Tax Avoidance Networks and the Push for a 'Historic' Global Tax Reform

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Extended Abstract

1 Introduction

Multinational corporations' (MNCs) tax avoidance activities rely on highly complex global subsidiary networks. Profitable innovative companies with a large portfolio of intangible assets use these networks intensively to minimize their tax liability in high-tax jurisdictions. In the aftermath of the Global Financial Crisis, public finances were depressed dramatically, and profit-shifting has intensified due to complex corporate structures (Figure 1). Both the governments' need for tax revenue, and the very small amount of taxes paid by MNCs in high-tax jurisdictions, have triggered dramatic changes in international efforts to reform tax systems.

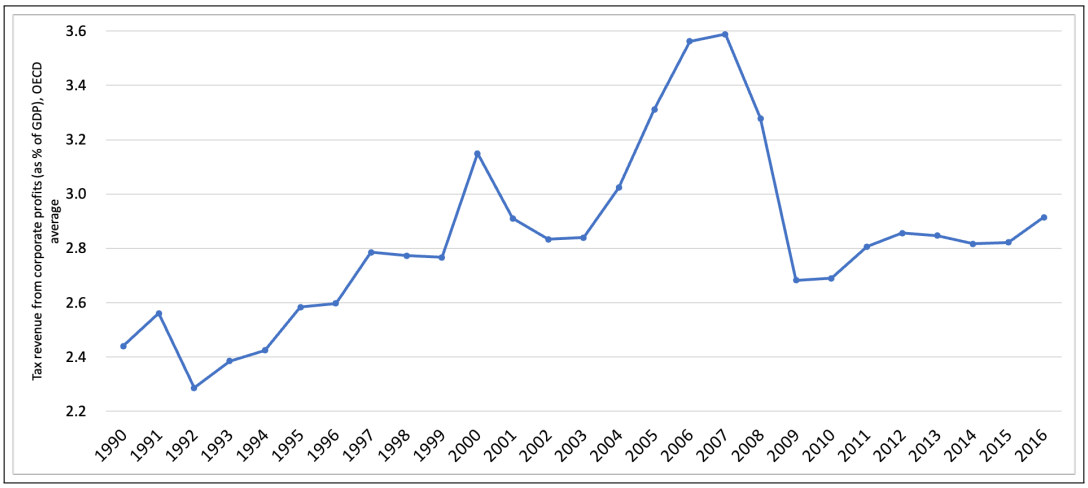
As of February 2022, the Global Minimum Tax proposal has agreement from 141 countries. These countries have further agreed to pass relevant domestic legislation by the end of 2022 for implementation to start in 2023.[1] The policy debate surrounding this unprecedented international tax reform agenda emphasizes R&D-intensive and innovative companies' superior ability to move capital easily around the world.

In this paper, we ask: "how do highly profitable MNCs shift profits to tax havens, and how can international tax reform change such patterns?" We propose to provide policy-relevant information on tax avoidance networks through the use of intellectual property

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

Figure 1: Taxes on income, profits and capital gains of corporates (as % of GDP), *Source: OECD*



(IP) and subsidiary-ownership relations. To achieve this, we use three novel datasets. First is the ORBIS Intellectual Property (IP) Database that covers patent applications globally. Many authors in the past have worked with PATSTAT data that covers European Patent Office's patent applications and United States Intellectual Property Office's intellectual property data. ORBIS IP dataset includes both of those, and additionally, expands the coverage beyond Europe and the US. The second important dataset that we will use is a historical company ownership dataset from ORBIS. This data allows us to track subsidiary locations of multinational firms from 2004 onwards. As such, the matched data covers the location of subsidiaries, and consequently, firm activities as well as patents around the globe and allows us to consider links between the location of IP and firm activity. Finally, we plan to examine confidential UK royalty flows data at the UK company-country level (available from the UK Office for National Statistics). We aim to explore the relationship between patenting activity, patent valuations and royalty flows.

Using our data, we provide two sets of main findings. The first set of findings relates to patents held by US companies globally. The second set relates to patents held by all companies globally. For US firms, we find a large increase in patenting activity (Figure 2). Patenting activity has intensified substantially since 1990. We also observe a large increase in the number of patent applications in tax havens, especially since the year 2000. However, since mid-1970s, the share of patent applications in tax havens has declined together with the share of patent applications abroad. In this paper, we will further explore whether the patents located in tax havens are the more valuable ones, and whether the number of

patents may be unrelated to the tax avoidance capability of MNCs.

The patenting activity of US MNCs has been mostly confined to US, Europe and Australia in 1960, as demonstrated in Figure 4. Since the 1980s, the globalization started and the patenting activity followed, shifting towards Asian countries, which now constitute a large portion of locations where US MNCs apply for patents. As a matter of fact, the top 5 locations outside of the US for patent applications in 1960 were UK, France, Germany, Belgium and Switzerland. In 2018, they were China, Japan, Australian, South Korea and Taiwan. This shift has been accompanied by the use of tax havens. In particular, the tax haven patent applications in the 1960s were predominantly done in Switzerland and Ireland. In 2018, Singapore and Hong Kong, followed by Cayman Islands dominate. This shift towards tax havens and foreign locations is reflected in the declining average corporate tax rates in locations where US firms are filing patent applications and in a decline in the share of high tax patent application locations (Figure 3).

Using all companies' (US and non-US) data, we find similar patterns. First, the total number of patents has been on the rise since 1980 (Figure 5). This has been driven by the largest firms (the top 1%) with a much smaller increase in the average number of patents held by smaller firms. The top 1% of the largest global companies have also been expanding the number of countries in which they hold patents most intensively. However, since the 1980s, there has been a decline in the average number of countries in which patents are held, which corresponded to an increase in the share of patents in the top 1 location. This suggests patent concentration. In Figure 6, we show the evolution of the top 1 patent locations for firms in our sample. These maps demonstrate that there has been an increase in the patenting activity between 2000 and 2010 in countries where patents were already being applied for, but no expansion in country coverage for the top 1 destinations. As such, the raw patent data does not immediately provide us with a complete picture of tax avoidance networks. These descriptives suggest that MNCs are sophisticated in building their tax avoidance networks and they do not simply apply for patents in tax havens.

Using Orbis ownership data on the presence of foreign subsidiaries in the firm structure, we demonstrate large changes in the types of firms that are involved in patenting activities. In the early wave of the patent application increase in 1980s, most of these applications were made by larger MNCs with larger foreign presence (Figure 7). Similarly, the expansion of foreign and tax haven patent applications has been pioneered by those larger firms. Since 2000, there has been a rapid expansion of patenting activities by smaller MNCs, i.e. those with fewer than 10 foreign subsidiaries. These firms have especially increased their patent applications in tax havens. This data suggests that there have been

important shifts in which firms use IP most often and how concentrated the use of patents amongst MNCs is. We plan to explore these further in the full draft of the paper, by linking the patenting data with firm financial data to establish links between patent locations and physical locations, especially in low tax jurisdictions.

More generally, in this paper, we describe the heterogeneity of profit shifting practices amongst businesses, focusing on patent holdings. The location of patents in low-tax jurisdictions has been shown to be one of the key methods of profit shifting for MNCs. MNEs can locate their patents in low-tax subsidiaries, such that any profits earned on those patents will be taxed at lower rates. Further, royalties for the use of those patents by other subsidiaries will also be taxed at lower tax rates, while the cost of paying the royalties will be deducted against profits in high-tax countries.

Major responses to concerns about the scale of tax avoidance in the form of profit shifting have arguably run ahead of academic evidence. There have been many empirical studies aimed at uncovering the extent 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. For example, in a recent study Riedel (2018) reports estimates of shifting from 5% to 30% of taxable profit and concluded that "[i]t is thus too early to draw final conclusions on the quantitative importance of international tax avoidance activities."[2]

Part of the reason for uncertainty with respect to the degree of profit shifting 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. But that is only partially the basis for the international allocation of taxing rights, which also allocates rights to jurisdictions in which valuable assets are owned, or lending originates. Other approaches taken in the literature are reviewed elsewhere.[3]

Our results also serve as a motivation for a related work on the costs of profit shift-

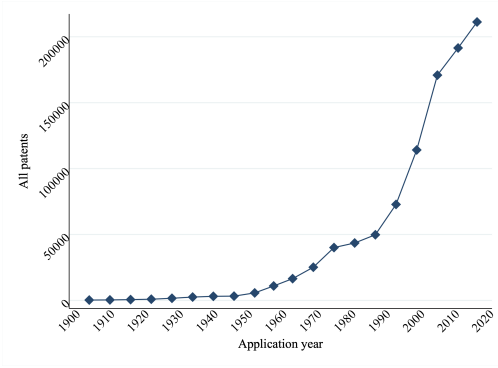
[2]See also, for example, Hines and Rice (1994), Grubert and Slemrod (1998), Desai et al. (2006), Slemrod and Wilson (2009), Egger et al. (2010), Dischinger and Riedel (2011), Dharmapala and Riedel (2013), Dischinger et al. (2014), and Gumpert et al. (2016).

[3]See, for example, Dharmapala (2014) and Riedel (2018).

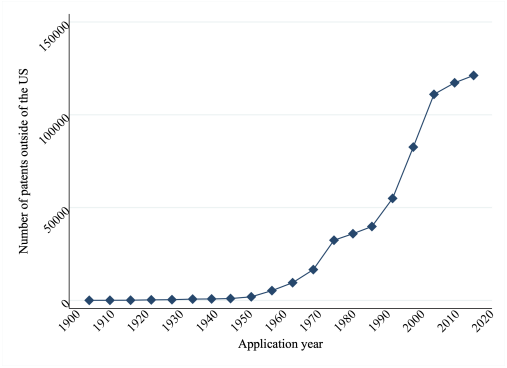
ing (Bilicka et al.; 2020). In our companion technical paper, we use company tax returns matched with global ownership information to assess the impact of domestic and international tax reforms combining a reduced form difference-in-difference framework with a structural approach. Dharmapala (2014) points out that there is a distinct difference in estimates of the scale of profit shifting in studies using micro data compared to earlier studies using macro data. As Dharmapala notes, "i*n the recent literature, the estimated magnitude of BEPS is typically much smaller than that found in earlier studies*". He goes to note the importance of existing legal and economic frictions and to state that "*one approach to understanding these frictions is for future research to model more precisely the costs of tax planning in a way that explains the apparent heterogeneity among firms in their tax-planning behaviour* (*in particular, by taking account of the possibility that tax planning involves fixed costs*)". We view the efficient and effective location of patents in low-tax jurisdictions as one of such fixed costs of tax planning.

