i.e., the rate that applies to profits from domestic sales $t_{ilh} = 1 - (1 + tr)^{-1}$ where $tr$ is the border-adjustment tax. Table I5 in the Appendix decomposes post-reform government revenues into domestic sales and border adjustment revenues. It also decomposes the change in GDP between domestic firms' activity and foreign firms' activity in the domestic market.

Table 7: Impact of radical reforms of the International Tax system

| | % change in ... | | | | | |
|---|---|---|---|---|---|---|
| | Tax revenues | Profit Shifting | Real Production | Consumption | Welfare | Price Index |
| Destination-Based Cash Flow Taxation | | | | | | |
| U.S. 20% | -18.2 | -100 | 3.00 | 2.90 | 0.66 | 24.24 |
| U.S. 33% (*) | 26.1 | -100 | 1.06 | -0.39 | 2.17 | 47.94 |
| U.S. 40% (BAT) | 46.4 | -100 | -0.23 | -2.35 | 1.82 | 64.99 |
| Japan 25% (*) | -44.5 | -100 | 1.79 | 1.30 | -2.75 | 31.95 |
| Japan 31% (BAT) | -37.3 | -100 | 1.53 | 0.16 | -3.03 | 42.75 |
| Formulary apportionment | | | | | | |
| Sales share in the formula = 50% | 15.6 | -100 | -0.17 | -0.39 | 1.19 | 0.00 |
| Sales share in the formula = 100% | 25.1 | -100 | 0.18 | -0.27 | 2.18 | 0.00 |

Note: Results are given for the U.S. except in the two Japan scenarios. (*) denotes the unilaterally optimal rate.

To build intuition, consider the introduction of a DBCFT in the U.S. such that profits from domestic sales of domestic firms are taxed at 20%, consistent with the main U.S. policy proposal. Since the pre-reform CIT rate is 40%, this halves the tax rate on domestic sales. Implementing a 20% CIT-equivalent rate requires a DBCFT rate of approximately

25%, which is also effectively the import tariff and export subsidy.

Government revenues from domestic firms decline by 18%. This reflects a −49% change from domestic sales of U.S. firms, partially offset by +31% in border-adjustment revenues (Appendix Table I5). The latter arises because the U.S. runs a trade deficit and therefore collects more from taxing imports than it pays in export subsidies.

Firm entry in the U.S. raises labor demand, increasing wages and consumption. These gains are largely offset by full pass-through of the border tax to consumer prices (+24%), consistent with Barbiero et al. (2019). The net consumption gain is offset by the large decline in tax revenues, yielding a small welfare effect of +0.7%.

These mechanisms extend to higher rates. A higher DBCFT rate reduces the revenue loss from domestic firms but lowers border-adjustment revenues and induces a strong appreciation of the terms of trade. At a CIT-equivalent rate of 40%, which leaves the effective tax rate on domestic sales unchanged, tax revenues rise, but private consumption falls, with an overall welfare gain of +1.8%. This case is of special interest since, by leaving the domestic sales profits tax rate unchanged, it represents a pure BAT: an import tariff and an export subsidy. Under Lerner Symmetry, this should be neutral (Costinot and Werning, 2019). The presence of multinational production and income effects from eliminating profit shifting implies our economy violates Lerner Symmetry, and the BAT generates substantial welfare gains for the U.S. Importantly, these welfare gains are driven by the large U.S. trade deficit, which implies a substantial windfall of BAT revenues. To understand the role of initial imbalances in shaping the effects of DBCFT, we study the implementation of a BAT in Japan, a large surplus economy. We find that this reverses these results relative to the U.S. case: tax revenues fall by −37.3% and welfare declines by 3%. The unilaterally optimal CIT-equivalent rates for the U.S. and Japan are similar at 33% and 25%, but the welfare effects are opposite at +2.2% and −2.8%, respectively. This highlights that DBCFT welfare effects are largely driven by a country's trade balance, generating fluctuations in tax revenues and prices far larger than under minimum taxation.

**Result 5.** *Unilaterally replacing the CIT with a DBCFT generates welfare changes an order of magnitude larger than under the minimum tax. Although the DBCFT also involves a trade-off between private and public consumption, the net welfare effect is highly sensitive to trade imbalances.*

**Formulary apportionment.** FA is a multilateral reform that consolidates multinational profits at the group level and allocates taxing rights using a formula based on observable factors such as assets, payroll, or sales. It eliminates profit shifting by design. FA is widely used to allocate taxing rights across sub-national entities, for example, across U.S. states or German municipalities, and is increasingly proposed as an alternative to the current international system (Clausing, 2016). We consider two standard formulas: one assigning 50% weight to sales and 50% to production factors, and one assigning 100% weight to sales. Statutory tax rates remain unchanged.

For the U.S., switching to FA raises welfare without the price-level volatility observed under the DBCFT. Welfare gains arise through two channels. First, eliminating profit shifting increases revenues by +6.6% (Appendix Table I2). Second, taxing rights are reallocated according to the formula. Countries whose share of world expenditure exceeds their share of booked profits under the status quo, including the U.S., gain taxing rights (Appendix Figure I6).

When the sales share is 100%, real GDP rises slightly as production reallocates toward more productive locations once tax distortions are removed. Consumption declines modestly because effective taxation increases globally, but higher revenues more than offset this loss, yielding positive net welfare effects.

Welfare gains increase with the sales weight: a 100% sales-based formula yields gains of 2.2%, compared to 1.2% under the balanced formula. Appendix Table I6 shows that a pure sales formula favors both the U.S. and the E.U., reflecting their large consumer markets relative to production. By contrast, a coalition including China and India would prefer production-weighted formulas, as their share of world production exceeds their expenditure share. In practice, countries disagree on how taxing rights should be allocated across sales and production factors. This disagreement, rather than opposition to unitary taxation itself, may explain why some negotiations have shifted from the OECD to the UN, where emerging economies have greater influence over the choice of formula.

**Result 6.** *Formulary apportionment eliminates profit shifting and generates positive welfare effects. The relative shares of world expenditure and production shape distributional outcomes: advanced economies favor sales-based formulas, while emerging economies prefer production-weighted formulas.*

# 7 Conclusion

The current international corporate tax system is outdated, as it is not robust to the variety of tax avoidance strategies firms use to shift their profits to tax havens. This paper examines reforms of this system, including the global minimum tax under various allocations of taxing rights (IIR, UTPR, QDMTT), and benchmarks them against alternative international tax architectures like Destination-Based Cash-Flow Taxation (DBCFT) and Formulary Apportionment (FA). We use a general equilibrium model of multinational production augmented with corporate taxation and profit shifting. A key empirical contribution is the recovery of trilateral profit-shifting flows using model-consistent triangle identities, along with estimates of profit-shifting frictions and elasticities. The profit-shifting elasticity is approximately three times that of the tax base, implying that minimum taxation primarily reshapes the geography of profit shifting while real production adjusts more gradually. Our findings indicate that a global minimum tax improves welfare in most non-haven countries, with a globally optimal rate of 21-22%. A 15% minimum tax partially restores *fiscal sovereignty*, reducing global profit shifting by 46%. We find little support for a "race to the minimum tax". Instead, the reform reduces the cost for countries to raise their corporate tax rate. Under a DBCFT, profit shifting is eliminated, but welfare effects are highly sensitive to trade imbalances through violations of Lerner symmetry. Under Formulary Apportionment, welfare gains can be an order of magnitude larger than under a global minimum tax, but countries disagree on formula design depending on their relative shares of world expenditure and production.

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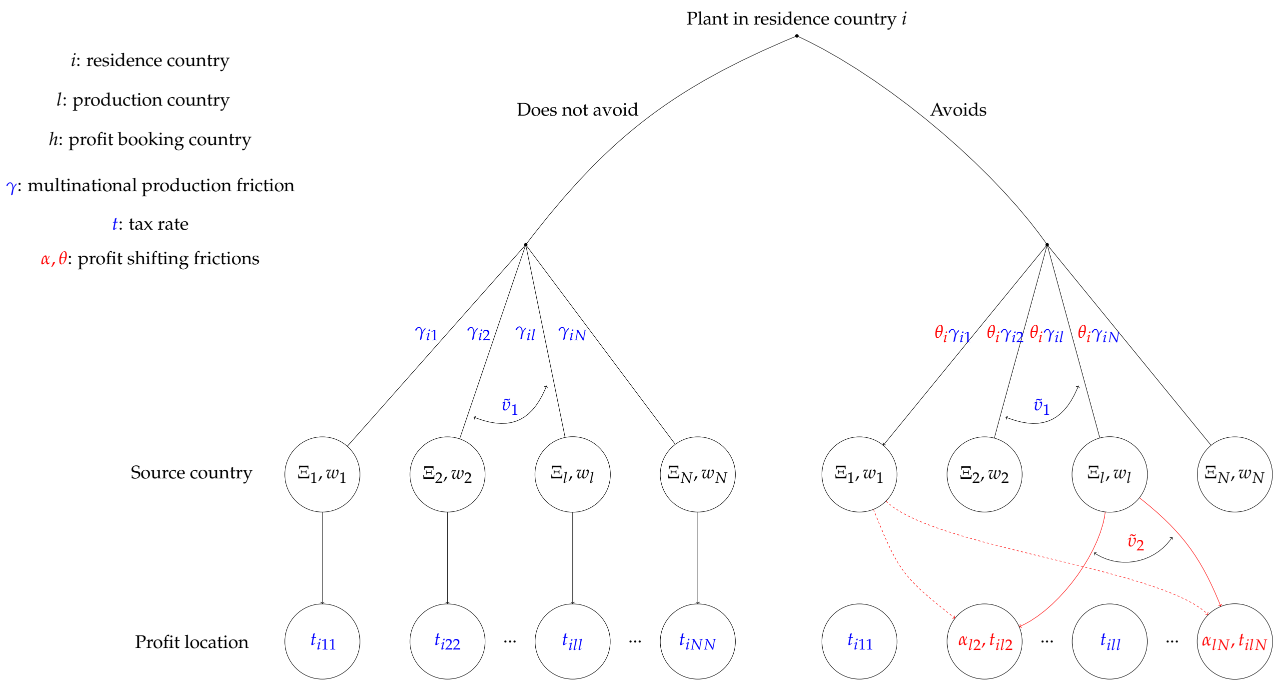
# Online Appendix

## Table of Contents

# A Model

## A.1 Representation of the model

Figure A1 shows a schematic representation of the model under a territorial taxation regime. For non-tax avoiders, all taxes are levied where production takes place, in country $l$. The location choice depends on corporate tax rates $t_{ill}$, market size and geography embedded in $\Xi_l$, and wages, $w_l$. For tax avoiders, multinationals producing in non-haven countries can transfer their profits to a tax haven (countries 2 and N) upon paying the cost $\alpha_{lh}$.




Note: The red color refers to the profit shifting activity of the firms and the blue color to their real activity. Countries 2 and N are tax havens.

Figure A1: Structure of the theoretical framework

## A.2 Proof of proposition 1

Taking equations (2) and (3) together, we have:

$$\frac{X_{ilh}}{X_i} = \frac{\tilde{A}_{ilh}(1-t_{ilh})^{\frac{\upsilon_1}{\sigma-1}-1}\iota_l^{-1}G_{i,lh}(\tilde{\mathbf{A}}_i, \mathbf{t})}{\sum_{jk}\tilde{A}_{ijk}(1-t_{ijk})^{\frac{\upsilon_1}{\sigma-1}-1}\iota_j^{-1}G_{i,jk}(\tilde{\mathbf{A}}_i, \mathbf{t})}$$

Thus, we can deduce easily:

$$\frac{X_{ilh}}{\sum_{j,k,k\neq j} X_{ijk}} = \frac{\tilde{A}_{ilh}^{\frac{\upsilon_2}{\upsilon_1}}(1-t_{ilh})^{\frac{\upsilon_2}{\sigma-1}-1}\iota_l^{-1}}{\sum_{j,k,k\neq j}\tilde{A}_{ijk}^{\frac{\upsilon_2}{\upsilon_1}}(1-t_{ijk})^{\frac{\upsilon_2}{\sigma-1}-1}\iota_j^{-1}}$$

# B Estimation of profit shifting: Theory

## B.1 Proof of Proposition 2

We first recall the logic of Proposition 2. We want to recover $\mathbb{P}_{i\ell h}$: the probability that a firm headquartered in $i$ produces in source country $\ell$ and books its profits in tax haven $h$. For shifted profits, Proposition 2 says that this probability can be written as

$$\mathbb{P}_{i\ell h} = \mathcal{P}_i \times \zeta_{i\ell} \times \chi_{\ell h}.$$

This decomposition separates the problem into three pieces. The first piece, $\mathcal{P}_i = \frac{PS_i}{\Pi_i}$, is the overall probability that profits of firms from residence country $i$ are shifted. The other two pieces describe where those shifted profits come from and where they are booked: $\zeta_{i\ell}$ allocates the shifted profits of firms from $i$ across source countries, while $\chi_{\ell h}$ allocates shifted profits generated in source country $\ell$ across tax havens. This appendix shows how the calibration recovers these two conditional margins from a system that allocates shifted profits across source-haven pairs.

Conditional on profit shifting ($h \neq \ell$), the model-implied probability can be written as

$$\mathbb{P}_{i\ell h} = \mathcal{P}_i \frac{\gamma_{i\ell}^{-\nu_2} y_{\ell h}}{\sum_m \sum_g \gamma_{im}^{-\nu_2} y_{mg}}$$

where $y_{\ell h}$ corresponds to the unknown source-haven ($\ell h$) term. Up to a common normalization,

$$y_{\ell h} = \widetilde{A}_{\ell\ell}^{\nu_2/\nu_1}\left[\alpha_{\ell h}\,(1-t_{\ell\ell})^{1/(1-\sigma)}\,\iota_\ell^{1/(1-\sigma)} w_\ell \Xi_\ell\right]^{-\nu_2}.$$

The common normalization is irrelevant because only ratios of allocation objects enter probabilities.

Defining the total source-haven attractiveness associated with source $\ell$: $Y_\ell \equiv \sum_{h\in\mathcal{H}} y_{\ell h}.$, we have:

$$\zeta_{i\ell} \equiv \frac{\gamma_{i\ell}^{-\nu_2} Y_\ell}{\sum_m \gamma_{im}^{-\nu_2} Y_m}, \tag{17}$$

$$\chi_{\ell h} \equiv \frac{y_{\ell h}}{Y_\ell}. \tag{18}$$

where $\zeta_{i\ell}$ allocates shifted profits of firms from $i$ across source countries, and $\chi_{\ell h}$ allocates shifted profits generated in $\ell$ across tax havens.

Multiplying (17) and (18) gives

$$\zeta_{i\ell}\chi_{\ell h} = \frac{\gamma_{i\ell}^{-\nu_2} Y_\ell}{\sum_m \gamma_{im}^{-\nu_2} Y_m} \frac{y_{\ell h}}{Y_\ell} = \frac{\gamma_{i\ell}^{-\nu_2} y_{\ell h}}{\sum_m \sum_g \gamma_{im}^{-\nu_2} y_{mg}}.$$

which proves Proposition 2: $\mathbb{P}_{i\ell h} = \mathcal{P}_i \zeta_{i\ell}\chi_{\ell h}$.

## B.2 The triangle of Profit Shifting

For each residence country $i$ and tax haven $h$, shifted profits booked in $h$ must be the sum of the profits generated in all possible source countries and booked in $h$:

$$PS_{ih} = \sum_\ell PS_{i\ell h} = PS_i \sum_\ell \zeta_{i\ell}\chi_{\ell h}.$$

Dividing by $PS_i$ gives the triangle identity:

$$\frac{PS_{ih}}{PS_i} = \sum_\ell \zeta_{i\ell}\chi_{\ell h}.$$

Therefore, the residence-haven moments $PS_{ih}/PS_i$ identify where firms from $i$ book shifted profits, but not where these profits were generated. Namely, at this point, we cannot allocate the $ih$ flows to each specific $\ell$ production country.

Technically, the residence-haven moments are not enough to determine all source-haven allocation terms $y_{\ell h}$ as $y_{\ell h}$ is identified only up to scale. Therefore, the system still requires $N - H - 1$ additional source-side restrictions. These restrictions help identify the production location $\ell$ in which shifted profits are generated. In the data, we do not observe the source distribution of shifted profits. However, we observe sales. This difference is substantial because profits are distorted by tax-rate differences while sales are not. Therefore, we make the following identifying assumption: suppose that there were no tax rate differences, then the spatial distribution of sales should coincide with that of profits for profit-shifting firms.

