# How Big Are Strategic Spillovers from Corporate Tax Competition?

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**Abstract**

In this paper I estimate the size of strategic spillovers from corporate tax competition. Existing evidence suggests that the revenue loss due to strategic spillovers is substantial. A three-country, three-firm model of tax competition predicts that the relative size of a government's optimal response to a neighbour's tax cut depends on the size of the capital flows induced by the neighbour's tax cut. I use this theoretical prediction to empirically identify the size of strategic spillovers. Using data on bilateral cross-country capital stocks to weight the average foreign tax rate, I find that governments respond to a 1 percentage point cut in the foreign tax rate with a 0.23 percentage point cut of their own. This estimate is a third of the size of previous estimates. This paper suggests that revenue loss from tax competition is modest compared to previous estimates.

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Keywords: Tax Competition; Corporate Taxation; Foreign Direct Investment

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# 1 Introduction

The central prediction of the theory of tax competition is that imposing distorting taxes on mobile capital will lead to the under-provision of public goods (Zodrow and Mieszkowski, 1986). This under-provision happens because each government has an incentive to lower their corporate tax rate to attract more capital. And other governments have an incentive to respond competitively by lowering their own corporate tax rates to recapture that lost capital. The act of lowering the corporate tax rate as a strategic response to another government's tax cut is what we define as **tax competition**. Economics predicts that tax competition leads to a Nash equilibrium where tax rates are collectively below their social optimum (Keen and Konrad, 2014). This implies that governments collectively lose revenue as a result of acting competitively.

How big is the revenue loss resulting from tax competition? This depends on how far below the social optimum tax rates fall due to tax competition. The difference between actual tax rates and the counterfactual social optimum can be identified by how large strategic responses to tax cuts are. These strategic best response to a neighbouring country's tax rate change is defined as a **strategic spillover**.

In this paper, I aim to identify the magnitude of strategic spillovers from corporate tax competition. I answer the question: how much does a government change its tax rate in response to a collective one percentage point change in its neighbours' tax rates? The answer I uncover is that a 1 percentage point reduction in the foreign tax rate results in a 0.23 percentage point tax rate cut in response by the home country. This is *a third* of the size of previous estimates, which suggest that a 1 percentage point reduction in the average foreign corporate tax rate induces the home country to lower its own corporate tax rate by 0.6 to 0.7 percentage points.

Using previous estimates, Beer et al. (2018) find that strategic spillovers from the United States' corporate tax rate cut in 2017 are likely more than double the size of the resulting tax base spillovers. The IMF (2019) similarly points that revenue loss from tax competition could likely outweigh the revenue loss from profit shifting substantially. The strategic spillovers I estimate I this paper moderate these concerns, suggesting that corporate tax competition likely results in much less revenue loss than previously implied.

The central contribution of this study is the use of a theoretical model of tax competition to guide empirical identification of the size of strategic spillovers. Estimating strategic spillovers typically relies on a spatial autoregressive strategy. Identification in this class of models depends on the correct specification of the weight matrix capturing the relative importance of one country to another. Unlike previous studies, I derive the weight matrix implied by a three-country three-multinational firm model of corporate tax competition. Theoretically, I find that the size of strategic spillovers depends crucially on the size of expected **tax base spillovers**—the effect of one country's corporate tax rate reform on another's corporate tax base. In particular, three types of cross-border investment are important for the base spillover between country $A$ and country $B$: the stock of capital from country $A$ invested in country $B$; the stock of capital from country $B$ invested in country $A$; and competition between countries $A$ and $B$ for capital from a third country country $C$. I empirically implement this using data on bilateral foreign direct investment stocks. This central contribution relies on the appropriate definition of tax competition: "noncooperative tax setting by independent governments, under which each government's policy choices influence the allocation of a mobile tax base among "regions" represented by these governments" (Wilson and Wildasin, 2004). That is, we cannot discern between tax competition, yardstick competition, or common intellectual trends if we do not identify a tax cut as being competition over the allocation of a mobile tax base. So where there is no tax base spillover, there is no strategic spillover. Identification of strategic spillovers depends critically on the expected base spillover.

I show that this strategy is more convincing than previous studies using ad hoc weight matrices such as distance, gross domestic product, population size, or the size of aggregate foreign direct investment. I examine whether identification is convincing through the theoretical model's main prediction: a country should respond more to a tax cut by a 'close' neighbour compared to a similar tax cut by a 'far' neighbour. By choosing a weight matrix, we are implying that these weights are an appropriate empirical measure of closeness. Using graphical evidence I show that this prediction is only true for the bilateral foreign direct investment weights I propose. In contrast, this simple test of identification is not met by any of the alternative ad hoc weighting schemes. Further, a uniform weight matrix cannot undergo any such identification test since it assumes that all countries generate the same base spillovers.

To show the importance of the divergence in estimates of strategic spillovers, I calculate a back-of-the-envelope measure of revenue loss as a percentage of total revenue. I find that the central estimate in this paper implies revenue loss in 2012 that is only 3.7 percent of total tax revenue. In comparison, alternative weighting methods such as distance, GDP or aggregate foreign direct investment imply under-provision between 10 and 16 percent of total tax revenue. The disparity in the estimated revenue loss is economically substantial.

In addition to the main contribution, I make three methodological contributions to the literature. First, I model the government's choice to change the tax rate as a dynamic decision with a cost of adjustment. This implies that we can only be sure the government is playing its best response to the tax competition game in periods where the tax rate is changed. I employ a two-stage Heckman selection model to isolate the optimal tax rate choice. Second, I use the spatial maximum likelihood method of estimating the spatial autoregressive model rather than the spatial instrumental variable method. The main concern with the spatial instrument variable method is that it inflates estimates, as pointed out by Lyytikäinen (2012), De Giorgi et al. (2016), Elhorst and Fréret (2009) and Fréret and Maguain (2017). This is particularly concerning when the bias in an ordinary least squares method should already be positive, if it exists. Third, I use a gravity model of foreign direct investment to instrument for the possibly endogenous weight matrix of bilateral foreign direct investment stocks.

This paper is related to an interesting line of literature that interrogates how governments set their corporate tax rates, particularly in relation to their neighbours. This paper follows very closely the research question posed by Devereux et al. (2008): how much do governments respond to a tax rate change in neighbouring countries? It is also related to the following works of Overesch and Rincke (2011), Redoano (2014), Davies and Voget (2008), and Exbrayat (2017) who ask very a similar question, but answer with different methods. This paper also draws on important points made by: Heinemann et al. (2010), that tax cuts are a discrete decision; Lyytikäinen (2012), that the standard spatial instrumental variable method gives inflated answers to the main research question of how much governments respond to their neighbours; by Davies and Voget (2008), that we should measure relative responses rather than absolute responses to achieve identification; and by Becker and Davies (2017), that governments do not always correctly perceive tax elasticities. More detailed examination of the empirical literature on corporate tax rate setting can be found in surveys by Leibrecht and Hochgatterer (2012) and Devereux and Loretz (2013).

In the following section, I sketch the theoretical framework of tax competition. In Section 3, I describe my empirical strategy for identifying strategic spillovers based on the theoretical model. I present the results of this integration of theory and empirics in Section 4. Finally, in Section 5, I use simple back-of-the-envelope calculations to show the implications of these new results for revenue loss.

# 2 A Model of Corporate Tax Competition

There are three countries, which are similar in all respects. These three countries are indexed $A$, $B$, $C$. There are three multinational firms, which are again similar. One multinational is domiciled in each country. Multinational firms are indexed $a$, $b$, $c$, where multinational firm $a$ is domiciled in country $A$ and so forth. Multinational firms raise a fixed amount of capital, $K$, in their home country. Each multinational firm has existing production capacity in each of the three countries. The value of capital multinational firm $a$ invests in country $B$ is denoted $k_{aB}$. The assumption that multinational firm $a$ raises capital in country $A$ implies that this reflects a capital *outflow* from country $A$ to country $B$.

In the first stage of the game, the governments choose their tax rates, taking the other countries' tax rates as given. In the second stage, multinational firms chooses their optimal allocation of capital across the three countries. As is standard practice, I solve the model using backward induction.

