Tax Policy, Investment and Profit-Shifting

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Preliminary and incomplete

Abstract

Multinational firms (MNEs) often pay no tax in high-tax countries because they shift a large fraction of their taxable income to tax havens. We build a model of tax policy and investment that incorporates unobserved heterogeneity in MNEs' profit-shifting capability and different costs of setting up a tax minimization network. The model matches the distribution of taxable profit and investment in detailed UK tax returns data. We use the model to quantify the policy tradeoff between raising tax revenue by combating tax avoidance (via, for example, a Global Minimum Tax) and attracting investment. The results solve a longstanding puzzle in the existing profit-shifting literature: our model reconciles the differences between previous micro- and macro-level estimates of profit-shifting elasticities by accounting for extensive margin decisions (to report positive or no taxable profit in a jurisdiction). We test the model's predictions using a reform in Italy that limited the profit-shifting activities of Italian MNEs as a quasi-natural experiment.[1]

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1 Introduction

What are the behavioral responses to changes in tax policy for multinationals that do not pay any tax at all? The incidence of reporting no taxable profit in high-tax jurisdictions is much more common for multinationals (MNEs) than it is for domestic companies, as MNEs have the resources to shift a substantial amount of their taxable profits to tax havens. As a result, MNEs' profits display sharp bunching at the taxable income zero-lower-bound in high-tax jurisdictions, highlighting the importance of extensive-margin investment and profit-shifting decisions (Bilicka; 2019; Koethenbuerger et al.; 2019). Surprisingly, the tax avoidance literature has placed a strong emphasis on intensive-margin profit-shifting decisions, generating a gap between macro- and micro-level studies that explore profit-shifting activities of multinationals (Dharmapala; 2014; Riedel; 2018). Understanding the responses of these no-tax paying MNEs and the tradeoffs they are facing has become ever more important, as *"leaders representing 80% of the world's GDP* [...] *made clear their support for a strong global minimum tax"*[2] to combat profit-shifting.

In this paper, we develop a model that generates corner solutions in multinationals' choices regarding their real presence and the proportion of profit that they shift to tax havens. As such, we address the commonly-overlooked issue of a high proportion of multinationals at the extreme positions of profit-shifting. We then use data from the UK tax returns to estimate structural profit-shifting parameters and test the model predictions by investigating the intensive- and extensive-margin effects of tax reforms on taxable profit declared in the UK by subsidiaries of foreign-owned multinationals. Finally, we conduct counterfactual policy experiments including the introduction of digital service taxes and the global minimum tax at varying rates. These findings allow us to: (i) reconcile the differences across estimates of profit-shifting based on macro- and micro-data, and (ii) quantify the *foregone* investment as a result of curbing tax avoidance and profit-shifting.

We start the paper by developing a model that considers a multinational's irreversible investment in a "tax avoidance asset", in addition to its decisions regarding the locations and amounts of investment in physical capital. Each non-haven subsidiary invests in productive capital, and the MNE centrally invests in a tax avoidance asset. Each MNE faces an idiosyncratic price of investing in each unit of the tax avoidance intangible. This heterogeneity mimics the real-world differences across companies that are not captured by standard sectoral variation: some business lines are more digitalized and have a more international customer base than others. Such firms find it easier to assign profits to lower

[2] Joe Biden, President of the United States, 30 October 2021.

tax jurisdictions. The common tax avoidance asset can be used across all productive subsidiaries of the MNE, and this asset then reduces the cost of shifting every additional dollar of profit to the tax haven.

There is a key difference between our model and the existing convex profit-shifting cost model of Hines and Rice (1994). Empirical studies typically use the Hines and Rice (1994) model as the basis for regression specifications. Most studies then either disregard the subsidiaries of MNEs at corner solutions of taxable income reporting or apply an ad hoc adjustment to the regression specification to deal with extreme forms of profit-shifting, arguably by the *worst offenders*. In our model, we place a structure around how the tax avoidance asset is accumulated in the first place. We then allow for every additional unit of the tax avoidance asset to reduce the cost of shifting each dollar of profit to tax havens. The simplest such adjustment to the standard convex cost model involves two new structural parameters to be estimated.

In our model, tax reforms induce both an extensive-margin and an intensive-margin effect on profit-shifting. For a company at the intensive margin, a rise in the effective tax rate of a tax haven country, for example, reduces the benefit of profit-shifting and may induce a new equilibrium with lower shifting. However, it may also induce that company to no longer shift any profit at all. A company that initially shifted all its profit may not respond at all if the benefits accruing from its tax avoidance asset are not reduced far enough. At the opposite extreme, a company not engaging in shifting at all may not respond to a greater tax benefit, since to do so requires an upfront entry cost of investing in the tax avoidance asset. In our description of the model and results, we distinguish between this entry cost and the *fixed* investment cost to accumulate the tax avoidance intangible.

The overall effect of tax reform is likely to aggregate the response of companies at the intensive and extensive margins. Some companies shifting all their profit prior to the reform may move to an interior solution with much less shifting. And if the benefits increase, then some companies may now undertake the requisite investment to enable them to shift profit. Micro studies that focus only on intensive margins may therefore understate the impact of tax reform on profit-shifting. Such a discrepancy is akin to the gap between macro- and micro-level labor supply elasticities in the presence of frictions in Chetty (2012).

The investment in tax avoidance asset reduces the cost of capital for tangible assets. The reforms that increase the costs of profit-shifting for MNEs may reduce their investment in tangible assets. This theoretical prediction is in line with the recent literature that shows that anti-tax avoidance regulations have real effects on investment and employment (Bilicka et al.; 2021; Serrato; 2018).

We then test the empirical implications of our model using the UK tax return data and a reform that limited the extent of profit shifting of Italian MNEs abroad. Our quasi-experimental variation arises from the 2002 Italian Controlled Foreign Company (CFC) reform. The CFC rules stipulate that the income of foreign low-tax subsidiaries should be included in the domestic tax base. Hence, they reduce or remove incentives to shift profit to countries with tax rates just above the CFC threshold rule (Clifford; 2019). In the context of our model, the CFC rule is akin to an increase in the tax haven's tax rate. We compare UK subsidiaries of Italian-headquartered MNEs with UK subsidiaries of Spanish-headquartered MNEs. The UK in this context acts as a high-tax subsidiary with the main corporate income tax rate of 30% during the sample period. The treatment group MNEs experienced a rise in the tax rate that applies on profit shifted to the tax haven. We conjecture that this rise in the tax haven tax rate induces an increase in profit reported in various high-tax subsidiaries of an MNE, but depending on the nature of the costs of shifting profits, we anticipate that the reform has a more dominant extensive-margin response than an intensive-margin response. Consistent with our prediction, we find a strong extensive-margin response, manifested by a significant reduction in the probability to report zero taxable income of treatment group firms in the UK. We estimate that the intensive-margin response is more modest and statistically insignificant. We capture the intensive-margin response through the change in the average reported taxable income in the UK.

In the third step, we carry out counterfactual policy experiments. Compared with the earlier literature, our model splits the profit-shifting cost into a 'fixed tax avoidance investment cost' and a variable cost of profit-shifting. The latter component is aligned with the earlier literature that assumes a cost convex in every dollar of profit shifted to tax havens. We find results consistent with MNEs investing in a tax avoidance intangible, whose price varies across MNEs. We expect that the nature of this price distribution is related to the firm's business, but broad sectors may not capture the heterogeneity in access to tax avoidance assets. Importantly, our structural estimates enable us to simulate the effects of recent reforms such as the digital service taxes and the global minimum tax. We demonstrate that the impact of the global minimum tax rests crucially on the chosen threshold rate. A 15% minimum tax threshold implies a substantial reduction in profit-shifting at sufficiently large values of the price of the tax avoidance intangible. This will increase tax revenue in high tax countries, but at a cost of reduced investment in tangible assets.

Our paper contributes to two broad strands of literature. First, is the discussion on the magnitudes of profit shifting. A consensus estimate from a meta-regression study by Heckemeyer and Overesch (2017), is a semi-elasticity of reported income with respect to the tax

rate differential across countries of 0.8, implying that a 10 percentage point increase in the tax rate differential between two countries would increase the pre-tax income reported by the subsidiary in the low-tax country by 8 per cent. However, this masks a wide range of estimates. Part of the reason for why there is uncertainty on this magnitude is that the counterfactual of the tax that would have been levied in the absence of profit-shifting is not well defined. The traditional approach to estimating this counterfactual is that of Hines and Rice (1994), who implicitly estimate profit in a jurisdiction based on the use of capital and labour located there. However, international tax system also allocates rights to jurisdictions in which valuable assets are owned, or lending originates.[3]

On the other hand, macro estimates of total profit shifted and total tax revenue foregone due to profit shifting are also mixed. The OECD BEPS project estimated foregone tax revenue of between $100 billion and $240 billion, between 4% and 10% of worldwide corporation tax revenues (OECD (2015)).[4] Other estimates are higher. Crivelli et al. (2016) estimate foregone revenue at around 1% of GDP for OECD countries and 1.3% of GDP for developing countries, while Tørsløv et al. (2021) estimate that 36% of all multinational profits are shifted to tax havens, implying total shifting of over $600 billion.[5] Our paper contributes to this literature by quantifying the costs of profit shifting relative to firm revenues and profits.