Formally, define the source-haven tax adjustment

$$\kappa_{\ell h} \equiv \left(\frac{\widetilde{t}_{\ell h}}{\widetilde{t}_{\ell\ell}}\right)^{\nu_2}, \qquad \widetilde{t}_{\ell h} \equiv (1 - t_{\ell h})^{-1/(\sigma-1)}.$$

This adjustment allows us to remove the part of the source-haven allocation driven by tax differences. Namely, we can define a $\tilde{y}_{\ell h} \equiv y_{\ell h}\kappa_{\ell h}$ as the prevailing $y_{\ell h}$ when there are no tax differences. Then, we can also define $\bar{Y}_\ell(y) \equiv \sum_h \tilde{y}_{\ell h} = \sum_h y_{\ell h}\kappa_{\ell h}$. The corresponding $\ell$ share of shifted profits absent tax incentives implied by the allocation is

$$\bar{s}_\ell^{PS}(y) = \sum_i \frac{PS_i}{\sum_j PS_j} \frac{\gamma_{i\ell}^{-\nu_2} \bar{Y}_\ell(y)}{\sum_m \gamma_{im}^{-\nu_2} \bar{Y}_m(y)}.$$

Since we use multinational production sales, we convert this profit share into a sales share.

The source sales share absent tax incentives implied by the allocation is

$$\bar{s}_\ell^{sales}(y) = \frac{1}{\iota_\ell} \frac{\bar{s}_\ell^{PS}(y)}{\sum_r \frac{1}{\iota_r} \bar{s}_r^{PS}(y)}.$$

Finally, the unknowns are the source-haven allocation terms $y_{\ell h}$, up to a common scale. We solve the following system, with data on the left-hand side and unknowns on the right-hand side:

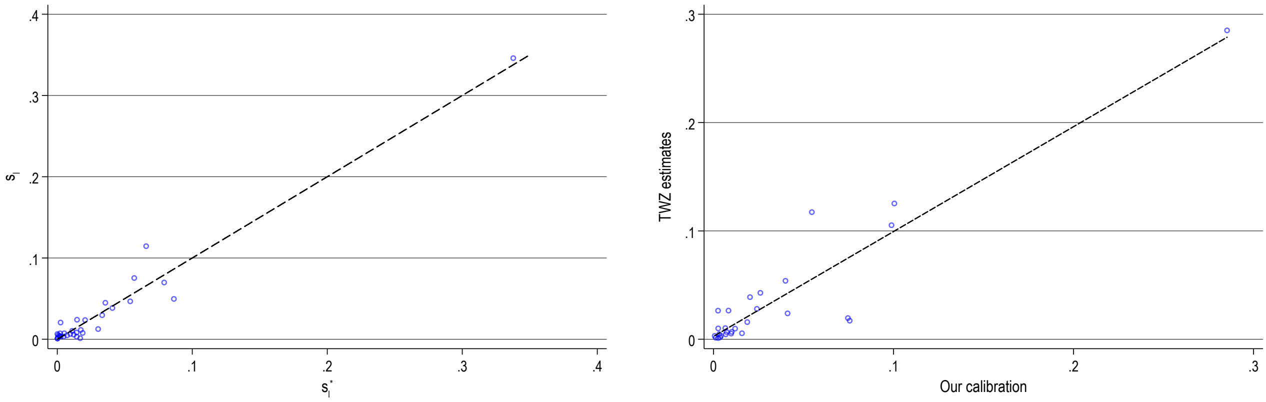
$$\frac{PS_{ih}}{PS_i} = \sum_\ell \frac{\gamma_{i\ell}^{-\nu_2} y_{\ell h}}{\sum_m \sum_g \gamma_{im}^{-\nu_2} y_{mg}}, \qquad \forall i, h, \tag{19}$$

$$\bar{s}_\ell^{sales,data} = \bar{s}_\ell^{sales}(y), \qquad \forall \ell, \tag{20}$$

Equation 19 matches the observed residence-haven shares. Equation 20 matches the source sales share absent tax incentives. The recovered source-haven allocation implies $(\zeta_{i\ell}, \chi_{\ell h})$ through (17)–(18), and therefore recovers $\mathbb{P}_{i\ell h}$ through Proposition 2.

In practice, some $y_{lh}$ produced by this system are negative. They represent 5.7% of total profit shifting. Therefore, the empirical sales vector is treated as a noisy proxy for the source share of sales by profit-shifting firms and replaced by the closest feasible sales vector. Concretely, let $S_i = \sum_m \sum_g \gamma_{im}^{-\nu_2} y_{mg}$ and normalize $\sum_i S_i = 1$. For any candidate $S$, the residence-haven equations imply, for each source $\ell$ and tax haven $h$, $\sum_m \gamma_{im}^{-\nu_2} y_{mh}(S) = \frac{PS_{ih}}{PS_i} S_i$ for all residence countries $i$. We choose $S$ to minimize $\sum_\ell [\bar{s}_\ell^{sales}(y(S)) - \bar{s}_\ell^{sales,data}]^2$ subject to $S_i > 0$ and $y_{\ell h}(S) \geq 0$. The final allocation, therefore, assigns nonnegative shifted profits to every source-haven pair.

Figure B1 shows two diagnostics about this procedure. Panel (a) compares the calibrated moment $s_l^{sales}$ to $s_l^{sales,\star}$, the adjusted moment that implies only positive values of profit shifting. Panel (b) compares the source share of profit shifting $(\frac{PS_l}{\sum_l PS_l})$ in our calibration and in TWZ.




(a) Calibrated moment $s_l$ and adjusted moment $s_l^\star$

(b) Source share of profit shifting $\frac{PS_l}{\sum_l PS_l}$

Figure B1: Diagnostics about profit shifting allocation

Note: Panel (a) compares the calibrated moment $s_l$ to $s_l^\star$, the adjusted moment that implies only positive values of profit shifting. Panel (b) compares the source share of profit shifting $(\frac{PS_l}{\sum_l PS_l})$ in our calibration and in TWZ.

# C Data

## C.1 FDI Income

We collect information on bilateral FDI income from 2012 to 2019 using the bilateral balance of payments data from the OECD. This data are complemented with data from the Hong Kong national accounts that provide information on aggregated inward and outward FDI income for the 10 largest immediate recipients and investors in Hong Kong.

FDI income has three components: reinvested earnings, dividends, and interest payments. Ideally, we want to use only information about reinvested earnings and dividends to construct the FDI income data. We want to exclude interest payments because in a typical tax avoidance scheme where the non-haven is indebted to a tax haven affiliate, interest would be paid from the parent company to the tax haven affiliates (Wright and Zucman, 2018).

**Taking conduit FDI into account** Foreign Direct Investment (FDI) income data, produced on an immediate investor basis under the BPM6 methodology (International Monetary Fund, 2009), can be influenced by conduit FDI. Conduit FDI refers to investment that passes through a country solely to take advantage of regulatory benefits. Since the recommendations of the Benchmark Definition $3^{rd}$ edition in 1996, some OECD countries are producing inward FDI statistics that separate standard FDI from FDI in Special Purpose Entities (SPEs).[1] These SPEs are the instruments of conduit FDI and are characterized by International Monetary Fund (2014) as follows: "their owners are not residents of the territory of incorporation, main parts of their balance sheets are claims on or liabilities to nonresidents, they are companies with little or no physical presence in their host economy, little or no employment, little or no significant production, and few (if any) nonfinancial assets, and many SPEs have bank accounts in the host economy (although they may be of a temporary nature)."

These statistics are not necessarily available for all the components of FDI income (dividends, reinvested earnings and interest). To address this issue, we compute the ratio of FDI through SPEs to total FDI for the most aggregated category (Total FDI income) and apply this ratio to each of the components of FDI income. This approach allows us to adjust the FDI income series for SPEs in the economies that report such data. Additionally, we exclude transactions where the immediate investor is a tax haven, which accounted for 29% of total conduit FDI income in 2015.

In a robustness sample, we apply the methodology of Damgaard and Elkjaer (2017) to impute conduit FDI income based on the relationship between the ratio of conduit FDI income to total FDI income and the ratio of total FDI income to GDP. Using the estimated correlation between these two variables, we can extrapolate the amount of conduit FDI income passing through an economy. Assuming that the shares of FDI income and conduit FDI income are proportionally the same, we can estimate the bilateral amount of conduit

[1] See Organisation for Economic Co-operation and Development (OECD), 2008.

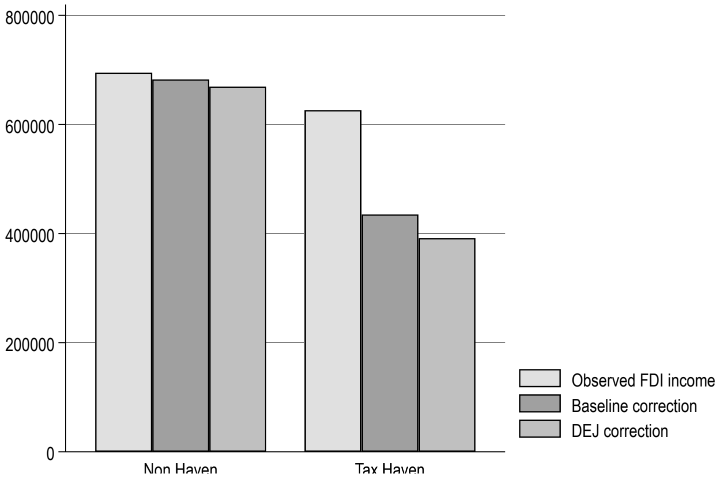



Figure C1: Total FDI income by receiving country type

Note: This figure compares different FDI income variables according to the type of the economy that receives the investment in 2017. It shows the differences in aggregate amount between the observed FDI income, the variable constructed using available information on SPEs (*Baseline correction*) and the variable constructed using an imputation inspired by DEJ. It excludes FDI income from investment originating from tax havens.

FDI income for countries not covered by the SPE statistics. This methodology is applied only to countries that are not classified as "*sink* FDI" economies as defined by Garcia-Bernardo et al. (2017).[2]

Figure C1 compares different FDI income variables by the type of economy receiving the investment in 2017. It shows the aggregate differences between observed FDI income, the variable adjusted for available information on SPEs (our baseline correction), and the variable adjusted using an imputation method inspired by Damgaard et al. (2024) (DEJ, hereafter). For non-tax havens, the correction is small and aligns with expectations. For tax havens, the uncorrected FDI income is almost as large as that for non-havens. Once corrected, it decreases significantly, by nearly one third. A further correction using the DEJ method slightly reduces the observed FDI income in tax havens.

**Imputation procedure** To improve the coverage of our bilateral FDI income series, we impute some missing values. The imputed flows are obtained in two steps. First, we use the unilateral balance of payments data from the IMF, which informs on inward FDI income, inward FDI stock, outward FDI income and outward FDI stock. This dataset helps us compute the unilateral rates of return on inward and outward investments. Second, we apply the unilateral rates of return on bilateral FDI stock data from the IMF CDIS. We use the outward rates of return only in the case of missing information on the inward rate. The correlation between imputed bilateral rates of return and observed rates of return in our dataset is 0.9.

It is important to note that this strategy tends to be conservative as it assigns the average rate of return to unobserved bilateral FDI flows in tax havens while the literature

[2]These are countries that "attract and retain foreign capital while conduit-OFCs are attractive intermediate destinations in the routing of international investments and enable the transfer of capital without taxation." (Garcia-Bernardo et al., 2017).

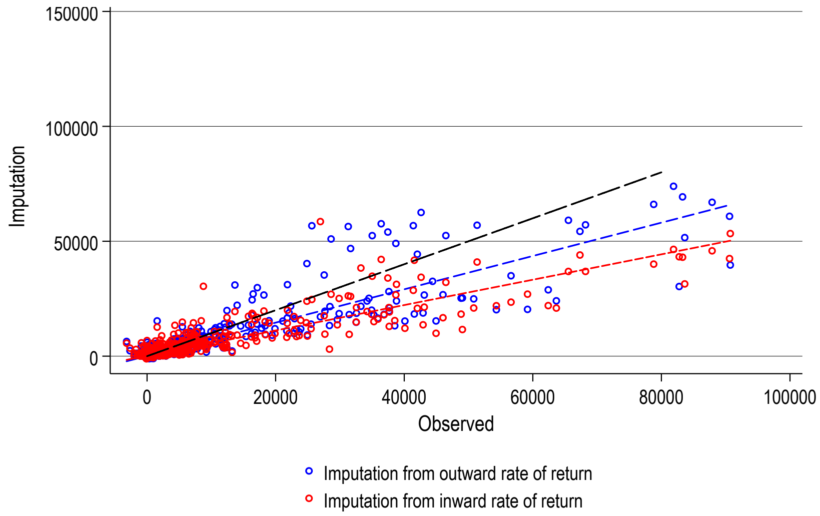



Figure C2: Comparison of observed and imputed flow FDI income.

Note: This figure compares, for cases where the receiving country of the investment is a tax haven, the observed bilateral FDI income to the imputed one for the flows for which we observe both of them (in which case we keep the observed flow).

suggests that tax havens generally have a rate of return higher than average (Vicard, 2022). In Figure C2, we show that for country pairs involving a destination tax haven, where both the actual flow and the imputed flow are observed, the imputed flow tends to underestimate the actual flow. This suggests that the imputation procedure underestimates profits in tax havens.

**Final dataset construction** The final data on bilateral FDI income is constructed following this procedure:

1. We use the participation revenue values directly provided by the OECD (60% of the aggregate value).
2. If missing, we sum dividend income and reinvested earnings (0.001% of the aggregate value).
3. If missing, we use the available value between dividend income and reinvested earnings (representing 1% and 12% of the aggregate value, respectively).
4. If missing, we set the value of FDI income from dividends and reinvested earnings as the difference between total FDI income and income from debt instruments (0.03% of the aggregate value).
5. If any component information is missing, we use total FDI income to estimate dividends and reinvested earnings (16% of the aggregate). Because FDI income includes debt income, this step slightly overstates dividends and reinvested earnings.
6. Steps 1 to 5 are applied separately for flows reported under the inward directional principle and the outward directional principle. For the estimation, we select the maximum value between the inward and outward flows.

7. We follow the imputation procedure described below for any remaining missing information (10% of the aggregate).

The final dataset covers 170 investing non-haven countries and 146 destination countries. The baseline estimation sample focuses on 68 countries: 34 non-haven countries, 6 individual tax havens, Hong Kong, Ireland, Luxembourg, the Netherlands, Singapore, and Switzerland, and 28 additional jurisdictions that are aggregated into a composite tax haven labeled Offshore Financial Centers.

## C.2 Country-by-country reporting (CbCR)

We use the OECD CbCR dataset to obtain an alternative measure of aggregated bilateral profits and to compute effective tax rates. This dataset consists in the aggregation of mandatory firm-level country-by-country reports at the residence country × source country level. Only large firms with a turnover larger than EUR 750 million have to fill the reports. This restriction allows us to concentrate on the firms that are the most likely to engage in profit shifting activities. The aggregation distinguishes profit-making from loss-making firms. We focus on profit-making firms to avoid an aggregation bias when computing the effective tax rates. The requirement to report CbCR for these large firms begins in 2016. We use the reports from the year 2016 and 2017 that are filed by firms from 25 different residence countries.

## C.3 Orbis' Firm-level pre-tax profits.

We closely follow the methodology outlined by Delis et al. (2022), which constructs a global database on MNE activities using all available "vintages" of Bureau Van Dijk's Orbis Historical database. As noted by Delis et al. (2022), Orbis Historical offers several advantages over the online version and other datasets. First, it captures dynamic ownership changes, crucial for avoiding misclassification of affiliates under different GUOs. Second, it covers a period longer than the standard ten years typically available online, addressing reporting lags identified by Kalemli-Özcan et al. (2024). The detailed procedure for building the micro-level dataset is provided in Delis et al. (2022). The dataset includes firms with non-negative pre-tax income and total assets. The closing date variable is used to determine the fiscal year. As in Delis et al. (2022), the average statutory tax rate for both firm and GUO countries in our dataset is 0.25. This average closely aligns with the global average statutory corporate tax rate of 0.24, as reported by Tørsløv et al. (2023). We keep data on pre-tax income, cash tax paid, fixed assets, and employment for the foreign affiliates of Global Ultimate Owners along with their locations by country. The cash effective tax rate (ETR) is calculated as the ratio of cash tax paid to pre-tax income and is winsorized for outliers at 1% and 90%, since values in the top decile often exceed 100 percent and are not economically meaningful. We aggregate the data at the GUO level and report profits by country. The estimation sample includes 13,331 GUOs across 60 countries for the period 2010-2017.

## C.4 Trade

Trade data comes from the International Trade and Production Database for Estimation (ITPD-E) from Borchert et al. (2021, 2022). This database provides consistent trade data for international and domestic flows using administrative data and avoiding any estimation of missing flows. It also includes trade in services making it a comprehensive and consistent data source for our purposes.

