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Tax competition in the presence of profit shifting [☆]

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A B S T R A C T

The popular view is that governments should crack down on tax avoidance by multinational corporations, but in practice, lax anti-profit-shifting policies are common. Here, we analyze how controlling profit shifting influences fiscal competition. Equilibrium tax rates are determined by the elasticities of two components: retained profit and capital mobility. Anti-profit-shifting policies decrease the elasticity of the first, but increase the elasticity of the second. The impact of these policies on equilibrium tax rates is then ambiguous. We show that there are cases in which laxer policies increase equilibrium tax rates and countries' well-being by favoring investments. We use estimates of different elasticities to show that our model can support lax enforcement.

JEL Codes: H87 H25 H26 F38 F23

Keywords: Tax competition, Profit shifting, International taxation, Capital mobility

1. Introduction

Firms can reduce their tax burden in many ways, but international corporations have more opportunities to do so, being able to shift profits from high-tax countries to low-tax ones.¹ While these practices allow firms to significantly lower their effective tax rates, they erode the ability of high-tax jurisdictions to generate

tax revenue. The Organisation for Economic Co-operation and Development (OECD) estimates that up to 10% of the global tax base escapes taxation due to profit shifting, while [Wier et al. \(2019\)](#) highlight that multinational corporations are able to avoid as much as 36% of their fiscal responsibility through this mechanism. For that reason, the OECD advocates strongly for policies and practices that limit firms' ability to take advantage of international tax differences.

A multinational corporation that wishes to shift profit from a high-tax country to a low-tax one can do so in various ways. One strategy is to reallocate debt to entities in high-tax countries, to benefit from the associated tax deductions.² This process leads to thinly capitalized firms. Many countries have introduced regulations limiting thin capitalization by using safe-haven debt-to-equity ratios, where tax deductions no longer apply when debt relative to equity reaches these ratios. The United Kingdom uses a strict ratio of 1:1, some countries such as France and the United States have adopted less restrictive ratios of 1.5:1, while others use even more permissive ratios. Between 1996 and 2009, the share of OECD countries imposing thin-capitalization rules increased from 45% to 70%.

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¹ Even firms with subsidiaries in subnational regions can take advantage of differences in regional tax rates. Delaware is often considered a "tax haven" within the United States.

² See [Mintz and Smart \(2004\)](#).

However, the average safe-haven debt-to-equity ratio remained fairly constant at around 3:1.³

Alternatively, multinational corporations can exploit tax-rate differentials by altering internal transfer pricing. To combat such practices, some countries have adopted “arm’s length principles” so that transfer prices are in line with prices for similar transactions between independent parties. [Lohse and Riedel \(2013\)](#) classified countries by the strictness of those arm’s length principles by looking at documentation requirements. Here again, according to Lohse and Riedel’s index, some countries have adopted strict requirements, such as the United Kingdom, with a score of 4 on a scale between 0 and 5, while some others are less demanding, such as the United States, with a score of 3. The proportion of OECD countries that regulate transfer pricing increased by almost 20 percentage points between 1996 and 2009, but the average regulation strictness index increased by only about one-half.⁴ This suggests that many countries are not doing as much as possible to control profit shifting. In light of this, we investigate why allowing some profit shifting to occur may be beneficial, even for profit-exporting countries.

To analyze why some countries allow some profit shifting to occur, we set up a tax competition model with two countries and a parasitic tax haven. In the model, heterogeneous multinational corporations settle their main production facilities in one of the two countries; they also operate a subsidiary in the tax haven to optimize tax planning. The firms are faced with country-specific costs, meaning that in the absence of tax differences, they have preferences over location decisions. In addition to location decisions, the corporations shift a share of their taxable income to the tax haven. Anti-profit-shifting controls and monitoring can make such activities either more or less costly. In our model, governments tax profits to maximize tax revenue. We also allow the governments to directly care about production facilities in their jurisdictions.⁵ We solve for equilibrium tax rates and look at the impact on countries’ welfare of enforcing anti-profit-shifting controls.

Our main aim is to derive conditions under which a government may prefer lenient profit-shifting controls. We identify four elements a government may consider when choosing the optimal level of enforcement. The first two elements are (i) the direct benefit of discouraging profit shifting and (ii) the cost of implementing controls. Stricter enforcement discourages profit-shifting activities by increasing the cost to corporations that violate regulations. If profit shifting is highly responsive to control, enforcement is desirable. By shifting profit, firms are able to lower their effective tax rate. (iii) Stricter enforcement inflates the domestic effective tax rate and makes investments in other countries more attractive. If investments are highly responsive to profit-shifting control, laxer enforcement may be desirable, particularly when there are significant non-fiscal benefits to attracting firms. (iv) Finally, controlling profit shifting influences how tax rates are determined. Thus, strict enforcement may not be desirable if it leads to lower tax rates. We call this the tax competition effect.

Both the nominal tax rate and degree of profit-shifting control jointly determine the effective tax rate. For a given investment level, an increase in either instrument leads to higher tax revenue. Holding enforcement constant, a higher statutory tax rate raises revenue collected from a given tax base. Similarly, stricter enforce-

ment reduces tax-base erosion and boosts tax-revenue collection. Because both instruments influence the effective tax rate, an increase in either the nominal tax rate or the degree of profit-shifting control discourages investments. The two instruments can be complementary in raising tax revenue. For example, a country that wants to raise fiscal revenue aggressively may increase the nominal tax rate and the degree of profit-shifting control at the same time. Alternatively, both instruments could be substitutes where stricter enforcement is associated with a lower tax rate or the inverse. This case is consistent with [Haufler and Schjelderup \(2000\)](#), where a government may want to set a low tax rate, but stricter depreciation allowances broaden the tax base.

The first step of our analysis is to understand how countries set tax rates balancing the need for tax revenue and the desire to attract investments. As in most tax competition settings, equilibrium tax rates are determined by the elasticity of each country’s tax base. A country that has a more volatile tax base has a stronger incentive to set a lower tax rate. In our environment, the total tax base can be divided into two components: (i) the per-firm retained profit, accounting for profit-shifting activity, and (ii) the number of firms a country can attract. We show that stricter enforcement limits the responsiveness of profit shifting. Faced with more difficult and costly ways to shift profits, a firm is less inclined to exploit the “tax differential” between the domestic and the parasitic tax rate. Thus, the per-firm retained profits are less sensitive to the domestic tax rate and reward setting a higher tax rate. At the same time, stricter enforcement makes local investment more sensitive to the domestic tax rate. When firms can shift profit easily, tax differences between the two countries do not matter much because firms can lower their effective tax rate. With stronger enforcement, investments become more sensitive to taxes, so it can be worthwhile to set a low rate. Consequently, our model shows that the impact on equilibrium tax rates of controlling profit-shifting is ambiguous. On the one hand, investment is made more responsive to domestic tax rates (inducing a more aggressive tax competition), while on the other hand, the responsiveness of profit-shifting behavior to domestic taxes is decreased (inducing a less aggressive tax competition). Thus, our model abstracts from the general equilibrium effects of taxation on the remuneration of factors of production and other production inefficiencies induced by taxation. Our model also ignores the direct impact of profit-shifting controls on firms’ gross profits as identified by [De Simone et al. \(2022\)](#).

We characterize both of our main results in terms of four observable semi-elasticities. The desirability of stricter profit-shifting controls depends positively on the responsiveness of retained profits to changes in enforcement, but depends negatively on the responsiveness of investments to a similar variation. Taxes are high when investments and retained profits are not as responsive to rates. Finally, foreign tax rates are lower when enforcement makes investments much more sensitive to the domestic tax rate and makes retained profits less sensitive to the same variable. We collect estimates for all of these variables and show that the conditions needed for the desirability of lax profit-shifting controls can be satisfied for reasonable parameters.

We also conduct simulations with two objectives in mind. First, we demonstrate that our model can generate equilibria with lax enforcement for reasonable parameter values. Second, we explore the impact of asymmetry between countries competing for capital. In equilibrium, larger countries have a comparative advantage in attracting capital. It is well known in the tax competition literature that larger countries set a higher tax rate because they have a less elastic tax base. Their comparative advantage creates something similar to market power, and thus larger countries also implement stricter profit-shifting enforcement. The same intuition applies because stronger enforcement is a way to collect additional tax

³ See [Lohse and Riedel \(2013\)](#) and [Buettner et al. \(2012\)](#).

⁴ [Tørsløv et al. \(2020\)](#) found that high-tax countries engage in limited enforcement of transfer pricing toward tax havens. They instead focus on transactions with other high-tax countries.

⁵ [Peralta et al. \(2006\)](#) make a similar assumption, and according to [Hong and Smart \(2010\)](#), governments want more firms because this increases wages. [Mathew et al. \(2021\)](#) estimate sizable spillovers associated with foreign direct investment, and we discuss their result further in Section 2.2 when introducing this feature in our model.

revenue by increasing the effective tax rates. This is consistent with observations by [Buettner et al. \(2018\)](#).