Second, profit shifting has been shown to have real consequences on firm operations that feed through the economy to estimates of GDP and productivity. On the micro level, there is growing evidence that anti-tax avoidance regulations reduce not only the extent of tax avoidance, as intended, but also curb down real business operations of MNEs. Serrato (2018) shows effects on investment and employment and consequences on local labor markets in the US, while Bilicka et al. (2021) show effects for real business operations in the UK and in foreign countries of MNE operations. Recently, Guvenen et al. (2022) find that profit shifting reduces US GDP and productivity estimates in the official statics and Coppola et al. (2021) find that offshore issuance reduces the scale of portfolio investment from developed countries to emerging market companies. As such, these papers suggest

[3]Other approaches include contributions by Desai et al. (2006); Dharmapala and Riedel (2013); Dischinger et al. (2014); Dischinger and Riedel (2011); Egger et al. (2010); Grubert and Slemrod (1998); Gumpert et al. (2016); Slemrod and Wilson (2009).

[4]See also Bradbury et al. (2018).

[5]This picture is complicated by a dispute over the possible misinterpretation of accounting data. In particular, Blouin and Robinson (2020) point out that in some cases there may have been a problem of double-counting. They reapply the analysis of Clausing (2016) to suggest that the tax revenue loss in the United States in 2012 was only $10 billion instead of Clausing's estimate of $77 to $111 billion; see also Clausing's response Clausing (2020) and Clausing (2021).

that profit shifting by MNEs affects measurement of GDP, production and international capital flows. Our paper highlights that profit shifting can come at the cost of investment in tangible assets and our model allows us to quantify these tradeoffs more systematically.

From a policy perspective, in recent years there has been growing concern over the ability of multinational corporations to shift profit from high-tax jurisdictions to tax havens in order to reduce their aggregate tax liabilities. Especially following the global financial crisis in 2008-9, governments seeking additional tax revenue have sought to combat such profit-shifting. This led to the OECD/G20 Base Erosion and Profit Shifting (BEPS) project in 2013-5, with sweeping measures aimed at protecting the tax base in high-tax countries. More recently, in 2021, over 140 members of the OECD's Inclusive Framework have agreed the most far-reaching reforms to the international taxation of profit in a century.[6] There is growing theoretical literature that analyses the implications of global minimum taxes for welfare and revenues of high- and low-tax countries (Hebous and Keen; 2021; Janeba and Schjelderup; 2022; Johannesen; 2022). Many countries have also introduced unilateral measures. For example, the US tax reform in 2017 introduced the global intangible low-taxed income (GILTI) provision, a form of minimum tax on worldwide income for US-based multinationals. Other countries have introduced Digital Services Taxes (DSTs) in an attempt to levy tax on large digital service companies in jurisdictions in which they have "users" or "activity". Such major responses to concerns about the scale of tax avoidance in the form of profit-shifting have arguably run ahead of systematic academic evidence.

2 Conceptual framework

2.1 A model of capital accumulation with profit-shifting

We model the behaviour of a multinational enterprise (MNE) in a single period. The novelty of the model lies in the process in which the MNE invests in an intangible asset which we call the "tax avoidance asset", Y. The accumulation of this asset incorporates different costs of organising the business to reducing its overall tax liability. As an example, consider the case of a business with ownership of intellectual property (IP). Many such businesses re-route their revenue generated from IP by locating the IP in a tax haven and they reduce income in high-tax jurisdictions by making royalty payments to the tax haven affiliate.

We consider a business that has operations in N jurisdictions. Each of these operations

[6] See OECD agreements in July 2021 and October 2021.

involve two types of investment: (i) productive investment in tangible capital, and (ii) investment in an intangible asset that reduces the cost of shifting profit to a tax haven.

The timing is as follows:

1. At the beginning of the period, each government j announces its tax rate, τ_j, and introduces anti-avoidance measures. Collectively the anti-avoidance measures determine how much the home government may affect a change in the tax levied on income on operations of tax haven subsidiaries. This 'tax haven tax rate' is labelled τ_X. Each MNE i invests in the tax avoidance asset Y_i that serves its subsidiaries globally. The cost to the multinational of purchasing units of the tax avoidance asset is denoted p. There is also an entry cost to investing in this asset, ϕ. We distinguish between the *entry cost* ϕ and the *fixed* investment cost for accumulating the tax avoidance intangible, which is priced at p_i for each firm i.

2. Still at the beginning of the period, but with knowledge of τ_j for all countries of operation j, τ_X, p and ϕ, each MNE i chooses investment in tangible capital K_{ij} in each country j.

3. At the end of the period, each subsidiary generates output of $F(K_{ij})$, with $F'(K_{ij}) > 0$ and $F''(K_{ij}) < 0$, and sells the remaining tangible capital for $(1-\delta)K_{ij}$. The tax avoidance asset is worthless at the end of the period.

4. Also at the end of the period, the multinational chooses the proportion α_{ij} of the tax base B_{ij} to shift to a tax haven with the tax rate of τ_X.

We assume that profit-shifting is not possible without some positive Y. We also assume that it is not possible to shift more than 100% of the tax base. This yields the following decision making process by the business:

1. Choose $Y_i = 0$, implying $\alpha_{ij} = 0$; or, $Y_i > 0$, in which case, the cost of purchasing Y is $pY + \phi$.

2. Conditional on $Y_i > 0$, choose $0 < \alpha_{ij} \leq 1$.

We assume that the variable costs of shifting profit out of jurisdiction i to a tax haven, conditional on $Y_i > 0$, are:

$$C_{ij} = c\left(\alpha_{ij}, Y_i, B_{ij}\right) B_{ij} \tag{1}$$

The tax base in country j for MNE i is:

$$B_{ij} = F(K_{ij}) - \delta K_{ij} \tag{2}$$

This implies that tax depreciation is equal to true economic depreciation and there is no relief for any financing costs.[7].

A proportion α_{ij} of the tax base is shifted to the tax haven where it is liable to tax at rate τ_X. The remainder is taxed in country j at rate τ_j. The overall tax liability for each MNE in each jurisdiction is therefore:

$$T_{ij} = \widehat{\tau_{ij}} B_{ij} = \left[\tau_j \left(1 - \alpha_{ij}\right) + \alpha_{ij}\tau_X\right] B_{ij} \tag{3}$$

where $\widehat{\tau_{ij}}$ can be thought of as an "effective statutory rate" on profit generated by MNE i in the subsidiary in j.

The MNE centrally chooses Y_i, and K_{ij} (and α_{ij}) for each subsidiary j, to maximise its beginning of period value:

$$V_i = -p_i Y_i - \phi(Y_i) - \sum_{j=1}^{N} K_{ij} + \beta \sum_{j=1}^{N} \left[F(K_{ij}) - T_{ij} - c\left(\alpha_{ij}, Y_i, B_{ij}\right) B_{ij} + (1-\delta)K_{ij}\right] \tag{4}$$

subject to constraints:

$$\begin{aligned} Y_i &\geq 0 \\ 0 \leq \alpha_{ij} &\leq 1 \end{aligned}$$

where $\phi(Y_i) = \bar{\phi}$ for positive values of Y and zero otherwise. $\beta = 1/(1+r)$ is the discount factor.

Firms differ in the price p of the tax avoidance intangible asset. Specifically, we envisage that each multinational faces a price of investing in tax avoidance. The natural log of this price, $\ln p_i$, has a Normal distribution with mean μ_p and variance σ_p^2.

2.1.1 Option 1: No investment in profit-shifting

Conditional on not investing in the profit-shifting intangible asset, $Y_i = 0$, then the share of profit shifted to the tax haven is zero for all subsidiaries; $\alpha_{ij} = 0 \, \forall j$. This also means that

[7]We ignore the use of debt to keep the model relatively simple

all the costs of profit-shifting are set to zero. In this scenario, the choice of tangible capital is derived the same way as under the standard neoclassical optimal capital accumulation framework (Hall and Jorgenson; 1967; Jorgenson; 1963), with the optimal tangible stock given by the first order condition in Equation 5:

$$F_K(K_{ij}) = \frac{r}{1-\tau_j} + \delta \tag{5}$$

This FOC generates an optimal value of K_{ij} for each subsidiary j, K^*_{ij} with an associated optimal tax base, B^*_{ij} and beginning of period firm value, V^*_i.

2.1.2 Option 2: Positive investment in the profit-shifting intangible

Conditional on some positive investment in the tax avoidance intangible asset, $Y_i > 0$, and interior solutions with $0 < \alpha_{ij} < 1$, the first order conditions for the tax avoidance intangible Y, the tangible capital K and the share of profit shifted to the tax haven are as follows:

$$Y: \qquad p_i = -\beta \sum_{j=1}^{N} c_Y(\alpha_{ij}, Y_i, B_{ij}) B_{ij} \tag{6}$$

$$K: \qquad F_K(K_{ij}) = \frac{r}{1 - [\widehat{\tau_{ij}} + c_B(\alpha_{ij}, Y_i, B_{ij}) B_{ij} + c(\alpha_{ij}, Y_i, B_{ij})]} + \delta \tag{7}$$

and

$$\alpha_{ij}: \qquad \{\tau_j - \tau_X - c_\alpha(\alpha_{ij}, Y_i, B_{ij})\} B_{ij} + \eta_{ij} = 0 \tag{8}$$
$$\eta_{ij}(\alpha_{ij} - 1) = 0$$

Conditional on the investment in the tax avoidance asset Y, each subsidiary j chooses how much of its profit to shift out to the tax haven, that is, the share α_{ij} of profit arising in jurisdiction j and K_{ij} independently. If none of the subsidiaries shifts all its profits to the tax haven, then $\eta_{ij} = 0 \; \forall j$, and the optimal capital depends on Equation 7. The optimal share of profit shifted from the high tax country to the tax haven equates the marginal cost of shifting profit to the tax rate differential between the home country rate and the tax haven tax rate. The larger the difference, the larger the marginal benefit of shifting the next dollar of profit to the tax haven. The subsidiary shifts up to the point that equates the marginal benefit of shifting $(\tau_{ij} - \tau_X)$ to the marginal cost of shifting, pinned down by c_α.