## 2.1 The Firm

A multinational firm's objective is to maximise profit across its global operations. Profit is defined by the increasing function $\pi(k)$, with the assumptions that $\pi'(k) > 0$, $\pi''(k) < 0$ and $\pi'''(k) = 0$. The multinational firm faces source taxation in each of these three countries. That is, it is taxed by the country in which production—and therefore profit—takes place. This ignores the possibility of artificially shifting profits, which is not crucial for this story. The tax rate in country $A$ is denoted $\tau_A$. It is an ad valorem tax directly of before-tax profits. Firm $a$'s profit maximisation problem is:

$$\begin{aligned} \max_{k_{aA},k_{aB},k_{aC}} \quad & \Pi_a = (1-\tau_A)\pi(k_{aA}) + (1-\tau_B)\pi(k_{aB}) + (1-\tau_C)\pi(k_{aC}) \\ s.t. \quad & K_a = k_{aA} + k_{aB} + k_{aC}, \end{aligned} \tag{1}$$

where $\Pi_a$ are firm $a$'s total profits and $K_a$ is the total capital it has raised. Capital, along with an unobserved fixed location-specific factor of production, is used to generate positive profits by producing a homogeneous good at a price normalised to 1.

The firm's maximises profits where marginal after-tax profits are equalised across countries. That is:

$$(1-\tau_A)\pi'(k^*_{aA}) = (1-\tau_B)\pi'(k^*_{aB}) = (1-\tau_B)\pi'(k^*_{aC}). \tag{2}$$

This condition holds for firm $b$ and firm $c$ as well. A change in any country's tax rate alters the multinational firm's optimal allocation of capital. Totally differentiating the firm's first order conditions and solving, we find that an increase in the tax rate in country $A$ leads to a decrease in the capital that firm $a$ locates in country $A$:

$$\frac{\partial k_{aA}}{\partial \tau_A} = -\frac{\pi'(k_{aA})[(1-\tau_B)\pi''(k_{aB}) + (1-\tau_C)\pi''(k_{aC})]}{(1-\tau_A)\pi''(k_{aA}[(1-\tau_B)\pi''(k_{aB}) + (1-\tau_C)\pi''(k_{aC})] + (1-\tau_B)\pi''(k_{aB})(1-\tau_C)\pi''(k_{aC})}. \tag{3}$$

This term is negative—the entire denominator is negative and the numerator is negative—implying that the firm intuitively substitutes capital away from the country with a higher tax rate. Since capital is fixed in supply, this implies that the tax change must lead to an increase in capital in countries $B$ and $C$, so that, for example:

$$\frac{\partial k_{aB}}{\partial \tau_A} = \frac{\pi'(k_{aA})(1-\tau_C)\pi''(k_{aC})}{(1-\tau_A)\pi''(k_{aA}[(1-\tau_B)\pi''(k_{aB})+(1-\tau_C)\pi''(k_{aC})]+(1-\tau_B)\pi''(k_{aB})(1-\tau_C)\pi''(k_{aC})}. \tag{4}$$

takes on a positive sign. These behavioural responses of the multinational firm are the central mechanism driving corporate tax competition. They are also the key fact allowing us to differentiate strategic spillovers from any other factor causing declines in corporate tax rates.

## 2.2 The Government

The government in country $A$ sets the corporate tax rate of profits to maximise tax revenue $R_A$. Revenue maximisation is a simplifying assumption I make so as to identify the maximum level of public good underprovision implied by tax competition. The government of country $A$ takes the tax rates in country $B$ and $C$ as given. In addition, the government incorporate the firm's optimality conditions as a constraint on its tax-setting behaviour. Country $A$'s objective is:

$$R_A = \tau_A \left[\pi(k_{aA}) + \pi(k_{bA}) + \pi(k_{cA})\right]. \tag{5}$$

The government has taxing rights over the profit of all three multinational firms generated within its jurisdiction. As per the source principle of taxation—which is the main principle used in corporate taxation globally—I assume the home government has no taxing rights over the home multinational's foreign profits. The government's first order condition for revenue maximisation is:

$$\frac{\partial R_A}{\partial \tau_A} = \pi(k_{aA}) + \pi(k_{bA}) + \pi(k_{cA}) + \tau_A \left[\pi'(k_{aA})\frac{\partial k_{aA}}{\partial \tau_A} + \pi'(k_{bA})\frac{\partial k_{bA}}{\partial \tau_A} + \pi'(k_{cA})\frac{\partial k_{cA}}{\partial \tau_A}\right] \tag{6}$$

The government's revenue-maximising level of taxation depends on the responsiveness of capital to the tax rate. The second derivative of the revenue function is

$$\frac{\partial^2 R_A}{\partial \tau_A^2} = \pi'(k_A)\left[\tau_A \frac{\partial^2 k_A}{\partial \tau_A^2} + 2\frac{\partial k_A}{\partial \tau_A}\right] + \tau_A \pi''(k_A)\left(\frac{\partial k_A}{\partial \tau_A}\right)^2, \tag{7}$$

which is negative.

## 2.3 Strategic Spillovers

Country $A$'s best response to a change in country $B$'s tax rate is defined as a **strategic spillover**. Strategic spillovers can be formalised by linearising the government's best response function around a symmetric equilibrium where $\tau_A = \tau_B = \tau_C$. A strategic spillover is defined as the total derivative,

$$\frac{d\tau_A^*}{d\tau_B} = -\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} \bigg/ \frac{\partial^2 R_A}{\partial \tau_A^2}. \tag{8}$$

Following Davies and Voget (2008), I argue that for empirical identification of the strategic spillover, we require the relative responsiveness of one government to another. This allows us to define the weight matrix and identify the absolute value of the spillover. It is then the response of country $A$ to a tax change in country $B$ relative to the response of country $A$ to a tax change in country $B$ that I am aiming to identify in this theoretical section. If we can identify what drives the relative responsiveness, I can design an empirical analogy to identify the absolute size of the response. I express the reaction functions $d\tau_A/d\tau_B$ and $d\tau_A/d\tau_C$ as a ratio, and consider what determines country $A$'s relative responsiveness to countries $B$ and $C$.

**Proposition 1. Base Spillovers.** The best response of country $A$ to country $B$ is increasing quadratically in three types of base spillover in response to a tax increase in country $B$:

1. the outflow of capital from country $A$,
2. the inflow of capital to country $A$ from country $B$, and
3. the inflow of capital to country $A$ from country $C$.

These base spillovers are defined by the set of partial derivatives:

$$\left\{ \frac{\partial k_{aA}}{\partial \tau_B}, \frac{\partial k_{bA}}{\partial \tau_B}, \frac{\partial k_{cA}}{\partial \tau_B} \right\}. \tag{9}$$

**Proof.** The ratio of country $A$'s strategic best responses to countries $B$ and $C$ is:

$$\frac{d\tau_A}{d\tau_B} \bigg/ \frac{d\tau_A}{d\tau_C} = \frac{-\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} \bigg/ \frac{\partial^2 R_A}{\partial \tau_A^2}}{-\frac{\partial^2 R_A}{\partial \tau_C \partial \tau_A} \bigg/ \frac{\partial^2 R_A}{\partial \tau_A^2}} = \frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} \bigg/ \frac{\partial^2 R_A}{\partial \tau_C \partial \tau_A}. \tag{10}$$

The cross partial derivative is:

$$\frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} = \pi'(k_{aA}) \frac{\partial k_{aA}}{\partial \tau_B} + \pi'(k_{bA}) \frac{\partial k_{bA}}{\partial \tau_B} + \pi'(k_{cA}) \frac{\partial k_{cA}}{\partial \tau_B}$$

$$+ \tau_A \left[ \pi''(k_{aA}) \frac{\partial k_{aA}}{\partial \tau_A} \frac{\partial k_{aA}}{\partial \tau_B} + \pi''(k_{bA}) \frac{\partial k_{bA}}{\partial \tau_A} \frac{\partial k_{bA}}{\partial \tau_B} + \pi''(k_{cA}) \frac{\partial k_{cA}}{\partial \tau_A} \frac{\partial k_{cA}}{\partial \tau_B} \right] \tag{11}$$