Finally, a discussion on the nature of costs of profit shifting is also motivated by the results of Bilicka (2019), who compared the UK tax position of subsidiaries of foreign-owned multinationals with that of domestic companies. She found that 50% of observations of foreign-owned multinationals reported zero UK taxable profits, compared to only 20% of domestic companies. This suggests that many multinationals are at a corner solution in choosing the proportion of profit which they shift. Instead of equating the marginal costs and benefits of shifting (on the assumption of a convex cost function, commonly used in the literature, presumably for convenience) at a proportion of shifting between zero and 100%, they may be in position where marginal benefits exceed marginal costs, but where they have reached the upper limit of the proportion of profit that can be shifted. Our discussion of where firms hold patents lends itself to this interpretation.

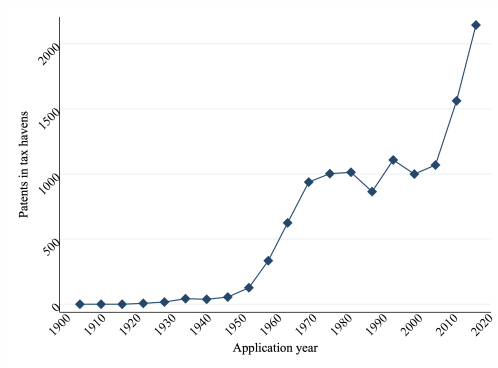
Figure 2: The evolution of firm patents over time: US firms.



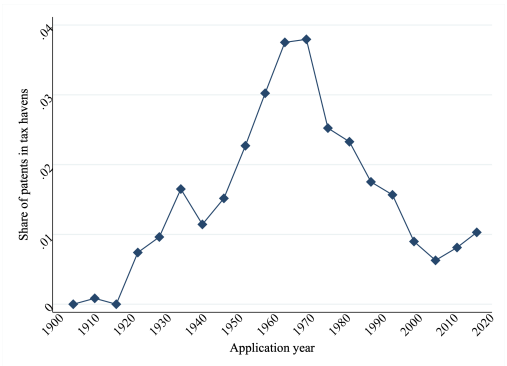
(a) Total patent applications.



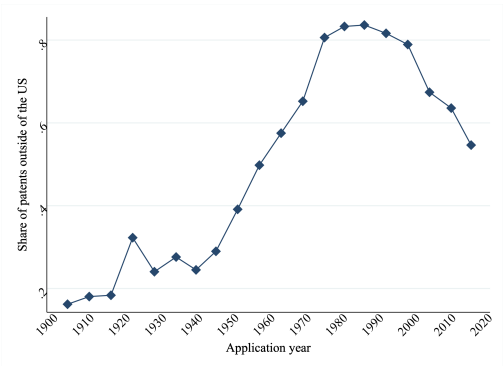
(b) Foreign patent applications.



(c) Tax haven patent applications.



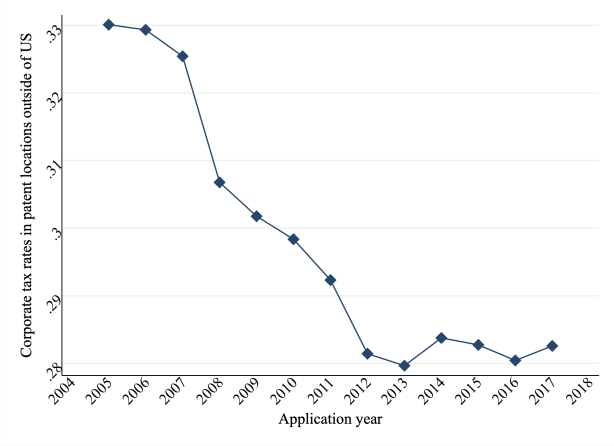
(d) Share of patent applications in tax havens.



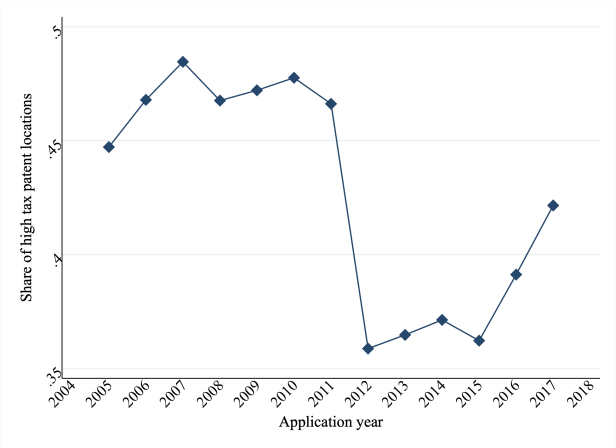
(e) Share of patent applications outside of the US.

Note: Source: matched Orbis IP data and Orbis ownership data. These figures demonstrate the evolution of the patenting activity of US firms. We include 14,000 firms for which we have total assets available at the consolidated level for at least one year.

Figure 3: Tax rates and patent location: US firms.



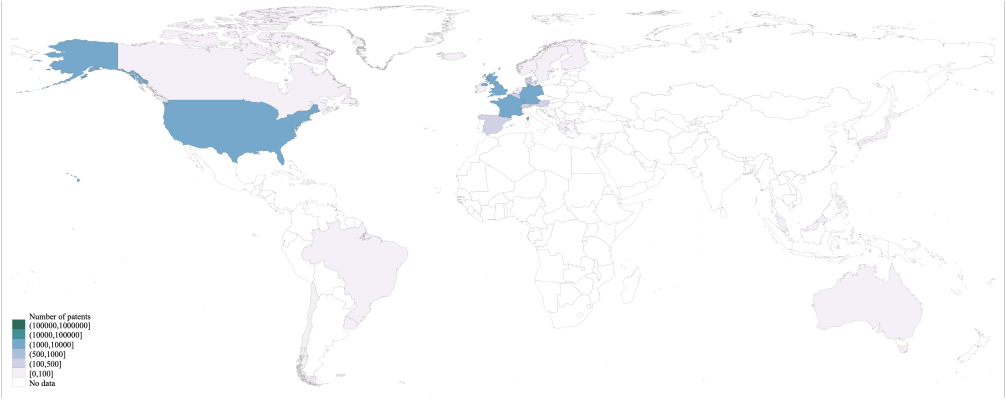
(a) Tax rate in patent application locations.



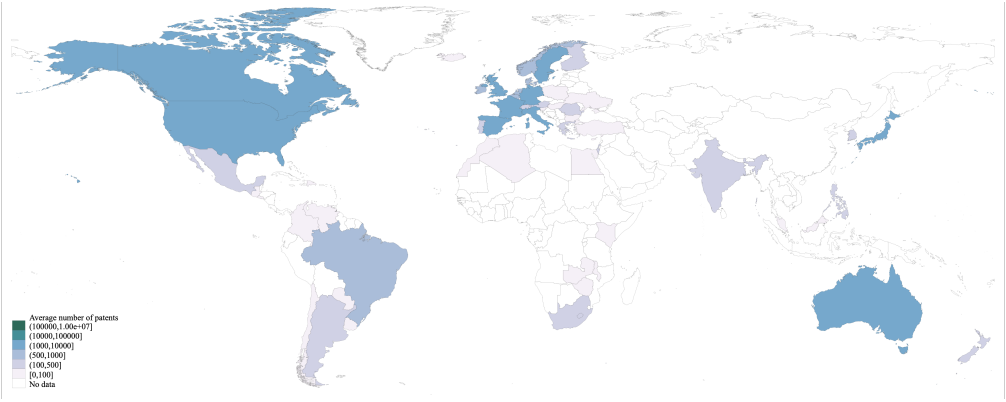
(b) Share of high-tax patent application locations.

Note: Source: matched Orbis IP data and Orbis ownership data. Panel a shows the evolution of the average corporate tax rates in locations where firms are applying for patents. Panel b shows changes in the share of high tax patent application locations. High tax is defined as above median tax rate in each of the years in the sample. We include 14,000 firms for which we have total assets available at the consolidated level for at least one year.

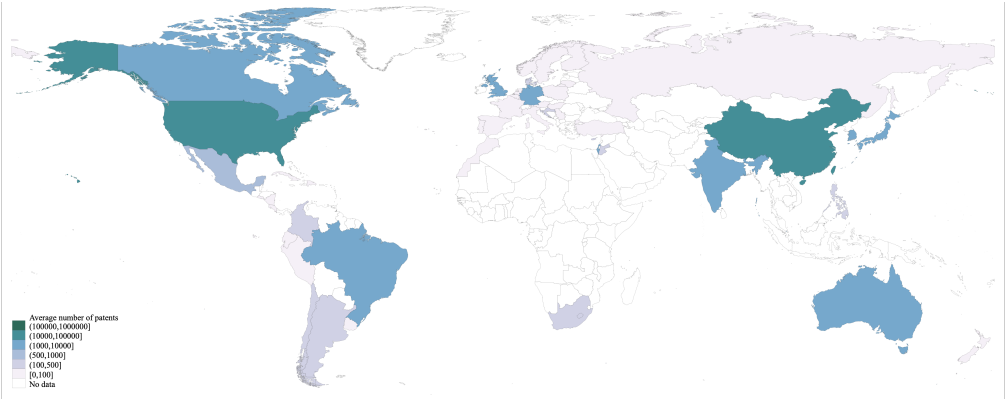
Figure 4: The location of US patents across years.