Other authors have looked at similar questions from different angles. [Haufler and Schjelderup \(2000\)](#), [Slemrod and Wilson \(2009\)](#), and [Weichenrieder and Xu \(2019\)](#) take a negative view of both profit shifting and tax havens: In addition to tax-base erosion, the first paper suggests that profit shifting distorts the optimal tax system, the second considers the detrimental effects of enforcement and concealment, and the last one discusses problems associated with round-tripping investments. Other authors, like us, highlight potential benefits associated with profit shifting. [Haufler and Schjelderup \(2000\)](#), [Mintz and Smart \(2004\)](#), and [Desai et al. \(2006\)](#) point out that lower effective tax rates stimulate investments. [Peralta et al. \(2006\)](#), [Bucovetsky and Haufler \(2008\)](#), and [Hong and Smart \(2010\)](#) indicate that profit shifting allows governments to fiscally discriminate between international firms and local firms that are unable to shift profits.⁶ [Johannesen \(2010\)](#), [Becker and Fuest \(2012\)](#), and [Stoewhase \(2013\)](#) argue that profit shifting may incite countries to set higher nominal tax rates. Our goal is to paint a broad picture of the problem and fill some gaps in our understanding of the forces at play.

Profit shifting influences the tax proceeds of jurisdictions through three different channels. The most obvious one is tax-base erosion because firms send profits to be taxed abroad instead of locally. This channel is considered in all of the papers mentioned above and unambiguously reduces the welfare of high-tax countries. The second channel is the capital allocation or investment channel. Here, because shifting profits abroad enables firms to lower their effective tax rates, high-tax jurisdictions become a more desirable location choice, making it easier for high-tax countries to attract capital and firms. Many of the papers above also consider this positive effect. The last, and least obvious, channel is the strategic tax-setting effect, whereby the tax competition game is altered by profit-shifting activities, and equilibrium tax rates may increase or decrease.

We set out to develop a model that considers all three channels simultaneously and where tax rates are determined endogenously and chosen to maximize the tax levy and spillover benefits. We thus depart from the existing literature. [Becker and Fuest \(2012\)](#) abstract from physical capital mobility, in [Mintz and Smart \(2004\)](#) tax rates are exogenous, [Slemrod and Wilson \(2009\)](#) and [Johannesen \(2010\)](#) treat profit-shifting controls as exogenous, and [Hong and Smart \(2010\)](#) include redistributive arguments. Our results are built on observable elasticities of both capital movement and tax-base erosion. Contrary to [Peralta et al. \(2006\)](#), [Johannesen \(2010\)](#), and [Stoewhase \(2013\)](#), we account for multiple heterogeneous international firms. We also ignore the merits of discrimination as proposed in [Peralta et al. \(2006\)](#), [Bucovetsky and Haufler \(2008\)](#), and [Hong and Smart \(2010\)](#), by assuming that all firms are international. In our model, the desirability of laxer enforcement arises from the enhanced ability to attract firms and the associated increase in the foreign tax rate. Adding domestic firms would allow for a lower effective tax rate on international firms while maintaining a higher rate for domestic ones.

In Section 2, we present our theoretical model and derive our main result. We first characterize firms' location and profit-shifting decisions for a given menu of taxes and regulatory enforcement policies. We then define governments' fiscal policies, taking profit-shifting controls as given. Finally, we investigate under what condition it is desirable to employ less than full effort to control profit shifting. In Section 3, we present our simulations and validate our results using the estimates collected. In Section 4, we discuss our conclusions. All proofs are in the Appendix.

⁶ See [Marceau et al. \(2010\)](#) for a discussion of the benefits and costs of fiscal discrimination.

2. The model

We describe an environment with two countries, labeled 1 and 2, and a parasitic tax haven. Each country sets a source-based profit tax at a rate of t_i . Governments also influence the cost of profit shifting via monitoring and well-designed regulations. Parameter $\alpha_i \in [0, \bar{\alpha}]$ summarizes the enforcement of profit-shifting controls by Country i , where $\bar{\alpha}$ is the maximal level of enforcement possible. The model is parsimonious and therefore stylized. Gross profits are exogenous, and profit shifting is generic and has no effect on gross profit. A large number of multinational corporations choose to establish the main sources of their economic activity in either Country 1 or Country 2. All firms generate profit A regardless of the country they are located in. These corporations also operate a foreign subsidiary in the tax haven for the sole purpose of shifting profits to this low-tax country. To ease the presentation, we assume that the tax haven has no corporate tax. Firms are indexed by a location-specific cost parameter c uniformly distributed on the support $[0, C]$. A firm of type c pays an additional unobservable cost c in Country 1 and $1 - c$ in Country 2. A classic interpretation for such costs is home biases created by the lack of information when investing abroad.⁷ A small cost c suggests that a firm has better information regarding investment opportunities in Country 1, which has an advantage in attracting firms when $C < 1$. In other words, if both countries announce the same tax level, there will be more firms located in Country 1 than in Country 2. At one extreme, when $C = 1/2$, none of the firms would locate in Country 2, whereas at the other extreme, when $C = 1$, both countries would attract the same number of firms.

Let γ_i be the share of taxable profits a firm located in Country i decides to shift to the tax haven. The costs of shifting a proportion γ_i of its fiscal responsibility are given by $\alpha_i \frac{\gamma_i^2}{2} A$. The policy parameter α_i is chosen by Country i to make profit shifting either more or less costly,⁸ while the parameter A determines the importance of those costs. Two existing measures of profit-shifting enforcement strictness are comparable to our parameter α . As discussed in Section 1, [Buettner et al. \(2012\)](#) proposed an indicator of the tightness of the thin-capitalization rule defined by $\frac{1}{1+s}$, where s is the safe-haven debt-to-equity ratio. Another example is the [Lohse and Riedel \(2013\)](#) index for the strictness of transfer-pricing regulations. The cost of regulating and enforcing profit-shifting activity is $K\alpha_i$.

[Fig. 1](#) represents the proposed environment. The allocation of capital is dictated by firms' location decisions, taking into consideration tax rates and profit-shifting controls. Firms also decide how much profit to shift to the tax haven. This is a similar setup to that discussed in [Keen and Konrad \(2013\)](#).

The timing is as follows. First, countries adopt a level of profit-shifting enforcement α_i . Then, countries compete by setting corporate tax rates. Finally, firms select their location and profit-shifting activities. We solve for the subgame perfect Nash equilibrium.

2.1. Multinationals' decisions

2.1.1. Profit shifting

Each firm decides how much profit to shift to the tax haven. A firm in Country i would shift profit according to

$$\gamma_i(\alpha_i, t_i) = \arg \max_{\gamma_i} \left\{ \left[(1 - t_i)[1 - \gamma_i] + \gamma_i - \alpha_i \frac{\gamma_i^2}{2} \right] A \right\}. \quad (1)$$

⁷ This cost structure is similar to the one proposed in [Mongrain and Wilson \(2018\)](#). See [Ahearne et al. \(2004\)](#) for an extensive survey of the literature on home biases. Also note that these costs are not a source of profit heterogeneity, as in [Krauthaim and Schmidt-Eisenlohr \(2011\)](#), because these costs are excluded from taxable income.

⁸ [Huizinga and Laeven \(2008\)](#), [Slemrod and Wilson \(2009\)](#), among others, use similar profit-shifting mechanisms.

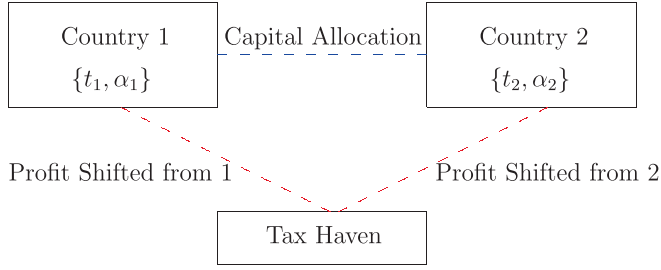


Fig. 1. Structure of the model.

Corporations end up facing a lower effective tax rate $\tau_i = [1 - \gamma_i(\cdot)]t_i$ by shifting profits abroad. However, curtailing fiscal obligations is not without cost. A firm that shifts a proportion $\gamma_i(\cdot)$ of its taxable profit incurs the cost $\alpha_i \frac{\gamma_i(\cdot)^2}{2}$.