## C.5 Multinational Production Sales

Multinational production (MP) sales correspond to the sales made in the production country $l$ by firms headquartered in the country $i$ and reported in $l$ (country $l$ may be identical to country $i$). They correspond to $X_{ill}$ in the model's notations. We build a $40 \times 40$ matrix of MP sales that covers the period 2015-2017. We use the Multinational Revenue, Employment, and Investment Database (MREID) developed by Ahmad et al. (2023). This database provides bilateral sector-level data on multinational sales, employment, and investment. The dataset is compiled by aggregating firm-level data from Orbis and does not rely on imputed data from gravity estimation, unlike other similar databases such as the OECD's Analytical AMNE database (Cadestin et al., 2018), which are more suited for estimation purposes. We then compute intra-national MP sales. It corresponds to the domestic sales made by domestic firms: $X_{lll}$. They are obtained by summing the exports of country $l$ and its intra-national trade ($\sum_{i,n} X_{iln}$) and subtracting the MP sales made in $l$ by other countries $i$, with $i \neq l$ ($\sum_{i,i \neq l} X_{ill}$).

## C.6 Tax rates

**Statutory tax rates.** We use data made accessible by the Tax Foundation's "Corporate Tax Rates Around the World" database (Tax Foundation, 2022). The model is calibrated using 2017's statutory tax rates from KPMG Corporate Tax Rate Table. We complement it with the Tax Foundation long panel (1980-2022). Both database mostly agree on rates and might diverge in the way they take into account local taxes in federal system (e.g. in Germany or in the U.S.) or additional taxes similar to the Corporate Income Tax (e.g. in France). In Appendix I5, we show that the two sources provide similar results for the optimal minimum tax rate.

**Tax havens' tax rates.** The model needs the tax rate available to tax-avoiding firms in tax havens ($t_{lh}$), which is not directly observable. Tax havens offer legal provisions that can make the effective tax rate differ greatly from the statutory tax rate. We use the OECD CbCR dataset to calculate effective tax rates based on taxes paid and profits. These data have been used in other studies that evaluate multinational firms' tax avoidance (Garcia-Bernardo and Janskỳ, 2024 at the macro level, Delpeuch and Laffitte, 2019, Bratta et al., 2021 or Fuest et al., 2021 at the micro-level).

We calculate effective tax rates (ETR) as tax paid divided by pre-tax profits, and remove negative and outlier values. For each tax haven in our sample, we observe the ETR paid by firms from each headquarter country reporting activity in the tax haven. It corresponds to 18 origin countries for Switzerland, 20 for Hong Kong, 18 for Ireland, 18 for Luxembourg, 22 for the Netherlands, 23 for OFCs, and 20 for Singapore.

We define $t_{lh}$ as the median effective tax rate observed in each tax haven. Therefore, $t_{lh}$ does not vary with country $l$ for $l \neq h$.

Notice that Tørsløv et al. (2023) provides data on the effective tax rate for many countries. However, this would measure $t_{lh}$ with a bias induced by firms having a real activity in tax havens and then paying a different tax rate than tax-avoiding firms. This is especially the case in large tax havens.

**Effective tax rates** Effective tax rates are used at different moments of the paper. They are computed as taxes paid over total revenues. When data are available, we compute the effective tax rate within the sample we are using. Therefore, the effective tax rates used in table 3 correspond to the micro-level effective tax rate computed in the Orbis dataset. In column (1) of table 4, we use bilateral effective tax rates computed using Country-by-country reporting data. To avoid outliers, we cap the effective tax rate at the level of the statutory tax rate. In column (2) that uses data from Tørsløv et al. (2023), we use the effective tax rates provided by the authors in their online replication package. Finally, in column (6) of table D2, we use macro-level unilateral effective tax rates provided by Wamser et al. (2026). This choice of data improves the coverage we would have using data from the CbCR.

## C.7 Profits

The calibration of the model requires information on profits in each country of the sample. Profits are composed of three components. They are computed as gross operating surplus minus depreciation less net interest paid. The main data source is the UN National Accounts Table 14 (United Nations, 2024) accessed in January 2024. The data is complemented with data gathered from national authorities for Malaysia, Hong Kong and Singapore. When missing, we impute the profits' component using the ratio of the component to the Gross Operating Surplus of other countries in the sample. The information is missing for Croatia and OFCs. We impute their profits by estimating them through a regression of profits on GNI, achieving an adjusted $R^2$ of 84%.

## C.8 Tax haven policies

We proxy tax havens' tax avoidance "technologies" using the TJN's Corporate Tax Haven Index (Jansky et al., 2020) for 2019 (the first available year). The index aggregates 20 *de jure* and *de facto* indicators from 5 categories of policies: Lowest available corporate income tax, Loopholes and gaps, Transparency, Anti-avoidance, and Double tax treaty aggressiveness. Out of the 20, we select 13 indicators that inform on the profit-shifting technology and take their average for each tax haven in our database (Foreign investment income treatment, Loss utilization, Capital gains taxation, Sectoral exemptions, Tax holidays and Economic zones, Fictional interest deduction, Public company accounts, Tax court secrecy, Interest deduction, Royalties deduction, Service payment deduction, CFC rules, and Tax treaties).

# D Estimation of profit shifting: Empirics

## D.1 Methodology

**Unilateral profit-shifting flows** The measurement of aggregate profit shifting at the country level is challenging. Most of the literature follows, in spirit, the approach pioneered by Hines and Rice (1994), which estimates unilateral profit shifting. The premise of this methodology is that the observed pre-tax profits of a firm correspond to the sum of *normal* profits and *shifted* profits. The combination of inputs and technology in production countries determines normal profits. Shifted profits are generated thanks to the fiscal environment and the incentives offered to foreign firms to shift profits out of production countries. Profit shifting is then estimated as the difference between total profits and estimated normal profits. When the countries of interest are tax havens, these are "excess profits"; when the countries of interest are non-havens these are "missing profits". Papers based on macro-level data estimate the amount of profit shifted to tax havens for the U.S. or at the global level (Zucman, 2014, Clausing, 2016, 2020, Janský and Palanský, 2019, Garcia-Bernardo and Janskỳ, 2024, or Tørsløv et al., 2023).

**Bilateral profit shifting: the methodology from Tørsløv et al. (2023)** Unilateral profit-shifting estimates may be allocated to bilateral pairs using an allocation key. TWZ are the first to propose a bilateral allocation of profit shifting across pairs of source countries and tax havens and pairs of residence countries and tax havens.

To estimate profit shifting, TWZ collect data on the geography of profits by local and foreign companies. They proceed in two independent steps. They first compute a benchmark level of *normal* profitability level from national account data. This benchmark is defined as the ratio of pre-tax profits to wages of domestic-controlled firms. The methodology assumes that, in the absence of profit shifting, the average ratio of pre-tax profits to wages of foreign-controlled firms is the same as that of domestic-controlled firms. They show that the ratio of foreign-owned firms in tax havens is an order of magnitude larger than the one of local firms. In tax havens, profits that are above the benchmark level of profitability are considered as "excessive". The difference between the excessive level of profits and the benchmark level is the amount of shifted profits. TWZ provide estimates of profit shifting to each tax haven and then aggregate it to obtain a worldwide estimate of $616bn in 2015. The estimation is extended to subsequent years in Wier and Zucman (2022).

In the second step, the profits shifted to tax havens are allocated across non-haven origin countries. Their methodology relies on the assumption that multinational corporations in high-tax countries use intra-firm interest payments and services imports to shift profits. Following Hebous and Johannesen (2021), TWZ identify "high-risk" services categories such as royalties and headquarter services (information and communication technologies, insurance, financial and management). TWZ define as a benchmark level of trade in "high-risk" services and intra-firm interest payments the average share of high-risk services exports and intra-firm interest received in the GNI of non-haven EU countries. These shares are then computed for each tax haven and their difference with respect to the benchmark informs on excessive flows going to tax havens.

**Differences between our approach and TWZ** The approach of TWZ has many advantages, one of which is that it relies on available trade in services data, arguably having a broader coverage than FDI income data. Nevertheless, the calibration of our model requires objects that cannot be recovered from bilateral flows in TWZ alone. Our approach relies on three elements that differ from TWZ's approach: i) internal accounting consistency, ii) allocation shares guided by theory, and iii) agnosticism about the channels through which profits are shifted.

**Trilateral accounting consistency.** Modern reforms differ in how they allocate taxing rights across jurisdictions. For instance, Pillar 2's Income Inclusion Rule allocates the taxing rights of the minimum tax to residence countries ($i$ in the model), the Undertaxed Profit Rule to source countries ($l$ in the model), and the Qualified Domestic Minimum Top-Up Tax to countries where profits are located ($h$ in the model). Therefore, evaluating these policies requires observing the trilateral object $PS_{ilh}$, the profits shifted by firms from residence country $i$, from source country $l$, to tax haven $h$.

TWZ construct two bilateral allocations independently: source-haven ($lh$) flows using excess high-risk services and interest payments, and residence-haven flows using ultimate ownership shares ($ih$). These allocations are well suited to measuring aggregate magnitudes but do not jointly determine the trilateral structure. Their allocation shares for residence-haven and source-haven flows are computed independently, so summing across each dimension yields different totals for profits shifted to tax havens (in other words, in their approach $\sum_l PS_{lh} \neq \sum_i PS_{ih}$).

By contrast, our calibration imposes triangular accounting identities. As a result, $PS_{ilh}$ is determined by a system of equations that ensures accounting consistency (as shown in section 4.1 of the paper). These constraints would be violated by allocation methods that determine $PS_{ih}$ and $PS_{lh}$ independently. Our system of equations solves for the unique trilateral distribution satisfying all accounting and theory constraints. This trilateral structure is the minimal requirement for determining which jurisdiction's tax base expands or contracts under alternative reforms. Section 4.1 provides the full derivation and Appendix D.2 shows consistency with TWZ's bilateral and aggregate magnitudes.

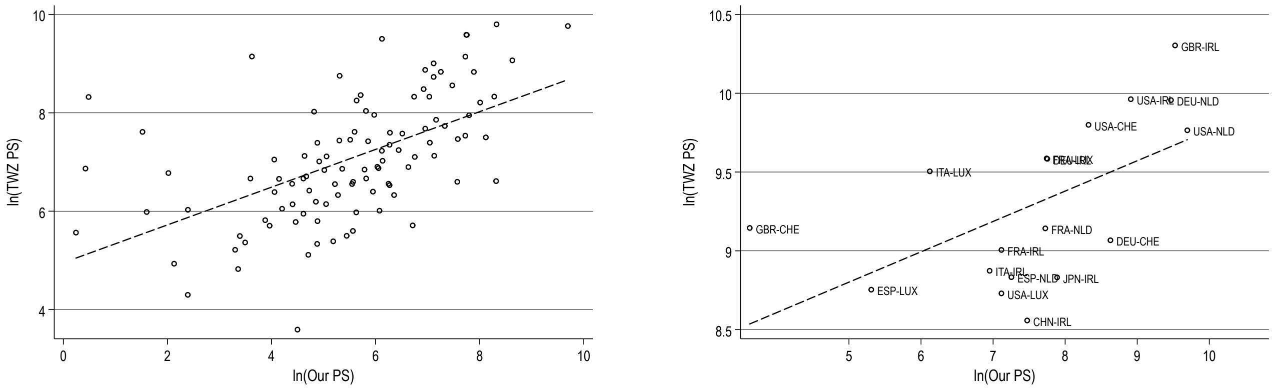
**Designing allocation shares** Our model imposes both accounting and theoretical constraints to construct $PS_{ilh}$. For instance, allocating profit shifting $PS_{ih}$ to source countries $l$ cannot rely solely on multinational production sales (at the $il$ level), as intuition might suggest. Intuitively, for profits to be shifted from $l$, production must occur in $l$. However, because production and paper profits have different elasticities, the pattern of shifted profits is a distorted reflection of real activity (captured by multinational production shares): our model implies that this distortion is shaped by elasticities $\tilde{v}_1$ and $\tilde{v}_2$ (see B.2).

**Channel agnosticism.** TWZ allocate bilateral flows using excessive "high-risk services" as the primary allocation key. We instead remain agnostic about the specific channels through which firms shift profits. This choice reflects evidence that multiple channels operate simultaneously. Hebous and Johannesen (2021) show that less than half of high-risk services imports from tax havens are intra-firm in Germany. Applying their 50% intra-firm share to Germany's high-risk services imports ($51.5bn in TWZ's data) implies roughly $26bn in potentially mispriced transactions, yet TWZ estimate $44bn in total excess services for Germany. This suggests that high-risk services account for only 60% of shifting even under favorable assumptions. In addition, several papers using transaction-level data from different countries have documented that transfer pricing in goods can be substantial (Davies et al., 2018; Flaaen, 2017; Liu et al., 2020; Viertola, 2024; Wier, 2020).

Finally, well-documented case studies show large-scale shifting through under-priced manufacturing services not classified as high-risk in TWZ: the U.S. Senate investigation of Caterpillar documented $8bn shifted to Switzerland using manufacturing service agreements priced at 7% margins (Levin, 2014). Appendix Figure D3 shows that excess high-risk services correlate with our estimates but systematically underestimate their magnitude. Our approach recovers total profit shifting across all channels jointly, without relying on channel-specific assumptions.

## D.2 Comparing $PS_{lh}$ to other estimates

**Comparison with TWZ.** To our knowledge, Tørsløv et al. (2023) (TWZ) is the only other paper in the literature that proposes a bilateral measure of profit shifting. We compare our measure of bilateral profit shifting to that of TWZ. We also compare our estimates of profit shifting aggregated at the country level with other estimates from the literature.




Panel A: European tax havens.

Panel B: PS flows greater than $5bn.

Figure D1: Comparison of TWZ's profit-shifting estimates with ours

Note: This figure compares the logarithms of the bilateral profit shifting from source countries $l$ to tax havens $h$ in this paper and in Tørsløv et al. (2023). Panel A shows the comparison for European tax havens, while Panel B focuses on large values of bilateral profit shifting.

In Panel A of Figure D1, we show for European tax havens the correlation between TWZ's estimates of profit shifting and ours (in naperian logarithm).[3] There is a positive relationship between the two variables. The Pearson correlation is 0.62, and the Spearman rank correlation is 0.67.

In Panel B, we focus on large profit-shifting flows (those greater than $5bn). We observe larger differences for higher values of profit-shifting flows. While the correlation remains high, most of the profit-shifting flows estimated by TWZ are larger than our estimates, reflecting higher aggregate profit shifting in their estimation.

**Comparison with unilateral estimations.** We now compare our estimates aggregated at the source-country level with other estimates in the literature. These estimates are taken from TWZ, the Tax Justice Network report (Cobham et al., 2020) and CORTAX, the model of the European Commission (Alvarez Martinez et al., 2016). To match with CORTAX data, we transform estimates of profit shifting into tax losses by multiplying them by the statutory tax rate. Figure D2 displays tax losses in selected source countries based on the available data in the CORTAX estimations, the study with the smallest sample of countries.

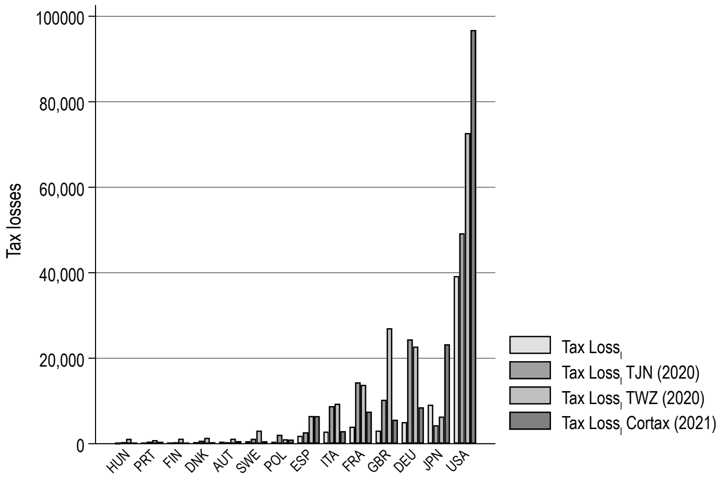



Figure D2: Comparison with other estimations.

Note: This figure compares the (unilateral) tax losses from profit shifting with Cobham et al. (2020), Tørsløv et al. (2023), and Alvarez Martinez et al. (2016). Tax losses are obtained by multiplying profit shifting out of source countries $l$ by their statutory tax rate.

This graph first reveals that the estimates of profit shifting are sensitive to methodologies and data. However, these studies find a similar order of magnitude for many countries. The CORTAX estimation is particularly high for the U.S., while our estimation, despite being lower than others, is close to the ones of the TJN. Overall, our quantification is in the range of the other studies but tends to display lower aggregate amount of profit shifting.