(a) 1960 patent application locations



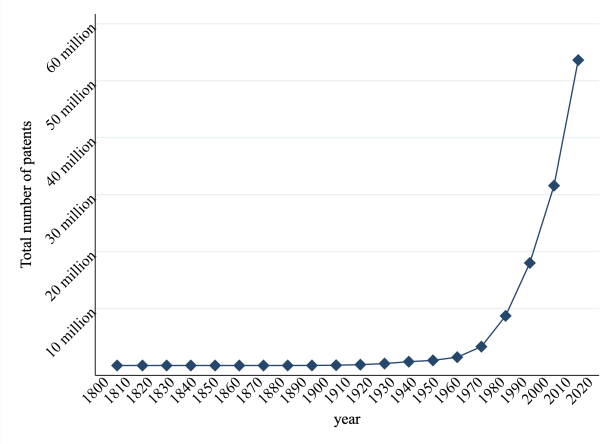
(b) 1980 patent application locations



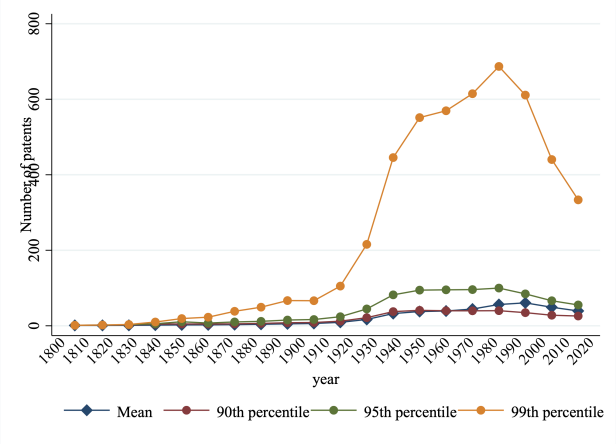
(c) 2018 patent application locations

Note: Source: matched Orbis IP data and Orbis ownership data. These maps plot the total number of patent applications by US companies in various global locations. Panel a shows the distribution in 1960, Panel b in 1980 and Panel c in 2018. We include 14,000 firms for which we have total assets available at the consolidated level for at least one year.

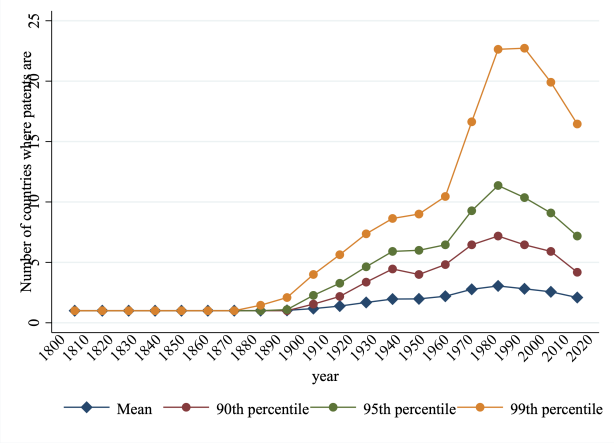
Figure 5: The evolution of firm patents over time.



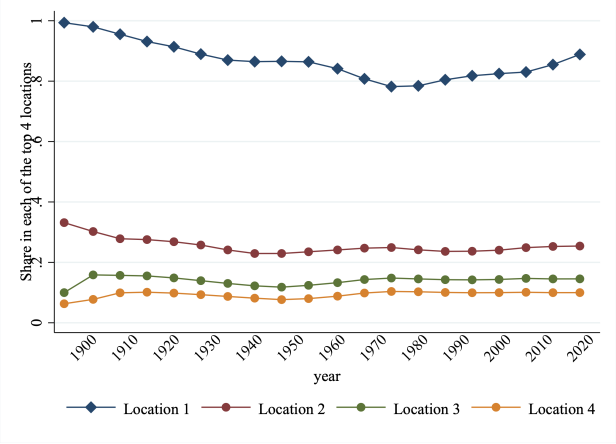
(a) Total number of patents



(b) Average number of patents



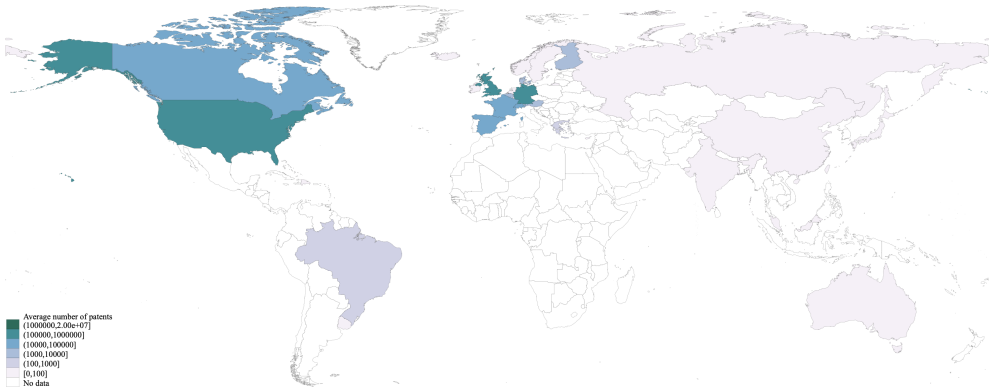
(c) Number of patent location countries



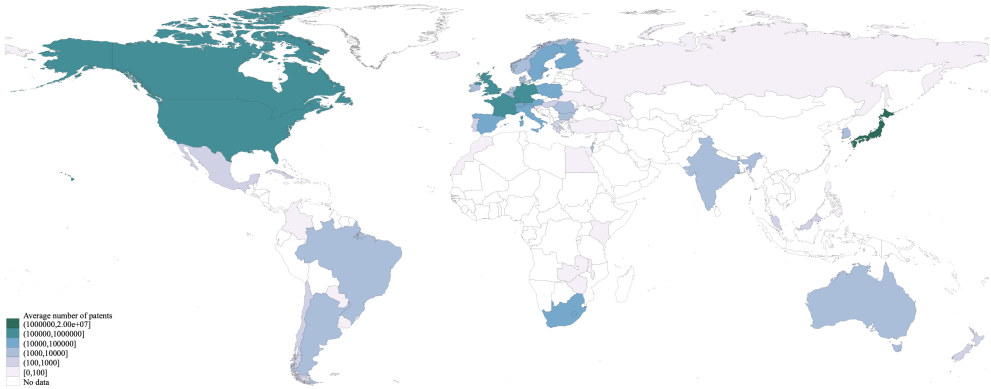
(d) Share of patents in each of the top 4 locations.

Note: Source: matched Orbis IP data and Orbis ownership data. These figures demonstrate the evolution of the patenting activity of all firms in the sample. We use aggregated patenting data here. In Panels a- c we track the total number of patent applications, the average number of applications, and the average number of countries where patents are applied for. In Panels b and c, the percentiles are related to distribution of firm-patent locations. In Panel d, we look at the share of patent applications across the top 4 locations in which patents are applied for.

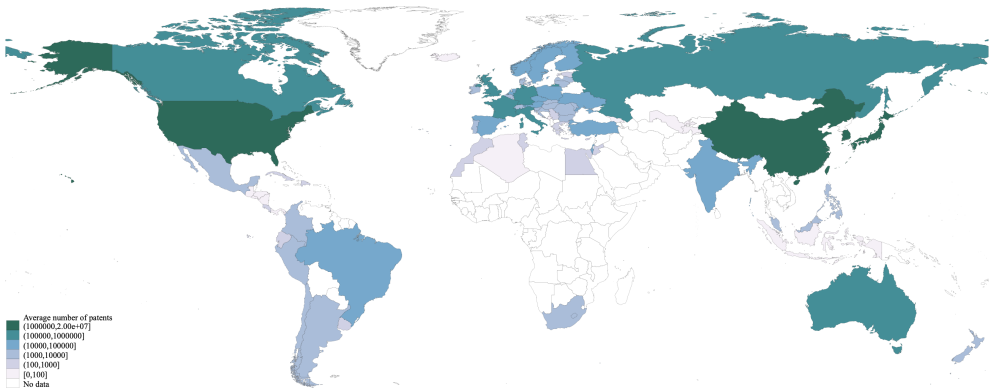
Figure 6: Top patent locations across years.



(a) 1960 top locations



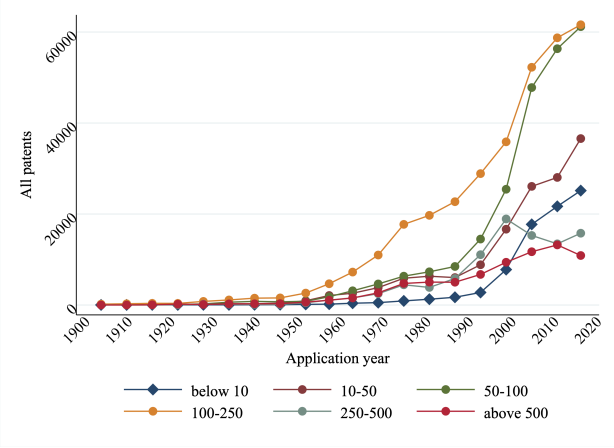
(b) 1980 top locations



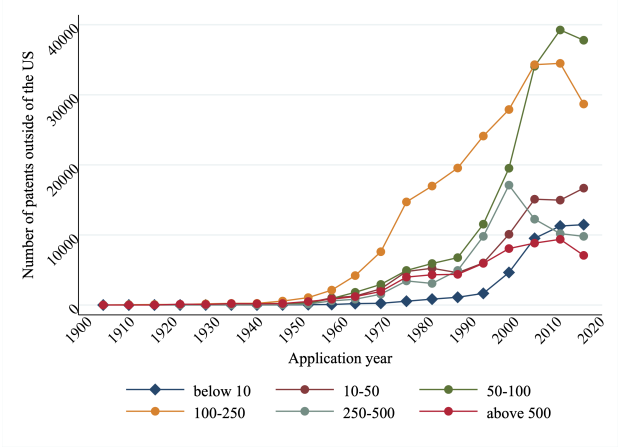
(c) 2019 top locations

Note: Source: matched Orbis IP data and Orbis ownership data. These maps plot the total number of patent applications in the top 1 patent application location for each firm. Panel a shows the distribution in 1960, Panel b in 1980 and Panel c in 2018. We include 14,000 firms for which we have total assets available at the consolidated level for at least one year.