The amount of shifted profit increases with the domestic tax rate t_i and decreases with the amount of monitoring α_i . More precisely, $\gamma_i(\alpha_i, t_i)$ is given by⁹

$$\gamma_i(\alpha_i, t_i) = \frac{t_i}{\alpha_i}. \quad (2)$$

We define $\varepsilon(1 - \gamma_i | t_i)$ as Country i 's per-firm retained profit semi-elasticity with respect to its tax, which is represented by

$$\varepsilon(1 - \gamma_i | t_i) = \frac{-1}{1 - \gamma_i(\cdot)} \frac{\partial[1 - \gamma_i(\cdot)]}{\partial t_i} = \frac{\gamma_i(\cdot)}{t_i[1 - \gamma_i(\cdot)]} = \frac{1}{\alpha_i - t_i} > 0. \quad (3)$$

For convenience, we express the semi-elasticity in positive terms so that even if an increase in tax rate leads to lower retained profits, $\varepsilon(1 - \gamma_i | t_i) > 0$. The fact that profit shifting reacts positively to taxation is well documented.¹⁰

Lemma 1. Stricter profit-shifting controls make retained profits less responsive to the domestic tax rate of Country i —lower $\varepsilon(1 - \gamma_i | t_i)$ —and has no effect on the similar variable in the other country.

Stricter monitoring increases the cost of shifting profits in the country where it is implemented. As a consequence, firms require a higher tax level to engage in evasive activities, and so retained profits become less sensitive to variation in tax rates. Stricter profit-shifting controls increase the desirability of higher tax rates because part of the tax base is made less responsive. [Buettner et al. \(2012\)](#) empirically confirm this result.

We can also define the semi-elasticity of retained profits with respect to profit-shifting control as $\varepsilon(1 - \gamma_i | \alpha_i)$, where

$$\varepsilon(1 - \gamma_i | \alpha_i) = \frac{1}{1 - \gamma_i(\cdot)} \frac{\partial[1 - \gamma_i(\cdot)]}{\partial \alpha_i} = \frac{\gamma_i(\cdot)^2}{t_i[1 - \gamma_i(\cdot)]} = \frac{t_i}{\alpha_i[\alpha_i - t_i]}. \quad (4)$$

Stricter enforcement allows a country to keep a larger part of its tax base. [Blouin et al. \(2014\)](#), [Buettner et al. \(2012\)](#), [Overesch and Wamser \(2010\)](#), [Wamser \(2014\)](#), and [Weichenrieder and Windischbauer \(2008\)](#) confirm that profit-shifting controls reduce profit-shifting activities.

2.1.2. Location decisions

When firms decide where to locate, they compare the net profit of investing in each of the two countries. A firm with cost c located in Country 1 generates

$$\Pi_1(c) = [1 - \tau_1]A - \alpha_1 \frac{\gamma_1(\cdot)^2}{2} - c \quad (5)$$

in after-tax profit. Alternatively, if the same firm locates in Country 2, the total net profit is given by

$$\Pi_2(c) = (1 - \tau_2)A - \alpha_2 \frac{\gamma_2(\cdot)^2}{2} - (1 - c). \quad (6)$$

We define \bar{c} as the cost parameter such that a firm is indifferent between locating in either country. [Fig. 2](#) shows the allocation of firms across countries. Firms with $c \leq \bar{c}$ locate in Country 1, while firms with $c > \bar{c}$ choose Country 2.

Solving the indifference condition $\Pi_1(c) = \Pi_2(c)$ implies that \bar{c} is given by¹¹

$$\bar{c} = \frac{1}{2} - \frac{A}{2} \left[(t_1 - t_2) - \frac{t_1 \gamma_1(\cdot) - t_2 \gamma_2(\cdot)}{2} \right]. \quad (7)$$

Where $N_i(t_i, t_j, \alpha_i, \alpha_j)$ denotes the number of firms operating in Country i , we can show that

$$N_i(t_i, t_j, \alpha_i, \alpha_j) = \tilde{N}_i - \frac{A}{2C} \left[(t_i - t_j) - \frac{t_i \gamma_i(\cdot) - t_j \gamma_j(\cdot)}{2} \right] \quad (8)$$

where $\tilde{N}_1 = \frac{1}{2\bar{c}}$ and $\tilde{N}_2 = 1 - \frac{1}{2\bar{c}}$. Note that \tilde{N}_i is the number of firms that would locate in Country i if there were no fiscal distortions. The number of local firms decreases with the domestic tax rate, but increases with the other country's tax rate. Similarly, stricter domestic profit-shifting control reduces the number of local firms, while stricter enforcement by the other country helps to attract firms locally.

We can define Country i 's semi-elasticity of capital with respect to the domestic tax rate as $\varepsilon(N_i | t_i) = \frac{-1}{N_i(\cdot)} \frac{\partial N_i(\cdot)}{\partial t_i}$, where

$$\varepsilon(N_i | t_i) = \frac{\frac{A}{2C} [1 - \gamma_i(\cdot)]}{\tilde{N}_i - \frac{A}{2C} \left[(t_i - t_j) - \frac{t_i \gamma_i(\cdot) - t_j \gamma_j(\cdot)}{2} \right]} = \frac{A}{2C} \frac{1 - \gamma_i(\cdot)}{N_i(\cdot)}. \quad (9)$$

As stated in [Lemma 2](#) below, an increase in α_i makes firms' location decisions more sensitive to the tax rate in Country i , but makes them less sensitive in the other Country j . If a firm can shift profits easily, locating in a high-tax country is not such a problem. However, if profit shifting becomes more difficult, differences in tax rates become more salient. Stricter profit-shifting control increases the sensitivity of capital location decisions with respect to the tax rate in that country. [Egger et al. \(2014\)](#) and [Buettner et al. \(2018\)](#) confirm this result empirically. When the other country regulates profit shifting more aggressively, firms are less inclined to invest in that country. This gives an advantage to the country that did not change its enforcement policy. As a consequence, investment in the latter country is less sensitive to changes in its tax rate.

Lemma 2. Stricter profit-shifting control makes investment more responsive to the domestic tax rate of Country i —higher $\varepsilon(N_i | t_i)$ —but makes the similar variable less responsive in the other country.

We can also define the semi-elasticity of firms' location decisions with respect to domestic enforcement as $\varepsilon(N_i | \alpha_i) = \frac{-1}{N_i(\cdot)} \frac{\partial N_i(\cdot)}{\partial \alpha_i}$, where

$$\varepsilon(N_i | \alpha_i) = \frac{\frac{A}{4C} \gamma_i(\cdot)^2}{\tilde{N}_i - \left[(t_i - t_j) - \frac{A}{2C} \frac{t_i \gamma_i(\cdot) - t_j \gamma_j(\cdot)}{2} \right]} = \frac{A}{4C} \frac{\gamma_i(\cdot)^2}{N_i(\cdot)}. \quad (10)$$

[Egger et al. \(2014\)](#), [Egger and Wamser \(2015\)](#), and [Buettner et al. \(2018\)](#) confirm that profit-shifting enforcement, in the form of thin-capitalization rules, harms capital inflow. [De Simone et al.](#)

⁹ We ignore the case where firms shift all of their profits, because it is not relevant in equilibrium. If it were, a government would not generate any tax revenue and would then prefer to lower taxes or raise enforcement.

¹⁰ See survey papers by [Dharmapala \(2014\)](#) and [Heckemeyer and Overesch \(2017\)](#).

¹¹ We ignore the cases in which all firms locate in one country, because we will show that it is always possible and profitable for a country to attract some firms.



Fig. 2. Allocation of firms.

(2022) point out that firms with less aggressive profit-shifting behavior are more sensitive to local investment conditions. In our context, the implementation of stricter profit-shifting controls makes investment more sensitive to fiscal decisions.

2.2. Governments' decisions

Governments are strategic players. They value tax revenue, but they also care about the number of multinational corporations located in their country. Attracting a firm generates spillover benefit $R_i \geq 0$ for the country.¹² These benefits can be interpreted in many ways: job creation and higher wages, higher returns on fixed factors, and tax spillovers from higher personal income or sale taxes. The spillover benefit could also be motivated by political economy arguments, such as politician prestige or higher re-election probability. Mathew et al. (2021) estimate that a foreign direct investment (FDI) of GBP1m generates just under three additional jobs and almost GBP100,000 of gross value added. In total, each job directly created by FDI can be valued at just over GBP200,000 on average. Mathew et al. (2021) consider not only direct capital and employment effects, but also indirect effects on wages and labor productivity, as well as employment and capital investment spillovers. The objective function of government i is therefore given by

$$\Omega_i(t_i, t_j) = t_i N_i(\cdot) [1 - \gamma_i(\alpha_i, t_i)] A + N_i(\cdot) R_i - K \alpha_i. \quad (11)$$

These are the payoffs of the two-stage game played by the governments. We solve for the subgame perfect Nash equilibrium.