Alternatively, in the case where at least one subsidiary shifts all its profit to the tax haven, with $0 < \alpha_{ij} \leq 1$ and $\exists j$ with $\alpha_{ij} = 1$, then $\eta_{ij} \neq 0$ for locations j with full shifting.

This renders the first order condition for α_{ij} to be:

$$\eta_{ij} = -\frac{\tau_j - \tau_X}{B_{ij}} + c_\alpha(\alpha_{ij}, Y_i, B_{ij}) \tag{9}$$

We demonstrate the implications of different choices combining conventional functional forms (convex costs and a Cobb-Douglas production function) with an adjustment to the shifting cost function to allow a zero-or-positive investment in the profit-shifting intangible. This adjustment generates regions of different shares of profit being shifted to the tax haven.

2.1.3 Functional forms

The functional form for the cost of profit-shifting in Equation 10 allows comparisons between the predictions from the conventional model (Dharmapala; 2014; Hines and Rice; 1994; Riedel; 2018) and the predictions from our current approach:

$$c\left(\alpha_{ij}, Y_i, B_{ij}\right) = \frac{\gamma}{2}\left(\frac{B_{ij}}{Y_i}\right)^m \alpha_{ij}^2 \tag{10}$$

Total costs of shifting profit, conditional on Y, are proportional to the tax base, B_{ij}. The proportion is, in a conventional way, quadratic in the proportion of the tax base shifted, α_{ij}. It also depends on the relative size of the tax base in subsidiary i and the tax avoidance asset, Y, raised to the power of m, where $m \in (0, 1)$.

In the simulation we also use a simple function form for $F(K_{ij})$:

$$F(K_{ij}) = \theta_{ij}^{1-A} {K_{ij}}^A \tag{11}$$

where productivity draw $\theta_{ij} = \theta \exp\left(\varepsilon_{ij}\right)$ may vary amongst subsidiaries following the process $\varepsilon_{ij} \sim \mathcal{N}(0, \sigma^2)$. In Appendix **??**, we describe this simplified production function.

This model does not have a closed-form solution, and we solve for the optimal tangible capital and the tax avoidance intangible for each state of cost of investing in the tax avoidance asset p_i and productivity draw ε_{ij} numerically.

2.2 Testable predictions

We demonstrate profit-shifting and capital accumulation choices for a range of cost draws p_i in Figure 1. We envisage an MNE with three subsidiaries, one in a high-tax country and

one in a low-tax country with real operations, and the third one in a tax haven. An MNE with subsidiaries in France (high-tax), Ireland (low-tax) and Bermuda (tax haven) is an example to such a setup.

We derive some key testable predictions that guide our empirical analysis in reduced-form in Section 4, and structurally in Section 5.

1. *Extensive-margin profit-shifting effect:* Companies that face a lower cost of investing in the tax avoidance intangible are more likely to shift all their profit to tax havens. The decision to invest in the tax avoidance asset is determined by the firm's unit cost of investing in tax avoidance, p_i, as well as the firm's productivity θ_{ij} in each of its subsidiaries. The model generates kinks along the distribution of the unit cost of the tax avoidance intangible (Figure 1a). Firms that face a lower *fixed* cost of investing in tax avoidance shift all their taxable profit out of both the low-tax country and the high-tax country. As the unit cost of the tax avoidance intangible p rises, first, the incentive to shift all taxable income out of the low-tax country diminishes. The marginal benefit of shifting profit out of the high-tax country is higher, but as the marginal cost of profit-shifting rises, the incentive to shift all profit out of the high-tax country also starts to diminish.

   With the increased cost of profit-shifting, the cost of tangible capital also starts to rise more steeply (Figure 1b). We observe that the same kinks as in Figure 1a are relevant for the choice of investment in productive capital. The increase in cost of capital is particularly steep for investment projects in the high-tax country.

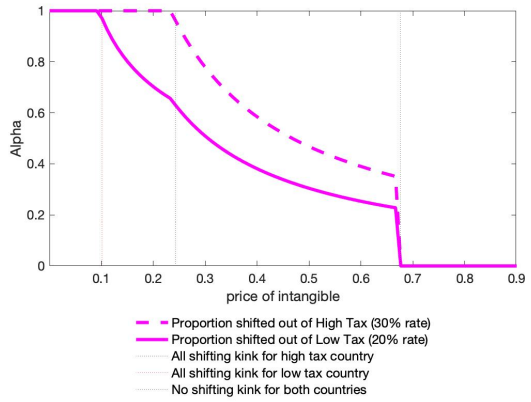
2. *Intensive-margin profit-shifting effect:* Companies that face a lower cost of investing in the tax avoidance intangible shift a larger proportion of their taxable income to tax havens. For the cases with an interior solution, a reduction in the unit cost of the profit-shifting intangible leads to a rise (at an increasing rate) in the share of shifted profit. For companies that shift some, but not all, of their profit to the tax haven, a lower unit cost of profit-shifting intangible means more more shifting, and more tangible capital accumulation (Figures 1a and 1b).

3. *Impact of international tax reform on profit-shifting:* A minimum tax (or also a CFC rule) results in a higher effective tax rate on the income shifted to tax havens. With a higher rate of tax on shifted profit, the marginal benefit of shifting profit to the tax haven declines while marginal cost of profit-shifting remains the same. Both the incentive

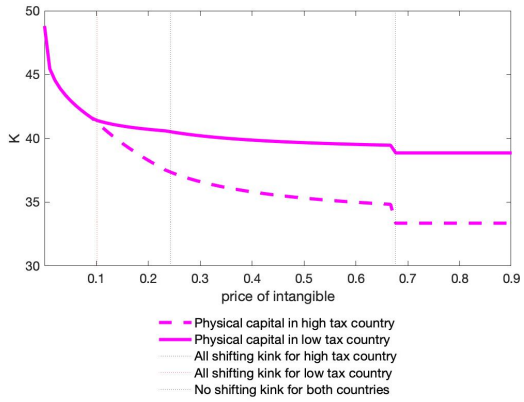
to shift *all* income and the incentive to shift *some* income become weaker, resulting in both extensive- and intensive-margin effects (Figure 1c).

4. *Impact of international tax reform on capital accumulation:* As the tax reform induces lower profit-shifting, it also increases the cost of capital through the higher tax haven tax rate. This is reflected in lower tangible capital accumulation. We demonstrate the firms' choice of tangible capital at different p-states in Figure 1d. The loss of capital stock in the high-tax country is higher than that of the loss in the low-tax country.

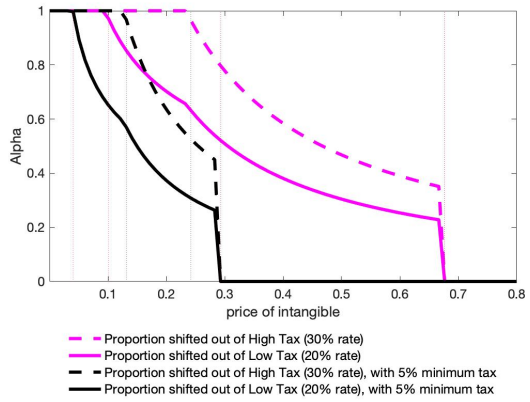
Figure 1: Profit-shifting and investment in tangible capital under the status quo and minimum tax



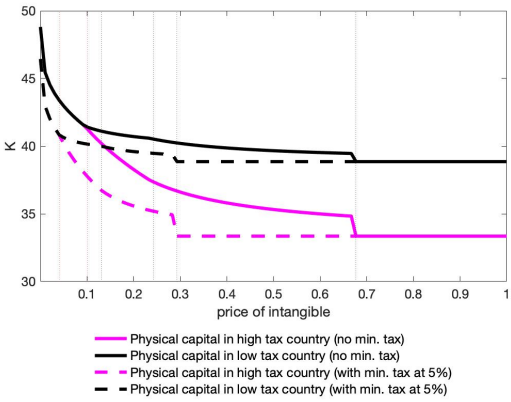
(a) Share of profit shifted, base case



(b) Choice of tangible capital, base case



(c) Share of profit shifted, with a min. tax



(d) Choice of tangible capital, with a min. tax

Note: The values on this figure are based on calibrated values and do not reflect the estimates that we present in Section 5. The calibrated values are for demonstration purposes only.

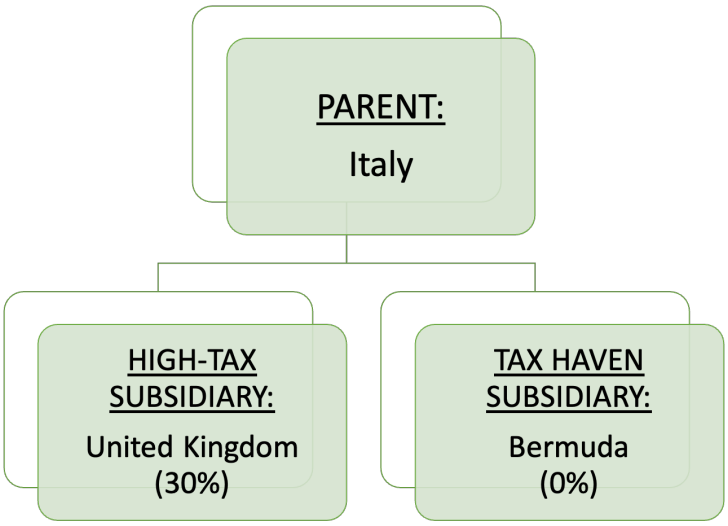
3 Empirical strategy

We make predictions regarding firms' responses to tax policy changes in two steps. First, we present the results from reduced-form difference-in-differences (diff-in-diff) regressions that demonstrate MNEs' responses to tax reforms in a quasi-experimental setting. We then use our reduced-form estimates as moments to match in a simulated method of moments estimation procedure and estimate the parameters of our structural model from Section 2. Finally, we evaluate the impact of counterfactual policy options.