Each of these partial derivatives can be interpreted as an *observable* flow of capital from one country to the other. For example, $\partial k_{cA}$ represents the outflow of capital from country $C$ to country $A$. Beginning from a symmetric equilibrium where $\tau_A = \tau_B = \tau_C$, then

$$\frac{\partial k_{aA}}{\partial \tau_A} = -\frac{\partial k_{aA}}{\partial \tau_B}. \tag{12}$$

If capital flows are symmetric in equilibrium, then we can rewrite the cross-partial derivative of the revenue function as:

$$\begin{aligned} \frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} &= \pi'(k_{aA}) \frac{\partial k_{aA}}{\partial \tau_B} + \pi'(k_{bA}) \frac{\partial k_{bA}}{\partial \tau_B} + \pi'(k_{cA}) \frac{\partial k_{cA}}{\partial \tau_B} \\ &\quad + \tau_A \left[ \pi''(k_{aA}) \left( \frac{\partial k_{aA}}{\partial \tau_B} \right)^2 + \pi''(k_{bA}) \left( \frac{\partial k_{bA}}{\partial \tau_B} \right)^2 + \pi''(k_{cA}) \left( \frac{\partial k_{cA}}{\partial \tau_B} \right)^2 \right] \end{aligned} \tag{13}$$

Further simplifying using the assumption of symmetry of multinational firms so that $\pi'(k_{aA}) = \pi'(k_{bA}) = \pi'(k_{cA}) = \pi'(k_A)$ and $\pi''(k_{aA}) = \pi''(k_{bA}) = \pi''(k_{cA}) = \pi''(k_A)$, then

$$\begin{aligned} \frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} &= \pi'(k_A) \left[ \frac{\partial k_{aA}}{\partial \tau_B} + \frac{\partial k_{bA}}{\partial \tau_B} + \frac{\partial k_{cA}}{\partial \tau_B} \right] \\ &\quad - \tau_A \pi''(k_A) \left[ \left( \frac{\partial k_{aA}}{\partial \tau_B} \right)^2 + \left( \frac{\partial k_{bA}}{\partial \tau_B} \right)^2 + \left( \frac{\partial k_{cA}}{\partial \tau_B} \right)^2 \right]. \end{aligned} \tag{14}$$

The response of country $A$ to a tax change in country $B$ is expressed as a quadratic function of three capital flows. Similarly, the relative responsiveness of country $A$ to countries $B$ and $C$ is also an increasing function of these three capital flows. What determines this ratio? This ratio would depend on $\{\partial k_{aA}/\partial \tau_C,\ \partial k_{bA}/\partial \tau_C,\ \partial k_{cA}/\partial \tau_C\}$. This implies that it is the relative ratio of these base spillovers from country $B$ to $A$, and from $C$ to $A$ that determine the relative optimal response of country $A$ to countries $B$ and $C$.

A tax change in country $B$ has three effects on country $A$'s tax base: total outflows, inflows from $B$, and third market inflows from country $C$. Similarly, a tax change in country $C$ has three effects on country $A$'s tax base: total outflows, inflows from $C$, and third market inflows from country $B$. The relative size of these flows determines the relative size of a country's best responses to its neighbours. By extending the model to three multinational firms, we can identify the specific capital flows that matter for tax competition. And these specific capital flows match the bilateral cross-border capital data that is available.

## 2.4 Dynamic Game

Tax competition is a dynamic game. Tax rates are adjusted in steps, rather than a single jump to equilibrium. However, corporate tax rates do not change continuously. Some perceive this as implying an autoregressive process (Overesch and Rincke, 2011). However, it is more likely to be the result of a discrete choice decision problem (Heinemann et al., 2010). Tax rates follow a jump process, with piece-wise constant trajectories—rather than drifting slowly over time like other macroeconomic variables.

I model tax competition as a dynamic game. I assume that any change in the corporate tax rate incurs a fixed cost $\gamma$. A government is therefore faced with a two-step choice: it has to first determine the revenue-maximising tax rate, then determine whether it wishes to change the existing tax rate to that revenue-maximising level or whether it will leave the tax rate unchanged. Dropping the country subscript for clarity, the government's problem at time $t$ is therefore to solve:

$$\max_{\tau} \quad R_t(\tau) - \gamma \mathbf{1}[\tau \neq \tau_{t-1}] \tag{15}$$

where $\mathbf{1}[\tau \neq \tau_{t-1}]$ takes the value of 1 if the government changes its tax rate and zero otherwise. Denote $\tau^R$ as the tax rate that solves the original revenue-maximisation problem:

$$\tau^R = \max\{\tau\,[\pi(k_a) + \pi(k_b) + \pi(k_c)]\} \tag{16}$$

at time $t$. Then given the cost of adjustment, the government's optimal choice of corporate tax rate at time $t$ is defined by the condition:

$$\tau_t^* = \begin{cases} \tau_t^R & \text{if} \quad R_t(\tau_t^R) - R_t(\tau_{t-1}) > \gamma \\ \tau_{t-1} & \text{if} \quad R_t(\tau_t^R) - R_t(\tau_{t-1}) \leq \gamma. \end{cases} \tag{17}$$

A government only changes its tax rate if the increase in revenue from setting the revenue-maximising tax rate exceeds the cost of adjustment. We do not observe the value of $\gamma$. The adjustment cost may be a financial cost arising from creating, writing, and implementing new legislation. It may be a cost that arises as the result of business uncertainty. Or, there might be an implicit political cost to changing the tax rate. Importantly, this model explains why corporate tax rates are only re-set infrequently rather than every year as interest rates are.

For our empirical analysis, the most important result is that we cannot be sure that the government is setting the optimal tax rate in a period where we do not observe a tax rate change. Only if there were no changes to the external environment from time $t-1$

to time $t$ would there reasonably be no change to the revenue-maximising corporate tax rate. Therefore, to empirically observe the government's best response to the underlying tax competition stage game, we must rely on corporate tax rate *changes*.

# 3 Empirical Strategy

## 3.1 Identification

The standard approach to estimating the magnitude of strategic spillovers is the **spatial autoregressive process**:

$$\tau_i = \rho \sum_{j \neq i}^{n} w_{ij} \tau_j + \varepsilon. \tag{18}$$

Identification in this model depends on the chosen **weight matrix** $W$. The weight matrix is chosen by the researcher, and the closer the weight matrix comes to approximating the true underlying spatial structure, the stronger and more convincing identification will be. For each pair of countries $i$ and $j$, the weight $w_{ij}$ should reflect the relative importance of country $j$ to country $i$.

In this paper, I use weights based on the theory of corporate tax competition. The previous section identifies that the relative weight that country $i$ places on countries $j$'s and $k$'s tax rate changes depend on the expected effects their respective tax rate changes will have on country $i$'s tax base. Denote $k_{ji}$ as capital originating in country $j$ but located in country $i$. In reality, governments do not have complete information about the full set of partial derivatives $\partial k_{ij}/\partial \tau_j$ for all $i, j = 1, \ldots, n$. Becker and Davies (2017) focus on this incomplete information, modelling the process of governments learning these elasticities based on previous outcomes (capital allocations) and strategies (tax rate choices). Even the academic literature is mainly limited to estimating a single semi-elasticity using data on a number of countries. If a government has an estimate of a single average semi-elasticity ($\bar{e}$), then it can approximate the expected effect of a specific country's tax rate change based on the size of existing cross-border investment between them. Using the definition of the semi-elasticity of capital with respect to the foreign tax rate, then for any pair of countries we get

$$-\bar{e} \cdot k_{ij} = \frac{\partial k_{ij}}{\partial \tau_j}. \tag{19}$$

So for a constant tax semi-elasticity, the larger the bilateral capital stock between country $i$ and country $j$, the larger will be the partial derivative. Where the government does not know the country-specific semi-elasticities but has knowledge of some average semi-elasticity, it can estimate of $\partial k_{ij}/\partial \tau_j$ using the size of the bilateral stock of investment between these two countries: $k_{ij}$.