2.2.1. Tax competition stage

For any given α_1 and α_2 , the effect of a change in tax rate t_i on Country i 's welfare is given by

$$\begin{aligned} \frac{d\Omega_i(t_i, t_j)}{dt_i} = & \underbrace{N_i(\cdot) [1 - \gamma_i(\alpha_i, t_i)] A}_{\text{Revenue gains from higher tax rate}} + \underbrace{t_i N_i(\cdot) \frac{\partial [1 - \gamma_i(\alpha_i, t_i)]}{\partial t_i} A}_{\text{Revenue losses from extra profit shifting}} \\ & + \underbrace{t_i [1 - \gamma_i(\alpha_i, t_i)] \frac{\partial N_i(\cdot)}{\partial t_i} A}_{\text{Revenue losses from less investments}} + \underbrace{\frac{\partial N_i(\cdot)}{\partial t_i} R_i}_{\text{Losses in spillover benefit}}. \end{aligned} \quad (12)$$

There are two sources of tax-base erosion. As Country i increases its tax rate, more profits are shifted away and more firms locate in the other jurisdiction. We define $r_i = \frac{R_i}{[1 - \gamma_i(\alpha_i, t_i)] A}$ as the per-firm location benefits relative to the per-firm tax base. According to Eq. (12), the first-order condition can be written as follows:

$$t_i \varepsilon(1 - \gamma_i | t_i) + [t_i + r_i] \varepsilon(N_i | t_i) = 1. \quad (13)$$

We define $t_i(t_j)$ as Country i 's best-response function, which is implicitly given by Eq. (13).¹³ In a classic setting, a tax-revenue-maximizing government would like the elasticity of the tax base to equal 1. In our case, there are two elasticities to consider: (i) the per-firm retained profit elasticity and (ii) the firms' location elasticity, commonly called capital movement elasticity. When the government increases its tax rate, some firms move away, and the

remaining ones shift more profits. In addition, each firm leaving generates location benefits losses R , which are worth r_i in relative terms.

Lemma 3. (i) Taxes are strategic complements. (ii) When $R_1 < 1$ and $R_2 < 2C - 1$, there exists a unique equilibrium with positive tax rates t_1^* and t_2^* , where $t_1^* = t_1(t_2^*)$ and $t_2^* = t_2(t_1^*)$ are given by Eq. (13) for both $i = \{1, 2\}$.

If the location spillover benefit is too valuable, a country may be willing to subsidize firms to be able to capture it. Fig. 3 shows both countries' best-response functions and the equilibrium tax rates. It illustrates a case where $C < 1$. Country 1, which can then be referred to as the larger country, has an advantage in attracting firms. Claim 1 and Claim 2, below, state some properties of the equilibrium.

Claim 1. Everything else equal, when $C < 1$, Country 1 attracts more firms and sets a higher tax rate. The lower C is, the lower the equilibrium tax rates.

Claim 2. The higher the spillover benefit the lower the equilibrium tax rates.

The second claim highlights the fact that the higher the spillover benefit for a country, the more aggressive it is in the fiscal competition game. Both equilibrium taxes decrease when the spillover benefit of a country increases, because of the strategic complementarity of the taxes. We now follow with Proposition 1 stating an important feature of the equilibrium.

Proposition 1. Stricter profit-shifting control by Country i leads to a lower equilibrium tax rate in Country i if and only if condition Γ_{ii} is satisfied and to a lower equilibrium tax rate in Country j if and only if condition Γ_{ji} is satisfied, where

$$\Gamma_{ii} = \underbrace{\frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial \alpha_i}}_{-} + \underbrace{\frac{t_i^* + r_i}{t_i^*} \frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i}}_{+} + \underbrace{\frac{\varepsilon(N_i | t_i)}{t_i^*} \frac{\partial r_i}{\partial \alpha_i}}_{-} + \lambda_i \underbrace{\frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i}}_{-} > 0,$$

$$\text{with } \lambda_i = \frac{\frac{(t_i^* + r_i)(t_j^* + r_j)}{t_i^*} \left[\frac{1 - \gamma_i(\cdot)}{1 - \gamma_j(\cdot)} \right] \varepsilon(N_i | t_i)^2}{[-SOC_j]}$$

$$\Gamma_{ji} = \underbrace{\frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial \alpha_i}}_{-} + \underbrace{\frac{t_i^* + r_i}{t_i^*} \frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i}}_{+} + \underbrace{\frac{\varepsilon(N_i | t_i)}{t_i^*} \frac{\partial r_i}{\partial \alpha_i}}_{-} + \lambda_j \underbrace{\frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i}}_{-} > 0,$$

$$\text{with } \lambda_j = \frac{[-SOC_i]}{t_i^* \left[\frac{1 - \gamma_i(\cdot)}{1 - \gamma_j(\cdot)} \right] \varepsilon(N_j | t_j)^2} > 0.$$

When condition Γ_{ii} is satisfied, stricter profit-shifting control is associated with a lower tax rate. Both instruments can be seen as substitutes in this case. Holding everything else constant, stronger enforcement generates additional tax revenue. However, other considerations discussed below may prompt a government to compensate by lowering its nominal tax rate. The effective tax rate may then stay fairly constant. Alternatively, tax rates and enforcement

¹² If we allowed for a negative spillover, our two main results would be qualitatively the same. Examples of negative spillover include displacement of local firms and negative externality such as environmental damage.

¹³ The Appendix shows that second-order conditions are verified.

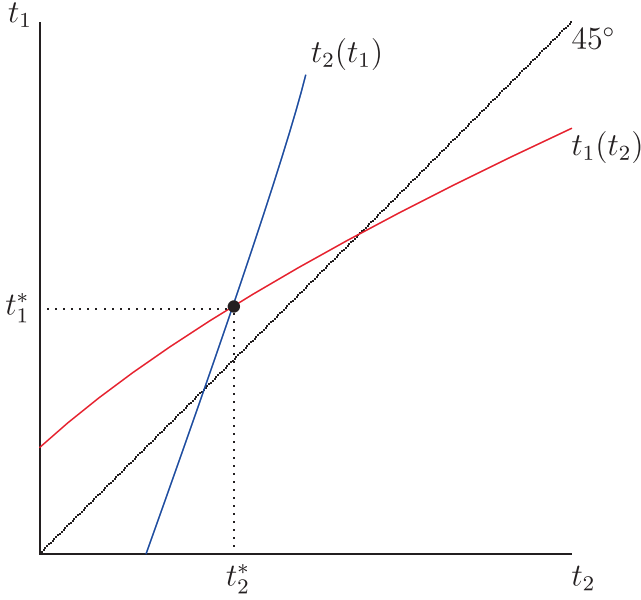


Fig. 3. Best responses and equilibrium tax rates.

may move in the same direction, in a complementary fashion. A reduction in the effective tax rate is associated with a broadening of the tax base and vice versa. We also look at the impact of controlling profit-shifting on the other country's equilibrium tax rate; this will be an important factor in the next section when looking at the optimal enforcement level.

The first three terms in conditions Γ_{ii} and Γ_{ji} represent the impact of α_i on Country i 's own best-response function. Stricter enforcement makes profit shifting less sensitive to the domestic tax rate, prompting Country i to set higher tax rates. This may contribute to an upward shift in Country i 's best-response function. At the same time, stricter profit-shifting enforcement makes investments more sensitive to the domestic tax rate and gives the incentive to lower taxes instead. This effect is weighted by $\frac{t_i^* + r_i}{t_i^*} > 1$ because attracting a firm generates a spillover benefit. The third term in conditions Γ_{ii} and Γ_{ji} represents a mechanical effect and is present only when R_i is positive. Stricter enforcement reduces the value of the spillover benefit relative to the per-firm tax base, as the latter increases. Consequently, Country i tends to set a higher tax rate. Finally, the fourth term represents the effect of α_i on Country j 's best-response function. An increase in α_i renders investments in Country j less sensitive to its own tax rate and encourages taxation. Both conditions represent similar movements in the best-response functions but with different weights. As a consequence, both tax rates may move in different directions. Fig. 4 illustrates a case where the equilibrium tax rate in the other country decreases with stricter domestic profit-shifting regulations.