3.1 Evaluating the impact of the CFC reform in Italy

In the absence of special rules, tax policy, including company taxation, applies to a country's residents. A controlled foreign company legislation opens up the possibility for a country to tax the foreign income of a multinational corporation. Under a CFC rule, subsidiaries of MNEs that are wholly or partly owned by a multinational parent that pays tax at an effective rate below a certain threshold (set by the *home* country) become liable to pay extra tax to the revenue authority of the *home* jurisdiction (Clifford; 2019).

Figure 2: Example structure for an MNE parent company in 2002



In 2002, Italy began to impose additional tax on certain types of income of a *tax haven subsidiary* that is financially controlled by a parent located in Italy. The tax haven definition under the Italian CFC regime, for the period of our study, was 13.75%.[8] A simple MNE

[8] A summary is available from the Library of Congress in the linked article here.

structure with a parent company in Italy, a high-tax subsidiary in the UK and a tax haven subsidiary in Cayman Islands illustrates the relevant corporate structure for our empirical analysis (Figure 2). The introduction of the CFC regime in Italy increased the tax haven tax rate on certain income of Italian MNEs to 13.75% (possibly from an effective rate of zero).

According to the theoretical framework in Section 2, we expect the Italian parent company's UK *high-tax* subsidiary to experience a change in its corporate tax return. We expect changes in the UK tax return along the following dimensions:

1. *Extensive-margin profit-shifting effect:* High-tax subsidiaries may become **less likely to report zero taxable profit**. If tax haven subsidiaries are taxed more intensively, less profit should be shifted out of any of the high-tax subsidiaries of Italian MNEs. This includes subsidiaries in the UK.

2. *Intensive-margin profit-shifting effect:* High-tax subsidiaries with existing profit in high-tax jurisdictions may **increase the amount of profit reported in high-tax jurisdictions**.

Depending on the size of the structural parameters $\bar{p}$ and γ, there may be more pronounced effects through the extensive-margin or the intensive-margin. We use the difference-in-difference approach to investigate the profit reporting behavior of multinational firms in the UK in response to the change in the CFC regime in Italy. According to country characteristics and tax reform trajectories, we select MNEs headquartered in Spain as a suitable control group against which we can benchmark the change in the profit reporting behavior of MNEs headquartered in Italy. We run two sets of regressions to assess: (i) the change in the probability to report zero taxable profit in the UK (using a linear probability model), and (ii) the change in the average profit reported in the UK:

$$\mathbb{1}(\text{Taxable Profit} \leq 0)_{i,t} = \alpha_1 + \beta_0 \text{Treated}_i \times \text{Post-reform}_t + \sigma_1 X_{it}^{'} + \theta_{i1} + \eta_{t1} + \varepsilon_{it1} \quad (12)$$

$$\ln(\text{Taxable Profit}_{i,t}) = \alpha_0 + \beta_1 \text{Treated}_i \times \text{Post-reform}_t + \sigma_0 X_{it}^{'} + \theta_{i0} + \eta_{t0} + \varepsilon_{it0} \quad (13)$$

In Equations 12 and 13, the dependent variables capture the extensive-margin and the intensive-margin profit-shifting effects, respectively. $\mathbb{1}(\text{Taxable Profit} \leq 0)_{i,t}$ represents a dummy equal to one when a firm reports zero taxable profits in a given year. Treated_i is a dummy variable that equals one, if a subsidiary is headquartered in Italy and zero otherwise; Post-reform_t is a dummy variable that equals one from 2003 onward for the

Italian CFC reform. $X_{it}^{'}$ is a set of firm-level control variables, θ_is are firm-specific fixed effect, η_ts are time fixed effects, and ε_{it}s are the error terms.

β_0 captures the effect of the reform on the propensity of the firm to report zero taxable profit in the high-tax jurisdiction (UK), i.e. the extensive margin. Under the model in Section 2, β_0 should be negative and significant for the case of the Italian anti-tax avoidance reform. Italian subsidiaries should report higher profits in the UK now that Italy is taxing profits located in lower tax jurisdictions in Italy. β_1 represents the intensive margin response to the introduction of the CFC legislation. This parameter is closely related to the variable cost parameter γ in the model that we developed in Section 2. Under convex variable cost assumption, γ represents the sensitivity of profit-shifting to each additional dollar shifted to the tax haven. We posit that the *fixed* investment cost in the tax avoidance intangible represented by $\bar{p}$ dominates the variable cost channel, in which case β_1 may be close to zero or statistically not significant.

3.2 Administrative data and balance sheet information

We use detailed administrative tax returns data from the UK (starting in 2000), matched with financial accounts information and ownership links provided by Bureau van Dijk data and test the predictions of the model. A change in the tax rate differential between high-tax jurisdictions and tax haven countries is sufficient for us to evaluate intensive- and extensive-margin profit-shifting elasticities and estimate our model's key structural parameters. However, tax rate changes are hardly ever exogenous to profit-shifting tendencies of multinationals. We therefore leverage exogenous variation in profit-shifting behavior triggered by a change in the controlled-foreign company (CFC) legislation in Italy.[9]

Before the changes to CFC rules, Italian-owned multinationals operating in the UK could freely shift profit to jurisdictions that are considered to be tax havens without any penalty and reduce their effective tax rate to close to zero. For the period that we study, the UK had a main corporate tax rate of 30% and was considered a high-tax country. This status changes in the years that followed, but we focus our attention to the 2000-2005 period without significant tax reforms.

The dataset comprises all items that are submitted on the corporation tax return form (CT600 form) and the unit of observation is an unconsolidated statement in each of the years. Each subsidiary of a company operating in the UK files a separate tax return. We

[9] Clifford (2019) provides further information on CFC legislation around the world and studies their impact on companies' behavior.

merge the HMRC data with the accounting data from the FAME dataset, collected by Bureau van Dijk. This data contains information on firm assets, employment, and other balance sheet items. Further, the ownership data from FAME allows us to identify the global ultimate parent companies that own UK subsidiaries and link their corporate tax returns with Italian and Spanish ultimate owners.

3.3 Summary statistics

We use matched tax return-financial accounts data over the years 2000 - 2005, corresponding to three years before the reform and three years after the reform. To begin with, we observe the patterns of reporting taxable profit or losses for the whole population of firms compared with the subsidiaries of multinational companies. In Figure 3, we demonstrate taxable profit or loss reporting behavior of companies that have filed company tax returns for a consecutive minimum of ten years (starting in the year 2000). The left-hand panel shows the patterns of taxable income reporting for domestic firms. The most common pattern for reporting over 10 years for domestic firms is to report positive taxable profit in most years. 68% of domestic firms in the company tax register report taxable profit in more than seven of the ten (or more) years of data. The second most common pattern is to report zero taxable profit every year, and 17% of active domestic firms report positive taxable income in fewer than three years. This may be due to company life-cycle or domestic avoidance and evasion activities.

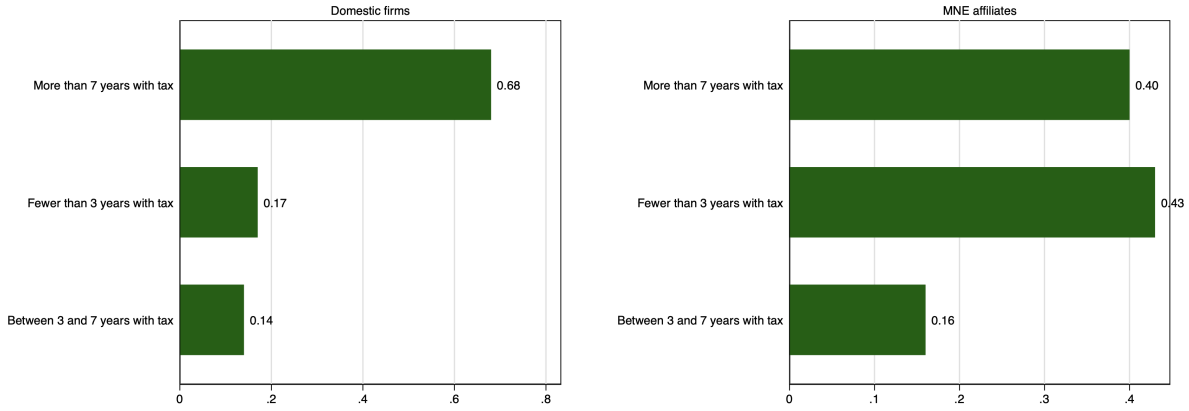
Figure 3 looks completely different for subsidiaries of multinational companies (right-hand panel). Of the multinational taxpayers, half of them always report zero taxable income in the UK. The next most common pattern is MNEs that always report zero taxable income, with 43% of MNEs reporting positive taxable income in fewer than three years.

The taxable profit reporting patterns support the view that multinationals either consistently move profit out of the high-tax subsidiary's jurisdiction, or consistently report positive profit in the high-tax jurisdiction over time. We interpret this to be consistent with firms choosing time-invariant *tax minimizing* or *tax-paying* types and supporting our simplifying choice of building the conceptual framework as a static model.