## 3.2 Bilateral Foreign Direct Investment Weights

I need an empirical analogy of Equation 14 that uses capital stock data. I use a weighting scheme similar to that used by the United States Federal Reserve and European Central Bank to produce trade-weighted exchange rates (see Loretan (2005) and Buldorini et al. (2002) for further details). In calculating $w_{ij}$ for each pair of countries, I account for three types of capital flow: capital inflows from $j$ to $i$, capital outflows from $i$ to $j$ and the competition between $j$ and $i$ for capital inflows from a third country $k$.

The weight that country $i$ places on country $j$ is given by $w_{ij}$ and uses data on inflows $x_{ji}$ from $j$ to $i$, outflows $v_{ij}$ from $i$ to $j$, and a measure of their competition for inflows from a third market $k$. I use the square of all values to approximate the quadratic form derived in the theoretical model. Many ad hoc weighting schemes in the literature apply the quadratic form to the inputs (for example Heinemann et al. (2010) and Overesch and Rincke (2011)). The reason is that it emphasises local clustering—making near neighbours very important—while not ignoring the possibility of global effects (Kopczewska et al., 2017). Additionally, using squared values creates a degree of sparsity in the spatial structure; and sparsity generates clearer identification.

The weights for inflows is given as the proportion of total inflows and that come from country $j$:

$$w_{ij}^X = \frac{x_{ji}}{\sum_{j\neq i}^N x_{ij}} \tag{20}$$

Similarly, the weight for outflows is calculated as the proportion of total outflows from country $i$ that go to country $j$:

$$w_{ij}^V = \frac{v_{ij}}{\sum_{j\neq i}^N v_{ij}} \tag{21}$$

The third market competitiveness weight, $w_{ij}^C$, combines the importance of inflows from each third country $k$ to country $i$'s total inflows ($w_{ik}^X$) and the level of market share that country $j$ has in that third market $k$, given by $w_{kj}^V$.

$$w_{ij}^C = \sum_{k\neq j\neq i}^N \frac{w_{ik}^X \cdot w_{kj}^V}{1 - w_{ki}^V} \tag{22}$$

These three weights are then combined, weighting them by the relative importance of outflows and inflows to country $i$:

$$w_{ij} = \left[ \frac{\sum_{j \neq i}^{N} v_{ij}}{\sum_{j \neq i}^{N} x_{ji} + \sum_{j \neq i}^{N} v_{ij}} \times w_{ij}^{V} \right] + \left[ \frac{\sum_{j \neq i}^{N} x_{ji}}{\sum_{j \neq i}^{N} x_{ji} + \sum_{j \neq i}^{N} v_{ij}} \times (0.5 \cdot w_{ij}^{X} + 0.5 \cdot w_{ij}^{C}) \right]. \quad (23)$$

## 3.3 Other Empirical Matters

**Heckman Two-Step Correction** I model tax competition as a two-stage process. First, I model the government's decision to change the tax rate. Second, I consider the best response to the tax competition game. I do not treat periods where no tax change occurred as being a best response to the tax competition state game. To model this two-stage process I adopt the Heckman (1976) sample selection approach. I first model the decision to change the tax rate as a function of the foreign tax rate and a number of controls capturing the dynamics of the political process. Heinemann et al. (2010) examine the factors that influence the government's decision to change its tax rate. I use the fraction of seats held by the government to measure the ease with which the government might be able to pass new legislation. I also include the Herfindahl Index Government which is measured as the sum of the squared seat shares of all parties in the government. This gives a more detailed measure of the concentration of government power. I add a categorical variable capturing the economic policy orientation of the governing party: left, right, or centre. Finally, I add a dummy for if there was a legislative election in the year and a dummy for if there was an executive election in the year. These political variables are all taken from the Inter-American Development Bank Database of Political Institutions. The estimation includes country fixed effects. From the first stage regression, I calculate the Inverse Mills Ratio (IMR) and include it in the second stage (the main model).

**Main Regression Controls** I include a number of country-specific controls that are likely alternative determinants of the tax rate. These are mostly in line with the preceding literature. I include a de jure measure of capital account openness: I use the Chinn and Ito (2008) capital account openness index to control for the potential that increasing openness alone drives corporate tax rates down. I also include a measure of trade openness: imports plus exports as a ratio of GDP. I control for the personal income tax in case the corporate tax acts as a backstop to the personal tax, or if tax reforms are undertaken as a full package. I include government consumption expenditure to gross domestic product (GDP) as a first-order proxy of the demand for public goods. I also include second-order determinants of the demand for the public good. I use the share of the population under 14 and the share of the population over 65, since these are the portions of the population ineligible to work and typically most dependent on government spending. I also include the share of the population living in urban areas. Finally, I add a variable that captures the share of a country's total outward foreign direct investment stock that is located in tax havens. This should separate responses to pure tax competition from responses to artificial profit shifting into tax havens. This final variable is the only real deviation from preceding works in the set of controls.

**Simultaneity Bias** The spatial econometric literature has had to deal with one major concern in the spatial autoregressive model: simultaneity bias. If all governments choose their tax rates at the same time, then we are likely to encounter simultaneity. This implies that the foreign tax rate is endogenous, as it would depend on the home country's tax rate. Where tax rates are expected to be strategic complements (moving in the same direction), simultaneity bias—if it exists—should bias the ordinary least squares estimate upward. There are two accepted methods of dealing with simultaneity bias in the spatial autoregressive model. The first is the spatial instrumental variable approach used in the majority of the preceding literature on tax competition. This approach uses the weighted average of neighbours' controls to instrument for the endogenous foreign tax rate. There are serious concerns with this approach. Lyytikäinen (2012) shows that the spatial instrumental variable approach finds large strategic spillovers where a natural experimental approach on the same data shows no evidence of strategic spillovers. In fact, initial estimations of the instrumental variable approach produce a larger coefficient than the OLS estimates. This is odd, since the problem that we are trying to fix is that OLS estimates are biased upward (De Giorgi et al., 2016). The approach appears to create additional bias rather than eliminating it. Both Elhorst and Fréret (2009) and Fréret and Maguain (2017) report and discuss these inflated estimates.

I adopt the second approach to dealing with simultaneity bias, which is estimation via maximum likelihood. It requires careful specification of the spatial patterns through theory in order to support credible causal interpretation. The maximum likelihood approach likely provides greater clarity and requires less caution in interpretation than the spatial instrumental variable approach (Fréret and Maguain, 2017).

**Weight Matrix Endogeneity** The possibility exists that the network structure itself might be endogenous to the tax rate. The tax rate is a determinant of the foreign direct investment flows to a country. A number of approaches to solving the endogeneity problem are discussed in Qu and Lee (2015). The most intuitive approach is the instrumental variable approach, which requires either an instrumental variable or knowledge of the network formation process. Fortunately, there is a rich gravity model literature examining the theoretical and empirical underpinnings of foreign direct investment flows across borders. I use a gravity model without the tax rate as a predictor. I estimate a simple version of the gravity model with foreign direct investment expressed in natural logs. Predictors included are the natural log of gross domestic product, the Chinn-Ito capital account openness index, the total population size, the urban population size, government consumption to GDP, the sum of imports and exports as a ratio of GDP, and dummies for the existence of a signed or in force bilateral trade agreement between the countries. I also include a full set of country-pair fixed effects and year fixed effects. I use the predicted values from the gravity model in the main spatial model to construct the weight matrix.

## 3.4 Data and Descriptive Statistics

I use tax rate data for 131 countries to calculate the weighted average foreign tax rate for each country, using all other countries in the dataset. I obtain data on top corporate tax rates from a number of sources. The main source is the Oxford University Centre for Business Taxation's top corporate tax rate. For countries where the Centre for Business Taxation does not have tax rate data, I augment it with data from the International Monetary Fund's Fiscal Affairs Division[1]. Tax rates vary from 75 percent in Iran from 1990 to 1992, to 0 percent in Moldova from 2008 to 2011.