2.2.2. Profit-shifting enforcement stage

In the first stage of the game, governments decide on profit-shifting enforcement while taking into account the impacts of their decision in the subsequent stages of the game. Controlling profit shifting has direct and indirect effects. Stricter enforcement means that each firm shifts a lower share of its profit, but because stricter enforcement also increases the effective tax rate, the country is made less attractive to investment. Enforcement policies also influence the equilibrium of the tax competition game, which has an indirect impact on a country's social welfare. The effect of a change in α_i on Country i 's welfare is given by

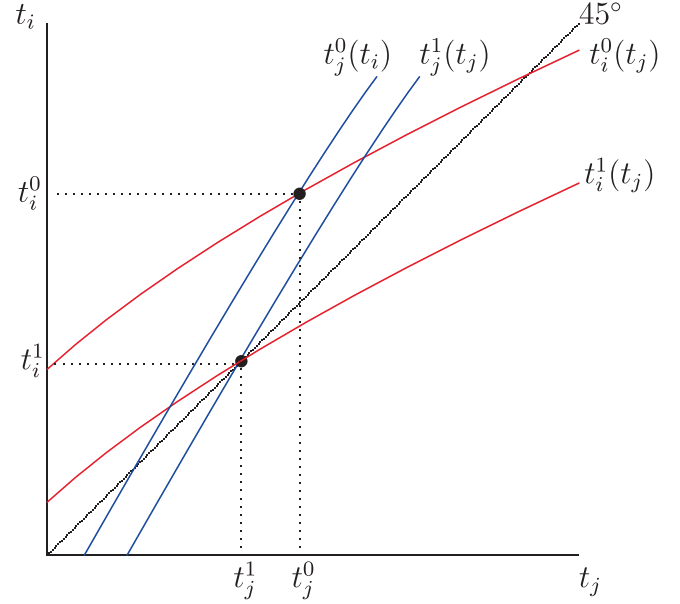


Fig. 4. A decrease in t_j following an increase in α_i .

$$\frac{d\Omega_i(\alpha_i, \alpha_j)}{d\alpha_i} = \underbrace{t_i^* N_i(\cdot) \frac{\partial [1 - \gamma_i(\alpha_i, t_i^*)]}{\partial \alpha_i}}_{\text{Revenue gain from less profit shifting}} A + \underbrace{t_i^* [1 - \gamma_i(\alpha_i, t_i^*)]}_{\text{Revenue losses from firms/movement}} \frac{\partial N_i(\cdot)}{\partial \alpha_i} A$$

$$\underbrace{\frac{\partial N_i(\cdot)}{\partial \alpha_i} R_i}_{\text{Losses in location benefits}} + \underbrace{\frac{d\Omega_i(\alpha_i, \alpha_j)}{dt_i} \frac{\partial t_i^*}{\partial \alpha_i}}_0 + \underbrace{\frac{d\Omega_i(\alpha_i, \alpha_j)}{dt_j} \frac{dt_j^*}{d\alpha_i}}_{\text{Taxcompetition effect (+)}} - K. \quad (14)$$

The first-order condition determining the optimal level of enforcement written in terms of semi-elasticities is given by

$$\varepsilon(1 - \gamma_i | \alpha_i) - \frac{t_i^* + r_i}{t_i^*} \varepsilon(N_i | \alpha_i) + \frac{t_i^* + r_i}{t_i^*} \frac{1}{N_i(\cdot)} \frac{\partial N_i(\cdot)}{\partial t_j} \frac{\partial t_j^*}{\partial \alpha_i} - \kappa_i \geq 0,$$

where $\kappa_i = \frac{K}{t_i^* [1 - \gamma_i(\cdot)] N_i(\cdot) A}$ represents the marginal cost of enforcement relative to tax revenue collected. When the condition can be satisfied only with inequality, then α_i is maximal.

Proposition 2. Less than full enforcement $\bar{\alpha}_i$ is desirable by Country i when condition Γ is satisfied at $\bar{\alpha}_i$ where

$$\Gamma = \varepsilon(1 - \gamma_i | \alpha_i) - \frac{t_i^* + r_i}{t_i^*} \varepsilon(N_i | \alpha_i) + \frac{t_i^* + r_i}{t_i^*} \left[\frac{1 - \gamma_j(\cdot)}{1 - \gamma_i(\cdot)} \right] \varepsilon(N_i | t_i) \frac{\partial t_j^*}{\partial \alpha_i} - \kappa_i < 0.$$

The first term in condition Γ represents the fact that when enforcement increases, profit shifting decreases and so tax revenue increases. The second term illustrates the fact that stricter enforcement chases firms away by increasing the effective tax rate. This leads to a loss not only in tax revenue but also in spillover benefits. When this effect is strong, lax enforcement can be welcomed. The third term is the tax competition effect. A higher tax rate posted by the other country leads to an inflow of investment generating additional tax revenue and spillover benefits. If a decrease in enforcement promotes an increase in the tax rate by the other country, lax enforcement is again welcomed. The last term represents the cost of enforcement relative to the total tax base. When the sum of all four effects evaluated at $\bar{\alpha}$ is negative, then less than full enforcement is optimal.

3. Simulations and validation of results

In this section, we provide numerical examples with a few objectives in mind. First, we demonstrate that our model can generate equilibria with lax enforcement for reasonable parameter values. We select parameter values that induce equilibria consistent with observations. This should not be seen as a calibration of the model, but as an illustrative exercise. Second, we explore the impact of asymmetry between countries competing for capital. We then use actual estimates for the variable of interest to show that the two conditions supporting our results in [Proposition 1](#) and [Proposition 2](#) can be satisfied for reasonable values of the spillover benefit.

3.1. Simulations

For the first set of simulations, we set $A = 1$ and use a reasonable value for the spillover benefit at $R_1 = R_2 = 0.25$ and set $K = 0.05$. With these values, the spillover benefit is around 25% of the taxable base a firm generates, and the costs of enforcement for $\alpha = 1$ correspond to about 5% of the same tax base. [Fig. 5](#) represents profit-shifting enforcement efforts for a symmetric and an asymmetric equilibrium. In both cases, enforcement efforts are strategic complements, in the same way as taxes, and less than maximal enforcement is desirable.

[Table 1](#) aids our understanding of the impact of asymmetry. The case where $C = 1$ is used as a reference point. We obtain tax rates consistent with high-tax countries as described in [Buettner et al. \(2018\)](#) for the period where profit-shifting controls are introduced and strengthened. The proportions of shifted profit are consistent with estimates from [Wier et al. \(2019\)](#). When $C < 1$, Country 1 has a comparative advantage in attracting capital. It not only sets a higher tax rate, but also implements stricter enforcement. Larger countries setting higher tax rates have been well documented in both the theoretical and empirical literature.¹⁴ Our finding that the larger country also implements stricter profit-shifting controls is consistent with observations from [Buettner et al. \(2018\)](#). [Haufler and Runkel \(2012\)](#) obtain a similar theoretical result at the margin, as long as public funds are not valuable relative to private consumption. Because both a higher tax rate and stricter profit-shifting enforcement discourage investment, even with $C = 0.75$ there is only a 12% gap between the number of firms in each country.

We continue our simulations to discuss the impact of enforcement costs on equilibrium outcomes. [Fig. 6](#) presents optimal profit-shifting control and profit shifting for different values of K for the symmetric case ($C = 1$). As expected, lower enforcement costs imply stricter controls and less profit shifting. However, even when costs are very low, enforcement efforts are not maximal, and some profit shifting is tolerated.

3.2. Magnitude of the semi-elasticities

Our two main results in [Proposition 1](#) and [Proposition 2](#) depend on four semi-elasticities. To check whether it is reasonable to conclude that our condition supports the desirability of lax enforcement, we need to know the magnitude of these semi-elasticities. The effect of taxes on capital mobility is by far the most studied.¹⁵ In a meta-analysis, [De Mooij and Ederveen \(2008\)](#) propose consensus values for $\varepsilon(N | t)$ between 0.4 and 0.65. We use two values for the

¹⁴ See [Mongrain and Wilson \(2018\)](#) for a discussion of the theoretical literature and [Buettner et al. \(2018\)](#) for evidence regarding tax rates.

¹⁵ Surveys by [De Mooij and Ederveen \(2008\)](#), [Hines \(1999\)](#), and [Devereux and Griffith \(2003\)](#) report fiscal semi-elasticity of capital mobility ranging from 0.1 to just around 2. [Devereux and Griffith \(1998\)](#), who estimate a model with firm mobility similar to our setup, suggest values between 0.5 and 1.3.