In Table 1, we present descriptive data on key variables for the pre-reform period separately for the Control Group (MNEs with parent company resident in Spain) and the Treatment Group (MNEs with parent company resident in Italy). UK subsidiaries of both Italian MNEs and Spanish MNEs report around 150 thousand pounds of average taxable profit. In Table 2, we narrow the sample down to companies that persistently report pos-

Figure 3: Patterns of reporting taxable profit or loss over 10 years for surviving firms

(a) Domestic firms (b) MNE subsidiary firms



Note: This figure shows the corporate tax payment patterns for corporate taxpayers that are in the dataset for at least 10 years continuously. We split these companies into three groups: (1) firms that had positive taxable profit in more than 7 years, (2) firms that had positive taxable profit in fewer than 3 years, (3) firms that had between 3 and 7 years with taxable profit. The left hand panel shows the ratios for domestic firms and the right hand panel shows the ratios for MNEs. The ratios sum to one for each panel.

itive taxable profit, and show, as expected, that the average taxable profit is much higher for this latter group of MNE subsidiaries.

Strikingly, in both the Treatment Group and the Control Group, close to half of all MNE subsidiaries in the UK report zero taxable profit in the pre-reform period; this share is 49.8% for the control group and 47.8% for the treatment group. Our extensive-margin response to tax reform traces the changes in the prevalence of reporting zero taxable profit. Average size of the subsidiaries in the control group is larger than the subsidiaries in the treatment group, and this is somewhat reflected in the profitability measure that is the ratio of taxable profit to balance sheet size. Consistently, the revenue as a share of firm size is also somewhat larger in levels for the control group firms. In Table 2, we show key descriptive statistics for firms that reported positive taxable profit in each of the pre-reform periods. As expected, the average reported profit for both treatment and control group subsidiaries is high, at more than double the average taxable profit for the whole sample. Similar to Table 1, the average asset size for the control group is higher than that of the treatment group, and the two groups have similar profitability ratios.

Table 1: All sampled companies – key descriptive statistics by treatment status, pre-reform period

Variable	*Control Group*			*Treatment Group*		
	Mean	**95% CI**		**Mean**	**95% CI**	
		lb	ub		lb	ub
Taxable profit (GBP)	155,891	134,253	177,530	145,155	130,886	159,424
Zero taxable profit (share)	50%	46%	54%	48%	45%	51%
Total assets ('000 GBP)	20,817	18,399	23,235	10,253	9,070	11,436
Profitability	6%	5%	7%	8%	7%	10%
Revenue / Assets	2.04	1.82	2.26	1.73	1.62	1.85

Note: This table shows selected descriptive statistics, pooled over the pre-reform period years available in the data (2000-2002). Control group companies are the UK subsidiaries of MNEs with parent companies located in Spain. Treatment group companies are the UK subsidiaries of MNEs with parent companies located in Italy. Taxable profit data are from the tax return and data on balance sheet size are from company accounts. Units for taxable profit and asset size are nominal British Pounds, with asset size values presented in thousands. Profitability is obtained by dividing taxable profit by total assets at the company-year level, then average over all pre-reform group observations. 'lb' and 'ub' represent lower and upper bounds of the 95% confidence intervals.

Table 2: Sampled companies with persistently positive taxable profit – key descriptive statistics by treatment status, pre-reform period

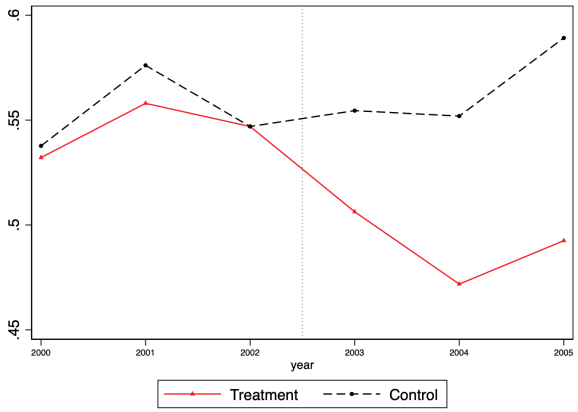
Variable	*Control Group*			*Treatment Group*		
	Mean	**95% CI**		**Mean**	**95% CI**	
		lb	ub		lb	ub
Taxable profit (GBP)	389,442	346,397	432,488	314,389	285,566	343,212
Zero taxable profit (share)	0%			0%		
Total assets ('000 GBP)	21,217	17,168	25,266	8,221	6,554	9,887
Profitability	13%	11%	15%	15%	14%	17%
Revenue / Assets	2.34	1.88	2.80	1.83	1.71	1.95

Note: This table shows selected pre-reform period descriptive statistics in the same format as Table 1. In this table, we limit the sample to firms that report positive taxable profit in each of the pre-reform periods, 2000, 2001 and 2002.

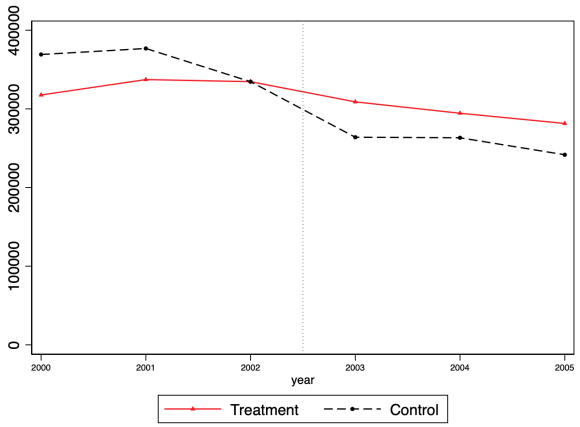
4 Graphical evidence and reduced-form regression results on profit-shifting

Figure 4: Trends in average propensity to report positive taxable income and average income by treatment status

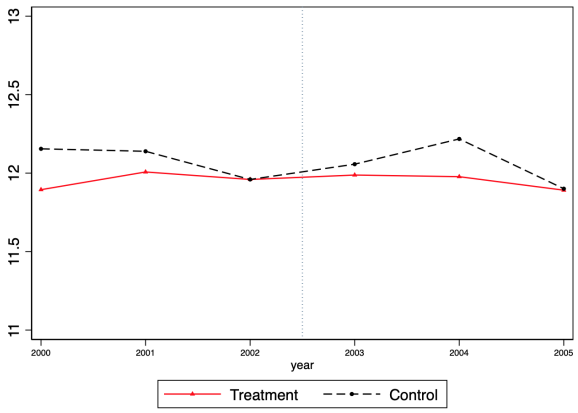
(a) Probability to report zero taxable profit



(b) Average taxable income (in level)



(c) Average taxable income (in log)



Note: In the top left-hand panel of this figure, we show the average probability to report zero taxable income in the United Kingdom (a high-tax country) for all sampled firms and the in the top right-hand panel, we show the average taxable income ('Profits chargeable to Corporation Tax' in the UK corporation tax return) for firms that report positive taxable profit in all pre-reform years. In the bottom panel, we present average taxable income in natural logarithm. We present the trends separately for the treatment group of Italian-headquartered MNEs (red, smooth line) and for the control group of Spanish-headquartered MNEs (black, dashed line). We demean all observations to remove individual effects and rescale the two trends to overlap in the last pre-reform period for ease of comparison. To do this, we subtract from each dot the group mean in the last pre-reform year and add back the pooled mean from the same year.

For the validity of the difference-in-difference approach, treatment and control groups

should satisfy common counterfactual trends. In the absence of treatment, the change in average outcome measures for the control and treatment group firms should be similar. Based on our data, we assess whether common counterfactual trends is a plausible assumption by exploring the trajectory of the average outcome variable in pre-reform years. In Figure 4, we demonstrate the time variation in our outcome variables for interest separately for treatment and control groups. In the top left-hand panel of Figure 4, we show the average probability to report zero taxable income. The two trends are parallel until the reform. After the reform, the average probability to report zero taxable profit drops significantly for the treatment group, but not for the control group. The drop in the average probability to report zero taxable profit is in line with our prediction that the CFC reform in Italy leads to a drop in the probability to shift profit out of the UK for Italian subsidiaries.

In the top right-hand panel and the bottom panel, we show the average taxable income in level and in natural logarithm. If there is a clear intensive margin effect of the CFC regime, then we should expect the treatment group to report a substantially higher taxable income than the control group. Examining the patterns in Figure 4b, the average taxable profit for treatment group firms exceed the average for the control group firms only after the reform, nevertheless, we do not observe a clear impact of the policy at this margin. We now present the results of panel regressions that address the same question, controlling for time-varying firm-level characteristics alongside time-invariant company effects and time trends.

In Table 3, we present the baseline difference-in-difference results. In column (1) and (2), we show results from panel regressions of the dummy variable that takes the value unity for firms that report zero taxable income and zero for firms with positive taxable income. After the reform, treatment group firms reduce their probability to report zero taxable income in the UK. In columns (3) and (4), we show the intensive margin effect, in other words, the change in the average taxable income (in natural logarithm), after the reform. We find a positive and imprecise effect of the policy change on the average taxable income reported in the high-tax country (UK) after the CFC rule change for Italian-headquartered multinationals.

Table 3: Baseline reduced-form regression results

	Extensive Margin		*Intensive Margin*	
Outcome:	$\mathbb{1}(\text{Taxable Profit} \leq 0)_{i,t}$		$\ln(\text{taxable income})$	
	(1)	(2)	(3)	(4)
Treated × Post-reform	-0.065**	-0.054*	0.073	0.076
	(0.032)	(0.032)	(0.154)	(0.165)
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Year-Sector FE	N	Y	N	Y
No of obs	3876	3876	1096	1096

Note: This table shows the results of difference-in-difference regression estimates based on Equation 12 and 13. The results in columns (1) and (3) are based on a specification that includes firm and year effects, and columns (2) and (4) are based on a specification that includes firm, year and sector-year effects. The sample in column (1) and (2) is the whole sample including all control and treatment group companies. The sample in column (2) and (4) includes only the firms with taxable profit in all pre-reform periods.