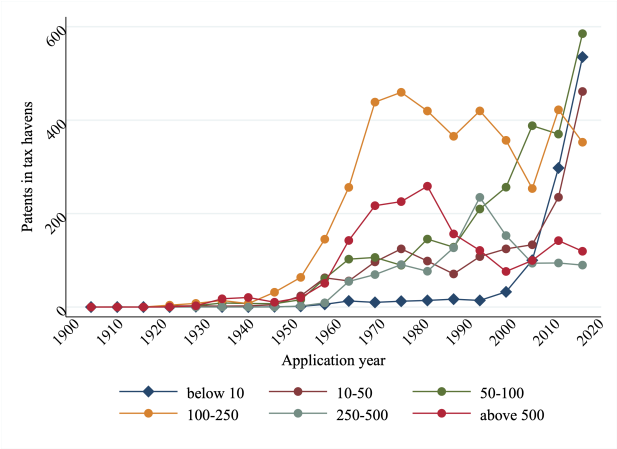
Figure 7: Firm ownership and patenting activity: US firms.



(a) Total patent applications.



(b) Foreign patent applications



(c) Tax haven patent applications.

Note: Source: matched Orbis IP data and Orbis ownership data. Panel a shows the evolution of the total number of patent applications, Panel b foreign patent applications and panel c tax haven patent applications. In each panel, we split the applications according to the number of foreign affiliates each MNCs has. To count as a foreign affiliate, the firm has to report to have at 50% of ownership share in that affiliate and it needs to be located outside of the US. Here, we include 14,000 firms for which we have total assets available at the consolidated level for at least one year and whihc are located in the US.

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Investing in Tax Avoidance: Optimization Frictions and the Fixed Cost of Profit Shifting

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Preliminary and incomplete

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Abstract

In this paper, we build a model that accounts for both intensive- and extensive-margin profit-shifting responses of multinationals to tax system differentials. Our new approach reconciles the differences between previous micro- and macro-level estimates of profit-shifting elasticities, by incorporating investment in tax avoidance assets, such as fixed tax advisor fees or in-house tax avoidance capabilities. We test the predictions of our model using tax returns data from the UK and a reform in Italy that limited profit-shifting activities of Italian multinationals from the UK to tax havens as a quasi-natural experiment. Both theoretically and empirically, we find that, as profit-shifting to tax havens becomes harder, firms both increase the amount of profit that they report in a high-tax jurisdiction (intensive margin effect) and the probability to report any profit in that jurisdiction (extensive margin effect). We match the key moments from our reduced-form analysis to their simulated counterparts and estimate the structural parameters of our model. We use this model to evaluate counterfactual policy experiments, including the effects of the global minimum tax proposal.[1]

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[1]We would like to thank the participants of Royal Economic Society 2021, IIPF 2021, NTA 2021 and seminar participants at the University of Michigan for their comments.

1 Introduction

This paper provides a novel framework for analyzing the heterogeneous investment and profit-shifting behavior of multinationals within the international tax system. The incidence of reporting zero-taxable profits 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, multinationals' profits display sharp bunching at the taxable income zero-lower-bound in high-tax jurisdictions, signaling 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 explored profit-shifting activities of multinationals (Dharmapala; 2014; Riedel; 2018).

At the time when *"leaders representing 80% of the world's GDP [...] made clear their support for a strong global minimum tax"*[2], understanding the consequences of international tax reforms is crucial. In this paper, in three steps, we reconcile the differences across estimates of profit-shifting based on macro- and micro-data. First, we develop a model that generates corner solutions in multinationals' choices regarding their real presence and the proportion of profit that they shift. As such, we address the commonly-overlooked issue of a high proportion of multinationals at the extreme positions of profit-shifting. Second, we use UK tax return data to investigate the intensive- and extensive-margin effects of tax reforms on taxable profit declared in the UK by subsidiaries of foreign-owned multinationals. Third, we use coefficients from this analysis to conduct counterfactual policy experiments including the introduction of digital service taxes and the global minimum tax at varying rates. We describe each in turn.

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. The investment in the tax avoidance asset generates frictions in the form of non-convex costs of shifting profits to tax havens. This is consistent with the structure of many large multinationals which have a network of branches and subsidiaries around the world. Setting up such structures requires forethought, time, and expense. However, conditional on having invested in this structure, the variable costs associated with shifting profit to low-tax countries are likely to be low.

Large multinationals with profits arising in many high-tax countries can benefit from

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

such a structure to shift profits from all over the world to low-tax jurisdictions. The benefits of doing so in terms of reduced overall taxation must at least cover the costs of the initial investment. For smaller and less profitable companies, the likely tax benefits may not outweigh the costs and so they may not invest in the tax avoidance asset. Alternatively, they may invest a small amount, leaving the variable costs of shifting still relatively high. Our model generates this heterogeneity in investment in the tax avoidance asset, which depends on the distribution of worldwide profits amongst businesses.

In this model, tax reform will induce both an extensive-margin and an intensive-margin effect on profit-shifting. For a company at the intensive margin, a rise in the tax rate of the low-tax 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 fixed cost of investing in the tax avoidance asset.

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).

In the second step, we test the empirical implications of our model using the UK tax return data and two sets of reforms. First, we explore the effects of 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 French- and Spanish-headquartered MNEs. We find a strong extensive-margin response — a smaller proportion of zero-profit reporters in the UK — and a modest (and statistically insignificant) intensive-margin response — lower profit-shifting from the UK. Second, we explore the effects of a 2008 German tax

rate cut for profit reporting of German MNEs relative to US and French MNEs in the UK. Consistent with our model, we find that this tax rate reduction increases the the likelihood of reporting no taxable profits in the UK, but alters the intensive margin of profit reporting marginally.

In the third step, using the data and the difference-in-difference coefficients, we estimate the structural parameters of our model and carry out counterfactual policy experiments. 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.

Related literature. Part of the reason for why there is uncertainty on the magnitude of profit-shifting 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]

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 40% of all multinational profits are shifted to tax havens, implying total shifting of over $600 billion. On the other hand, the 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).

One other paper offers a different model to explain the phenomenon of full profit-

[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); Hines and Rice (1994); Slemrod and Wilson (2009).

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

shifting, by focusing on transfer pricing frictions. Koethenbuerger et al. (2019) note that the effective tax rate typically changes at the point at which profit becomes zero. The value of $1 of taxable loss depends on the generosity of the treatment of losses, but in most cases, it is less valuable than the tax rate. This change in the tax rate can, in principle, cause bunching at a taxable income of zero, just as in other cases of bunching at a kink in the tax rate schedule. As such, their approach focuses on firms that have a "true" profit just above zero. In light of Bilicka's 2019 evidence that there is far more bunching by large and profitable multinational firms than by small and less profitable domestic firms, our approach provides an insight into the behavior of large and profitable multinationals.

Policy developments. In recent years there has been growing concern over the ability of multinational corporations to shift profit from high-tax to low-tax jurisdictions 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, which led to 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.[5] Many countries have also introduced unilateral measures. For example, the US tax reform in 2017 introduce the 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".

Such major responses to concerns about the scale of tax avoidance in the form of profit shifting have arguably run ahead of academic evidence. There have been many empirical studies aimed at uncovering the extent of profit shifting. A consensus estimate from a meta-regression study by Heckemeyer and Overesch (2013), 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.

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

2 The model

We model the behaviour of a multinational business in a single period. The novelty of the model lies in setting up an intangible asset which we can the "tax avoidance asset", Y. This is intended to represent the costs of organising the business to reduce its overall tax liability. This can be expensive and time-consuming. As an example, consider the case in which the business invests in R&D, and intends to route revenue generated from successful R&D through a tax haven. One approach would be to create a equity-financed subsidiary in the haven, which then notionally finances a large proportion of the costs of the R&D. Under what is known as a "cost contribution arrangement" that can entitle the subsidiary to the same share of revenue as its share of costs. But of course, the royalty stream may not arise for several years, and so this is a long term investment. Conditional on having created this arrangement, the costs of shifting profit to the haven in any subsequent period are significantly lower than they otherwise would be. Governments seek to protect their tax bases by introducing anti-avoidance measures.

The costs of setting up such an arrangement may be substantial, and well above any value which a small business may derive from shifting to the haven. So we might expect such activities to be undertaken only by large and profitable businesses. We therefore consider a business that has operations in a fixed number, N of jurisdictions. Each of these operations is a standard investment with tangible capital. The incentive to invest in the tax avoidance asset depends on the number and size of these operations in aggregate. This implies that two identical businesses in a jurisdiction may behave differently with respect to profit shifting: one may be part of a large multinational which has already invested in the tax avoidance asset, while the other, for example, may be a small standalone business.

2.1 Model Set-up

The timing is as follows.

1. At the beginning of the period, each government i announces its tax rate, τ_i, and introduces anti-avoidance measures. Collectively the anti-avoidance measures determine the cost to the multinational of purchasing units of the tax avoidance asset, denoted p. There is also a fixed cost of purchasing this asset, ϕ.

2. Still at the beginning of the period, but with knowledge of τ_i, p and ϕ, the firm chooses investment in tangible capital in each country i, K_i, and investment in the tax avoid-

ance asset, Y.

3. At the end of the period, each subsidiary generates output of $F(K_i)$, and sells the remaining tangible capital for $(1-\delta)K_i$. 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_i of the tax base B_i to shift to a tax haven with a 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 a two-stage decision making process by the business:

1. Stage 1: Choose (a) $Y = 0$, implying $\alpha_i = 0$, or (b) $Y > 0$ - in which case the cost of purchasing Y is $pY + \phi$.