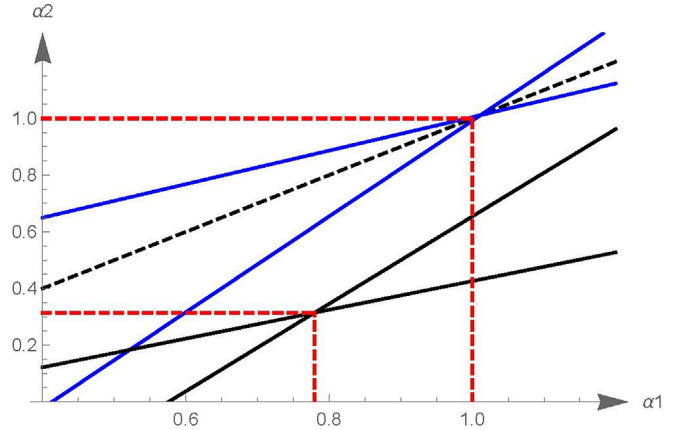


Fig. 5. Profit-shifting enforcement efforts for symmetric (blue) and asymmetric (black) equilibria. The dotted-dashed line is the 45° line. The blue lines represent the best-response function $\alpha_1(\alpha_2)$ leading to the equilibrium enforcement levels $\alpha_1 = \alpha_2 = 1$ for the case where $C = 1$. The black solid lines represent the best-response function $\alpha_1(\alpha_2)$ leading to the equilibrium enforcement levels $\alpha_1 = 0.78$ and $\alpha_2 = 0.31$ for the case where $C = 0.8$.

capital movement semi-elasticity. The first one is 0.5, which is in the middle of the consensus values. A value of 0.7 is used to represent a more elastic investment pattern. The effect of taxes on shifted profit is also well studied.¹⁶ Using meta-regression analysis, [Dharmapala \(2014\)](#) and [Heckemeyer and Overesch \(2017\)](#) propose $\varepsilon(1 - \gamma_1 | t) = 0.8$. We use this value and a value of 1 to represent more elastic profit-shifting behaviors.

Findings by [Egger et al. \(2014\)](#), [Egger and Wamser \(2015\)](#), and [Buettner et al. \(2018\)](#) confirm our result that profit-shifting enforcement harms capital inflow. Specifically, [Buettner et al. \(2018\)](#) estimate a semi-elasticity of FDI with respect to the introduction of a 3:1 thin-capitalization rule $\varepsilon(N | \alpha)$ of around 0.1 for high-tax countries. Their semi-elasticity is defined as $\frac{\partial \ln(FDI)}{\partial \alpha}$. [Lemma 2](#) predicts that stricter profit-shifting enforcement increases the responsiveness of capital to tax rates. [Buettner et al. \(2018\)](#) estimate that the introduction of a safe-haven debt-to-equity ratio of 3:1 increases the tax-rate sensitivity of FDI from 0.586 to 1.1.¹⁷ Consequently, $\varepsilon(N | t)$ increases by about 0.5 following a significant change in the tightness indicator. A linear approximation of $\frac{\partial \varepsilon(N | t)}{\partial \alpha}$ would yield a value of 2, as the indicator changes from 0 to 0.25.

Thin-capitalization rules have been shown to curb profit-shifting behaviors. [Overesch and Wamser \(2010\)](#) and [Weichenrieder and Windischbauer \(2008\)](#) show that thin-capitalization rules reduce intracompany loans significantly. [Buettner et al. \(2012\)](#) estimate that the implementation of a safe-haven debt-to-equity ratio of 2:1 reduces the internal debt ratio by almost 12% of its mean value. This corresponds to $\varepsilon(1 - \gamma | \alpha)$ equal to 0.36. [Blouin et al. \(2014\)](#) show that the introduction of an average thin-capitalization rule of 3:1 reduces the leverage ratio by 6.3%, corresponding to $\varepsilon(1 - \gamma | \alpha)$ equal to 0.25. We will use these two sets of values. [Buettner et al. \(2012\)](#) look at the impact of introducing a safe-haven debt-to-equity ratio of 2:1 on the ratio of debt to assets for German multinational firms. They estimate

¹⁶ Early estimates, such as those by [Hines and Rice \(1994\)](#), suggested that profit shifting reacts sharply to taxes, with estimates of over 2. More recent estimates indicate that profit shifting is much less responsive, with semi-elasticities as low as 0.4. See [Dischinger et al. \(2014\)](#), [Grubert \(2012\)](#), [Heckemeyer and Overesch \(2017\)](#), [Lohse and Riedel \(2013\)](#), and [Weichenrieder \(2009\)](#), to name just a few.

¹⁷ [Egger et al. \(2014\)](#) show that an increase of 1 percentage point in the tax rate reduces the fixed assets of non-avoiders by 0.8, but has almost no effect on avoiders and is between these two values.

Table 1
Simulated variables of interest.

	t_1^*	α_1^*	γ_1^*	N_1^*	t_2^*	α_2^*	γ_2^*	N_2^*
$C = 1$	0.35	1.01	0.34	0.50	0.35	1.01	0.34	0.50
$C = 0.95$	0.32	0.95	0.34	0.51	0.29	0.83	0.34	0.49
$C = 0.9$	0.30	0.89	0.34	0.52	0.23	0.66	0.35	0.48
$C = 0.85$	0.28	0.84	0.34	0.53	0.17	0.48	0.35	0.47
$C = 0.80$	0.26	0.78	0.339	0.54	0.11	0.31	0.36	0.46
$C = 0.75$	0.24	0.73	0.337	0.56	0.06	0.15	0.36	0.44

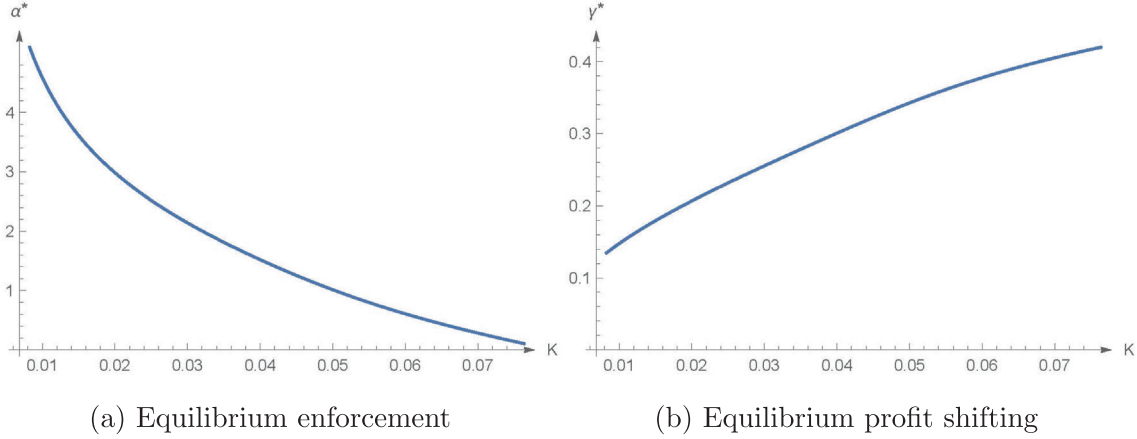


Fig. 6. Equilibrium values when $C = 1$ for different K .

that an increase of 1 percentage point in the tax rate leads to an increase of 1.2 percentage points in the internal debt ratio when regulated. Because the average internal debt ratio is equal to 0.28, we can then infer a 4% change relative to its mean value. This is about half of the unregulated estimate, suggesting a change in $\varepsilon(1 - \gamma_1 | t)$ by about 0.04 for a change of 0.33 in the enforcement index. This would correspond to a linear approximation for $\frac{\partial \varepsilon(1 - \gamma_1 | t)}{\partial \alpha}$ of about -0.12 . [Table 2](#) presents the relevant estimates.

3.3. Validation of conditions Γ_{ii} , Γ_{ji} , and Γ

We now assess whether conditions Γ_{ii} and Γ_{ji} , guaranteeing that tax rates are declining with stricter profit-shifting control, and condition Γ , needed for optimal tax enforcement, can be satisfied given the semi-elasticities collected. [Table 3](#) summarizes our results. This exercise is done under the symmetric case where $C = 1$. Because the enforcement costs can be difficult to evaluate, we set $K = 0$, which corresponds to the case where condition Γ is the least likely to be satisfied. We use corporate tax rates of 10% to represent large tax havens such as Ireland, 25% to represent countries with an average tax rate, and 35% to represent high-tax countries such as the United States and Germany over the period where profit-shifting controls were introduced and strengthened. We use the first-order conditions on equilibrium tax rates to compute the r that would be compatible with an equilibrium tax rate respectively equal to $t = \{0.1, 0.25, 0.35\}$, where r represents the spillover benefit relative to the net tax base a firm brings, $\frac{R}{(1-\gamma)A}$. To put these numbers in perspective, we can make a back-of-the-envelope calculation using the estimate of [Mathew et al. \(2021\)](#) that an FDI of GBP1m generates GBP100,000 of additional gross value added. If the investment is assumed to generate 10% in taxable income, then it is compatible with $r = 1$.

As stated in [Claim 2](#), lower tax rates are supported by a higher relative spillover benefit r . At the consensus values for $\varepsilon(N | t)$ and $\varepsilon(1 - \gamma | t)$, the spillover benefit can be significant. A tax rate of 35%

Table 2
Estimates for the variables of interest.