Bilateral foreign direct investment (FDI) data are obtained from a combination of the UN Conference on Trade and Development's (UNCTAD) database and the Organisation for Economic Co-operation and Developments (OECD) database. The primary source is the OECD's database, with UNCTAD data used to fill the gaps.

The Chinn-Ito index of capital account openness Chinn and Ito (2008) is used to measure capital account openness. Personal income tax rates are obtained from a combination of sources including the Urban-Brookings Tax Policy Center and the OECD. The top personal income tax rate is used. In some cases, top local tax rates are combined with top federal tax rates to produce an overall top personal income tax rate. Public consumption is quantified as public expenditure as a percentage of nominal GDP. This data is obtained from the World Bank. Gross Domestic Product (GDP) and population data are also obtained from the World Bank. The proportion of the population under 14, the proportion of the population over 65, and the proportion of the population living in urban areas are obtained from the World Bank's World Development Indicators. All political variables used in the first stage of the two-stage Heckman sample selection model are obtained from the Inter-American Development Bank's Database of Political Indicators.

To capture the effect of profit shifting activity on tax rates, I employ the stock of foreign

[1] I must express thanks to Ruud De Mooij for providing the data used in Crivelli, De Mooij, and Keen (2016).

direct investment held by country $i$ in all tax havens as a proxy. This is measured as a percentage of total outward foreign direct investment from country $i$. Corporate profit shifting requires setting up a subsidiary in a tax haven irrespective of the form profit shifting takes (Palan et al., 2013). Setting up subsidiaries leaves a trail of investment that is captured in foreign direct investment statistics. That tax havens attract a level of foreign direct investment disproportionate to their size is a smoking gun. Even excluding three outlier tax havens with inward foreign direct investment to GDP ratios in excess of 1,000 percent, the average inward foreign direct investment stock of tax havens was still 129.5% of GDP. In the full data set, the average foreign direct investment held in tax havens as a percentage of total outward foreign direct investment is 10.8 percent. There are a large number of zero observations, implying either that we do not observe the bilateral foreign direct investment stocks or there is no bilateral investment into tax havens. The average, excluding these zero values, is 15.3 percent. Tax havens are defined as in Davies et al. (2017): countries with abnormally corporate-friendly tax policies that are likely to encourage artificial location of profits. The primary sample of tax havens is drawn from the OECD's original blacklist of 37 countries. I broaden this sample to include a number of countries that are widely acknowledged to be tax havens, giving a total of 65 tax havens.[2]

# 4 Estimates of Strategic Spillovers

I estimate the reaction function for 76 countries where there were 359 corporate tax rate reforms from 1984 to 2015. This is less than the full dataset of 131 countries since data for the controls variables are not available for all countries, and not all countries change their tax rates. However, all available tax rate data are used in the construction of the weighted average foreign tax rate (the spatial lag).

The main results of this study are obtained from a maximum likelihood estimation using the proposed foreign direct investment weights instrumented using the predictions from a foreign direct investment gravity model. The results of this gravity model are presented in Table 7. I demean the main data so that the model controls for country fixed effects. This eliminates between-country variation and uses only within-country variation, controlling for country-specific time-invariant characteristics. I also include the Inverse Mills Ratio, estimated from a first-stage regression on the decision to change the tax rate using 1,771 observations. The results of this first-stage regression are shown in Table 8. The dependent variable is therefore $1(t \in T)$, where $t$ denotes the periods where the tax rate was changed so that $\tau_t \neq \tau_{t-1}$. The Inverse Mills Ratio should account for possible selection bias in estimating

[2]The list of tax havens is available on request from the author.

the best responses to the tax competition game. The main estimated model is therefore:

$$\tau_{it} = \alpha_i + \rho \sum_{j \neq i}^{n} w_{ijt} \cdot \tau_{jt} + \beta X_{it} + \gamma \text{IMR} + \varepsilon_{it}. \tag{24}$$

for all $t \in T$. The main results of this paper are presented in Table 1. These results are estimated using only periods where the corporate tax rate was changed. The coefficient of interest is $\rho$, which measures the average strategic spillover from corporate tax competition.

Table 1: Main Estimates of Strategic Spillovers on Corporate Tax Rates

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| $w \cdot \tau_J$ | 0.409*** | 0.242* | 0.227* | 0.232* |
| | (0.096) | (0.111) | (0.106) | (0.103) |
| Gov't consumption | 0.045 | 0.139 | 0.112 | 0.112 |
| | (0.092) | (0.095) | (0.094) | (0.094) |
| Personal tax rate | 0.069 | 0.040 | 0.106 | 0.131 |
| | (0.369) | (0.346) | (0.341) | (0.338) |
| Chinn-Ito Index | −0.052*** | −0.037* | −0.028 | −0.033* |
| | (0.015) | (0.015) | (0.016) | (0.015) |
| FDI to tax havens | −0.089*** | −0.033 | −0.032 | −0.027 |
| | (0.017) | (0.017) | (0.017) | (0.017) |
| Population 0-14 | | 0.649** | 0.570* | 0.655** |
| | | (0.238) | (0.251) | (0.231) |
| Population 65 and up | | −0.784*** | −0.699** | −0.499** |
| | | (0.236) | (0.230) | (0.169) |
| Urban Population | | −0.040 | −0.007 | −0.070 |
| | | (0.120) | (0.122) | (0.117) |
| (Imports+Exports)/GDP | | | −0.055*** | −0.056*** |
| | | | (0.015) | (0.014) |
| Inverse Mills Ratio | −0.013** | −0.013 | −0.010 | |
| | (0.004) | (0.008) | (0.008) | |
| $R^2$ | 0.315 | 0.416 | 0.433 | 0.431 |
| Observations | 359 | 359 | 359 | 359 |

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The dependent variable is the statutory tax rate $\tau_i$.

I first estimate the model using only a small set of controls: government consumption, the personal income tax rate, the Chinn-Ito capital account openness index, and the share of foreign direct investment to tax havens. This estimation returns a strategic spillover of 0.409. The second model estimated includes the shares of the population under 14 and over 65, along with the share of the population living in urban areas. These demographic controls improve the fit of the model and reduce the estimated strategic spillover to 0.242. Adding the sum of imports and exports as a ratio of GDP further reduces the estimated coefficient to 0.227. Finally, estimating the full model, but excluding the Inverse Mills Ratio increases the estimate only marginally to 0.232.

The preferred estimate of 0.227 is interpreted as *a 1 percentage point decrease in the weighted average foreign tax rate induces a 0.227 percentage point decrease in the home tax rate*. This is substantially smaller than the main estimates of 0.69 uncovered by Devereux et al. (2008) and Overesch and Rincke (2011), and the 0.71 uncovered by Redoano (2014). These previous estimates are *three times larger* than my estimate. This is partially explained by the modelling strategy, and partially explained by the choice of weight matrix.

Two factors in particular seem to play a strong role in the reduction of corporate tax rates: capital account openness and trade openness. Their impacts are unsurprising. In fact, a substantial portion of the early literature on tax competition focused on the effect of increasing openness on tax rates, discussed in Devereux and Loretz (2013). It is intuitive to think that higher levels of mobility lead to lower optimal corporate tax rates. The results suggest that greater openness has led to lower corporate tax rates. Increasing foreign direct investment to tax havens also seems to play a role in tax rate cuts.

**Two-Stage Process** The decision to model tax competition as a two-stage process results in lower estimates of strategic spillovers. I re-estimate the main model without using the Heckman two-stage process. All observations available are included in the regression, giving 1,356 observations rather than the 359 used in Table 1. Table 2 shows the results of this exercise. The main estimate increases from 0.227 to 0.379. This suggests that including all observations as best responses inflates estimates of strategic spillovers.

Table 2: Using All Observations as Best Responses

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| $w \cdot \tau_J$ | 0.523*** | 0.414*** | 0.379*** | 0.387*** |
| | (0.042) | (0.047) | (0.045) | (0.047) |
| $R^2$ | 0.346 | 0.393 | 0.427 | 0.430 |
| Observations | 1356 | 1356 | 1356 | 1345 |

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. Models 1 to 3 use the same controls as Models 1 to 3 in Table 1. In Model 4 I add the controls used in the first stage regression in the Heckman sample selection model.