2. Stage 2: Conditional on $Y > 0$, choose $0 \leq \alpha_i \leq 1$.

We assume that the variable costs of shifting profit, conditional on $Y > 0$, are:

$$C_i = c\left(\alpha_i, Y, B_i\right) B_i \tag{1}$$

We use a very simple formulation of the tax base:

$$B_i = F(K_{_i}) - \delta K_i \tag{2}$$

This implies that tax depreciation is equal to true economic depreciation and there is no relief for any financing costs. (We ignore the use of debt to keep the model relatively simple). We assume a simple and standard functional form for

A proportion α_i 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 i at rate τ_i. The overall tax liability is therefore

$$T_i = \hat{\tau} B_i = \left[\tau_i \left(1 - \alpha_i\right) + \alpha_i \tau_X\right] B_i \tag{3}$$

where $\hat{\tau}$ can be thought of as an "effective statutory rate" on profit generated in the subsidiary in i.

2.2 Maximization

The firm chooses Y, and K_i and α_i for each subsidiary i, to maximise its beginning of period value:

$$V = -pY - \phi(Y) - \sum_{i=1}^{N} K_i + \beta \sum_{i=1}^{N} \{F(K_i) - T_i - c(\alpha_i, Y, B_i) B_i + (1-\delta)K_i\} \tag{4}$$

subject to constraints

$$Y \geq 0 \tag{5}$$

$$0 \leq \alpha_i \leq 1 \tag{6}$$

where $\phi(Y) = \phi$ iff $Y > 0$; otherwise $\phi(Y) = 0$, and $\beta = 1/(1+r)$ is the discount factor.

2.2.1 Option 1: $Y = \alpha_i = 0$ for all i

Conditional on $Y = \alpha = 0$, then $c(\alpha_i, Y, B_i) = 0$. The model then reverts to a standard formulation, with the optimal tangible stock given by the first order condition

$$F_K(K_i) = \frac{r}{1-\tau_i} + \delta \tag{7}$$

This FOC generates an optimal value of K_i for each subsidiary i, K_i^* with an associated optimal tax base, B_i^* and beginning of period firm value, V^*.

2.2.2 Option 2: $Y > 0$

Conditional on $Y > 0$, the first order conditions are

$$Y: \qquad p = -\beta \sum_{i=1}^{N} c_Y(\alpha_i, Y, B_i) B_i \tag{8}$$

$$K_i: \qquad F_K(K_i) = \frac{r}{1 - [\hat{\tau} + (1+m)c(\alpha_i, Y, B_i)]} + \delta \tag{9}$$

$$\alpha_i : \qquad \{\tau_i - \tau_X - c_\alpha(\alpha_i, Y, B_i)\} B_i \ + \eta_i = 0 \tag{10}$$

$$\eta_i(\alpha_i - 1) = 0 \tag{11}$$

Conditional on Y, each subsidiary i chooses α_i and K_i independently. To investigate these outcomes further, and for the purposes of simulation, we assume a functional form for the variable costs of profit shifting:

$$c(\alpha_i, Y, B_i) = \frac{\gamma}{2}\left(\frac{B_i}{Y}\right)^m \alpha_i^2 \tag{12}$$

Total costs of shifting profit, conditional on Y, are proportional to the tax base, B_i. The proportion is, in a conventional way, quadratic in the proportion of the tax base shifted, α_i. 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.

Note also that in the simulation we also use a simple function form for $F(K)_i$:

$$F(K_i) = \theta_i {K_i}^A \tag{13}$$

where θ_i may vary amongst subsidiaries.

Consider first the case in which $0 < \alpha_i < 1$ for subsidiary i. Then the first order condition for α_i is

$$\alpha_i = \frac{(\tau_i - \tau_X)}{\gamma}(\frac{Y}{B_i})^m \tag{14}$$

Substituting into the first order condition for K_i:

$$F_K(K_i) = \frac{r}{1 - \tau_i + (1-m)c(\alpha_i, Y, B_i)} + \delta \tag{15}$$

Note that this has an additional term in the denominator compared to the 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_i. This requires $m < 1$. Note that for $m = 1$, then profit shifting would have no impact on K_i.

If $\alpha_i = 1$, the first order condition for K_i becomes

$$F_K(K_i) = \frac{r}{1 - \tau_X - (1+m)\frac{\gamma}{2}(\frac{B_1}{Y})^m} + \delta \tag{16}$$

Note that in this case, the cost of capital is independent of the domestic tax rate τ_i, since all profit is shifted to the haven. This does depend on the haven tax rate, tau_X. Note though, that even if $tau_X = 0$, tax still has an indirect impact on the cost of capital. This is because account has to be taken of the marginal costs of profit shifting, reflected in the last term of the denominator.

The optimal choice of each subsidiary depends on the optimal level of Y. With $Y > 0$ there are three possible outcomes.

1. $0 < \alpha_i < 1$ for all α_i
2. $0 < \alpha_i < 1$ for at least one subsidiary i, and α_j=1 for at least one subsidiary j.
3. $\alpha_i = 1$ for all α_i

Using the functional form for $c(\alpha_i, Y, B_i)$ set out above, the first order condition for Y is

$$Y = \left\{ \frac{m\gamma}{2p(1+r)} \sum_{i=1}^{N} B_i^{1+m} \alpha_i^2 \right\}^{\frac{1}{1+m}} \tag{17}$$

2.3 Overall optimisation

The firm simultaneously chooses Y, and K_i and α_i for each subsidiary i. It may choose not to engage in profit shifting at all, $Y = 0$. Conditional on some profit shifting, it may choose to shift all of its profit some any subsidiary i, implying that $\alpha_i = 1$. This model does not have a closed-form solution, and we solve numerically.

3 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.

3.1 Base case

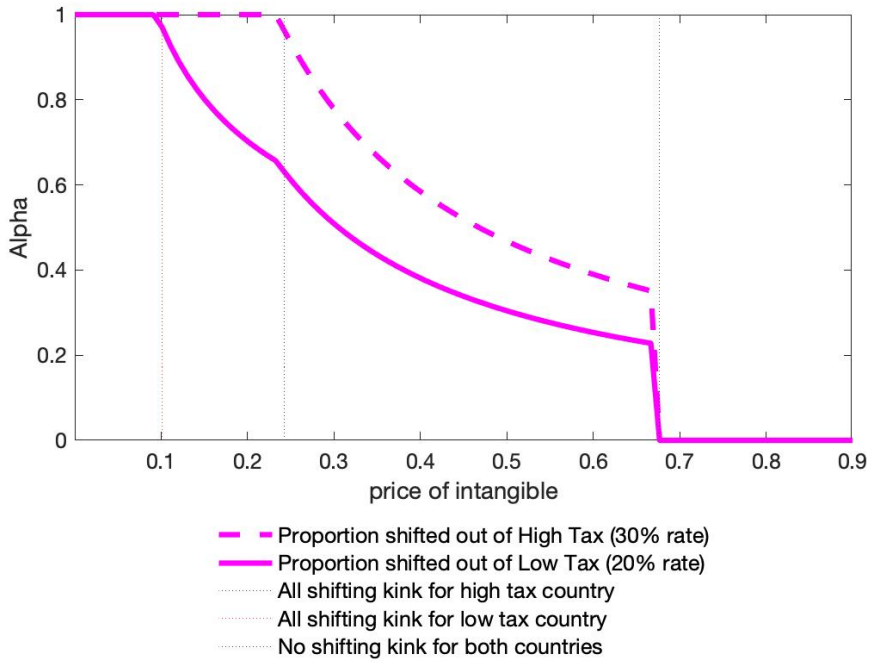
Figure 1 illustrates the choices of α_H and α_L for a range of values of the unit price of Y, p. The price of a unit investment in physical capital is normalized to one. Values of the structural parameters used in this base case are: $\gamma = 0.2$, total factor productivity $\theta = 0.9$, output elasticity 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.

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 2, 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 2). The higher Y reduces the variable costs of profit shifting, and so both α_H and α_L rise (Figure 1).

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.

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 3, where again H is represented by the dashed line and L by the

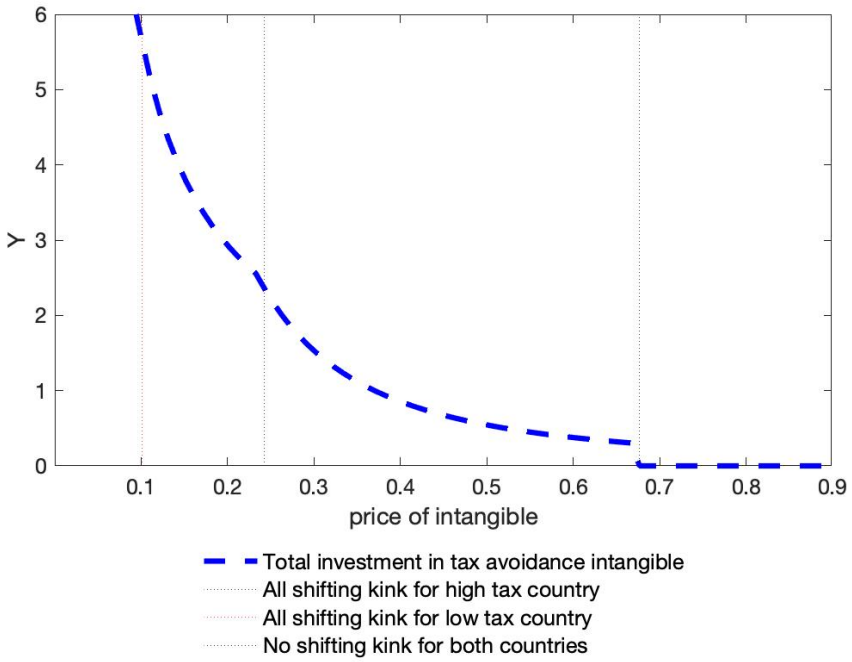
Figure 1: Extent of profit shifting in H and L



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 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.