## D.3 Robustness of profit-shifting estimates

This section explores the robustness of our bilateral profit-shifting estimates.

[3]Due to aggregation of OFC, Hong Kong and Singapore in TWZ files, we are not able to display a similar graph that separately includes these countries.

**Comparing $PS_{lh}$ with excess trade in services in tax havens.** In Figure D3, we assess the correlation between our profit-shifting allocation and an allocation based on excess imports of services from tax havens. We use a reduced-form methodology to directly approximate $PS_{lh}$ from the observations of bilateral services flows. For each pair of countries $l$ and $h$, we estimate the amount of bilateral profit shifting as excessive "high-risk" services computed from a gravity equation.

Using the OECD-WTO's BATIS database, we regress the trade values in services exported from country $k$ to country $n$ for the service category $s$ at date $t$ on a dummy equal to one when a "high-risk" service $s$ is exported by a tax haven $k$. "High-risk" services are defined following Tørsløv et al. (2023) as insurance and pension services, financial services, charges for using intellectual property, telecommunications, computer and information services, and other business services. The methodology that is used to estimate excesses follows the one used to estimate profit shifting in Section 4 of the paper. An advantage in the context of service data is that we can include exporting country × year fixed effects. Therefore, the estimation of excesses is based on the excess exports of high-risk services compared to standard services in tax havens compared to this excess in non-tax-haven countries. We estimate, by PPML, $Service_{knst} = exp(\beta_1 (High - Risk_s \times Haven_k) + \mu_{nst} + \mu_{kt} + \mu_{kn} + \mu_s) \times \epsilon_{knst}$. We compute the excess high-risk services exported by tax havens as the difference between the prediction of this equation and its prediction assuming that $\beta_1 = 0$.

Figure D3 shows a positive and significant correlation between excessive high-risk services and the theoretically consistent measure of bilateral profit shifting.

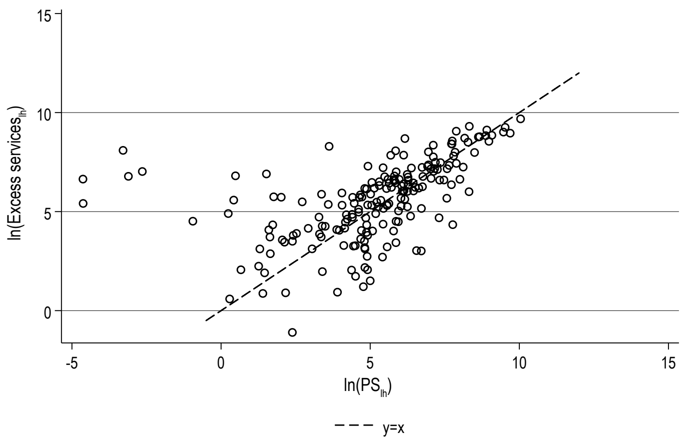



Figure D3: Excessive high-risk services and our measure of bilateral profit shifting

Note: This figure compares our series of profit shifting from production countries $l$ to tax havens $h$, to the excess of high-risk services exported by tax havens. High-risk services are defined following Tørsløv et al. (2023) as insurance and pension services, financial services, charges for the use of intellectual property, telecommunications, computer, and information services, and other business services.

The Spearman rank correlation coefficient of 0.64 indicates a relatively high correlation between both series. This result suggests that services trade is an important driver of profit shifting between source countries and tax havens, but it is not the only determinant.

In particular, the excess services are sometimes too low to account for the estimated level

| in \$bn | $PS_{lh}$ | $Excess_{lh}$ |
|---|---|---|
| Total | 313 | 232 |
| Mean | 1.36 | 1.17 |
| Median | 0.28 | 0.29 |

Table D1: Comparing estimated profit shifting and excess high-risk services.

of $PS_{lh}$. This is evident from the comparison of the aggregate, mean, and median values of both variables in Table D1. These findings suggest that services alone are insufficient to explain the total amounts of bilateral profit shifting.

Table D2: Profit shifting estimates: robustness to destination tax controls

| | (1) Baseline | (2) No region | (3) No imputation | (4) $STR_d$ | (5) $EATR_d$ | (6) Benchmark method |
|---|---|---|---|---|---|---|
| $\text{Haven}_d$ (average marginal effect) | 1.572*** | 1.597*** | 1.439*** | 1.505*** | 1.512*** | |
| | (0.192) | (0.194) | (0.163) | (0.170) | (0.175) | |
| $\text{STR}_{dt}$ | | | | -5.112*** | | |
| | | | | (1.808) | | |
| $\text{EATR}_{dt}$ | | | | | -5.335** | -7.830*** |
| | | | | | (2.155) | (2.103) |
| Headquarter-Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Region-Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Region × Haven FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Additional controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 73,120 | 73,120 | 67,741 | 73,050 | 58,966 | 58,966 |
| Number of destination countries | 146 | 146 | 144 | 146 | 144 | 144 |
| **Implied profit shifting** | | | | | | |
| Implied PS | 358921 | 354091 | 298589 | 351761 | 354399 | 356168 |
| Share sample's profits | 33 | 33 | 30 | 32 | 33 | 33 |
| Correlation baseline | | 0.923 | 0.985 | 0.989 | 0.990 | 0.620 |

Note: The table replicates our baseline estimate in column (2) of Table 1 across different specifications. It reports the average marginal effect of the tax haven dummy. The dependent variable is bilateral profits. The controls include log GDP and log GDP per capita of the destination country, log distance, contiguity, shared colonial ties, common colonizer, and common legal origin. Column (6) uses a benchmark tax rate of 25% following Garcia-Bernardo and Janskỳ (2024) and identifies profit shifting from deviations relative to this benchmark combined with an elasticity of profits to taxes. Reported estimates are obtained from a PPML estimator. Standard errors are clustered at the country level and reported in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% confidence levels, respectively.

### Robustness of profit shifting estimation

Table D3: Implied profit shifting by region: baseline vs. regional heterogeneity

| Region | Common effect | Regional effects | % change |
|---|---|---|---|
| Africa | 2950 | 2147 | 37% |
| Asia | 104440 | 96088 | 9% |
| Caribbean | 43458 | 38876 | 12% |
| European NoEU | 27723 | 50013 | -45% |
| Northern America | 41456 | 9656 | 329% |
| Northern Europe | 47940 | 68321 | -30% |
| Oceania | 310 | 602 | -49% |
| Southern Europe | 1815 | 2229 | -19% |
| Western Europe | 88828 | 86159 | 3% |

Note: Column (1) lists destination regions containing tax havens. Column (2) reports implied shifted profits under a common haven effect (column (2) of table D2). Column (3) reports implied shifted profits when region-haven interactions are included (column (1) of table D2). Column (4) reports the percentage difference relative to the regional-effects specification.

# E Estimation of elasticities and robustness

Table E1: Estimation of elasticities $\tilde{v}_1$ and $\tilde{v}_2$

| | Estimation $\tilde{v}_1$ | | Estimation $\tilde{v}_2$ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $ln(\tilde{t}_{ll})$ | 1.085*** | 2.042** | | |
| | (0.204) | (0.867) | | |
| $ln(\tilde{t}_{lh})$ | | | 3.844*** | 6.827*** |
| | | | (0.541) | (1.307) |
| Employment (log) | | | 0.290*** | 0.428*** |
| | | | (0.056) | (0.077) |
| Asset (log) | | | 0.345*** | 0.551*** |
| | | | (0.029) | (0.051) |
| GDP (log) | -1.318*** | -1.942 | | |
| | (0.428) | (2.617) | | |
| Per-Capita GDP (log) | 1.643*** | 2.638 | | |
| | (0.430) | (2.669) | | |
| Observations | 216,397 | 216,397 | 2,649 | 2,649 |
| Adj. $R^2$ | 0.524 | 0.896 | 0.602 | 0.979 |
| Estimator | OLS | PPML | OLS | PPML |
| Firm × Year | Yes | Yes | Yes | Yes |
| Origin × Destination | Yes | Yes | No | No |
| Origin × Destination × Year | No | No | Yes | Yes |

Note: Columns (1) and (2) include controls for GDP and GDP per capita, while columns (3) and (4) include controls for employment and fixed assets. All controls are logged. The reported estimates are derived from OLS and Poisson Pseudo-maximum Likelihood (PPML) estimation. Standard errors, robust to clustering at the country level, are shown in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% confidence levels, respectively.

Table E2: Elasticities before and after the BEPS initiative

| | Estimation $\tilde{v}_1$ | | Estimation $\tilde{v}_2$ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $\ln(\tilde{t}_{ll}^{pre-2015})$ | 1.305*** | 2.222*** | | |
| | (0.209) | (0.813) | | |
| $\ln(\tilde{t}_{ll}^{post-2015})$ | 0.748*** | 1.865* | | |
| | (0.215) | (0.971) | | |
| $\ln(\tilde{t}_{lh}^{pre-2015})$ | | | 3.276*** | 6.508*** |
| | | | (0.618) | (1.486) |
| $\ln(\tilde{t}_{lh}^{post-2015})$ | | | 5.058*** | 7.279*** |
| | | | (0.696) | (1.505) |
| Baseline elasticities | 1.085 | 2.042 | 3.844 | 6.827 |
| **P-value equality test with baseline** | | | | |
| Pre-BEPS coefficient | 0.294 | 0.826 | 0.358 | 0.830 |
| Post-BEPS coefficient | 0.116 | 0.855 | 0.0819 | 0.764 |
| Observations | 216,397 | 216,397 | 2,649 | 2,649 |
| Estimator | OLS | PPML | OLS | PPML |
| Controls | Yes | Yes | Yes | Yes |
| Firm × Year | Yes | Yes | Yes | Yes |
| Destination | Yes | Yes | No | No |
| Origin × Destination | Yes | Yes | No | No |
| Origin × Destination × Year | No | No | Yes | Yes |

Note: This table reports elasticity estimates separately for pre-2015 and post-2015 periods. Columns (1) and (2) include controls for GDP and GDP per capita, while columns (3) and (4) include controls for employment and fixed assets. All controls are logged. Baseline elasticities correspond to the full sample estimates from Table 3. P-values test whether each coefficient differs significantly from the baseline coefficient. Standard errors clustered at the country level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table E3: Alternative identification of $\tilde{\upsilon}_2$

| Data Source | $PS_{ilh}$ (1) | TWZ (2) |
|---|---|---|
| Implied $\tilde{\upsilon}_2$ | 4.495*** | 7.178*** |
| | (1.705) | (2.108) |
| ln(Dist$_{lh}$) | -0.260** | -0.553*** |
| | (0.124) | (0.173) |
| Contiguity | 1.679*** | -0.0625 |
| | (0.320) | (0.256) |
| Common legal origin | -0.550* | 0.118 |
| | (0.291) | (0.262) |
| Common Language | 1.259*** | -0.305* |
| | (0.451) | (0.157) |
| Corporate Tax Haven Index | 0.0794*** | 0.0615** |
| | (0.0124) | (0.0296) |
| Observations | 2,601 | 589 |
| Estimator | PPML | PPML |
| Data structure | Cross-section ($ilh$) | Panel ($lht$) |
| Fixed effects | $il$ | l × year |

Note: PPML estimations throughout. In column (1), we use the share of profit shifting implied by our model, $\frac{PS_{ilh}}{\sum_{l,h} PS_{ilh}}$. This follows the specification of equation 10. In column (2), we directly use profit-shifting data from Wier and Zucman (2022) (WZ). It is a panel at the source country-haven level ($lh$). In parentheses, standard errors clustered at the residence country-tax haven ($ih$) level in column (1) and at the source country level in column (2). ***, **, *: 1%, 5%, 10% significance.

Table E4: Estimation of semi-elasticities of the tax base and profit shifting to taxes

| | Semi-elasticity of the tax base | | Semi-elasticity of profit shifting | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $t_{lt}$ | -1.250*** | -2.716** | | |
| | (0.275) | (1.218) | | |
| $t_{fiht}$ | | | -4.577*** | -8.250*** |
| | | | (0.660) | (1.575) |
| Observations | 216,397 | 216,397 | 2,649 | 2,649 |
| Adj. $R^2$ | 0.524 | 0.896 | 0.593 | 0.979 |
| Estimator | OLS | PPML | OLS | PPML |
| Controls | Yes | Yes | Yes | Yes |
| Firm × Year | Yes | Yes | Yes | Yes |
| Origin × Destination | Yes | Yes | No | No |
| Origin × Destination × Year | No | No | Yes | Yes |

Note: Columns (1) and (2) include controls for GDP and GDP per capita, while columns (3) and (4) include controls for employment and fixed assets. All controls are logged. Standard errors, robust to clustering at the country level, are shown in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% confidence levels, respectively.

# F A variable profit-shifting elasticity

In our baseline model, the elasticity of profit-shifting with respect to the keep rate $(1-t_h)$ is constant and given by $\tilde{\upsilon_2}$. We introduce a variable elasticity of profit shifting by augmenting the determinants of firms' location with $(t_l - t_h)^k$, so that the cost of shifting profits depends on the tax differential. In this setup, the elasticity of profit shifting to the net-of-tax rate is $\tilde{\upsilon_2} + k\frac{\upsilon_2}{\upsilon_1}\frac{1-t_h}{t_l-t_h}$. There are two parameters to calibrate: $\upsilon_2$ and $k$. We write a system of two equations with two unknowns to calibrate these parameters, targeting two different moments in our data.

First, we calibrate the non-linear elasticity so that it equals the estimated constant elasticity, noted $\tilde{\upsilon_2}^{linear}$, when $t_l$ and $t_h$ are at their average value, respectively, in the sample. Second, we target the elasticity to be larger than $\tilde{\upsilon_1}$ when $\frac{1-t_h}{t_l-t_h} \to 1$, meaning $t_l \to 1$ and $t_h \to 0$. When the tax differential is large, we expect the elasticity to be small, but bounded by $\tilde{\upsilon_1}$. To ensure the non-linear $\tilde{\upsilon_2}$ remains larger than $\tilde{\upsilon_1}$, we set a lower bound of $1.5\tilde{\upsilon_1}$. As shown in Figure F1, the choice of the lower bound does not significantly affect the shape of the non-linear function. Formally, we solve the following system:

$$\begin{cases} \tilde{\upsilon_2} + k\frac{(\tilde{\upsilon_2}+1)(\sigma-1)}{\upsilon_1}\overline{\frac{1-t_h}{t_l-t_h}} = \tilde{\upsilon_2}^{linear} \\ \tilde{\upsilon_2} + k\frac{(\tilde{\upsilon_2}+1)(\sigma-1)}{\upsilon_1} = \frac{3}{2}\tilde{\upsilon_1} \end{cases}$$

with $\overline{\frac{1-t_h}{t_l-t_h}}$, the average value of $\frac{1-t_h}{t_l-t_h}$ in the sample. Solving the system, we find $k = 0.66$ and $\tilde{\upsilon_2} = 2.35$. Figure F1 shows the value of the profit-shifting elasticity based on the tax differential between the production affiliate and the tax haven, with $t_h = 0.05$. The black dashed line represents the baseline constant elasticity, while the solid red line illustrates the main calibration of the non-linear elasticity. Thin orange lines depict alternative shapes of the non-linear elasticity, depending on the chosen lower bound.

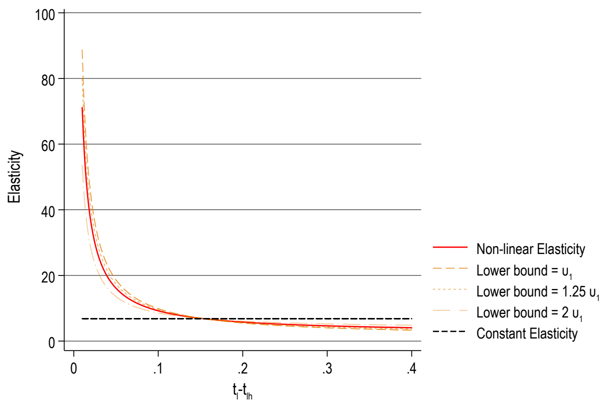



Figure F1: Elasticity of profit shifting w.r.t. net-of-tax rate, as a function of tax differentials.

Note: This figure plots the value of the non-linear elasticity of profit shifting to taxes according to the tax differential between the source country $l$ and the tax haven $h$. It is calibrated to match different data moments as detailed in section F. The graph is plotted for a given tax haven tax rate of 5%. The black dashed line corresponds to the baseline constant elasticity $\tilde{\upsilon_2}$ while the plain red line displays the main calibration of the non-linear elasticity where the lower bound of the non-linear elasticity is set to $1.5\tilde{\upsilon_1}$. Thin orange lines correspond to alternative shapes of the non-linear elasticity, according to the chosen lower bound.