5 Structural profit-shifting elasticities

In this section, we present structural estimates for the parameters of the distribution of our key *fixed* investment for tax avoidance price p and the variable cost γ of this model, using an indirect inference approach (Gallant and Tauchen; 1996; Gourieroux et al.; 1993). In our method of simulated moments (MSM) procedure, we simulate firms over unobserved productivity draws with $\varepsilon_i \sim \mathcal{N}(0, \sigma^2)$. Our structural estimates minimize the MSM criterion function, which takes the form:

$$L(\Theta) = h(\Theta)^{'} W_N h(\Theta) \tag{14}$$

where Θ is the vector of structural parameters of interest. $h(\Theta)$ is the vector of M moment conditions constructed as the difference between simulated moments computed over S simulated firms and empirical moments computed over the population of corporation tax returns composed of N companies. As the weight matrix, we use the diagonal elements of the inverse variance-covariance matrix of empirical moments.

The policy environment consists of a *high-tax* location, a *low-tax* location and a *tax haven*. All real investment takes place in the high-tax and the low-tax countries, but profit is then

shifted to the tax haven. The high-tax location in our case is the United Kingdom with 30% main corporate income tax rate over the relevant period. We envisage a low-tax location with 20% rate, but the availability of this alternative investment location in the model does not have a material impact on our estimates. The tax haven initially applies a tax rate of zero percent, which subsequently rises to 13.75% after the introduction of the CFC reform for treatment group companies, but the haven rate remains at 0% for the control group. We assume that the entry cost parameter $\bar{\phi}$ in Equation 4 is zero for the MNEs that are in our sample. We assume that the set-up cost for a network of subsidiaries is absorbed into the cost of the tax avoidance intangible captured at the MNE level by p_i and for which the distribution over firms is uniform between zero and $\bar{p}$.

We estimate production function parameters outside of the MSM procedure and find consistent estimates across various specifications. In Equation 11, we propose a static constant returns to scale (CRTS) production function that can be linearized and estimated as follows:

$$\ln R_{ij} = (1 - A) \ln \theta + A \ln K_{ij} + (1 - A)\varepsilon_{ij} \tag{15}$$

where R_{ij} is the output of subsidiary j that belongs to MNE i. We recover the production function parameters from the regression of the turnover (in natural log) on capital (in natural log) at the firm level.

In Table 4, we present the estimates from our preferred specification and show additional results in Appendix D. We estimate that the elasticity a of output with respect to tangible capital K is 0.649, and the total factor productivity θ (in log) is 4.767. We then take the residuals from this regression and use the standard deviation of residuals as an assumed parameter in our MSM procedure.

In our MSM procedure, we use simulated annealing with a simulated dataset size of 20,000, matching the key extensive and intensive margin reduced-form diff-in-diff moments to their simulated counterparts. We argue that both reduced-form coefficients are useful in identifying $\bar{p}$ and γ jointly, but we emphasize the direct link between the extensive margin diff-in-diff coefficient and $\bar{p}$, and between the intensive margin diff-in-diff coefficient and γ. We also match the pre-reform, control group levels of the average (log) taxable profit and the incidence of zero taxable for the same group.

We estimate that the unit cost of the tax avoidance intangible is distributed uniformly over the interval $(0, 2)$, meaning that the unit cost of the tax avoidance intangible is twice as high as the unit cost of tangible capital. We also estimate the convex cost parameter γ

Table 4: Structural estimates

	Assumed and Estimated Parameters		Method
δ:	Depreciation Rate, assumed	0.1	Assumed
β:	Discount Factor, assumed	0.95	Assumed
$\hat{\bar{p}}$:	Upper bound, cost of intangible	2.009***	MSM
		(0.497)	
$\hat{\gamma}$:	Convex cost of shifting	0.360***	MSM
		(0.093)	
$\hat{\theta}$:	Total factor productivity (in log)	4.767***	OLS and WG panel
		(0.362)	
$\hat{a}$:	Output elasticity wrt K	0.649***	OLS and WG panel
		(0.024)	
$\hat{\sigma}$	Std.dev of productivity draw	1.210	Post-estimation residuals
No of obs		3322	

Note: This table shows the assumed parameters, the parameters estimated outside of the MSM procedure and our estimates for the structural profit-shifting cost parameters using our MSM procedure. We use the diff-in-diff coefficient estimates from Section 4 to match to simulated counterparts, as well as the level of average (log) taxable income and the share of reporters of zero taxable profit for the control group in the pre-reform period.

to be significant, but not very large, at 0.36. We infer that the inclusion of what we call the *fixed* tax avoidance cost also helps to pin down the convex cost parameter more precisely.

Model fit is satisfactory, with simulated moments estimated to be 0.095 for the intensive-margin reduced-form coefficient, relative to the corresponding data moment of 0.073 (0.154) and -0.040 for the extensive-margin reduced-form coefficient, relative to the corresponding data moment of $-0.065^{**}(0.032)$.

6 Discussion: reconciling micro- and macro-level estimates of profit-shifting elasticities

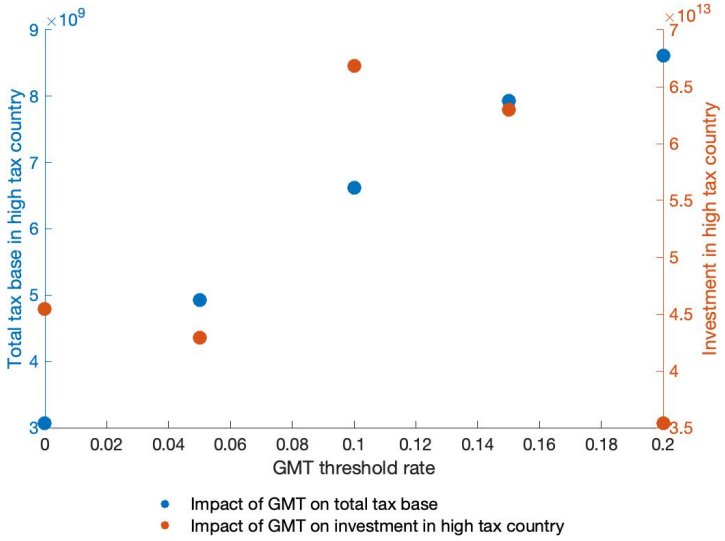
There are three major ways in which our approach in this paper differs from the earlier treatments of profit-shifting in the literature. First, we modify the profit-shifting cost structure to demonstrate the impact of investment in a tax avoidance network. Second, by modeling the nonconvex profit-shifting cost, we also account for zero profit-reporting MNEs in a jurisdiction in our elasticity calculation. This naturally leads to a comparison between macro-level and micro-level semi-elasticities of declared profit in a jurisdiction with respect to the tax rate differential with the lowest tax haven tax rate. Combining these two effects, we find that the macro-level profit-shifting elasticity is 45% higher than the micro-level profit-shifting elasticity that ignores zero taxable income reporters.

Third, we model unobserved heterogeneity across firms in their ability to shift profits to tax havens through the idiosyncratic price of the tax avoidance intangible faced by the multinational, p_i. The most flexible multinationals in their profit-shifting ability respond to changes in the tax rate differential 10 times more than the least flexible MNEs. The macro taxable income elasticity estimate of -9.6% (in response to a percentage point rise in the tax rate differential) masks the high-elasticity firms' response of around -40% and the low elasticity firms' response of -4%. The policy response depends on what types of firms the government would like to tax. Often, in policy discussions, government officials point at 'the worst offenders' as the digital firms such as Google or Facebook. Arguably, these firms are in the high-elasticity group as they face low prices to set up tax avoidance networks thanks to the nature of their business.

7 Counterfactual policy experiments

The model that we have developed in Section 2 provides a convenient tool to examine the effects of counterfactual policies. Governments have, in the past, used tax rate changes, controlled foreign company rules and taxes on revenues to *punish* tax avoidance behavior and increase tax revenue. More recently, as we have outlined in Section 1, negotiations for the global minimum tax proposal have intensified. In line with this policy portfolio, we analyze the effects of corporate income tax rate changes and the jurisdictional global minimum tax at different thresholds. Using our framework, it is also possible to assess the impact of alternative policies such as digital service taxes or controlled foreign company rules.

Figure 5: Impact of global minimum tax on the tax base and investment



8 Conclusion

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Appendices

A Production Functions

A.1 Simple Case

Choose K and L to maximise profit:

$$\pi = p(Y) - rK - wL \tag{16}$$

where

$$Y = AK^{\alpha}L^{\beta} \tag{17}$$

Note that we are going to need either imperfect competition or non-constant returns to scale to identify the profit maximising position. I have left both in.

Conditional on K, the optimal L is given by

$$\pi_L = (p_Y Y + p)Y_L - w = 0 \tag{18}$$

Rearranging,

$$p(1 - \frac{1}{\epsilon})\beta AK^{\alpha}L^{\beta-1} = p(1 - \frac{1}{\epsilon})\beta\frac{Y}{L} = w \tag{19}$$

where

$$\epsilon = -Y_p\frac{p}{Y} \tag{20}$$

which is a function of Y. Define $R = p(1 - \frac{1}{\epsilon})$ to be marginal revenue.So

$$L = \frac{R\beta}{w}Y \tag{21}$$

Then

$$Y = AK^{\alpha}(\frac{R\beta}{w}Y)^{\beta} = (\theta K^{\alpha})^{\frac{1}{1-\beta}} \tag{22}$$

where

$$\theta = A(\frac{R\beta}{w})^{\beta} \tag{23}$$

In the case of constant returns to scale in K and L, so that $\alpha + \beta = 1$, this is

$$Y = \theta^{\frac{1}{1-\beta}}K \tag{24}$$

where, to recall in the absence of perfect competition, θ depends on Y. With perfect competition and CRS, the optimal scale of the investment / company is not defined.