Figure 2: Investment in the Tax Avoidance Asset Y



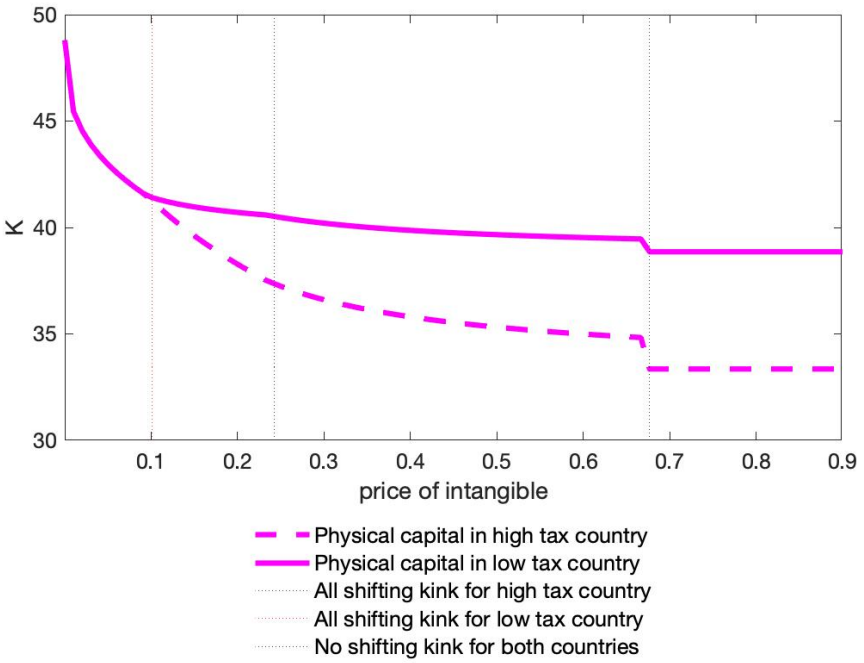
3.2 Minimum worldwide tax

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 4 describes the impact on profit shifting in our base case. The Figure reproduces the position in the absence of the minimum tax from Figure 1. 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

Figure 3: Investment in tangible capital, K_H and K_L

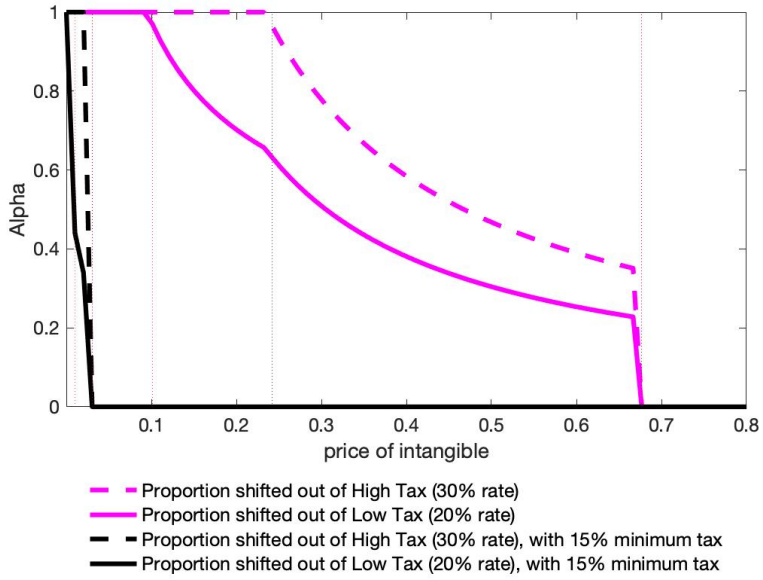


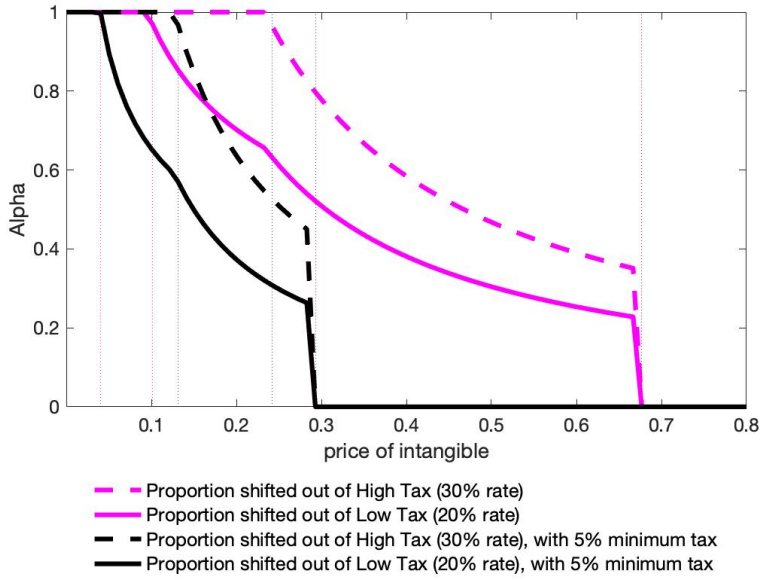
not to invest in Y unless its price is below around 0.3. For a minimum tax of 15%, this falls to 0.04. In the latter case, especially, apart from at very low values of p - which in the absence of the minimum tax yielded 100% profit shifting in both H and L - the minimum tax prevents any profit shifting 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 4, which establishes the minimum tax rate at 5%. The change in profit shifting substantially more mild in the second panel of the figure.

Figure 4: Extent of profit shifting in H and L with a 15% (top panel) and 5% (bottom panel) minimum tax





3.3 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.

4 Reduced-form evidence

4.1 Data and sample construction

To examine the effects of the CFC reform in Italy and the tax rate cut in Germany on profit reporting in the UK, we use the confidential universe of unconsolidated corporation tax returns in the UK for the years 2000 - 2014 provided by the UK tax authorities (HMRC). 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, i.e. each subsidiary of a company operating in the UK files a separate tax return. We use this data to obtain information on the taxable profits variable. The HMRC data does not include any firm level characteristics, apart from trading turnover. Therefore we merge the HMRC data with the accounting data from the FAME dataset. FAME dataset, collected by Bureau van Dijk, provides balance sheet information for most of the UK companies. For instance, it gives us information on total assets, accounting profits, age of firms, number of employees, industry and leverage.[6]

We use the FAME ownership information to identify firms as UK subsidiaries of foreign multinational companies which are subsidiaries of multinational companies that have headquarters outside of the UK. In particular, we select firms for which we can identify the headquarter to be in Germany, Italy (for our treatment groups) and Spain, France and US (for our control groups).

In additional robustness checks, we limit the sample of multinational firms to subsidiaries that have direct links between the UK subsidiary and given headquarter. Thus, we only include UK subsidiaries that report to be owned directly 100% by the headquarter. We do this, because we think that the direct link between headquarter and subsidiary might strengthen the profit shifting incentives. In addition, we also conduct a robustness check in which we limit the sample to include only multinational groups that report to have no tax haven subsidiaries as part of their group structure. We hypothesise that these multinationals may have larger incentives to shift profits between higher tax jurisdictions

[6]Matching the HMRC data with accounting data restricts the sample size. We find a matched unconsolidated accounting statement in FAME for 76 percent of unconsolidated tax returns from the HMRC data, which includes 89 percent of the total tax liability and 92 percent of total trading turnover in the UK. We further ensure that we have non-missing total assets information and full 12 months accounting period for each matched HMRC-FAME observation.

that we consider in this paper, rather than shift most of their profits to tax havens (Dowd et al. (2017)).

When we consider the effects of Italian CFC reform, our sample contains 1,278 unique Italian subsidiaries, 736 unique Spanish subsidiaries and 2,910 unique French ones. There are 1,248 Italian subsidiaries that belong to multinationals with no links to tax havens, 2,814 French ones and 711 Spanish ones. This analysis is conducted using years 2000 - 2005, i.e 2 years before the reform and 2 years after the reform.

When we consider the effects of German tax rate cut, our sample contains 3,870 unique German subsidiaries, 2,910 unique French subsidiaries and 16,724 unique US subsidiaries. There are 8,123 US subsidiaries with direct links, 1,248 French ones and 1,454 German ones. There are 3,726 German subsidiaries that belong to multinationals with no links to tax havens, 2,814 French ones and 15,791 US ones. This analysis is conducted using years 2006 - 2010, i.e 2 years before the reform and 2 years after the reform.

4.2 Empirical specification

We use the difference-in-difference approach to investigate the profit reporting behaviour of multinational firms in the UK in response to the two reforms. Subsidiaries of multinational firms reporting in the UK that are headquartered in Germany and in Italy are in our treated groups. Subsidiaries of multinational firms reporting in the UK that are headquartered in France, US and Spain are in our control groups. We run two sets of difference-in-difference models using two reforms separately. Further, within each reform, we run two sets of difference-in-difference models using two types of dependent variables. We use the following general specifications:

$$ROA_{i,t} = \alpha + \beta_1 treated_i \times post_t + \sigma_1 X_{it}^{'} + \theta_i + \eta_t + \epsilon_{it} \tag{18}$$

$$ztp_{i,t} = \alpha + \beta_2 treated_i \times post_t + \sigma_2 X_{it}^{'} + \theta_i + \eta_t + \epsilon_{it} \tag{19}$$

where $ROA_{i,t}$ is the ratio of taxable profits to total assets for each UK subsidiary belonging to a foreign multinational and $ztp_{i,t}$ is 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 either Germany or Italy and zero otherwise; $post_t$ is a dummy variable that equals one from 2009 onward for the German tax cut reform and from 2003 onward for the Italian CFC reform. $X_{it}^{'}$ is a set of firm-level control variables, such as group size

and UK size; θ_i is a firm-specific fixed effect, η_t is a time fixed effect, and ϵ_{it} is the error term.