# G Profit shifting frictions

## G.1 Derivation of profit shifting frictions.

We start from the following definitions of $\mathbb{P}_{ilh}$and $\mathbb{P}_{ill}$, assuming that, for all $l$, $\alpha_{ll}=1$, and noting $\tilde{t_k}=(1-t_k)^{\frac{1}{1-\sigma}}$:

$$\mathbb{P}_{ilh}=\frac{(A_{lh})^{\frac{\upsilon_2}{\upsilon_1}}\left(\gamma_{il}\alpha_{lh}\tilde{t}_{ilh}\iota_l^{\frac{1}{1-\sigma}}w_l\Xi_l\right)^{-\upsilon_2}\times\theta_i^{-\upsilon_1}\left(\sum_{j,k,k\neq j}(A_{jk})^{\frac{\upsilon_2}{\upsilon_1}}\left(\gamma_{ij}\alpha_{jk}\tilde{t}_{ijk}\iota_j^{\frac{1}{1-\sigma}}w_j\Xi_j\right)^{-\upsilon_2}\right)^{\frac{\upsilon_1}{\upsilon_2}-1}}{\sum_j A_{jj}\left(\gamma_{ij}\tilde{t}_{ijj}\iota_j^{\frac{1}{1-\sigma}}w_j\Xi_j\right)^{-\upsilon_1}+\theta_i^{-\upsilon_1}\left(\sum_{j,k,k\neq j}(A_{jk})^{\frac{\upsilon_2}{\upsilon_1}}\left(\gamma_{ij}\alpha_{jk}\tilde{t}_{ijk}\iota_j^{\frac{1}{1-\sigma}}w_j\Xi_j\right)^{-\upsilon_2}\right)^{\frac{\upsilon_1}{\upsilon_2}}};$$

$$\mathbb{P}_{ill}=\frac{A_{ll}\left(\gamma_{il}\tilde{t}_l\iota_l^{\frac{1}{1-\sigma}}w_l\Xi_l\right)^{-\upsilon_1}}{\sum_j A_{jj}\left(\gamma_{ij}\tilde{t}_{ijj}\iota_j^{\frac{1}{1-\sigma}}w_j\Xi_j\right)^{-\upsilon_1}+\theta_i^{-\upsilon_1}\left(\sum_{j,k,k\neq j}(A_{jk})^{\frac{\upsilon_2}{\upsilon_1}}\left(\gamma_{ij}\alpha_{jk}\tilde{t}_{ijk}\iota_j^{\frac{1}{1-\sigma}}w_j\Xi_j\right)^{-\upsilon_2}\right)^{\frac{\upsilon_1}{\upsilon_2}}}.$$

We replace $\theta_i$ with $\tilde{\theta_i}\bar{\theta}$ to allow for the following normalization. We impose that, given the same fundamentals and absent profit shifting frictions ($\alpha_{lh}=1$, $\forall l,h$) firms are indifferent between shifting and not shifting. Formally, we impose $\sum_{l,h,l\neq h}\mathbb{P}_{ilh}=\sum_l\mathbb{P}_{ill}$. We obtain:

$$\frac{\sum_{l,h,l\neq h}(A_{lh})^{\frac{\upsilon_2}{\upsilon_1}}\left(\gamma_{il}\alpha_{lh}\tilde{t}_{ilh}\iota_l^{\frac{1}{1-\sigma}}w_l\Xi_l\right)^{-\upsilon_2}\times\left(\sum_{j,k,k\neq j}(A_{jk})^{\frac{\upsilon_2}{\upsilon_1}}\left(\gamma_{ij}\alpha_{jk}\tilde{t}_{ijk}\iota_j^{\frac{1}{1-\sigma}}w_j\Xi_j\right)^{-\upsilon_2}\right)^{\frac{\upsilon_1}{\upsilon_2}-1}}{\sum_l A_{ll}\left(\gamma_{il}\tilde{t}_l\iota_l^{\frac{1}{1-\sigma}}w_l\Xi_l\right)^{-\upsilon_1}}=\left(\tilde{\theta}_i\bar{\theta}\right)^{\upsilon_1}.$$

We now set all fundamentals identical across countries and all the $\tilde{\theta}_i=1$. This gives us $\frac{\left(\sum_{j,k,k\neq j}A_{jk}^{\frac{\upsilon_2}{\upsilon_1}}\right)^{\frac{1}{\upsilon_2}}}{\left(\sum_l A_{ll}\right)^{\frac{1}{\upsilon_1}}}=\bar{\theta}$. Since we cannot separately identify $A_{lh}$ and $\alpha_{lh}$, we load all bilateral variation on $\alpha_{lh}$: $A_{lh}=A_{ll},\forall\, l,h$. As a consequence, we can write:

$$\frac{\left(\sum_{j,k,k\neq j}A_{jj}^{\frac{\upsilon_2}{\upsilon_1}}\right)^{\frac{1}{\upsilon_2}}}{\left(\sum_l A_{ll}\right)^{\frac{1}{\upsilon_1}}}=\bar{\theta},$$

which simplifies to

$$\bar{\theta}=\frac{\left(H\sum_j A_{jj}^{\frac{\upsilon_2}{\upsilon_1}}\right)^{\frac{1}{\upsilon_2}}}{\left(\sum_l A_{ll}\right)^{\frac{1}{\upsilon_1}}}.$$

Given this normalization, we start by comparing $\mathbb{P}_{ill}$to an alternative $\mathbb{P}_{imm}$. We obtain the following vector of relative productivities:

$$\frac{A_{ll}}{A_{mm}}=\frac{\mathbb{P}_{ill}}{\mathbb{P}_{imm}}\frac{\left(\gamma_{il}\tilde{t}_l\iota_l^{\frac{1}{1-\sigma}}w_l\Xi_l\right)^{\upsilon_1}}{\left(\gamma_{im}\tilde{t}_m\iota_m^{\frac{1}{1-\sigma}}w_m\Xi_m\right)^{\upsilon_1}}.$$

We set $A_{USUS} = 1$ as a normalization to recover the vector of productivities in levels. This implies that, for all countries $l$:

$$A_{ll} = \frac{\mathbb{P}_{ill}}{\mathbb{P}_{iUSUS}} \frac{\left(\gamma_{il}\tilde{t}_{l}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_1}}{\left(\gamma_{iUS}\tilde{t}_{US}\iota_{US}^{\frac{1}{1-\sigma}} w_{US} \Xi_{US}\right)^{\upsilon_1}}.$$

Using a similar rationale on $\mathbb{P}_{ilh}$ and $\mathbb{P}_{ill}$ we obtain:

$$\frac{\tilde{\theta}_i^{-\upsilon_1} A_{lh}^{\frac{\upsilon_2}{\upsilon_1}} \alpha_{lh}^{-\upsilon_2}}{A_{ll}} = \frac{\mathbb{P}_{ilh}}{\mathbb{P}_{ill}} \frac{\left(\gamma_{il}\tilde{t}_{ilh}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_2} \times \bar{\theta}^{\upsilon_1} \left(\sum_{j,k,k\neq j} (A_{jk})^{\frac{\upsilon_2}{\upsilon_1}} \left(\gamma_{ij}\alpha_{jk}\tilde{t}_{ijk}\iota_{j}^{\frac{1}{1-\sigma}} w_j \Xi_j\right)^{-\upsilon_2}\right)^{1-\frac{\upsilon_1}{\upsilon_2}}}{\left(\gamma_{il}\tilde{t}_{l}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_1}}.$$

Using again $A_{lh} = A_{ll}, \forall\, l,\ h$ allows us to write:

$$\tilde{\theta}_i^{-\upsilon_1} A_{lh}^{\frac{\upsilon_2}{\upsilon_1}-1} \alpha_{lh}^{-\upsilon_2} = \frac{\mathbb{P}_{ilh}}{\mathbb{P}_{ill}} \frac{\left(\gamma_{il}\tilde{t}_{ilh}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_2} \times \bar{\theta}^{\upsilon_1} \left(\sum_{j,k,k\neq j} (A_{jk})^{\frac{\upsilon_2}{\upsilon_1}} \left(\gamma_{ij}\alpha_{jk}\tilde{t}_{ijk}\iota_{j}^{\frac{1}{1-\sigma}} w_j \Xi_j\right)^{-\upsilon_2}\right)^{1-\frac{\upsilon_1}{\upsilon_2}}}{\left(\gamma_{il}\tilde{t}_{l}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_1}}. \tag{21}$$

We now consider the ratio of $\mathbb{P}_{ilh}$ and an alternative triplet $\mathbb{P}_{irs}$ and find:

$$\left(\frac{A_{lh}}{A_{rs}}\right)^{\frac{\upsilon_2}{\upsilon_1}} \left(\frac{\alpha_{lh}}{\alpha_{rs}}\right)^{-\upsilon_2} = \frac{\mathbb{P}_{ilh}}{\mathbb{P}_{irs}} \frac{\left(\gamma_{il}\tilde{t}_{ilh}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_2}}{\left(\gamma_{ir}\tilde{t}_{irs}\iota_{r}^{\frac{1}{1-\sigma}} w_r \Xi_r\right)^{\upsilon_2}}. \tag{22}$$

With this result we can go back to (21) and multiply by $A_{lh}^{\left(1-\frac{\upsilon_1}{\upsilon_2}\right)\left(-\frac{\upsilon_2}{\upsilon_1}\right)} \alpha_{lh}^{\left(1-\frac{\upsilon_1}{\upsilon_2}\right)\upsilon_2}$:

$$\tilde{\theta}_i^{-\upsilon_1} \alpha_{lh}^{-\upsilon_1} = \frac{\mathbb{P}_{ilh}}{\mathbb{P}_{ill}} \frac{\left(\gamma_{il}\tilde{t}_{ilh}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_2} \times \bar{\theta}^{\upsilon_1} \left(\sum_{j,k,k\neq j} \left(\frac{A_{jk}}{A_{lh}}\right)^{\frac{\upsilon_2}{\upsilon_1}} \left(\frac{\alpha_{jk}}{\alpha_{lh}}\right)^{-\upsilon_2} \left(\gamma_{ij}\tilde{t}_{ijk}\iota_{j}^{\frac{1}{1-\sigma}} w_j \Xi_j\right)^{-\upsilon_2}\right)^{1-\frac{\upsilon_1}{\upsilon_2}}}{\left(\gamma_{il}\tilde{t}_{l}\iota_{l}^{\frac{1}{1-\sigma}} w_l \Xi_l\right)^{\upsilon_1}}.$$

We can now use equation (22) to obtain:

$$\tilde{\theta}_i^{-\upsilon_1} \alpha_{lh}^{-\upsilon_1} = \frac{\mathbb{P}_{ilh}^{\frac{\upsilon_1}{\upsilon_2}}}{\mathbb{P}_{ill}} \bar{\theta}^{\upsilon_1} \left(\sum_{j,k,k\neq j} \mathbb{P}_{ijk}\right)^{1-\frac{\upsilon_1}{\upsilon_2}} \left(\frac{\tilde{t}_{ilh}}{\tilde{t}_l}\right)^{\upsilon_1}.$$

The right-hand side of the equation is fully observable. After manipulations, we obtain the formula of Proposition 4:

$$\bar{\theta}\tilde{\theta}_i\alpha_{lh} \left(\frac{1-t_{ll}}{1-t_{ilh}}\right)^{\frac{1}{\sigma-1}} = \left(\frac{\mathbb{P}_{ilh}}{\mathbb{P}_{ill}}\right)^{-\frac{1}{\upsilon_1}} \left(\frac{\mathbb{P}_{ilh}}{P_i}\right)^{\frac{1}{\upsilon_1}-\frac{1}{\upsilon_2}}.$$

## G.2 Impact of frictions on the profit-shifting premium.

This Appendix section describes how we move from an unconditional measure of the magnitude of profit shifting frictions, which does not account for selection into shifting, to an estimate of profit-shifting cost, conditional on profit shifting. The purpose of this derivation is to obtain a metric that can be directly compared to those reported in alternative models in the literature (McClure, 2023, Bilicka et al., 2024, and Altshuler et al., 2025).

A firm headquartered in $i$ chooses a production location $l$ and a profit-booking location $h$. It can book profits domestically ($h = l$) or in a tax haven ($h \neq l$). Abstracting from all non-tax determinants other than profit-shifting frictions, and exploiting the nested Fréchet structure with shape parameters $\upsilon_1$ (across nests) and $\upsilon_2 \geq \upsilon_1$ (within the tax-avoidance nest), the choice probabilities simplify to:

$$\mathbb{P}_{ill} = \frac{\tilde{t}_{ill}^{-\upsilon_1}}{\sum_j \tilde{t}_{ijj}^{-\upsilon_1} + \theta_i^{-\upsilon_1} \left( \sum_j \sum_{k \neq j} (\alpha_{jk}\, \tilde{t}_{ijk})^{-\upsilon_2} \right)^{\upsilon_1/\upsilon_2}}, \tag{23}$$

$$\mathbb{P}_{ilh} = \frac{\theta_i^{-\upsilon_1}\, (\alpha_{lh}\, \tilde{t}_{ilh})^{-\upsilon_2} \left( \sum_j \sum_{k \neq j} (\alpha_{jk}\, \tilde{t}_{ijk})^{-\upsilon_2} \right)^{\upsilon_1/\upsilon_2 - 1}}{\sum_j \tilde{t}_{ijj}^{-\upsilon_1} + \theta_i^{-\upsilon_1} \left( \sum_j \sum_{k \neq j} (\alpha_{jk}\, \tilde{t}_{ijk})^{-\upsilon_2} \right)^{\upsilon_1/\upsilon_2}}.$$

By the nested Fréchet aggregation property, the maximum payoff across all haven options and the maximum payoff across all domestic options are each marginally $\upsilon_1$-Fréchet. The problem thus reduces to a binary race between these two aggregates. Standard results on Fréchet order statistics then yield a closed-form expression for the *profit-shifting premium*: the expected gain from booking profits in the best available tax haven rather than the best available non-haven country, conditional on tax avoidance being profit-maximizing (denoted $E[\Pi_H^* - \Pi_L^* \mid H]$), expressed as a fraction of the expected profitability of shifting:

$$\frac{E[\Pi_H^* - \Pi_L^* \mid H]}{E[\Pi_H^* \mid H]} = \frac{1 - \left( \sum_l \mathbb{P}_{ill} \right)^{1/\upsilon_1}}{1 - \sum_l \mathbb{P}_{ill}}, \tag{24}$$

where $\mathbb{P}_{ill}$ is given by (23). Equation (24) is increasing in the total probability of shifting $1 - \sum_l \mathbb{P}_{ill}$ and depends on the full set of tax rates, shifting frictions, and the nesting structure only through the aggregate domestic share $\sum_l \mathbb{P}_{ill}$ and the shape parameter $\upsilon_1$.

Figure G1 plots the distribution of the cost of profit shifting as a share of the profit shifting benefits of shifters for each residence country. On average, these costs account for 13% of the total benefits of profit shifting.

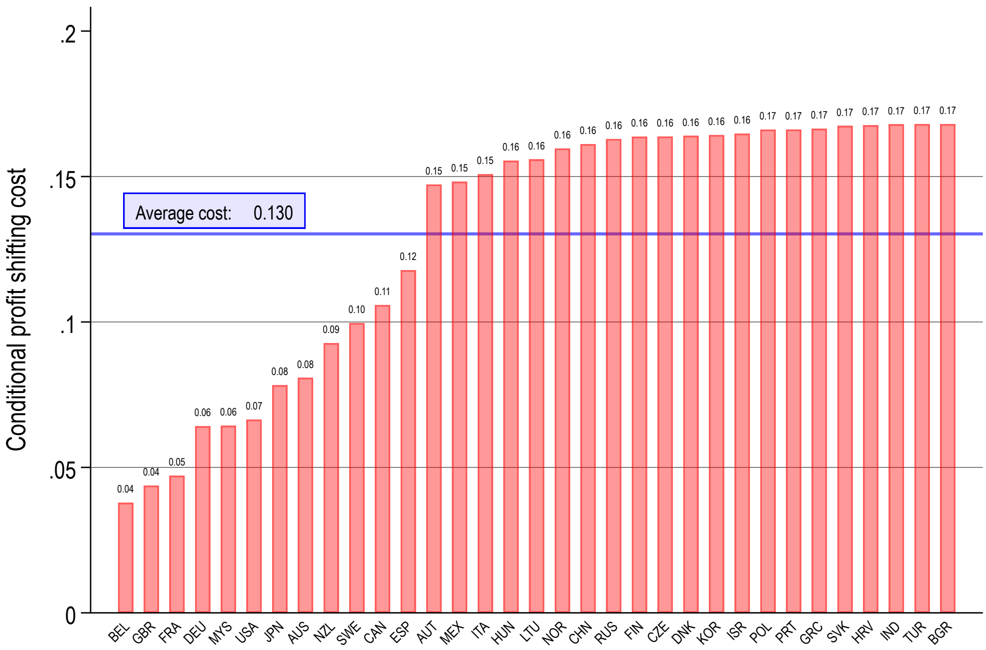



Figure G1: Conditional cost of profit shifting as a share of profit shifting benefits

Note: This plot shows the conditional cost of profit shifting as a share of profit shifting benefits by residence country. The average cost is 13%.