## 4.1 Comparisons

Previous works have used weighting schemes that aim to loosely approximate the true nature of interaction between countries. These can be broken into two types: aggregate weights and bilateral weights. Aggregate weighting schemes assume that all countries have approximately the same importance to all other countries. An aggregate weighting scheme constructs a leave-out-one weighted average in calculating the foreign average tax rate, where the country left out is the home country. Therefore variation in the foreign tax rate across countries depends on the share of the home country in the aggregate. Examples are the uniform weight (or unweighted average), gross domestic product (GDP) weights, total foreign direct investment weights (Devereux et al., 2008), and population size (Exbrayat, 2017). Bilateral weights acknowledge the heterogeneity of importance across neighbours. For example, Canada might be more important to the United States than China is, but China is more important to India than Canada is. The main form of bilateral weights used are distance weights (Overesch and Rincke, 2011; Redoano, 2014). Other bilateral weights used include market potential weights (Davies and Voget, 2011), and trade integration (Exbrayat, 2017). A further survey of the literature can be found in Leibrecht and Hochgatterer (2012).

I test whether the choice of weight matrix substantially alters the estimated coefficient. I re-estimate Model 3 in Table 1 using uniform weights, GDP weights, total inward plus outward foreign direct investment weights (aggregate foreign direct investment), and inverse distance weights. For comparability, I continue to use the Heckman two-stage approach, treating only tax rate changes as best responses. The results of these estimates are presented in Table 3.

Table 3: Estimates Strategic Spillovers Using Alternative Weight Matrices

| | Uniform | GDP | FDI | Distance |
|---|---|---|---|---|
| $w \cdot \tau_J$ | 0.511*** | 0.499*** | 0.395*** | 0.389*** |
| | (0.113) | (0.124) | (0.110) | (0.090) |
| $R^2$ | 0.461 | 0.455 | 0.446 | 0.461 |
| Obs. | 398 | 398 | 380 | 398 |

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The models estimated in the table are the same specification as that estimated in Model 3 of Table 1. Models include all controls and are estimated using the Heckman sample selection method. For each model estimated, the specified weight matrix is given by the column name.

The estimated strategic spillover is 0.511 for uniform weights, 0.499 for GDP weights,

Table 4: All Observations as Best Responses for Alternative Weight Matrices

| | Uniform | GDP | FDI | Distance |
|---|---|---|---|---|
| $w \cdot \tau_J$ | 0.653*** | 0.623*** | 0.475*** | 0.511*** |
| | (0.050) | (0.051) | (0.051) | (0.035) |
| $R^2$ | 0.447 | 0.434 | 0.424 | 0.458 |
| Obs. | 1620 | 1620 | 1508 | 1620 |

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The models estimated in the table are the same specification as that estimated in Model 3 of Table 2. Models include all controls without using the Heckman sample selection method. For each model estimated, the specified weight matrix is given by the column name.

0.395 for aggregate foreign direct investment weights, and 0.389 for distance weights. These estimated coefficients are between 1.7 to 2.2 times larger than the corresponding estimated coefficient of 0.227 for the bilateral foreign direct investment weights. These estimates are smaller than the estimates produced in previous works using the same weight matrices. The main reason for this difference is the exclusion of periods where tax rates did not change. Including periods where the tax rate did not change, the uniform weights generate a coefficient of 0.653, very close to the main result of 0.69 from Devereux et al. (2008) (see Table 4).

The main estimate of 0.69 in Devereux et al. (2008) is based on an unweighted network structure. Devereux et al. (2008) also include a model that weighs each country by their total inflows plus outflows of foreign direct investment, producing a smaller coefficient of 0.34. However, they reject these estimates on the grounds of endogeneity. The estimate of 0.69 in Overesch and Rincke (2011) is based on distance weights. Similarly, Redoano (2014) use distance weights in her main estimate of 0.71. Redoano (2014) explicitly explains that distance is a proxy for the cost of bilateral cross-border investment flows, which is expected to be inversely related to cross-border investment flows. I take a more direct approach and simply use cross-border flows as the weights. Crivelli et al. (2016) find an estimate around 0.47 using an inverse distance weighting matrix for 125 countries, which is still twice as large as the estimated coefficient in this paper.

LeSage and Pace (2014) make clear that *small* changes in the weight matrix should not induce substantial changes in the estimated coefficients. To examine whether these weight matrices are similar (or not substantially different), they suggest a simple method. They suggest generating a standard independent normal $n \times 1$ vector $u$ and calculating the correlation $\text{Corr}(W_1 u, W_2 u)$ to capture the correlation between two alternative weight matrices $W_1$ and $W_2$. If these two are highly correlated, the results of the models should not be economically different.

Table 5: Correlation Among Weight Matrices

| | Bilateral FDI | Aggregate FDI | Distance | GDP |
|---|---|---|---|---|
| Aggregate FDI | 0.018 | | | |
| Distance | 0.047 | 0.063 | | |
| GDP | -0.001 | -0.001 | -0.002 | |
| Uniform | 0.069 | 0.093 | 0.159 | -0.002 |

This correlation matrix presents the average pairwise correlation for each pair of weight matrices $W_1$ and $W_2$. This is calculated as $\text{Corr}(W_1u, W_2u)$ over 10,000 draws where $u$ is a standard independent normal $n \times 1$ vector.

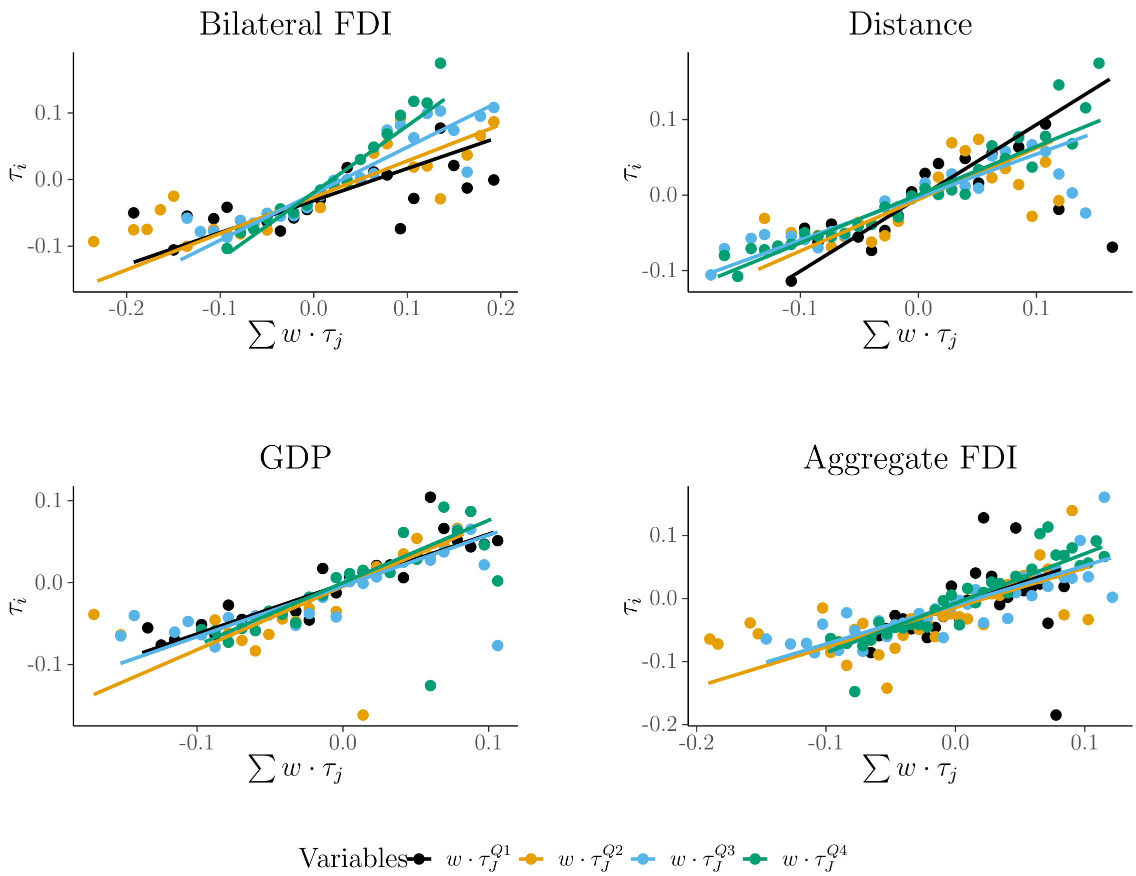
I recalculate the correlation matrix 10,000 times using different random draws for $u$. In Table 5 I present the average of these 10,000 correlation matrices for the various weighting schemes. The results show that there is very little correlation among the matrices, suggesting that they each contain very different information.