The parameters of interest are βs. β_1 captures the effect of the reform on the ratio of taxable profits to total assets, i.e. the intensive margin. β_2 captures the effect of the reform on the propensity of the firm to report zero taxable profits, i.e. the extensive margin. Under the fixed cost hypothesis, we should observe β_2 to be positive and significant for the case of the German tax reform. German subsidiaries should report less profits in the UK now that the German tax rate is lower than the UK one, since they may have larger incentive to report these profits back home. β_2 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 anyway. In both cases, under the fixed cost hypothesis, β_1 should be close to zero or statistically not significant.

4.2.1 Dynamic specification

The results using the difference-in-difference approach present causal estimates of the effects of the analysed reform on reported profits for the treated group under the assumption that absent each reform, reported profits would have evolved in a similar way to the control group. To test this assumption, we further expand the simple difference-in-difference approach to event study methodology. This allows us to evaluate the pre-reform trends to confirm the validity of our difference-in-difference approach. Further, we consider the dynamic effects of the reforms. Thus, we estimate the following specifications that correspond to (1) and (2) directly:

$$ROA_{i,t} = \alpha + \beta_1 treated_i \times \sum_{\kappa=-2}^{2} \delta_t \mathbb{1}[t = \kappa] + \sigma_1 X_{it}^{'} + \theta_i + \eta_t + \epsilon_{it} \tag{20}$$

$$ztp_{i,t} = \alpha + \beta_2 treated_i \times \sum_{\kappa=-2}^{2} \delta_t \mathbb{1}[t = \kappa] + \sigma - 2X_{it}^{'} + \theta_i + \eta_t + \epsilon_{it} \tag{21}$$

where $\mathbb{1}[t = \kappa]$ is a series of year dummies that equal one when the tax reform was κ years away. Each of the δ_t coefficients measures a change in reported profits (3) or in the propensity to report zero taxable profits (4) for a treated firm relative to a control firm in the κ year before or after the reform. We omit $\kappa = -1$ year, which means that we estimate the effect δ_t relative to the year before each reform came into effect.

4.2.2 Selection model

Finally, we combine the results from equations (1) and (2) for $ROA_{i,t}$ and $ztp_{i,t}$ in a Heckman style model. The importance of the extensive margin for taxable profit reporting in response to the analyzed reforms suggests that there may be a selection of companies into zero and positive taxable profit reporting groups. Hence, the OLS estimates from pooling all observations together may be inconsistent and downward biased. Further, Heckman selection model would help to disentangle whether our results are driven by the extensive or intensive margin. We assume that the variables determining whether the company reports a positive profit are separate from variables determining how much profit the company is reporting, once it decides to do so at all. Therefore, the first equation we estimate will determine why companies report positive profits. This involves regressing dummy equal to 1 when a firm reports positive profits and 0 otherwise on determinants of reporting positive profits. The second equation involves estimating a regression of taxable profits divided by total assets conditional on reporting positive taxable profits. This is equivalent to equation (1) but on a restricted sample of positive taxable profits only. We estimate those two equations jointly using the maximum likelihood technique, with error terms from both equations assumed to be bivariate normal.

For identification purposes estimating Heckman selection model requires at least one variable in the first stage that is not a determinant in second stage. In our case we need a variable that determines whether a firm chooses to report any profits at all that is not a determinant of how much profits a firm is going to report. We use the following selection of variables in the first stage: dummies for reporting zero taxable profits in at least 2 of the last 3 years, lagged zero table profit dummies, presence of a tax haven parent, last years losses carried forward, and average industry turnover.

A firm that reports no taxable profits in at least 2 out of the last 3 years or that reports zero taxable consistently each year prior to the reform may be doing this not because it made no profits, but because it may be signalling 'aggressive tax avoidance' behaviour. Similarly, having a tax haven parent may determine whether a company is an aggressive tax avoider. These two determinants may affect whether a company decides to report any profits in the UK or whether it shifts everything to, for example, its tax haven headquarter. The presence of the tax haven parent per se does not affect the profitability of the company in the UK, i.e. its ROA. Further, each company filing a tax return in the UK has to report whether is has any losses from previous periods that it wants to use to offset against taxable profits in this period. They affect whether the company reports zero taxable profits as

it can use those losses to reduce its taxable profits, but they may not affect how much profit the company made this year. Finally, we use the average industry turnover, which approximates the business cycle fluctuations that would affect the proportion of companies reporting zero taxable profits in a particular year. Average industry turnover is calculated for each year and each 2 digit industry code using mean trading turnover from the tax returns data. We use combinations of those five variables together with total assets in the first stage equation that determines whether a company reports zero or positive profits. In the second stage equation we use the following determinants of the reported profits: total assets, leverage ratio, statutory tax rate in the location of the parent firm, whether a firm made losses in the previous year, whether a firm owns a tax haven subsidiary, logarithm of trading turnover.

4.3 Reduced form results

In Table 1 we present the baseline difference-in-difference results. In column 1-4 we summarize the results using the German tax rate reform, comparing the UK subsidiaries of multinationals headquartered in Germany to those headquartered in the US (columns 1-2) and to those headquartered in France (columns 3-4). We find that the German tax rate cut significantly increases the likelihood of reporting zero taxable profits for German multinationals in the UK relative to both US and French ones. Specifically, German multinationals are 2.3% more likely to report zero taxable profits relative to US ones and 3.5% more likely relative to French ones. The effect of the reform on the reported ratios of taxable profits to total assets is small and negative when we compare German firms to the US ones and close to zero and insignificant when we compare them to French ones. These effects are larger when we consider only the sub-sample of firms that are directly owned by parents in respective countries (Table 4) and similar in magnitudes when we consider the sample of multinational firms which have no links to tax havens listed in FAME dataset (Table 5).

This result is consistent with our hypothesis that when German tax rate drops below the UK one, German firms might choose to report lower profits in the UK. This may occur for two reasons, which we cannot distinguish. First, before the tax cut German firms were using UK as a low tax destination and shifting profits towards the UK from Germany. After the reform, they choose not to shift. Second, before the reform German firms were using UK as a low tax hub, where some profits were shifted to and from tax havens. After the reform, they do not use UK hub at all, but directly do their operations using the German headquarter. We show that the majority of this adjustment happens at the extensive

margin, where firms choose to stop reporting taxable profits all together. Since our fixed cost hypothesis embeds the convex cost hypothesis, it is entirely possible that there is some small adjustment along the intensive margin. This is what we observe when we compare German multinational subsidiaries to the US ones.

Columns 5-6 in Table 1 summarizes the results using the Italian anti-tax avoidance reform, i.e. an introduction of tighter CFC regulations. We compare the UK subsidiaries of multinationals headquartered in Italy to those headquartered in France (columns 5-6) and those headquartered in Spain (columns 7-8). We find that Italian CFC reform has significantly reduced the likelihood of reporting zero taxable profits for Italian multinationals in the UK relative to both French and Spanish ones. Specifically, Italian multinationals are 7.8% less likely to report zero taxable profits relative to French ones and 6.1% less likely relative to Spanish ones. Here, the effect of the reform on the reported ratios of taxable profits to total assets in almost zero and insignificant in both comparison cases. These effects are similar in magnitude when we consider the sample of multinational firms which have no links to tax havens listed in FAME dataset (Table 6).

4.4 Selection model results

The results from Heckman selection model confirm our baseline findings. In Table 2 we show that the effect of the German tax rate reform on reported profits is entirely driven by the extensive margin. The results from first stage regressions on the determinants of reporting positive profits are statistically significant across specifications. The negative coefficients on the interaction term between $treated_i \times post_t$ suggest that after the German tax rate cut, firms in our treated groups were less likely to report positive taxable profits in the UK. This is exactly the same results as presented in columns (1) and (2) in Table **??**. The magnitude of the effect is larger here than in the simple OLS estimations, suggesting that after the German tax rate cut, German firms in the UK are 8-10% less likely to report positive taxable profits relative to French multinational subsidiaries. This results holds in terms of both significance and magnitude irrespective of the first stage determinants of positive taxable profit reporting we use. The second stage coefficients are insignificant and very close to zero in magnitudes in all specifications.[7]

[7] In unreported exercises we perform Heckman selection estimations on the restricted models that only include subsidiaries directly owned by the parent and subsidiaries belonging to multinational groups that do not report to have any tax haven subsidiaries. The results hold in both cases, with very similar coefficient magnitudes. We also run the same estimation using the US multinationals as a comparison group to obtain very similar effects.

Table 1: The effects of tax reforms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Germany vs US		Germany vs France		Italy vs France		Italy vs Spain	
	ztp	ROA	ztp	ROA	ztp	ROA	ztp	ROA
$treated_t \times post_t$	0.023**	-0.013***	0.035**	-0.009	-0.078***	-0.007	-0.061**	0.000
	(-0.009)	(-0.004)	(-0.015)	(-0.008)	(-0.019)	(-0.007)	(-0.028)	(-0.010)
Observations	32,620	32,525	12,321	12,298	8,062	8,047	3,650	3,638
Number	9,816	9,789	9,816	9,789	1,902	1,900	864	863
Year FEs	✓	✓	✓	✓	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓	✓	✓	✓	✓

Note: This table reports results on the effects of the German tax rate change in 2008 (column 1-4) and the Italian CFC reform in 2002 (column 5-8). For column 1-4, we use years 2006 - 2010 and for columns 5-8, we use time period 2000 -2005. In columns 1-2 we compare German and US firms, in columns 3-4 German and French firms, in column 5-6 Italian and French firms and in columns 7-8 Italian and Spanish firms. Columns marked ztp use as outcome variable a dummy equal to 1 when taxable profits are zero. Columns marked ROA use as outcome variable the ratio of taxable profits to total assets. When looking at the effects of the German tax rate cut, we have 3870 unique German subsidiaries, 2910 unique French subsidiaries and 16724 unique US subsidiaries. When looking at the effects of the Italian CFC reform, we have 1,278 unique Italian subsidiaries, 736 unique Spanish subsidiaries and 2,910 unique French ones. In all specifications we control for firm fixed effects and year fixed effects. Standard errors are clustered at the firm level. In all specifications we control for the subsidiary size by including log of total assets and for multinational size by including the number of subsidiaries that multinationals report in FAME data. Source: matched HMRC and FAME data.