## G.3 Determinants of profit shifting costs $\alpha_{lh}$.

Table G1: Gravitational determinants of profit-shifting frictions

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | | | $ln(\alpha_{lh})$ | | |
| $ln(distance_{lh})$ | 0.0200** | 0.244*** | 0.247*** | 0.253*** | 0.222*** | 0.230*** |
| | (0.00768) | (0.0556) | (0.0644) | (0.0510) | (0.0473) | (0.0437) |
| $ln(distance_{lh})^2$ | | -0.0142*** | -0.0144*** | -0.0146*** | -0.0131*** | -0.0135*** |
| | | (0.00358) | (0.00404) | (0.00330) | (0.00313) | (0.00296) |
| Ever colony $_{lh}$ | | | 0.00678 | | | 0.0176 |
| | | | (0.0299) | | | (0.0330) |
| Common legal origin $_{lh}$ | | | | 0.0136 | | 0.00262 |
| | | | | (0.0137) | | (0.0185) |
| Linguistic Proximity | | | | | -0.0579** | -0.0636* |
| | | | | | (0.0245) | (0.0368) |
| Observations | 231 | 231 | 231 | 231 | 231 | 231 |
| R-squared | 0.903 | 0.912 | 0.912 | 0.913 | 0.915 | 0.915 |
| Source Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Haven Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors clustered at the $l$ level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

## H Exact hat algebra

This section describes the Exact Hat Algebra algorithm used in the paper.

### H.1 Relative changes in probabilities $\hat{\mathbb{P}}_{ilh}$

**Non-haven residence countries $i \notin \mathcal{H}$.** We introduce $N_{ill}$ and $N_{ilh}$ to denote the numerator of $\mathbb{P}_{ill}$ and $\mathbb{P}_{ilh}$ respectively and $\mathcal{D}_i = \sum_l N_{ill} + \left(\sum_{l \notin \mathcal{H},h,h\neq l} N_{ilh}\right)^{\frac{\upsilon_1}{\upsilon_2}}$ their denominator so that:

$h \neq l \Rightarrow \mathbb{P}_{ilh} = \frac{N_{ilh}\left(\sum_{l \notin \mathcal{H},h,h\neq l} N_{ilh}\right)^{\frac{\upsilon_1}{\upsilon_2}-1}}{\mathcal{D}_i}$ and $h = l \Rightarrow \mathbb{P}_{ill} = \frac{N_{ill}}{\mathcal{D}_i}$.

Relative changes in $\mathbb{P}_{ill}$ and $\mathbb{P}_{ilh}$ are given by

$$\widehat{\mathbb{P}}_{ill} \equiv \frac{\hat{N}_{ill}}{\sum_l \hat{N}_{ill}\mathbb{P}_{ill} + (1-\sum_l \mathbb{P}_{ill})^{1-\frac{\upsilon_1}{\upsilon_2}}\left(\sum_{l \notin \mathcal{H},h,h\neq l} \hat{N}_{ilh}\mathbb{P}_{ilh}\right)^{\frac{\upsilon_1}{\upsilon_2}}}$$

and

$$\widehat{\mathbb{P}}_{ilh} \equiv \frac{\hat{N}_{ilh}\,(1-\sum_l \mathbb{P}_{ill})^{1-\frac{\upsilon_1}{\upsilon_2}}\left(\sum_{l \notin \mathcal{H},h,h\neq l} \hat{N}_{ilh}\mathbb{P}_{ilh}\right)^{\frac{\upsilon_1}{\upsilon_2}-1}}{\sum_l \hat{N}_{ill}\mathbb{P}_{ill} + (1-\sum_l \mathbb{P}_{ill})^{1-\frac{\upsilon_1}{\upsilon_2}}\left(\sum_{l \notin \mathcal{H},h,h\neq l} \hat{N}_{ilh}\mathbb{P}_{ilh}\right)^{\frac{\upsilon_1}{\upsilon_2}}}$$

where

$$\hat{N}_{ill} = \widehat{w_l \Xi_l \tilde{t}_{ill}}^{\,-\upsilon_1} \qquad \hat{N}_{ilh} = \widehat{w_l \Xi_l \tilde{t}_{ilh}}^{\,-\upsilon_2}.$$

**Haven-residence countries $i \in \mathcal{H}$.** Relative changes in the probability to locate in $l$ are given by $\widehat{\mathbb{P}}_{ill} = \frac{\hat{N}_{ill}}{\sum_l \mathbb{P}_{ill}\hat{N}_{ill}}$.

### H.2 Computing counterfactual equilibria

Notations: we introduce the share of sales by firms from $i$ and sourcing in $l$ that book their profits in $h$: $\eta_{ilh} = \frac{X_{ilh}}{\sum_h X_{ilh}}$. From equation (10), we obtain

$$\eta_{ilh} = \frac{\mathbb{P}_{ilh}/\left((1-t_{ilh})\iota_l\right)}{\sum_{l,h} \mathbb{P}_{ilh}/\left((1-t_{ilh})\iota_l\right)}.$$

We denote by $\mu_{ln}$ the share of sales to country $n$ by firms producing in $l$. This share does not depend on the firm's residence:

$$\mu_{ln} = \frac{\tau_{ln}^{1-\sigma} Y_n P_n^{\sigma-1}}{\sum_n \tau_{ln}^{1-\sigma} Y_n P_n^{\sigma-1}} \equiv \left(\frac{\Xi_{ln}}{\Xi_l}\right)^{1-\sigma}.$$

The sales of firms from $i$ producing in $l$ is denoted by $X_{il} = \sum_{h=l;h\in\mathcal{H}} X_{ilh}$ and their sales in market $n$ by $X_{iln} = \mu_{ln} X_{il}$.

Endogenous variables $z$ are denoted $z$, and $z'$, respectively the initial and the new equilibrium so that $\hat{z} = z'/z$. Following Dekle et al. (2007), we look for a fixed point in changes $\hat{\mathbf{w}} = (\hat{w}_l)_{l\in[[1,N]]}, \hat{\mathbf{Y}} = (\hat{Y}_n)_{n\in[[1,N]]}, \hat{\mathbf{P}} = (\hat{P}_n)_{n\in[[1,N]]}, \hat{\mathbf{N}} = (\hat{\mathcal{N}}_i)_{i\in[[1,N]]}$ . Given $\hat{\mathbf{w}}, \hat{\mathbf{Y}}, \hat{\mathbf{N}}, \hat{\mathbf{P}}$ and the change in policy, we can compute the implied change in market potential $\hat{\Xi}_l$ . This pins down the change in $\hat{\mathbb{P}}_{ilh}$ (see next subsection) and thereby the changes $\hat{\eta}_{ilh}$

and $\hat{\mu}_{ln}$. The output in $l$ produced by firms with residence in $i$ is then obtained as

$$X'_{il} = \frac{\mathcal{N}'_i}{T_i^{1-\sigma}} \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \sum_h \left(\mathbb{P}'_{ilh} \iota_l^{-1} (1-t_{lh})^{-1}\right) \mathcal{D}_i'^{\frac{\sigma-1}{\upsilon_1}} \Gamma \left(1 - \frac{\sigma-1}{\upsilon_1}\right).$$

We thus get $X'_{iln} = \mu'_{ln} X'_{il}$ and $X'_{ilh} = \eta'_{ilh} \left(\sum_n X'_{iln}\right)$. A fixed point in changes is obtained when:

- wages satisfy the labor-market clearing

$$w'_k = \frac{1}{\sigma L_k} \sum_{l,h,n} \eta'_{klh} \left(1 - t'_{klh}\right) \iota_l X'_{kln} + \frac{\sigma-1}{\sigma L_k} \sum_i X'_{ik};$$

- total expenditures are equal to labor income, tax revenues, adjusted for the friction $\iota_l$ and imbalances

$$Y'_k = w'_k L_k + \frac{1}{\sigma} \left( \sum_{i,n} t'_k \eta'_{ikk} \iota_k X'_{ikn} + \sum_{i,l,n,l\neq k} t'_{ilk} \eta'_{ilk} \iota_l X'_{iln} \right) + \frac{1}{\sigma} \sum_{i,n} (1-\iota_k) X'_{ikn} + \Delta_k;$$

- price indices for all countries but the numeraire verify

$$P_n'^{1-\sigma} = \sum_l \tau_{ln}^{1-\sigma} \Xi_l'^{\sigma-1} \sum_i X'_{il};$$

- and the number of firms satisfies the free-entry condition

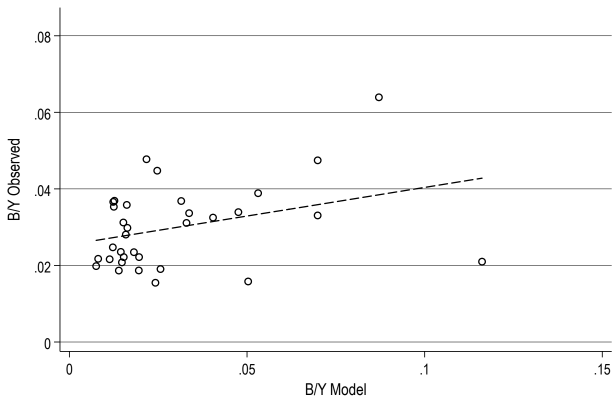
$$\mathcal{N}'_i = \frac{\frac{1}{\sigma} \sum_{l,h,n} \left(1 - t'_{ilh}\right) \iota_l X'_{ilh}}{w'_i f_E}.$$

# I Supplements to section 6

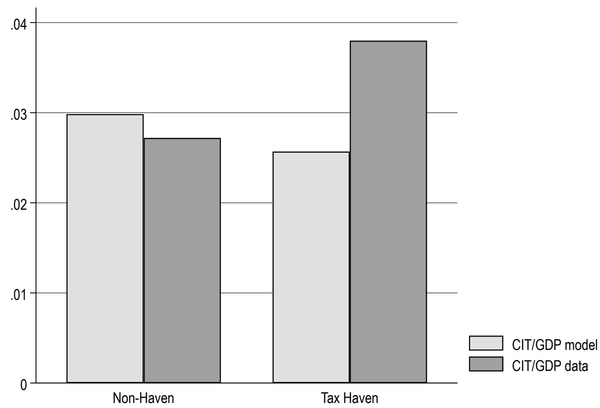
## I.1 Calibration overview and validation

Table I1: Calibration overview

| Variables | Definition/Source/Methodology/Reference | Section |
|---|---|---|
| *Endogenous variables* | | |
| $X_{ln}$ | Trade in goods and services and own trade from ITPD-E | Appendix C.4 |
| $X_{ill}$ | Multinational Production Sales from MREID | Appendix C.5 |
| $X_{ilh}$ | Profit shifting. Estimated using the model's accounting equations and using data from OECD bilateral balance of payments, IMF Balance of payments data. | Section 4.2, Appendix C.1 |
| *Parameters* | | |
| $t_l$ | Statutory tax rate. KPMG Statutory Corporate tax rate tables | Appendix C.6 |
| $t_{lh}$ | Tax havens' tax rate. OECD's Country-by-Country reporting. | Appendix C.6 |
| $\Pi_l$ | Profits recorded in $l$. National Accounts, methodology from Tørsløv et al. (2023). | Appendix C.7 |
| $\iota_l$ | Profits-sales gap. Computed using: $\iota_l = \sigma \frac{\Pi_l}{\sum_i X_{ill}}$. | Section 4.2 |
| $\sigma$ | Elasticity of substitution. Set to 6.88 following a 17% markup in French firm-level data (De Loecker and Warzynski, 2012 methodology). | Section 4.2 |
| $\tilde{\upsilon}_1$ | Elasticity of the tax base. Estimated following equation (15) using Orbis data. Set to 2.05 | Section 4.4 |
| $\tilde{\upsilon}_2$ | Elasticity of profit shifting. Estimated following equation (14) and Orbis data. Set to 6.83 | Section 4.4 |
| $k$ | Non-linear elasticity of profit shifting shape parameter. Calibrated to match data moments. Set to 0.66 | Section F |
| *Frictions* | | |
| $\gamma_{il}$ | Multinational production frictions. Backed out from $X_{ill}$ shares. | Appendix G |
| $\tau_{ln}$ | Trade frictions. Backed out from $X_{ln}$ shares. | Appendix G |
| $\alpha_{lh}$ | Profit shifting frictions. Backed-out from $X_{ilh}$. | Section 5.2, Appendix G |




(a) In non-haven countries




(b) Tax havens vs. non-havens

Figure I1: Tax revenues over GDP ($B/Y$): data versus model

Note: Data on corporate tax revenues over GDP is obtained from UNU-WIDER's Government Revenue Dataset. We select the variable "Taxes on income, profits and capital gains from corporation" (corresponding to OECD item 1200). The figure in Panel (a) is drawn for the sample of non-haven countries. Panel (b) compares tax havens and non-havens

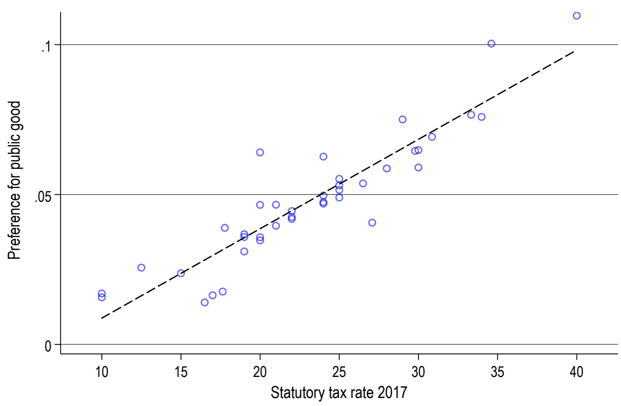



Figure I2: Preference for public goods and the tax rate

Note: This plot shows the correlation between the estimated preference for public goods and the statutory tax rate in 2017. The correlation between both variables is 0.92.

## I.2 Illustrating model mechanisms

Table I2 illustrates the impact of different scenarios on tax revenues, profit shifting, real production, consumption and welfare.

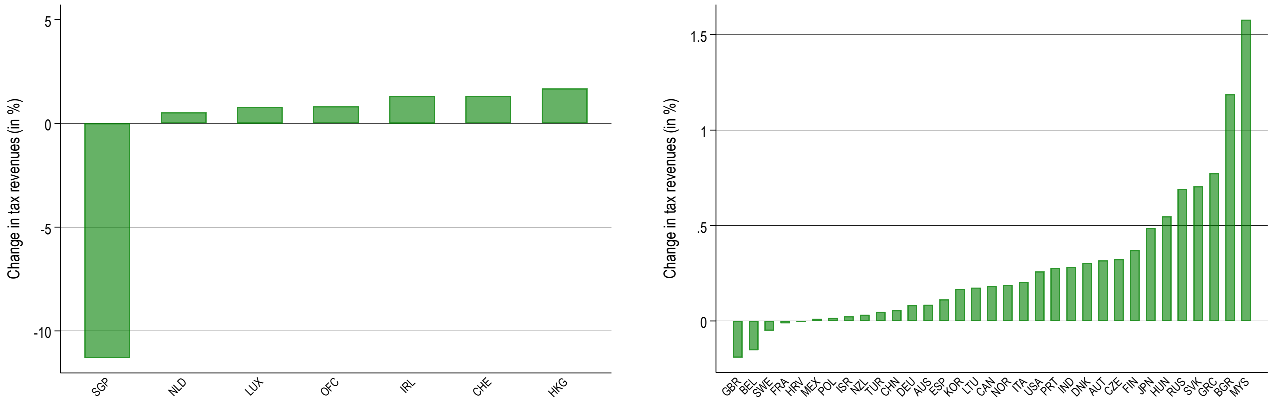
**Unilateral tax reform.** We illustrate the percentage change of a unilateral reduction of 5% in the U.S. corporate tax rate (from 40% to 38%) on five outcomes in Table I2. We show that it increases consumption by 0.44% while slightly reducing welfare by 0.03%. The changes in tax revenues, profit shifting, and real production are presented in Table I2.