## 4.2 Graphical Evidence

Tax competition presents a simple testable prediction for identification: *a country should respond more to a tax cut by a 'close' neighbour compared to a similar tax cut by a 'far' neighbour*. Nearness is defined by the empirical weight $w_{ij}$ we choose to represent the relationship between two countries. To examine this prediction for each weight matrix, I separate neighbouring countries into four groups of 'nearness'. We expect a tax cut in near neighbours to induce a larger response. We expect a tax cut in far neighbours to induce a smaller response. Quartile 1 ($Q1$) captures far neighbours while quartile 4 ($Q4$) captures near neighbours. Nearness is calculated based on an average of $w_{ij}$ over the entire period. Within each quartile, I calculate a simple average foreign tax rate.

I present this results of this test of identification graphically in Figure 1. I plot a scatterplot of the home tax rate, $\tau_i$, against the weighted average foreign tax rate for each quartile, $\sum w_{ij} \cdot \tau_j$. These are expressed as deviations from the mean. For visual clarity I bin the scatter points and add bivariate regression lines for each quartile. The prediction of the spatial model is that identification is convincing if the bivariate regression lines are steeper for nearer neighbours.

The graphical evidence strongly implies that bilateral foreign direct investment weights achieve the desired identification. Each successively closer group plots a steeper slope for the relationship between the foreign tax rate and the home tax rate. As theory predicts, governments respond more to tax cuts by countries with large cross-border investment relationships.




The chart plots the weighted average tax rate against the home tax rate. All data are expressed in deviations from the country-specific mean. Only periods where the tax rate was changed are included. Regression lines are a separate bivariate regression for each quartile. Binned values are the average home tax rate for a range of the weighted average foreign tax rate. Each chart represents a different weighting scheme. For robustness, I exclude significant outliers, which do not change the nature of these charts.

Figure 1: Binned Scatterplot by Quartile Alternative Weights

Similar identification is not observed for any of the alternative weights. For aggregate weights—GDP and aggregate foreign direct investment—there is no clear identification. The slopes across quartiles are very similar for both weights. Distance weights would perversely suggest that countries respond most intensely to their farthest neighbours. Note that I cannot conduct this exercise for the uniform weights since all countries are assumed to be equally near.

# 5 Revenue Loss

The estimate of revenue loss from corporate tax competition depends crucially on the size of the estimated size of strategic spillovers. Given that the size of strategic spillovers might reasonably be expected to be between 0 and 1, the difference in magnitude between an estimate of 0.69 and an estimate of 0.23 is potentially large.

I use a simple back-of-the-envelope calculation to compare revenue loss under various estimates of the strategic spillover. Revenue loss is measured simply as $(\tau^0 - \tau)B$, where $\tau^0$ is the counterfactual tax rate were there no tax competition, $\tau$ is the actual tax rate, and $B$ is the tax base. For simplicity, I assume that capital is fixed globally and the worldwide tax base would not shrink under a higher tax rate. This implies these estimates represent an upper bound on revenue loss from tax competition.

Using data for 2012, I calculate the counterfactual tax rate for each country in the dataset as if there were no tax competition. I set the coefficient on the weighted average foreign tax rate to zero and compare the original fitted values of the model to the counterfactual tax rate with no strategic spillovers. I use the preferred estimate of 0.227 for the bilateral foreign direct investment weights, and the results from the corresponding specifications for the alternative weighting schemes. I also include a model using uniform weights with all observations as in Table 4. The coefficient is 0.653, close to the standard estimate of 0.69 in the literature.

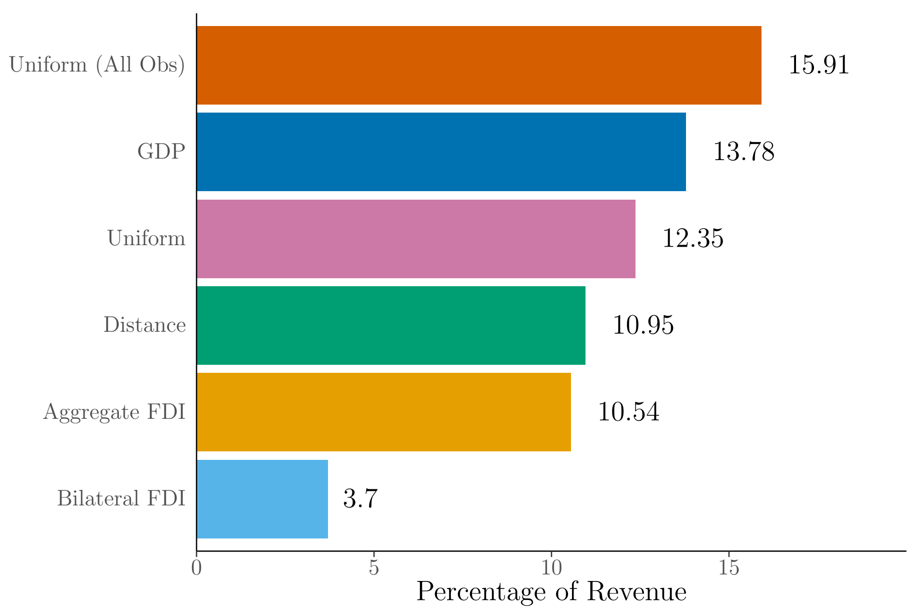



Figure 2: Public Good Underprovision Due to Tax Competition

Figure 2 shows the result of this calculation in terms of corporate tax revenue lost due to tax competition in 2012. The standard uniformly-weighted matrix including all observation implies a 15.91 percent revenue loss. With the two-stage Heckman sample selection method, uniform weights imply a 12.35 percent revenue loss. GDP weights imply a 13.78 percent revenue loss; distance weights imply a 10.95 percent revenue loss; and aggregate foreign direct investment weights imply a 10.54 percent revenue loss. In stark contrast, estimates using bilateral foreign direct investment weights imply only a 3.7 percent loss in revenue due to corporate tax competition.

The difference between the public good under-provision implied by the alternative weight matrices and the bilateral foreign direct investment weight matrices is economically substantial. The strategic spillovers I estimate in this paper suggest that the losses from tax competition are modest compared to the losses implied by previous estimates. The losses implied by previous estimates ranging from 0.6 to 0.7 would be even larger than those presented above. Estimates in the range of 0.6 to 0.7 have been used to inform analyses such as the IMF (2014) spillover analysis. In analysing the spillover effects from the United States corporate tax rate cut from 35 to 21 percent, Beer et al. (2018) suggest that a strategic spillover estimate of 0.6 would triple the estimated loss in tax revenue from base spillovers in neighbouring countries. The results of this paper suggest that tax competition generates far more muted under-provision of the public good than previous estimates suggest. Magnitudes matter, and this exercise highlights the importance of clearly identified estimates of tax competition for informing the policy debate on the race to the bottom.

Aggregating to the world level, total corporate tax revenue in 2012 was USD 1.9 trillion according to the ICTD / UNU-WIDER Government Revenue Dataset 2019. A 15.9 percent loss in revenue would add up to USD 302 billion in 2012. In comparison a 3.7 percent loss in revenue would only add up to USD 70 billion in 2012.