In Table 3 we show similar results using the Italian CFC reform. Here, the results from the first stage regressions on the determinants of reporting positive profits are statistically significant with very large magnitudes. They suggest that after the CFC reform, Italian firms in the UK are 52-57% less likely to report positive taxable profits relative to French multinational subsidiaries. This results holds in terms of both significance and magnitude irrespective of the first stage determinants of positive taxable profit reporting we use. Here, we observe a significant effect in second stage regression too. However, the magnitude of the effect is much smaller than the one in first stage regressions. Again, this is consistent with our approach that allows adjustment on intensive margin by embedding the convex cost hypothesis into the fixed cost of profit shifting model.

Taken together, The results from Tables 1, 2 and 3 suggest that the effects of foreign tax rate cuts and foreign anti-tax avoidance reforms that result in changes in incentives to shift profits to the UK affect the extensive margin of profit reporting with little to no effect on the intensive margin. It is important to note here that we do not observe the same patterns when we use profit and loss from the accounting statement and the likelihood of reporting losses in the financial statements.

Table 2: The effects of German tax rate cut: Heckman selection model.

	(1)	(2)	(3)	(4)
First stage results				
$treated_i \times post_t$	-0.092***	-0.080**	-0.099***	-0.083**
	(0.032)	(0.034)	(0.031)	(0.034)
Constant	0.573***	0.580***	0.380***	0.637***
	(0.082)	(0.086)	(0.078)	(0.083)
Second stage results				
$treated_i \times post_t$	-0.003	-0.005	-0.003	-0.005
	(0.019)	(0.019)	(0.019)	(0.019)
Constant	0.317***	0.282***	0.306***	0.284***
	(0.019)	(0.018)	(0.020)	(0.018)
Observations	12,213	12,213	12,213	12,213
No of firms	3,605	3,605	3,605	3,605
Control variables: First Stage				
Size	x	x	x	x
Losses in last 2 out of 3 years	x	x	x	
Industry turnover	x	x		
Previous loss	x	x		
Tax haven sub	x	x		
Previous loss	x	x		
Lagged ztp		x		x

Note: These are Heckman selection results from considering the effects of German tax rate change in 2008 on the reported taxable profits of UK subsidiaries of German HQ companies relative to French HQ ones. In all specifications lambda is significant and negative at 1% level. First stage results show the result from regression of the likelihood of reporting positive taxable profits on determinants of reporting positive taxable profits. First stage controls are listed in the Table under each corresponding column. Second stage results show the results from OLS specification using the ratio of taxable profits divided by total assets as a dependant variable on the restricted sample of positive taxable profits only. The data contains 3870 unique German subsidiaries and 2910 unique French subsidiaries. In all specifications we control for firm fixed effects and year fixed effects. Standard errors are clustered at the firm level. In the second stage equation we use the following determinants of the reported profits: leverage ratio, statutory tax rate in the location of the parent firm, whether a firm made losses in the previous year, whether a firm owns a tax haven subsidiary, logarithm of trading turnover. All subsidiaries are included here. Source: matched HMRC and FAME data.

Table 3: The effects of Italian anti-avoidance reform: Heckman selection model.

	(1)	(2)	(3)	(4)
First stage results				
$treated_i \times post_t$	0.559***	0.527***	0.568***	0.521***
	(0.058)	(0.063)	(0.057)	(0.063)
Constant	0.624***	0.641***	0.521***	0.750***
	(0.163)	(0.167)	(0.153)	(0.160)
Second stage results				
$treated_i \times post_t$	-0.098***	-0.089***	-0.102***	-0.091***
	(0.027)	(0.027)	(0.027)	(0.027)
Constant	0.242***	0.225***	0.257***	0.229***
	(0.027)	(0.026)	(0.029)	(0.026)
Observations	3,613	3,613	3,613	3,613
Control variables: First Stage				
Size	x	x	x	x
Losses in last 2 out of 3 years	x	x	x	
Industry turnover	x	x		
Previous loss	x	x		
Tax haven sub	x	x		
Previous loss	x	x		
Lagged ztp		x		x

Note: These are Heckman selection results from considering the effects of Italian CFC reform in 2002 on the reported taxable profits of UK subsidiaries of Italian HQ companies relative to Spanish HQ ones. In all specifications lambda is significant and negative at 1% level. First stage results show the result from regression of the likelihood of reporting positive taxable profits on determinants of reporting positive taxable profits. First stage controls are listed in the Table under each corresponding column. Second stage results show the results from OLS specification using the ratio of taxable profits divided by total assets as a dependant variable on the restricted sample of positive taxable profits only. Our sample contains 1,278 unique Italian subsidiaries and 736 unique Spanish subsidiaries In all specifications we control for firm fixed effects and year fixed effects. Standard errors are clustered at the firm level. In the second stage equation we use the following determinants of the reported profits: leverage ratio, statutory tax rate in the location of the parent firm, whether a firm made losses in the previous year, whether a firm owns a tax haven subsidiary, logarithm of trading turnover. All subsidiaries are included here. Source: matched HMRC and FAME data.

5 Structural Estimation

In this section, we present structural estimates for the parameters of the distribution of the fixed cost F 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 and use the existing allocation of ownership patterns of firms in the population of UK corporations to assign available tax rates and allowances to firms of different sizes. Our structural estimates minimize the MSM criterion function, which takes the form:

$$L(\Theta) = h(\Theta)^{'} W_N h(\Theta) \tag{22}$$

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.

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Appendices

Table 4: The effects of German tax reform: direct subsidiaries only.

	(1) ztp ols	(2) ztp probit	(3) ROA	(4) ztp ols	(5) ztp probit	(6) ROA
$treated_i \times post_t$	0.033*	0.089**	-0.012	0.047**	0.125**	-0.019*
	(0.017)	(0.045)	(0.008)	(0.022)	(0.060)	(0.011)
Constant	0.476***	-0.062	0.106***	0.527***	0.059	0.091***
	(0.017)	(0.043)	(0.007)	(0.034)	(0.088)	(0.013)
Observations	15,390	15,378	15,344	4,696	4,696	4,693
Number of firms	4,636	4,636	4,623	1,386	1,386	1,385

Note: These are regression results from considering the effects of German tax rate change in 2008 on the reported taxable profits of UK subsidiaries of German HQ companies relative to French HQ ones - columns 4-6 and US HQ ones - column 1-3. ztp ols refers to OLS specification results using zero taxable profits as a dependant variable, ztp probit refers to probit specification results using zero taxable profits as a dependant variable, ROA refers to OLS results using the ratio of taxable profits to total assets as a dependant variable. The data contains 1454 unique German subsidiaries, 1248 unique French subsidiaries and 8123 unique US subsidiaries. In all specifications we control for firm fixed effects and year fixed effects. Standard errors are clustered at the firm level. In all specifications we control for the subsidiary size by including log of total assets and for multinational size by including number of subsidiaries that multinational report in FAME data. Only subsidiaries which are directly - 100% owned by the headquarter are included here. Source: matched HMRC and FAME data.

Table 5: The effects of German tax reform: no tax havens.

	(1) ztp ols	(2) ztp probit	(3) ROA	(4) ztp ols	(5) ztp probit	(6) ROA
$treated_i \times post_t$	0.022**	0.113**	-0.014***	0.038**	0.095**	-0.010
	(0.009)	(0.050)	(0.004)	(0.015)	(0.038)	(0.008)
Constant	0.497***	-0.043	0.113***	0.561***	0.151***	0.102***
	(0.012)	(0.031)	(0.006)	(0.021)	(0.055)	(0.011)
Observations	31,833	31,833	31,738	12,138	12,134	12,115
Number of firms	9,587	9,587	9,560	3,561	3,561	3,554

Note: These are regression results from considering the effects of German tax rate change in 2008 on the reported taxable profits of UK subsidiaries of German HQ companies relative to French HQ ones - columns 4-6 and US HQ ones - column 1-3. ztp ols refers to OLS specification results using zero taxable profits as a dependant variable, ztp probit refers to probit specification results using zero taxable profits as a dependant variable, ROA refers to OLS results using the ratio of taxable profits to total assets as a dependant variable. The data contains 3726 unique German subsidiaries, 2814 unique French subsidiaries and 15791 unique US subsidiaries. In all specifications we control for firm fixed effects and year fixed effects. Standard errors are clustered at the firm level. In all specifications we control for the subsidiary size by including log of total assets and for multinational size by including number of subsidiaries that multinational report in FAME data. Only subsidiaries that are part of multinational groups that did not report to have any tax haven links are included here. Source: matched HMRC and FAME data.

Table 6: The effects of Italian anti-avoidance reform: no tax havens

(1)	(2) ztp ols	(3) ztp probit	ROA
$treated_i \times post_t$	-0.060**	-0.302**	0.001
	(0.028)	(0.135)	(0.010)
Constant	0.454***	-0.225**	0.095***
	(0.022)	(0.103)	(0.012)
Observations	3,590	3,590	3,578
Number of firms	850	850	849

Note: These are regression results from considering the effects the Italian CFC refrom in 2002 on the reported taxable profits of UK subsidiaries of Italian HQ companies relative to French HQ ones - columns 1-3 and Spanish HQ ones - column 4-6. ztp ols refers to OLS specification results using zero taxable profits as a dependant variable, ztp probit refers to probit specification results using zero taxable profits as a dependant variable, ROA refers to OLS results using the ratio of taxable profits to total assets as a dependant variable. Our sample contains 1,248 unique Italian subsidiaries, 711 unique Spanish subsidiaries and 2,814 unique French ones. In all specifications we control for firm fixed effects and year fixed effects. Standard errors are clustered at the firm level. In all specifications we control for the subsidiary size by including log of total assets and for multinational size by including number of subsidiaries that multinational report in FAME data. Only subsidiaries that are part of multinational groups that did not report to have any tax haven links are included here. Source: matched HMRC and FAME data.