**Closing a tax haven.** In Table I2, we examine the impact of closing Singapore on U.S. tax revenues, GDP, profit shifting, consumption, and welfare. Figure I3 shows the impact of this reform on i) tax revenues across tax havens (Panel a) and on ii) tax revenues across

Table I2: Impact of different counterfactual scenarios

| Scenario | % change in ... Tax revenues | Profit Shifting | Real Production | Consumption | Welfare |
|---|---|---|---|---|---|
| 5% decrease statutory tax rate | -4.19 | -7.35 | 0.34 | 0.44 | -0.03 |
| Closing Singapore | 0.26 | -3.95 | -0.02 | -0.02 | 0.01 |
| Effective anti-abuse regulations | 6.55 | -100.00 | -0.37 | -0.51 | 0.19 |

non-tax havens (Panel b).




(a) Impact on tax revenues in tax havens

(b) Impact on tax revenues in non-havens

Figure I3: Effect of closing Singapore as a tax haven

Note: These two histograms illustrate the impact of closing the access to Singapore as a tax haven. Panel (a) shows how this reform would impact tax revenues in tax havens. Panel (b) shows how this reform would impact tax revenues in non-havens

**Effective anti-abuse laws.** *What are the effects of implementing multilateral effective anti-abuse laws in non-haven countries?*

Assuming costless implementation, Table I2 shows the results for the U.S. policy. The policy raises the U.S. effective tax rate and generates a 6.55% increase in tax revenues while reducing production by 0.37%. Consumption decreases by 0.51%, but the welfare effect is positive (0.19%) due to a large increase in corporate tax revenues.

The increase in tax revenues is due to reduced profit shifting and reallocation of production. High-tax countries benefit from tax havens, and non-haven countries might use lax enforcement of anti-abuse laws to attract mobile firms (for instance Altshuler and Grubert, 2005, Hong and Smart, 2010 or Dharmapala, 2020).

## I.3 Short-run effects

Table I3 shows the short-run effects of various Minimum Tax implementations. We define a short-run scenario as one in which firms can relocate production and profit-booking location $l$ and $h$ but cannot change the headquarters country $i$. This also implies that there is no entry or exit in this scenario. The welfare difference with the long-run case is largely driven by the lack of exit following the implementation of the minimum tax. This manifests itself as smaller consumption losses due to love-for-variety in the CES aggregator.

Table I3: Impact of minimum taxation for the U.S. (rate: 15%)

| Minimum Taxation | % change in ... Tax revenues | Profit Shifting | Real Production | Consumption | Welfare |
|---|---|---|---|---|---|
| | | | **Short Run** | | |
| Unilateral | | | | | |
| – Residence | 3.96 | -37.3 | 0.03 | -0.04 | 0.39 |
| – Source | 3.80 | -37.9 | -0.01 | -0.06 | 0.35 |
| Multilateral | | | | | |
| – Residence | 3.97 | -37.3 | 0.04 | -0.03 | 0.40 |
| – Source | 3.83 | -37.3 | 0.04 | -0.03 | 0.38 |

Note: This table shows the *short-run* effects of different settings of a 15% minimum tax. It replicates the setting of table 5. In this context, *short-run* means that we fix the number and location of firms' headquarters, preventing entry and exit.

## I.4 Quantification of equilibrium effects

This subsection illustrates the quantification of equilibrium effects in long-run minimum taxation scenarios. We compute what would have been the effect of these reforms if we did not allow the tax base to adjust. This is tantamount to forcing production choices, including location and profit shifting to remain unchanged after the introduction of a minimum tax. The goal of this exercise is to quantify the mismeasurement of the reforms' impact if we considered only the mechanical tax rate effects.

Post-reform tax revenues of country $k$ are given by

$$B'_k = \sum_{i,l,h} t'^{g_k}_{ilh} \mathcal{N}'_i \mathbb{P}'_{ilh} \frac{w'_i f_E}{1 - t'_{ilh}}.$$

This includes a mechanical adjustment of the tax rate $t'^{g_k}_{ilh}$ and an equilibrium response of the tax base $\mathcal{N}'_i \mathbb{P}'_{ilh} \frac{w'_i f_E}{1-t'_{ilh}}$. We define a counterfactual tax revenue stream in which we force the tax base not to move. Formally

$$B'^{TRE}_k = \sum_{i,l,h} t'^{g_k}_{ilh} \mathcal{N}_i \mathbb{P}_{ilh} \frac{w_i f_E}{1 - t'_{ilh}},$$

where we use the superscript $TRE$ to denote the tax rate effect. For clarity, we separate the change in tax revenues between those coming from the corporate income tax base and those coming from the minimum tax base.

Along similar lines, we note that the real expenditure of country $k$ post-reform is given by $\frac{Y'_k}{P'_k} = \frac{w'_k L_k + B'_k + \Delta'_k}{P'_k}$. This is clearly driven by a tax revenue effect, $B'_k$, as well as the rest of the equilibrium adjustment, for example, the changes in wages and prices. We can then define a mechanical real expenditure response as $\frac{w_k L_k + B'^{TRE}_k + \Delta_k}{P_k}$, where only the tax revenues are allowed to move and only through mechanical tax rates effects.

**Results** Table I4 breaks down the change in tax revenues for different scenarios under a 15% minimum tax rate. We present results for the implementation of a unilateral, residence-based minimum tax by the U.S. Our model predicts a 3.77% increase in tax revenues. Since the corporate tax rate remains unchanged, the direct effect on the CIT base is zero. However, the reduction in profit shifting increases tax revenues by 2.59%, all else being equal. This is partially offset by a real effect on the CIT base of -0.14%.

New revenues are also collected on the minimum tax base, with the mechanical tax rate effect raising revenues by 2.18%. This effect is reduced by -0.83% due to decreased profit shifting after the reform. Additionally, changes in production choices slightly lower tax revenues on this base (-0.03%).

When source-based minimum taxation is applied, the additional tax revenues from reduced profit shifting are larger than in the residence-based scenario.

When tax havens adjust their tax rate in response to the implementation of the minimum tax, no MNE is taxed below the minimum rate and therefore no minimum tax is levied. The change in tax revenues only comes from changes in the profit shifting behavior and in the production choices of MNEs. This change is the same as in other multilateral scenarios (+2.59%) as the world distribution of tax rates is the same.

Table I4: Profit-shifting and GE effects of a 15% minimum tax on tax revenues

| Counterfactual | Change in real tax revenues (in %) | CIT Base - Contribution (in %) | | | Min. tax Base - Contribution (in %) | | |
|---|---|---|---|---|---|---|---|
| | | Tax Rate Effect | PS effect | Real effect | Tax Rate Effect | PS effect | Real effect |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *15% min. tax* | | | | | | | |
| Unil. Residence | 3.77 | 0.00 | 2.59 | -0.14 | 2.18 | -0.83 | -0.03 |
| Unil. Source | 3.67 | 0.00 | 2.63 | -0.14 | 1.94 | -0.76 | -0.00 |
| Multi. Residence | 3.77 | 0.00 | 2.59 | -0.14 | 2.18 | -0.83 | -0.02 |
| Multi. Source | 3.64 | 0.00 | 2.59 | -0.14 | 1.94 | -0.74 | -0.00 |
| TH adjustment | 2.44 | 0.00 | 2.59 | -0.15 | 0.00 | 0.00 | 0.00 |

Note: Results in this table are provided for the United States. Column (1) corresponds to the effect computed using our quantitative model."Tax Rate Effect" in columns (2), and (5) indicates the reform's effect as computed assuming no change in profit-shifting activity or production location. "PS effect" in columns (3), and (6) indicates the change in tax revenues due to the change in the profit-shifting strategy of MNEs all other things being equal. "Real effect" in column (4), and (7) indicates the change in tax revenues due to the change in the location strategy of MNEs all other things being equal.

The table highlights the importance of considering profit-shifting and real effects when predicting the impact of tax reforms on tax revenues and real expenditure. It is also worth mentioning that unilateral and multilateral scenarios lead to identical results concerning the change in tax revenues from the minimum tax base in estimations that do not consider the reallocation of real and paper profits (those estimates would rely on column 5 only). These tables capture relevant channels that a pure "accounting" exercise would miss.

## I.5 Sensitivity to alternative specification of parameters

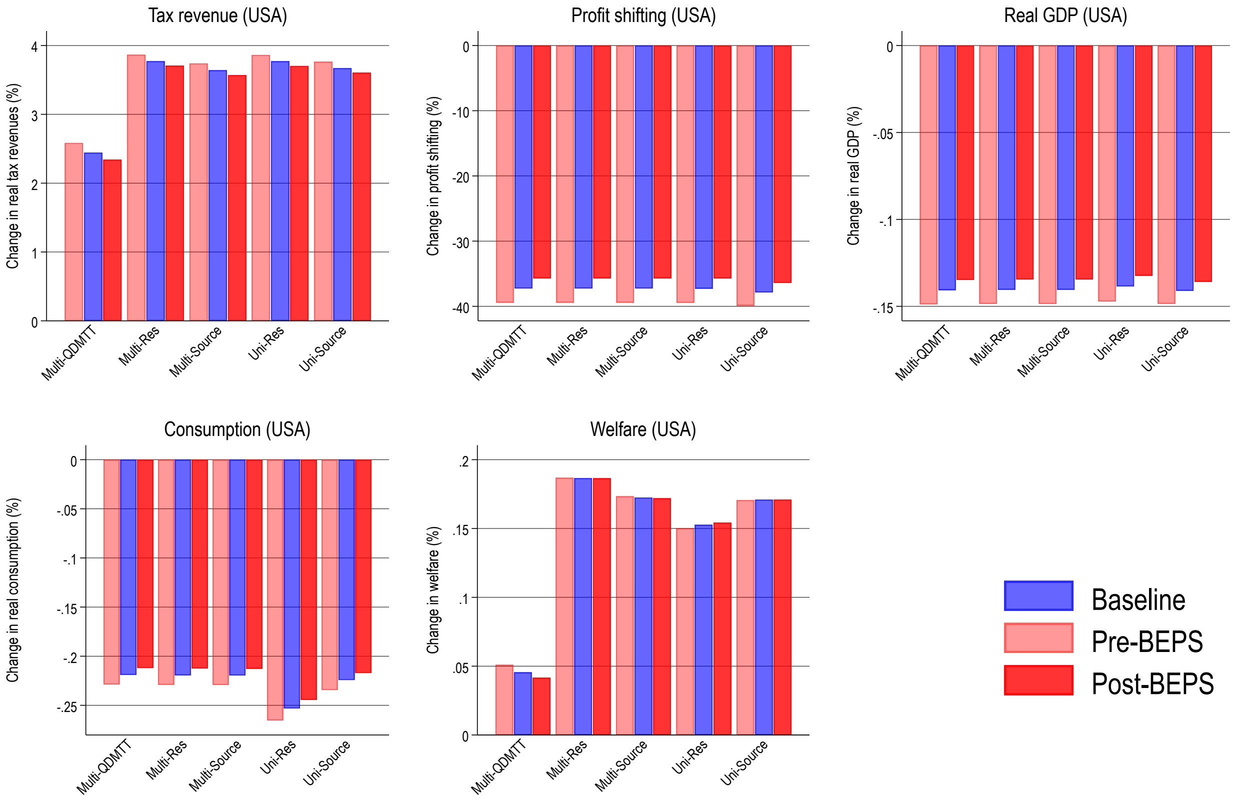



Figure I4: Sensitivity of minimum-taxation results to alternative parameter calibrations

Note: This figure plots the results of the minimum taxation counterfactuals under three different parameter specifications. In blue we show the baseline results reported in the main text of the paper. In red we use the pre-BEPS coefficients from Table E2. In light red we use the post-BEPS coefficients from Table E2.

## I.6 DBCFT

**Implementation** We first update the definition of market access as follows:

$$\Xi_l^{1-\sigma} = \sum_n \Xi_{ln}^{1-\sigma} = \sum_n \tau_{ln}^{1-\sigma} (1 + s_{ln})^{\sigma-1} \left(\frac{1}{1 + tr_{ln}}\right)^{\sigma} Y_n P_n^{\sigma-1}.$$

Simplifying with

$$\Xi_l^{1-\sigma} = \sum_n \Xi_{ln}^{1-\sigma} = \sum_n \tau_{ln}^{1-\sigma} (1 + s_l)^{\sigma-1} \left(\frac{1}{1 + tr_n}\right)^{\sigma} Y_n P_n^{\sigma-1},$$

we obtain that post-tax profits are given by

$$(1 - t_{ilh}) \frac{\iota_l}{\sigma} \left(\frac{\sigma}{\sigma - 1} \frac{\gamma_{il}\alpha_{lh}}{\varphi} w_l \Xi_l\right)^{1-\sigma} \qquad \text{where } \Xi_l^{1-\sigma} = \sum_n \frac{\tau_{ln}^{1-\sigma} (1 + s_l)^{\sigma-1}}{(1 + tr_n)^{\sigma}} \frac{Y_n}{P_n^{1-\sigma}},$$

and where $n = l \Rightarrow tr_n = s_n$.

The change in trade costs here are given by $\hat{\tau}_{ln} = \frac{1}{1+s_l} \left(\frac{1}{1+tr_n}\right)^{\frac{\sigma}{1-\sigma}}$. It determines the new $\mathbb{P}_{ilh}$ as a function of $Y_n$,$P_n$, $w_l$.

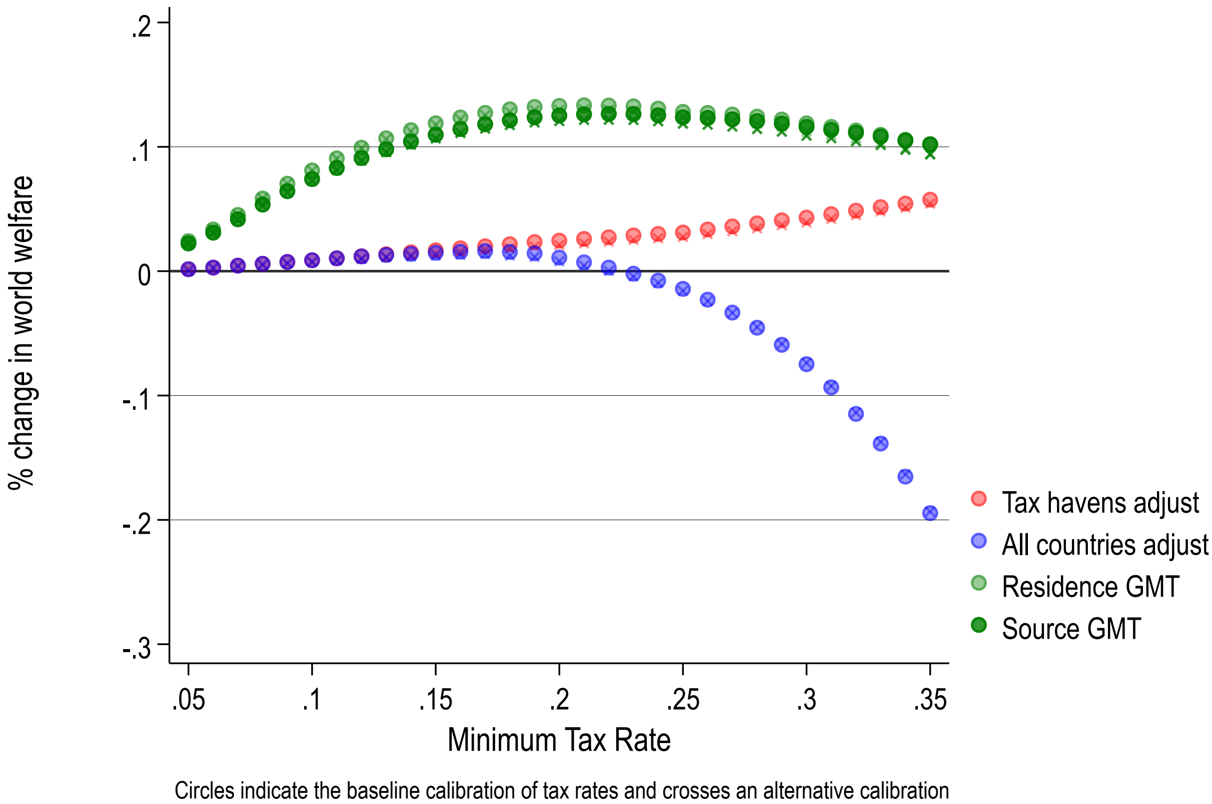



Figure I5: Sensitivity of the optimal minimum tax to alternative tax rate calibration

Note: This figure plots the optimal minimum tax counterfactual presented in Figure 6 with the baseline statutory tax rate calibration and an alternative one using rates from the Tax Foundation's long panel of statutory corporate income tax rates. Circles indicate results from the baseline calibration while crosses indicate results using the alternative calibration.