A.2 Slightly More Complicated Case

Now think of A reflecting some knowledge capital, and set out a production function as:

$$Y = A^{\phi}(K^{\alpha}L^{\beta})^{1-\phi} \tag{25}$$

which imposes CRS on A and the composite of K and L.
Conditional on K, the foc for L is

$$L = \frac{R\beta(1-\phi)}{w}Y \tag{26}$$

Substituting,

$$Y = A^{\phi}(K^{\alpha}(\frac{R\beta(1-\phi)}{w}Y)^{\beta})^{1-\phi} \tag{27}$$

So

$$Y^{(1-\beta(1-\phi))} = A^{\phi}(\frac{R\beta(1-\phi)}{w})^{\beta(1-\phi)}K^{\alpha(1-\phi)} \tag{28}$$

$$Y = \theta^{\lambda}K^{\alpha(1-\phi)\lambda} \tag{29}$$

where

$$\theta = A^{\phi}(\frac{R\beta(1-\phi)}{w})^{\beta(1-\phi)} \tag{30}$$

and

$$\lambda = \frac{1}{1-\beta(1-\phi)} \tag{31}$$

B Guiding cases

Consider first the case in which $0 < \alpha_{ij} < 1$ for subsidiary j. Then the first order condition for α_{ij} and K_{ij} is:

$$\alpha_{ij} = \frac{(\tau_{ij} - \tau_X)}{\gamma}(\frac{Y_i}{B_{ij}})^m \tag{32}$$

$$F_K(K_{ij}^{\text{Interior}}) = \frac{r}{1 - \tau_{ij} + (1-m)\frac{\gamma}{2}\left(\frac{B_{ij}}{Y_i}\right)^m \alpha_{ij}^2} + \delta \tag{33}$$

Note that Equation 33 has an additional term in the denominator compared to the traditional case with no profit-shifting. In what might be regarded as a normal case, we would expect this term to be positive, lowering the cost of capital and hence raising the optimal level of the tangible capital stock, K_{ij}. This requires $m < 1$.

If $\alpha_{ij} = 1$, the first order condition for K_{ij} becomes:

$$F_K(K_{ij}^{\text{Full shifting}}) = \frac{r}{1 - \tau_X - (1+m)\frac{\gamma}{2}(\frac{B_{ij}}{Y_i})^m} + \delta \tag{34}$$

In Equation 34, the cost of capital is independent of the domestic tax rate τ_j, since all profit is shifted to the haven, but now the haven tax rate, τ_X is relevant. Note though, that even if $\tau_X = 0$, tax still has an indirect impact on the cost of capital through the marginal cost of profit-shifting in the last term of the denominator.

The optimal choice of tangible capital K_{ij} for each subsidiary still depends on the optimal level of Y. With $Y_i > 0$ there are three possible outcomes of interest that generate kinks in the policy function:

1. $0 < \alpha_{ij} < 1$ for all α_{ij};
2. $0 < \alpha_{ij} < 1$ for at least one subsidiary j, and α_{ij}=1 for at least one subsidiary j;
3. $\alpha_{ij} = 1$ for all α_{ij}.

Using the functional form for $c(\alpha_{ij}, Y_i, B_{ij})$ set out above, the first order condition for Y_i is:

$$Y_i = \left\{ \frac{m\gamma}{2p(1+r)} \sum_{i=1}^{N} B_{ij}^{1+m} \alpha_{ij}^2 \right\}^{\frac{1}{1+m}} \tag{35}$$

C Model solution

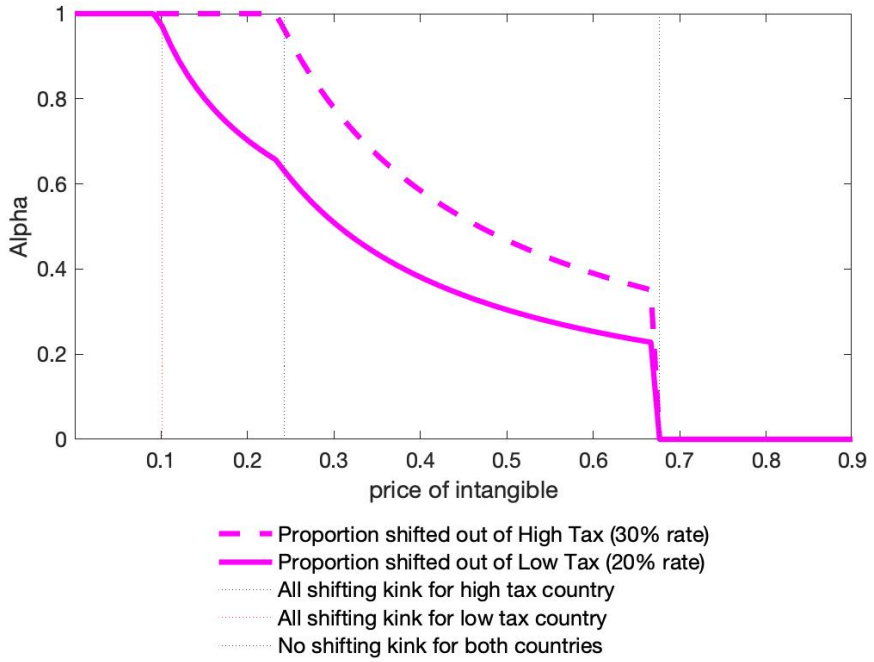
We now illustrate the properties of the model in a numerical simulation. We consider a multinational with real activities in two subsidiaries, one in a relatively high-tax country, H and one in a relatively low-tax country, L. In our base case the tax rates in the two countries are 30% and 20% respectively. The multinational also has a third subsidiary, located in a tax haven, initially with a zero tax rate. The multinational optimally chooses its investment in the tax avoidance asset, Y, the tangible capital located in H, K_H, and L, K_L, and the proportion of the tax base shifted to the haven from H, α_H, and from L, α_L.

C.1 Base case

Figure 6 illustrates the choices of α_H and α_L for a range of values of the unit price of Y, p. The price of a unit investment in physical capital is normalized to one. Values of the

structural parameters used in this base case are: $\gamma = 0.2$, total factor productivity $\theta = 0.9$, output elasticity with respect to physical capital $a = 0.65$, depreciation rate for physical capital $\delta = 0.1$. We also allow for a fixed cost of investing in the tax avoidance intangible of ϕ that only applies to those firms with any profit-shifting. In the simulations, we set ϕ to be 0.2. The dashed line shows α_H and the continuous lines shows α_L.

Figure 6: Extent of profit shifting in H and L

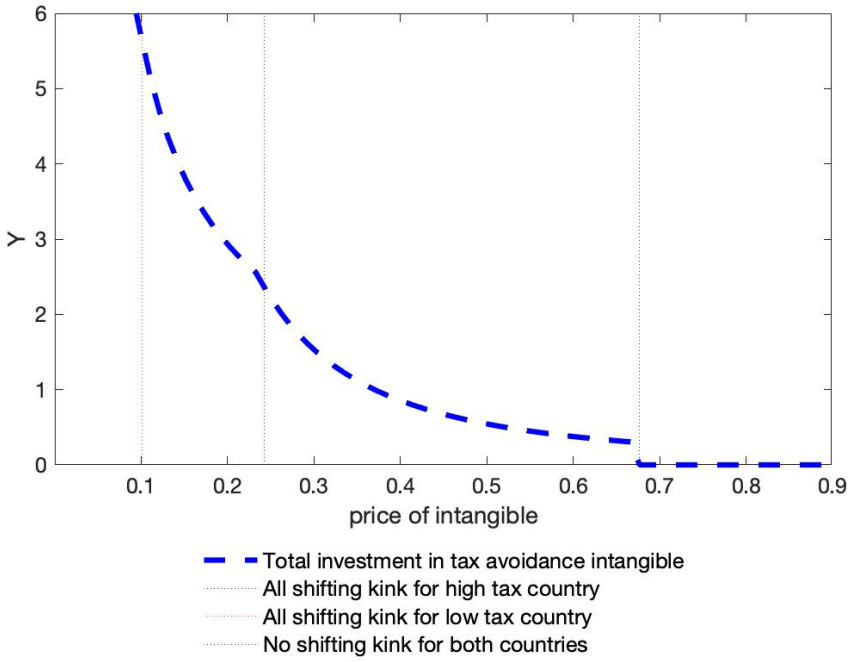


The Figure is mostly easily interpreted as the value of p falls from 1. At the right had since of the Figure, for $p = 1$, $\alpha_H = \alpha_L = 0$ - there is no profit shifting from either country. As shown in 7, this reflects the fact that the multinational has also not invested in the tax avoidance asset, Y. However, as p falls to around 0.68, it becomes worthwhile for the firm to invest in Y. As p falls further, investment in Y increases (Figure 7). The higher Y reduces the variable costs of profit shifting, and so both α_H and α_L rise (Figure 6).