	Range	Relevant Estimate (s)
$\varepsilon(N t)$	[0.1, 2]	0.5 and 0.7
$\varepsilon(1 - \gamma t)$	[0.4, 2.25]	0.8 and 1
$\varepsilon(N \alpha)$	0.1	0.1
$\frac{\partial \varepsilon(N t)}{\partial \alpha}$	2	2
$\varepsilon(1 - \gamma \alpha)$	[0.25, 0.36]	0.25 and 0.36
$\frac{\partial \varepsilon(1 - \gamma t)}{\partial \alpha}$	-0.12	-0.12

Table 3
Validation of conditions Γ_{ii} , Γ_{ji} , and Γ .

	$\varepsilon(N t) = 0.5$ $\varepsilon(1 - \gamma t) = 0.8$	$\varepsilon(N t) = 0.7$ $\varepsilon(1 - \gamma t) = 1$
$\varepsilon(1 - \gamma \alpha) = 0.25$		
$t^* = 0.35$	$r = 1.09$; $\Gamma = -0.76$ ($\underline{r} = 0.25$)	$r = 0.58$; $\Gamma = -0.26$ ($\underline{r} = 0.24$)
	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -1.61$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.29$	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -0.78$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.13$
$t^* = 0.25$	$r = 1.35$; $\Gamma = -1.54$ ($\underline{r} = 0.21$)	$r = 0.82$; $\Gamma = -0.69$ ($\underline{r} = 0.20$)
	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -1.79$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.36$	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -0.89$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.17$
$t^* = 0.1$	$r = 1.74$; $\Gamma = -5.99$ ($\underline{r} = 0.12$)	$r = 1.19$; $\Gamma = -3.24$ ($\underline{r} = 0.12$)
	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -2.06$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.48$	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -1.06$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.25$
$\varepsilon(1 - \gamma \alpha) = 0.36$		
$t^* = 0.35$	$r = 1.09$; $\Gamma = -0.63$ ($\underline{r} = 0.41$)	$r = 0.58$; $\Gamma = -0.14$ ($\underline{r} = 0.40$)
	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -1.57$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.28$	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -0.76$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.13$
$t^* = 0.25$	$r = 1.35$; $\Gamma = -1.40$ ($\underline{r} = 0.34$)	$r = 0.82$; $\Gamma = -0.56$ ($\underline{r} = 0.33$)
	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -1.74$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.35$	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -0.87$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.17$
$t^* = 0.1$	$r = 1.74$; $\Gamma = -5.75$ ($\underline{r} = 0.19$)	$r = 1.19$; $\Gamma = -3.03$ ($\underline{r} = 0.19$)
	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -2.00$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.46$	$\frac{\partial \Gamma_{ii}}{\partial \alpha_i} = -1.02$; $\frac{\partial \Gamma_{ji}}{\partial \alpha_i} = -0.23$

would imply that the spillover benefit must be as important as the tax base a firm brings ($r = 1.09$). A low tax rate, such as in Ireland, can be supported only when the spillover benefit is valued 75% more than the net tax base. As we discussed in Section 3.2, there is a lot of variation in the estimation for the two underlying semi-elasticities. When employing slightly higher semi-elasticities of $\varepsilon(N | t) = 0.7$ and $\varepsilon(1 - \gamma | t) = 1$, then r drops considerably. A high tax rate can be supported by a spillover benefit of just over half of the net tax base.

Conditions Γ_{ii} and Γ_{ji} are satisfied for all estimates for the semi-elasticities found in the literature. Consequently, tax rates should decrease with stricter enforcement. This is a similar mechanism to that described by [Haufler and Schjelderup \(2000\)](#) as the reduction in tax rate is associated with a broadening of the tax base. This is also consistent with [Buettner et al. \(2018\)](#), who found no evidence of upward trends in corporate taxes during the period where profit-shifting regulations were introduced and strengthened. In fact, OECD countries' corporate tax rates decreased on average during that period. Because the value of the conditions is not particularly informative apart from the sign, we report in [Table 3](#) the derivative of each equilibrium tax rate for a change in enforcement. As we can see, stricter enforcement has a larger impact on the domestic tax rate than on the foreign tax rate, which is intuitive because the second effect is indirect. Because the introduction of a 3:1 debt-to-equity ratio represents a change in α from 0 to 0.25, then $\frac{\partial \alpha_i^*}{\partial \alpha_i} = -1.61$ means that the domestic tax rate should decline by 40 percentage points. For the more responsive tax bases, this number drops by half.

All of the semi-elasticities estimates also support lax enforcement as condition Γ is always negative. Because the value of the condition is again difficult to interpret, in [Table 3](#) we add \underline{r} to represent the minimum relative spillover benefit needed for $\Gamma = 0$. The condition is satisfied for all $r > \underline{r}$. When profit shifting responds only slightly to enforcement, $\varepsilon(1 - \gamma | \alpha) = 0.25$, the required spillover benefit is never more than a quarter of the net tax base. When using the more responsive profit-shifting behavior, the required spillover benefit is under half of the net tax base.

4. Conclusion

We have identified two important tax bases: per-firm retained profits and the size of investments. More stringent profit-shifting control makes the former less sensitive to taxes, but makes the latter more sensitive. Stricter profit-shifting control may put downward pressure on tax rates. At the same time, profit-shifting control directly affects a country's tax base. Stricter enforcement reduces the export of profits, but also chases firms away. Overall enforcement has an ambiguous effect on high-tax countries' well-being. We found conditions under which lax profit-shifting control can be desirable. Estimates of the relevant semi-elasticities found in the literature suggest that these conditions can be reasonably satisfied.

We deliberately ignored other factors proposed in the literature because they worked against profit-shifting control, such as the presence of local and international firms allowing for fiscal discrimination. Instead, we focused on more basic mechanisms that allowed us to have both endogenous tax rates and endogenous profit-shifting enforcement.

We found that profit-shifting controls can be viewed as fiscal measures. Stronger enforcement, such as higher taxes, generates additional tax revenues for a given number of firms. However, it chases firms away, in a similar way to taxation.

As in previous studies, we introduced a parasitic tax haven that posts an exogenous zero tax rate. In future work, it may be interesting to endogenize tax havens' decisions. Parasitic tax havens

are similar in nature: They tend to be small countries with little production capabilities that have little or no corporate taxation. Other tax havens, classified as the "Big 7" by [Hines and Rice \(1994\)](#) for example, tend to be larger countries with non-negligible production capabilities that set low corporate tax rates. In fact, profit shifting even happens between non-tax-haven countries when there are tax differences to exploit. There is certainly the scope to better understand these interactions. Different tools are used to shift profits. The manipulation of financial assets can be effective to shift profit to parasitic tax havens, but the manipulation of transfer prices may require active production in the host country.

Data availability

No data was used for the research described in the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Appendix

Proof of Lemma 1: We can show that $\frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial \alpha_i} = \frac{-1}{[\alpha_i - t_i]^2} = -\varepsilon(1 - \gamma_i | t_i)^2 < 0$. It is clear that α_i has no impact on $\varepsilon(1 - \gamma_j | t_j)$. ■

Proof of Lemma 2: The effect of α_i on $\varepsilon(N_i | t_i)$ is given by

$$\frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i} = \varepsilon(N_i | t_i)[\varepsilon(1 - \gamma_i | \alpha_i) + \varepsilon(N_i | \alpha_i)], \quad (16)$$

which is positive. We can also show that

$$\frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_j} = -\varepsilon(N_i | t_i)\varepsilon(N_i | \alpha_i) \left[\frac{\gamma_j(\cdot)}{\gamma_i(\cdot)} \right]^2, \quad (17)$$

which is negative. ■

Second-Order Conditions: The second-order conditions are given by

$$SOC_i = - \left[\varepsilon(1 - \gamma_i | t_i) + \varepsilon(N_i | t_i) + \varepsilon(N_i | t_i) \frac{\partial r_i}{\partial t_i} \right] - t_i \frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial t_i} - [t_i + r_i] \frac{\partial \varepsilon(N_i | t_i)}{\partial t_i}. \quad (18)$$

Using the fact that $\frac{\partial \varepsilon(N_i | t_i)}{\partial t_i} = \varepsilon(N_i | t_i)[\varepsilon(N_i | t_i) - \varepsilon(1 - \gamma_i | t_i)]$ and $\frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial t_i} = \varepsilon(1 - \gamma_i | t_i)^2$, we can show that

$$SOC_i = -[\varepsilon(1 - \gamma_i | t_i) + \varepsilon(N_i | t_i) + r_i \varepsilon(N_i | t_i) \varepsilon(1 - \gamma_i | t_i)] - t_i \varepsilon(1 - \gamma_i | t_i)^2 + (t_i + r_i) \varepsilon(N_i | t_i) \varepsilon(1 - \gamma_i | t_i) - (t_i + r_i) \varepsilon(N_i | t_i)^2. \quad (19)$$