# 6 Conclusion

Corporate tax competition is expected to lead to revenue loss and an under-provision of the public good. At the Nash equilibrium of the tax competition game, tax rates are below the social optimum. But how far below that social optimum? And how much revenue loss does it imply?

This paper seeks to answer those questions. I estimate the magnitude of strategic spillovers on corporate tax rates between governments. I extend the standard model of tax competition to a three-country model with three multinational firms. This model implies that the size of a government's response to a neighbour's tax cut depends on the size of the base spillover implied by that tax cut. I use the stock of foreign direct investment between two countries to measure that bilateral base spillover. I convert these bilateral foreign direct investment ties into a weight matrix using the approach typically applied to trade-weighted exchange rates. Using this weight matrix derived from the theory of tax competition, I estimate a spatial autoregressive model of tax competition.

The results of this estimation suggest that a 1 percentage point reduction in the weighted average foreign tax rate leads to a 0.23 percentage point tax cut by the home country in response. This estimate of strategic spillovers is substantially smaller than previous estimates using ad hoc weighting schemes. The consensus existing estimate suggests the home country would respond by 0.6 to 0.7 percentage points. I show that these ad hoc weights do not appropriately identify the structure of tax competition. In fact, only the theoretically-implied bilateral foreign direct investment weights manage to satisfy a simple test of identification: that countries should respond more to a tax cut by near neighbours than to a similar tax cut by far neighbours.

I use a back-of-the-envelope calculation to measure the difference in revenue loss implied by the various weighting schemes. The ad hoc weights—uniform, GDP, aggregate foreign direct investment, and distance—all suggest revenue loss between 10 and 14 percent of annual revenue. The bilateral foreign direct investment weights suggest that revenue loss is approximately 4 percent of revenue. This study finds that strategic spillovers on corporate tax rates between national governments exist, but the magnitude of these spillovers is a third of the size of existing estimates. The implication is that tax competition appears to result in only modest losses in corporate tax revenue.

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# A Data

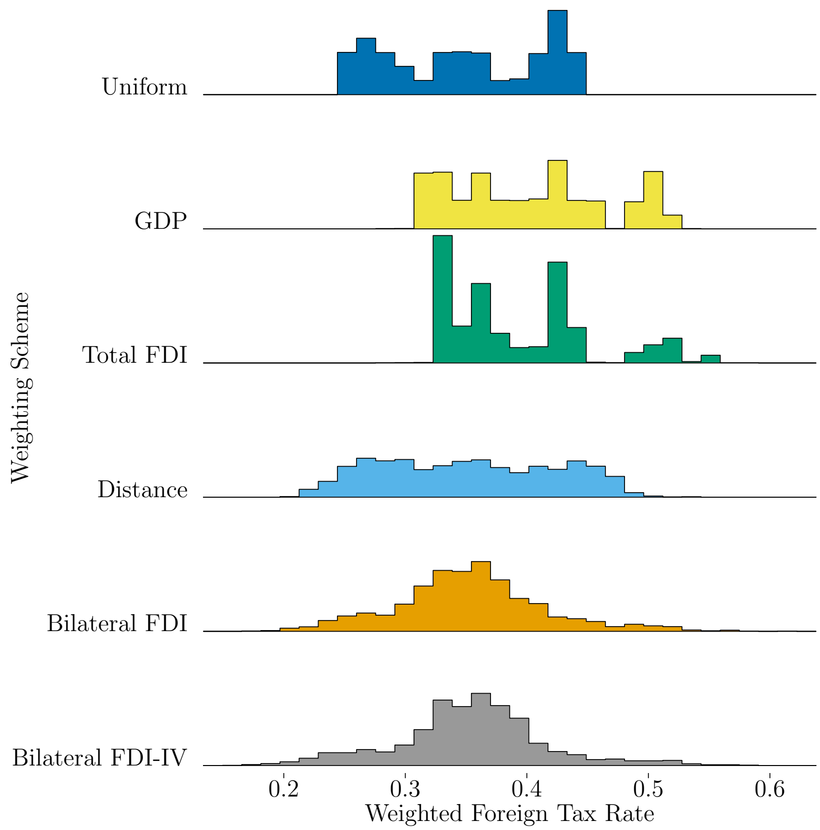


Figure 3: Histogram of Weighted Foreign Tax Rates

Table 6: Number of Countries in Main Regression by World Bank Income Classification in 1990 (rows) and 2014 (columns)

| | Low | Lower Middle | Upper Middle | High | NA | Sum |
|---|---|---|---|---|---|---|
| Low | 4 | 10 | 1 | 1 | 0 | 16 |
| Lower Middle | 1 | 4 | 13 | 3 | 0 | 21 |
| Upper Middle | 0 | 0 | 4 | 5 | 0 | 9 |
| High | 0 | 0 | 0 | 18 | 0 | 18 |
| NA | 0 | 3 | 3 | 6 | 0 | 12 |
| Sum | 5 | 17 | 21 | 33 | 0 | 76 |

'NA' is where the World Bank did not have an income classification for the country. Rows represent the classification in 1990 and 2014 represents the classification in 2014.

# B Robustness

Table 7: Gravity Model for FDI Instruments

| | |
|---|---|
| $\ln(\mathrm{GDP}_i)$ | $0.751^{***}$ |
| | (0.082) |
| $\ln(\mathrm{GDP}_j)$ | $-0.360^{***}$ |
| | (0.089) |
| Chinn-Ito Openness$_i$ | $0.345^{***}$ |
| | (0.070) |
| Chinn-Ito Openness$_j$ | $0.561^{***}$ |
| | (0.079) |
| Urban Population$_i$ | 0.780 |
| | (0.568) |
| Urban Population$_j$ | $-1.205^{*}$ |
| | (0.626) |
| Population Growth$_i$ | $-0.067^{**}$ |
| | (0.027) |
| Population Growth$_j$ | $-0.040$ |
| | (0.026) |
| Government Consumption$_i$ | $-0.761^{*}$ |
| | (0.457) |
| Government Consumption$_j$ | $-1.507^{***}$ |
| | (0.434) |
| (Imports+Exports)/GDP$_i$ | $1.071^{***}$ |
| | (0.086) |
| (Imports+Exports)/GDP$_j$ | $1.411^{***}$ |
| | (0.097) |
| Bilateral Investment Treat In Force | $0.285^{***}$ |
| | (0.076) |
| Bilateral Investment Treat Signed | $-0.175^{**}$ |
| | (0.079) |
| Observations | 56,195 |
| $R^2$ | 0.935 |
| *Notes:* | Country $i$ is the capital-receiving country. Country $j$ is the capital-sending country. Model includes country-pair and year fixed effects. Standard errors in parentheses. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1. |

Table 8: Estimation of Probability of Changing Tax Rate

| | |
|---|---|
| $w \cdot \tau_J$ | $-0.077$ |
| | (0.654) |
| Majority | $-0.392^{**}$ |
| | (0.186) |
| Legislative Election | $-0.131^{*}$ |
| | (0.071) |
| Executive Election | 0.003 |
| | (0.107) |
| Herfindahl Index Government | $-0.546^{***}$ |
| | (0.147) |
| Exec. Left/Right/Centre | $-0.037$ |
| | (0.036) |
| Observations | 1,772 |
| Log Likelihood | $-1{,}208.134$ |
| Akaike Inf. Crit. | 2,428.268 |
| *Notes:* | Estimated as probit model. Standard errors in parentheses. Statistical significance is given by *** p< 0.01, ** p< 0.05, and * p< 0.1. |

Table 9: Estimates of Strategic Spillovers without Instrumented FDI Weights

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| $w \cdot \tau_J$ | $0.433^{***}$ | $0.271^{**}$ | $0.251^{**}$ | $0.255^{**}$ |
| | (0.085) | (0.098) | (0.094) | (0.092) |
| $R^2$ | 0.331 | 0.423 | 0.438 | 0.435 |
| Observations | 359 | 359 | 359 | 359 |

Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The dependent variable is the statutory tax rate $\tau_i$.