There are two offsetting effects on the relative values of α_H and α_L. First, the higher tax rate in H would induce more profit shifting. Second, however, the tax base in L is higher, since K_L is higher, as set out below. The first of these effects dominates in our base case, so that over this region $\alpha_H > \alpha_L$. However, this depends on the productivity in each location: for example, if L is more productive ($\theta_L > \theta_H$), then it is possible for this ordering to be

reversed.

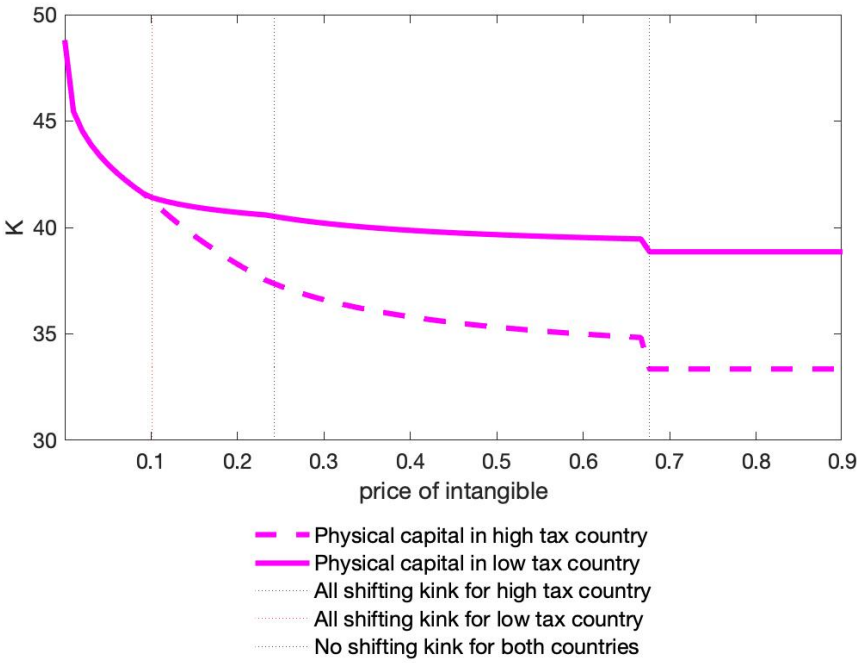
Figure 7: Investment in the Tax Avoidance Asset Y



In this base case, we are assuming the same production functions in H and L ($\theta_L = \theta_H$). In the absence of profit shifting, for $p > 0.68$, the difference in tangible capital between the two countries is determined only by the difference in tax rates, implying that $K_L > K_H$. This is shown in Figure 8, where again H is represented by the dashed line and L by the unbroken line. However, at values of p where both subsidiaries begin to shift profit, the tax rates fall in both countries, and so K_L and K_H both rise. Note that the difference in the "effective" statutory tax rates is diminished due to profit shifting, and so K_H rises more quickly than K_L.

As p falls to around 0.24, profit shifting from H hits the constraint of $\alpha_H = 1$. All profit in H is shifted to the haven; no tax is then paid in H, although H continues to bear the variable costs of shifting. This reduces the marginal benefit of Y, generating a small kink in Y, and also in K_H. The same happens for L when p reaches around 0.09. At this point, all profit is being shifted to the haven, and no tax is paid anywhere. At this point, there is no benefit in increasing Y any further, and so Y is at its maximum level for all values of p below this. At this point, investment in tangible capital is no longer affected by tax, but it

Figure 8: Investment in tangible capital, K_H and K_L



is affected by the costs of profit shifting. However, the costs of profit shifting are now the same in H and L, and so K_H and K_L are also equal. Lowering p further does not induce more investment in Y, but it does reduce costs for the multinational, resulting in further increases in both K_H and K_L.

C.2 Minimum worldwide tax

In October 2021, the OECD's Inclusive Framework agreed to introduce a worldwide minimum tax at a 15% effective tax rate. This would be implemented in the first instance by the country of the parent introducing a tax to top up any tax in any other location to make it up to at least 15% of profit. A key aim of this policy is to raise more tax revenue from profit, either by more tax being levied from profit arising in low-tax jurisdictions, or by discouraging profit being shifted to such countries in the first place. We now consider the likely effects of this policy in the context of our model, and the base case set out above.

We model the minimum tax by raising the tax rate in the tax haven to either 5% or 15%. This clearly reduces the benefits from shifting profit to the haven. This in turn reduces the incentive to invest in the tax avoidance asset, Y, and so makes it more likely that

multinationals will respond on the extensive margin by no longer shifting any profit.

Figure 9 describes the impact on profit shifting in our base case. The Figure reproduces the position in the absence of the minimum tax from Figure 6. The new lines represent the case of the minimum tax at 5% and 15%. Given the parameters in the base case, this has a dramatic impact on profit shifting. At a minimum tax of 5%, the multinational chooses not to invest in Y unless its price is below around 0.3. For a minimum tax of 15%, this falls to 0.04. In the latter case, especially, apart from at very low values of p - which in the absence of the minimum tax yielded 100% profit shifting in both H and L - the minimum tax prevents any profit shifting from taking place. For low values of p, the subsidiary in country H moves almost directly from zero profit shifting to full profit shifting. By contrast, even at p very close to zero, the subsidiary in country L does not reach full profit shifting.

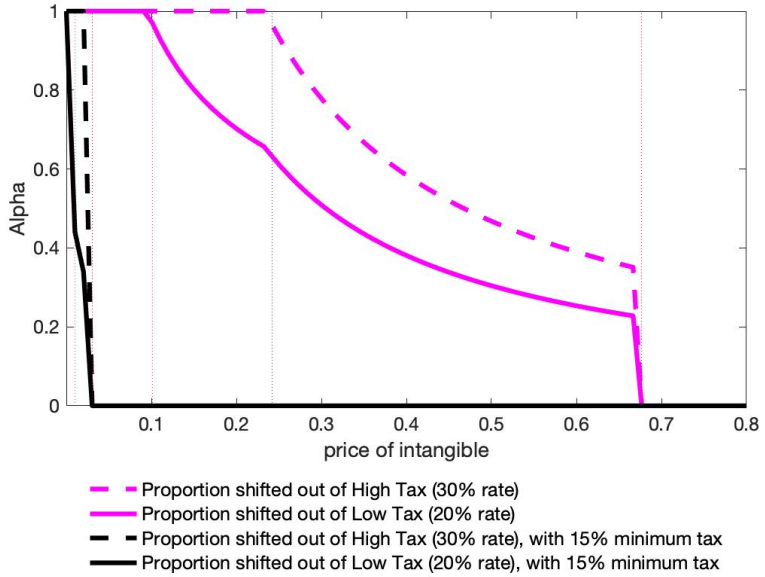
This suggests that there are plausible cases in which the key response to the minimum tax is on the extensive, rather than the intensive, margin. At moderate values of p, both subsidiaries would move from partial shifting to no shifting. Only at very low values of p wold there be any profit shifting at all. We now turn to estimating the parameters of the model.

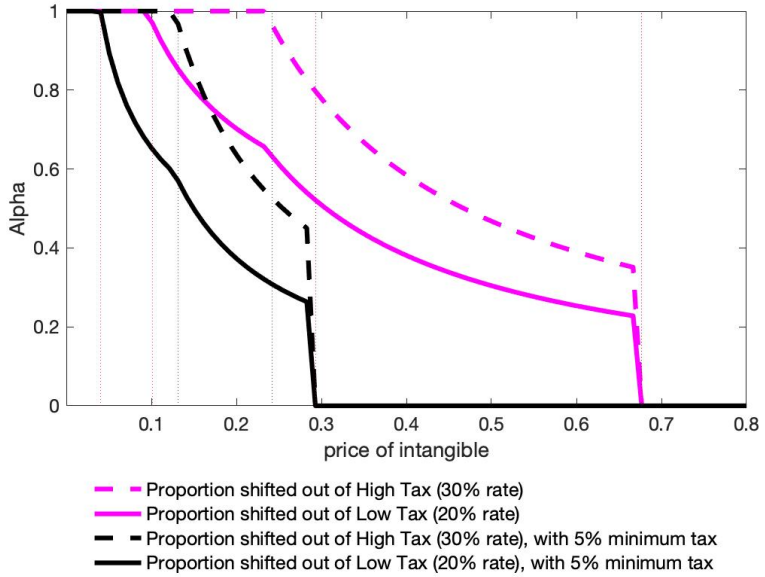
We demonstrate the importance of the statutory minimum tax rate in the second panel of Figure 9, which establishes the minimum tax rate at 5%. The change in profit shifting substantially more mild in the second panel of the figure.

C.3 Response to changes in other variables

In this section, we revert back to the case without any minimum tax, but we present the response of profit shifting, investment in the tax avoidance intangible and investment in physical capital when policy parameters and structural parameters change.

Figure 9: Extent of profit shifting in H and L with a 15% (top panel) and 5% (bottom panel) minimum tax





D Production function estimates

Table 5: Production function estimates, static

Dep var: $\ln y$	1	2	3	4	5	6
$\ln k$	0.638***	0.638***	0.649***	0.715***	0.716***	0.721***
	(0.023)	(0.023)	(0.024)	(0.019)	(0.019)	(0.021)
Constant	5.313***	5.236***	4.767***	4.230***	4.151***	3.740***
	(0.329)	(0.329)	(0.362)	(0.275)	(0.278)	(0.334)
R^2	0.504	0.505	0.548	0.532	0.533	0.57
No of obs	3322	3322	3322	3322	3322	3322
Firm FE?	Y	Y	Y	N	N	N
Mean$(\hat{\varepsilon})$	0	0	0	0	0	0
St.dev$((1-A)\hat{\varepsilon})$	1.269	1.268	1.210	1.233	1.232	1.181

E Other reforms