Using the first-order conditions $(t_i + r_i) \varepsilon(N_i | t_i) = 1 - t_i \varepsilon(1 - \gamma_i | t_i)$, we can show that

$$SOC_i = -\varepsilon(N_i | t_i)[1 + r_i \varepsilon(1 - \gamma_i | t_i)] - 2t_i \varepsilon(1 - \gamma_i | t_i)^2 - (t_i + r_i) \varepsilon(N_i | t_i)^2. \quad (20)$$

The second-order conditions are negative. ■

Proof of Lemma 3: First-order conditions are continuous in (t_i, t_j) ; therefore $t_i(t_j)$ is also continuous in t_j . As $\varepsilon(1 - \gamma_i | t_i)$ does not depend on t_j , and $\varepsilon(N_i | t_i)$ is decreasing in t_j , we can show that taxes are strategic complements:

$$\frac{\partial t_i(t_j)}{\partial t_j} = \frac{[t_i + r_i] \frac{\partial \varepsilon(N_i | t_i)}{\partial t_j}}{SOC_i} > 0. \quad (21)$$

When $R_1 < 1$ and $R_2 < (2C - 1)$, we find that

$$\frac{d\Omega_i(0,0)}{dt_i} = 2AC(2C\bar{N}_i - R_i) > 0. \quad (22)$$

Therefore, $t_i(0) > 0$. This implies that there exists a fixed point t_i^* and t_j^* where $t_i^* = t_1(t_2^*)$ and $t_j^* = t_2(t_1^*)$. ■

Proof of Claim 1: Note that C has no impact on $\varepsilon(1 - \gamma_i | t_i)$. We can show that

$$\frac{\partial FOC_i}{\partial C} = -(t_i + r_i) \frac{\partial \varepsilon(N_i | t_i)}{\partial C} = (t_i + r_i) \frac{A}{2C^2 N_i^2} \frac{\partial(N_i C)}{\partial C} > 0. \quad (23)$$

Note that $N_i C$ is independent of C and that $\frac{\partial(N_i C)}{\partial C} = 1$. This means that the best response of Country 1 is not affected and that the best response of Country 2 shifts upward. ■

Proof of Claim 2: Note that R_i has a direct impact on the first-order condition of Country i and not on Country j . We can show that

$$\frac{\partial FOC_i}{\partial R_i} = -\varepsilon(N_i | t_i) \frac{\partial r_i}{\partial R_i} < 0. \quad (24)$$

Therefore, the best response of Country i shifts downward, and the best response of Country j is not affected. Because of strategic complementarity, this induces a decrease in both equilibrium tax levels. ■

Proof of Proposition 1: Let H represent the matrix of derivatives of Eq. (13) for $i = \{1, 2\}$ with respect to t_1 and t_2 . The determinant H is given by

$$|H| = [SOC_1][SOC_2] - \left[(t_1^* + r_1) \frac{\partial \varepsilon(N_1 | t_1)}{\partial t_2} \right] \left[(t_2^* + r_2) \frac{\partial \varepsilon(N_2 | t_2)}{\partial t_1} \right]. \quad (25)$$

We can then show that

$$|H| = [SOC_1][SOC_2] - [(t_1^* + r_1) \varepsilon(N_1 | t_1)^2 [(t_2^* + r_2) \varepsilon(N_2 | t_2)^2]. \quad (26)$$

Because $SOC_i = \varepsilon(N_i | t_i)[1 + r_i \varepsilon(1 - \gamma_i | t_i)] + 2t_i \varepsilon(1 - \gamma_i | t_i)^2 + (t_i + r_i) \varepsilon(N_i | t_i)^2$, then $|H|$ is positive.

The impact of α_i on t_i^* is given by $\frac{\partial t_i^*}{\partial \alpha_i} = -\frac{|H_{ii}|}{|H|}$, where

$$|H_{ii}| = \left[t_i^* \frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial \alpha_i} + (t_i^* + r_i) \frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i} + \varepsilon(N_i | t_i) \frac{\partial r_i}{\partial \alpha_i} \right] [-SOC_j] - \left[(t_i^* + r_i) \frac{\partial \varepsilon(N_i | t_i)}{\partial t_j} \right] \left[(t_j^* + r_j) \frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i} \right]. \quad (27)$$

Because $\frac{\partial N_i}{\partial \alpha_i} = -\left[\frac{1 - \gamma_i(\cdot)}{1 - \gamma_i(\cdot)} \right] \frac{\partial N_i(\cdot)}{\partial \alpha_i}$, we can show that

$$\frac{|H_{ii}|}{t_i^* [-SOC_j]} = \frac{\partial \varepsilon(1 - \gamma_i | t_j)}{\partial \alpha_i} + \frac{t_i^* + r_i}{t_i^*} \frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i} + \frac{\varepsilon(N_i | t_i)}{t_i^*} \frac{\partial r_i}{\partial \alpha_i} + \frac{(t_j^* + r_j)(t_i^* + r_i) \left[\frac{1 - \gamma_i(\cdot)}{1 - \gamma_i(\cdot)} \right] \varepsilon(N_i | t_i)^2}{t_i^* [-SOC_j]} \frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i}. \quad (28)$$

A reduction in α_i leads to a higher equilibrium tax rate t_i^* as long as condition Γ_{ii} in the proposition is satisfied. Similarly, the impact of α_i on t_j^* is given by $\frac{\partial t_j^*}{\partial \alpha_i} = -\frac{|H_{ji}|}{|H|}$, where

$$|H_{ji}| = \left[(t_j^* + r_j) \frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i} \right] [-SOC_i] - \left[(t_j^* + r_j) \frac{\partial \varepsilon(N_j | t_j)}{\partial t_i} \right] \left[t_i^* \frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial \alpha_i} \right] + (t_i^* + r_i) \frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i} + \varepsilon(N_i | t_i) \frac{\partial r_i}{\partial \alpha_i}. \quad (29)$$

Because $\frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i} = -\left[\frac{1 - \gamma_j(\cdot)}{1 - \gamma_j(\cdot)} \right] \varepsilon(N_j | t_j)^2 < 0$, we can show that

$$\frac{|H_{ji}| \left[\frac{1 - \gamma_j(\cdot)}{1 - \gamma_j(\cdot)} \right]}{t_i^* (t_j^* + r_j) \varepsilon(N_j | t_j)^2} = \frac{\partial \varepsilon(1 - \gamma_i | t_i)}{\partial \alpha_i} + \frac{t_i^* + r_i}{t_i^*} \frac{\partial \varepsilon(N_i | t_i)}{\partial \alpha_i} + \frac{\varepsilon(N_i | t_i)}{t_i^*} \frac{\partial r_i}{\partial \alpha_i} + \left[\frac{\partial \varepsilon(N_j | t_j)}{\partial \alpha_i} \right] \left[\frac{-SOC_i}{t_i^* \varepsilon(N_j | t_j)^2} \right] \left[\frac{1 - \gamma_j(\cdot)}{1 - \gamma_j(\cdot)} \right]. \quad (30)$$

As a consequence, $\frac{\partial t_j^*}{\partial \alpha_i}$ is negative when Γ_{ji} is positive. ■

Proof of Proposition 2: By using the first-order condition from the tax competition stage, which states that $\frac{\partial \Omega_i(\cdot)}{\partial t_i} = 0$, we can rewrite Eq. (14) as

$$\frac{d\Omega_i(\cdot)}{d\alpha_i} = (t_i^* + r_i)[1 - \gamma_i(\cdot)]A \frac{\partial N_i(\cdot)}{\partial \alpha_i} - t_i^* N_i(\cdot)A \frac{\partial \gamma_i(\cdot)}{\partial \alpha_i} + \frac{\partial \Omega_i(\cdot)}{\partial t_j} \frac{dt_j^*(\cdot)}{d\alpha_i} - K.$$

Because we can show that $\frac{\partial \Omega_i(\cdot)}{\partial t_j} = (t_i^* + r_i)[1 - \gamma_i(\cdot)]A \frac{\partial N_i(\cdot)}{\partial t_j}$, the equation above can be rewritten as

$$\frac{d\Omega_i(\cdot)}{d\alpha_i} = [1 - \gamma_i(\cdot)]N_i(\cdot) \left[t_i^* \varepsilon(1 - \gamma_i | \alpha_i) - (t_i^* + r_i) \varepsilon(N_i | \alpha_i) + \frac{t_i^* + r_i}{N_i(\cdot)} \frac{\partial N_i(\cdot)}{\partial t_j} \frac{dt_j^*}{d\alpha_i} \right] A - K. \quad (32)$$

Because $\frac{\partial N_i(\cdot)}{\partial t_j} = -\left[\frac{1 - \gamma_j(\cdot)}{1 - \gamma_j(\cdot)} \right] \frac{\partial N_i(\cdot)}{\partial \alpha_i} > 0$, welfare then decreases in α_i whenever Γ is negative. ■

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