In the labor market, we have

$$w_i L_i = N_i w_i f_E + \frac{\sigma - 1}{\sigma}(1 + s_i)Q_i.$$

Using

$$\frac{X_{ln}}{X_l} = \frac{(1 + tr_n)^{-\sigma}(1 + s_l)^{\sigma-1}\tau_{ln}^{1-\sigma}\left(Y_n/P_n^{1-\sigma}\right)}{\Xi_l^{1-\sigma}},$$

the price index is (implicitly) given by:

$$P_n^{1-\sigma} = (1 + tr_n)^{1-\sigma}\sum_l \frac{X_l}{\Xi_l^{1-\sigma}}\tau_{ln}^{1-\sigma}\left(1 + s_l\right)^{\sigma-1},$$

where the value of production in $k$ is

$$Q_l = \sigma\sum_{k,h} N_k \frac{\mathbb{P}_{klh} w_k f_E}{(1 - t_{klh})\,\iota_l}.$$

**Additional results** Table I5 decomposes the change in real tax revenues (column 1) and the change in real GDP (column 4) when DBCFT is implemented.

The change in real tax revenues is separated between the taxation of domestic sales (when $l = n$) and the border adjustment. The border adjustment corresponds to the difference between additional tax revenues from taxing imports and tax expenses from subsidizing exports. Columns (2) and (3) add up to the change in tax revenues in column (1). The change in real GDP is decomposed between the contribution of domestic sales, and the contribution of foreign multinationals' sales to real GDP. Columns (5) and (6) add up to the change in GDP in column (4).

Table I5: Breakdown of the increase in real tax revenues

| CIT-equivalent DBCFT rate | % Change real tax rev. (1) | Contrib. domestic tax (2) | Contrib. Border Adjustment (3) | % Change real GDP (4) | Contrib. domestic sales (5) | Contrib. Foreign MP (6) |
|---|---|---|---|---|---|---|
| **USA** | | | | | | |
| 5.0% | -77.85 | -86.99 | 9.14 | 4.57 | 4.52 | 0.05 |
| 10.0% | -56.89 | -74.11 | 17.23 | 4.13 | 3.71 | 0.42 |
| 20.0% | -18.16 | -48.90 | 30.75 | 3.00 | 1.56 | 1.45 |
| 30.0% | 16.51 | -24.61 | 41.12 | 1.56 | -1.60 | 3.15 |
| 33.3% (⋆) | 27.08 | -16.76 | 43.84 | 1.00 | -2.98 | 3.98 |
| 40.0% (BAT) | 46.37 | -1.51 | 47.87 | -0.23 | -6.52 | 6.29 |
| **Japan** | | | | | | |
| 25.0% (⋆) | -44.48 | -25.65 | -18.83 | 1.79 | -3.63 | 5.42 |
| 30.0% (BAT) | -37.31 | -8.86 | -28.45 | 1.53 | -6.60 | 8.12 |

Note: This table breaks down the change in real tax revenues and in real GDP. The change in tax revenues is broken down between the contribution of domestic revenues (as compared with B, the tax revenues collected at the initial equilibrium) and the contribution of the border adjustment. The latter is presented as the net effect between the revenues coming from the taxation of imports and the revenues spent by subsidizing exports. Columns (2) and (3) add up to the change in tax revenues in column (1). The change in GDP is broken down between the contribution of domestic sales and the contribution of foreign multinationals' sales. Columns (5) and (6) add up to the change in GDP in column (4). The ⋆ represents the optimal rate.

## I.7 Formulary Apportionment: Additional results

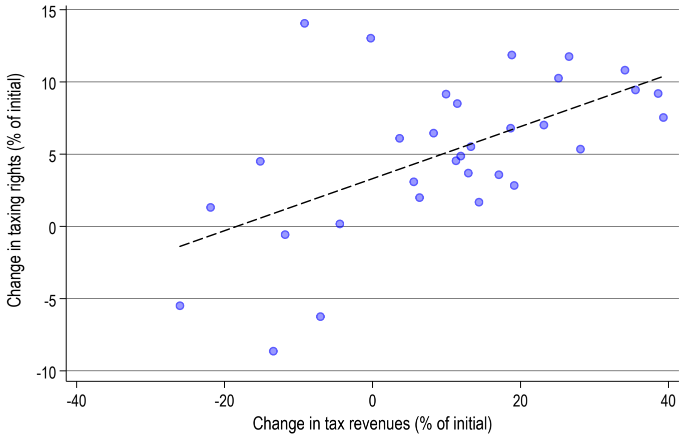



Figure I6: Formulary apportionment: change in taxing rights

Note: This figure plots the link between the expected change in the share in world's taxing rights ($100 \times \left(\frac{\sum_{i,l} X_{iln}}{\sum_{i,l,n} X_{iln}} / \frac{\sum_{i,l} X_{ilh}}{\sum_{i,l,h} X_{ilh}} - 1\right)$) from the implementation of formulary apportionment with a 100% weight on sales and the actual change in tax revenues. Tax havens and one outlier country are taken out of the sample.

## I.8 Summary Tables

Table I6: The effect of international taxation reforms on welfare

| Policy | Impact on welfare in ... World | US | EU | IND-CHN | Other Developed | Havens |
|---|---|---|---|---|---|---|
| *Benchmark scenarios* | | | | | | |
| U.S. 5% statutory cut | -0.019 | -0.029 | 0.003 | -0.005 | 0.004 | 0.001 |
| Closing Singapore | 0.005 | 0.008 | -0.011 | 0.009 | -0.005 | 0.032 |
| Effective anti-abuse | 0.081 | 0.186 | -0.269 | 0.179 | -0.171 | -0.512 |
| *Unilateral minimum tax - Residence principle* | | | | | | |
| US | 0.101 | 0.153 | -0.001 | 0.025 | -0.001 | -0.045 |
| EU (no TH) | 0.003 | 0.011 | -0.051 | 0.027 | 0.010 | -0.101 |
| India-China | 0.000 | 0.001 | 0.003 | -0.005 | 0.002 | 0.005 |
| Other developed | 0.015 | 0.021 | 0.018 | 0.043 | -0.057 | -0.044 |
| *Unilateral minimum tax - Source principle* | | | | | | |
| US | 0.109 | 0.171 | -0.001 | -0.004 | -0.001 | -0.038 |
| EU (no TH) | 0.005 | 0.010 | -0.003 | -0.001 | 0.003 | -0.096 |
| India-China | -0.010 | -0.021 | -0.060 | 0.136 | -0.048 | -0.023 |
| Other developed | 0.007 | 0.011 | 0.008 | 0.002 | -0.011 | -0.032 |
| *Multilateral minimum tax* | | | | | | |
| Residence | 0.119 | 0.187 | -0.030 | 0.091 | -0.046 | -0.192 |
| Source | 0.110 | 0.173 | -0.060 | 0.135 | -0.061 | -0.192 |
| Tax haven adjustment | 0.017 | 0.045 | -0.154 | 0.083 | -0.109 | 0.416 |
| *Deviation from 15% minimum (13%)* | | | | | | |
| US | 0.094 | 0.170 | -0.155 | 0.079 | -0.110 | 0.260 |
| EU (no TH) | 0.028 | 0.043 | -0.009 | 0.078 | -0.111 | 0.145 |
| India-China | 0.017 | 0.045 | -0.155 | 0.093 | -0.110 | 0.391 |
| Other developed | 0.019 | 0.041 | -0.158 | 0.076 | -0.027 | 0.325 |
| *Digital services tax (1% ideal)* | | | | | | |
| US | 0.163 | 0.253 | 0.000 | 0.002 | 0.001 | -0.015 |
| EU (no TH) | 0.024 | 0.004 | 0.168 | 0.002 | 0.001 | -0.022 |
| India-China | 0.003 | -0.004 | -0.014 | 0.071 | -0.009 | -0.009 |
| Other developed | 0.010 | 0.005 | 0.002 | 0.001 | 0.064 | -0.006 |
| *Destination-based cash flow tax* | | | | | | |
| US 20% | 0.421 | 0.661 | 0.014 | -0.105 | 0.032 | 0.097 |
| US 33% (⋆) | 1.404 | 2.170 | 0.031 | -0.076 | 0.058 | 0.272 |
| US 40% (BAT) | 1.190 | 1.819 | 0.059 | -0.069 | 0.100 | 0.463 |
| Japan 25% (⋆) | -0.066 | 0.096 | 0.018 | -0.000 | -1.374 | -0.060 |
| Japan 31% (BAT) | -0.054 | 0.133 | 0.027 | 0.005 | -1.519 | -0.055 |
| *Formulary apportionment* | | | | | | |
| 50% sales | 0.757 | 1.193 | 0.124 | -0.110 | -0.132 | -0.141 |
| 100% sales | 1.410 | 2.180 | 0.497 | -0.442 | -0.099 | 0.069 |

Table I7: The effect of international taxation reforms on real tax revenues

| Policy | Change PS World | Impact on real tax revenues in... World | US | EU | IND-CHN | Other Developed | Havens |
|---|---|---|---|---|---|---|---|
| *Benchmark scenarios* | | | | | | | |
| U.S. 5% statutory cut | -1.6 | -1.354 | -4.189 | 0.008 | -0.043 | 0.012 | -0.130 |
| Closing Singapore | -4.3 | 0.135 | 0.259 | 0.100 | 0.156 | 0.265 | -1.559 |
| Effective anti-abuse | -100.0 | 4.112 | 6.553 | 7.023 | 2.667 | 4.133 | -16.007 |
| *Unilateral minimum tax - Residence principle* | | | | | | | |
| US | -12.1 | 1.210 | 3.772 | -0.007 | 0.186 | -0.015 | -1.472 |
| EU (no TH) | -16.6 | 0.724 | -0.001 | 4.851 | 0.253 | 0.012 | -2.440 |
| India-China | -3.9 | 0.185 | 0.000 | 0.009 | 0.649 | 0.002 | -0.921 |
| Other developed | -13.4 | 0.534 | -0.003 | 0.030 | 0.364 | 3.109 | -2.425 |
| *Unilateral minimum tax - Source principle* | | | | | | | |
| US | -10.5 | 1.118 | 3.671 | -0.009 | -0.019 | -0.014 | -1.227 |
| EU (no TH) | -14.5 | 0.623 | -0.001 | 4.672 | 0.011 | -0.012 | -2.132 |
| India-China | -12.0 | 0.509 | -0.035 | 0.002 | 1.792 | 0.038 | -2.328 |
| Other developed | -9.4 | 0.390 | -0.002 | -0.002 | 0.005 | 2.803 | -1.618 |
| *Multilateral minimum tax* | | | | | | | |
| Residence | -46.3 | 2.661 | 3.772 | 4.895 | 1.468 | 3.125 | -7.301 |
| Source | -46.3 | 2.643 | 3.641 | 4.654 | 1.796 | 2.815 | -7.299 |
| Tax haven adjustment | -46.3 | 2.378 | 2.444 | 3.247 | 1.275 | 2.018 | 9.885 |
| *Deviation from 15% minimum (13%)* | | | | | | | |
| US | -44.3 | 2.393 | 3.236 | 3.248 | 1.247 | 2.019 | 3.628 |
| EU (no TH) | -43.5 | 2.322 | 2.444 | 4.224 | 1.234 | 2.015 | 4.768 |
| India-China | -45.5 | 2.362 | 2.443 | 3.246 | 1.343 | 2.018 | 8.831 |
| Other developed | -43.8 | 2.343 | 2.444 | 3.244 | 1.216 | 2.692 | 6.544 |
| *Digital services tax (0.75% ideal)* | | | | | | | |
| US | -4.0 | 0.932 | 2.937 | 0.024 | 0.017 | 0.026 | -0.524 |
| EU (no TH) | -4.0 | 0.478 | 0.011 | 3.251 | 0.023 | 0.016 | -0.618 |
| India-China | -3.4 | 0.242 | 0.011 | 0.030 | 0.752 | 0.036 | -0.629 |
| Other developed | -2.7 | 0.287 | 0.026 | 0.040 | 0.019 | 1.772 | -0.472 |
| *Destination-based cash flow tax* | | | | | | | |
| US 20% | -21.6 | -6.269 | -18.156 | -0.221 | -0.696 | -0.347 | -4.079 |
| US 33% ($\star$) | -24.1 | 7.833 | 26.050 | -0.358 | -0.380 | -0.611 | -5.696 |
| US 40% (BAT) | -25.0 | 14.312 | 46.368 | -0.399 | -0.256 | -0.734 | -6.399 |
| Japan 25% ($\star$) | -6.1 | -3.724 | 0.008 | -0.115 | -0.125 | -22.429 | -2.164 |
| Japan 31% (BAT) | -6.4 | -3.141 | 0.013 | -0.140 | -0.084 | -18.778 | -2.524 |
| *Formulary apportionment* | | | | | | | |
| 50% sales | -100.0 | 5.625 | 15.439 | 10.326 | -3.706 | 4.868 | -10.713 |
| 100% sales | -100.0 | 7.213 | 24.759 | 13.812 | -10.382 | 5.639 | -5.328 |

Table I8: The effect of international taxation reforms on consumption

| Policy | Impact on consumption in... World | US | EU | IND-CHN | Other Developed | Havens |
|---|---|---|---|---|---|---|
| *Benchmark scenarios* | | | | | | |
| U.S. 5% statutory cut | 0.185 | 0.441 | 0.002 | 0.003 | 0.004 | 0.006 |
| Closing Singapore | -0.015 | -0.020 | -0.015 | -0.005 | -0.020 | 0.012 |
| Effective anti-abuse | -0.439 | -0.509 | -0.685 | -0.090 | -0.460 | 0.160 |
| *Unilateral minimum tax - Residence principle* | | | | | | |
| US | -0.106 | -0.253 | -0.000 | -0.004 | -0.001 | 0.004 |
| EU (no TH) | -0.069 | 0.011 | -0.362 | -0.003 | 0.011 | 0.033 |
| India-China | -0.004 | 0.000 | 0.003 | -0.040 | 0.002 | 0.023 |
| Other developed | -0.031 | 0.022 | 0.015 | 0.002 | -0.270 | 0.024 |
| *Unilateral minimum tax - Source principle* | | | | | | |
| US | -0.093 | -0.224 | -0.000 | -0.001 | -0.001 | 0.003 |
| EU (no TH) | -0.057 | 0.010 | -0.298 | -0.001 | 0.002 | 0.031 |
| India-China | -0.034 | -0.017 | -0.051 | -0.042 | -0.066 | 0.035 |
| Other developed | -0.025 | 0.011 | 0.006 | 0.002 | -0.189 | 0.011 |
| *Multilateral minimum tax* | | | | | | |
| Residence | -0.210 | -0.219 | -0.345 | -0.044 | -0.258 | 0.084 |
| Source | -0.210 | -0.220 | -0.345 | -0.043 | -0.258 | 0.084 |
| Tax haven adjustment | -0.210 | -0.219 | -0.346 | -0.043 | -0.259 | 0.091 |
| *Deviation from 15% minimum (13%)* | | | | | | |
| US | -0.193 | -0.179 | -0.347 | -0.043 | -0.259 | 0.089 |
| EU (no TH) | -0.198 | -0.221 | -0.284 | -0.043 | -0.261 | 0.082 |
| India-China | -0.209 | -0.219 | -0.347 | -0.035 | -0.259 | 0.086 |
| Other developed | -0.204 | -0.224 | -0.349 | -0.044 | -0.207 | 0.085 |
| *Digital services tax (1% ideal)* | | | | | | |
| US | -0.027 | -0.065 | -0.001 | 0.001 | -0.001 | 0.003 |
| EU (no TH) | -0.013 | 0.003 | -0.071 | 0.001 | -0.001 | 0.013 |
| India-China | -0.009 | -0.005 | -0.013 | -0.012 | -0.014 | 0.008 |
| Other developed | -0.006 | 0.002 | -0.001 | -0.000 | -0.044 | 0.008 |
| *Destination-based cash flow tax* | | | | | | |
| US 20% | 1.226 | 2.897 | 0.023 | -0.000 | 0.045 | 0.230 |
| US 33% (⋆) | -0.124 | -0.392 | 0.044 | -0.028 | 0.082 | 0.453 |
| US 40% (BAT) | -0.915 | -2.348 | 0.070 | -0.043 | 0.132 | 0.665 |
| Japan 25% (⋆) | 0.130 | 0.095 | 0.021 | 0.017 | 0.508 | -0.038 |
| Japan 31% (BAT) | 0.074 | 0.132 | 0.031 | 0.021 | 0.062 | -0.032 |
| *Formulary apportionment* | | | | | | |
| 50% sales | -0.419 | -0.388 | -0.641 | -0.189 | -0.536 | -0.053 |
| 100% sales | -0.401 | -0.269 | -0.601 | -0.296 | -0.617 | -0.274 |

## References of the Appendix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