How Big Are Strategic Spillovers from Corporate Tax Competition?

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Abstract

I estimate the size of strategic spillovers from corporate tax competition using a theoretically-implied measure of 'influence' between countries. Using a three-country, three-firm model of tax competition, I propose that the influence a country's tax reform has on its neighbour's optimal tax rate depends on the size of the capital flow induced by the tax reform. I approximate expected capital flows with data on bilateral capital stocks, which are used to create the measure of 'nearness' in a spatial autoregressive model of 359 corporate tax reforms across 76 countries. I find that a 1 percentage point cut in the foreign tax rate is associated with a 0.23 percentage point cut in the home tax rate. This estimate is approximately one-third of the size of previous estimates, suggesting more modest gains from global tax rate coordination.

JEL: H0; H25; H77

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1 Introduction

Many predict that corporate tax competition will lead to a race to the bottom, sparking calls for tax coordination. Tax coordination would reverse the global tax revenue losses accrued under competitive tax-setting. Such tax coordination now seems possible: the OECD has proposed a global minimum corporate tax rate that would ensure multinational firms pay at least a minimum rate of tax on their global profits. Multinational firms would have less incentive to shift mobile capital around the world in response to corporate tax rates. This puts a floor under tax competition, therefore reducing the incentive for governments to compete for mobile capital using their corporate tax rates.

The theory of international tax competition predicts that governments settle at a Nash equilibrium where corporate tax rates are too low, and that governments collectively lose revenue by acting competitively (Zodrow and Mieszkowski, 1986; Keen and Konrad, 2014). These predictions are generally backed by empirical findings which emphasise that strategic spillovers—the tax rate response of one government to another government's tax rate change—are large (Devereux et al., 2008; Overesch and Rincke, 2011; Redoano, 2014; IMF, 2014; Crivelli et al., 2016). The implications of large strategic spillovers are readily seen in the findings of Beer et al. (2018). Using consensus estimates of 0.6, they predict that other governments would substantially lower their corporate tax rates in response to the United States' tax cut from 35 percent to 21 percent. Beer et al. (2018) suggest that the revenue loss from these strategic spillovers would be so large that they would be more than double the revenue loss from companies shifting production and profits as a behavioural response to the tax cut. Since strategic spillovers are the optimal response to a tax base spillover, those estimates seem to imply that the government's optimal response to base spillovers are more than twice as harmful as the base spillovers themselves.

In this paper, I provide new evidence that strategic spillovers in international corporate tax competition are likely much smaller than previous estimates suggest. I propose an identification strategy based on the theory of tax competition. In this model, the predicted response of the government is based on an intuitive sufficient statistic: a home government should respond more to a foreign tax rate change if it is expected to have a bigger impact on the home country's tax base. This theoretical prediction informs the estimation strategy, and leads to much smaller estimates of strategic spillovers. I find that a 1 percentage point reduction in the foreign tax rate is associated with a 0.23 percentage point tax rate cut in response by the home country. This is one-third of the size of previous estimates, which suggest that a 1 percentage point reduction in the average foreign corporate tax rate is associated with a tax cut of 0.6 to 0.7 percentage points (Devereux et al., 2008; Overesch and

Rincke, 2011; Redoano, 2014).

The key difference between this paper and the preceding literature on tax competition is how I specify the *influence* one country has on another. I use a similar methodology to preceding works for estimating the size of strategic spillovers—the spatial autoregressive model. The main criticism of spatial autoregressive models is that the notion of influence—empirically represented by a weight matrix—is often arbitrarily specified (Arbia and Fingleton, 2008). Previous works in the tax competition literature do not escape this criticism. Ideally, the weight matrix should represent the underlying theory about the nature of interactions and influence between countries since the results we derive are conditional on the choice of our weight matrix (Leenders, 2002).

I contribute to the study of corporate tax competition by using a three-country, three-multinational firm model of corporate tax competition to derive the theoretically-implied influence that each country has on another country's tax rate. This notion of influence or 'nearness' relies on the simple proposition that for tax competition to exist, there must be a base spillover: that one country's corporate tax rate cut must affect another country's tax base (Wilson and Wildasin, 2004). In international corporate tax competition, base spillovers occur through cross-border capital movement. The theory suggests that base spillovers between two countries depend not only on inward and outward flows of capital between two countries, but also on their competition for capital from third countries. I measure capital flows empirically using data on bilateral foreign direct investment (FDI) from the UNCTAD and the OECD. Most existing results in this literature rely instead on ad hoc specifications of influence, while others rely on trade models to define influence (Davies and Voget, 2011; Exbrayat, 2017). This key change alone reduces the estimate of strategic spillovers by over 40 percent relative to consensus estimates.

I compare my central estimates to four common alternative measures of influence: geographical distance, size of gross domestic product, size of aggregate inward and outward foreign direct investment, and uniform influence. I show that each of these measures contains a different set of information. But which set of weights is more informative in identifying tax competition? I provide a simple testable prediction from the theory: a country should respond more to a tax cut by a 'close' neighbour in comparison to a similarly-sized tax cut by a 'far' neighbour. I show graphically that only the theoretically-implied bilateral foreign direct investment weight matrix satisfies this simple testable prediction for identification.

There are three additional concerns that arise in the estimation of strategic spillovers using a spatial autoregressive model. The first is simultaneity bias: if all governments choose their corporate tax rates at the same time, then the choice of the foreign tax rate is endogenous to the home tax rate. I deal with this through the standard approach of maximum likelihood estimation since spatial instrumental variable approaches appear to introduce rather than eliminate bias (Lyytikäinen, 2012; De Giorgi et al., 2016; Elhorst and Fréret, 2009; Fréret and Maguain, 2017). The second concern is that corporate tax rates are not re-set every period. Instead tax reforms are discrete choice decisions, where reform costs induce periods of inaction. This limits concerns about simultaneity bias. I estimate the model using only periods where the tax rate was changed under the rationale that these reflect best responses to the tax competition game. I also control for the decision of whether to change the tax rate or not. The third concern is that the choice of weight matrix is potentially endogenous to the tax rate, as with any theoretically-derived spatial concept. Fortunately, FDI gravity models already give us a good idea of the process by which the theoretical weight matrix is formed. I use a gravity model to instrument for potentially endogenous spatial weights.

To highlight the economic significance of the divergence in the 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 geographical distance, GDP or aggregate foreign direct investment imply under-provision between 10 and 16 percent of total tax revenue.

This paper is related to the line of literature that studies how governments set 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 (2011), 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; 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 outline the theoretical framework of tax competition and derive the spatial weights. 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 that multinational firm a invests in country B is denoted k_{aB}. Since multinational firm a raises capital in country A, 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 choose their optimal allocation of capital across the three countries. I solve the model by backward induction.

2.1 The multinational firm

Each 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 $\pi'''(k) = 0$. Each multinational firm faces source taxation in each of these three countries so that profits are assumed to be taxed where production takes place. The tax rate in country A is denoted τ_A. 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 Π_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 profits by producing a homogeneous good at a price normalised to unity.

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. Changes to 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 mechanism allowing us to differentiate strategic spillovers from any other factors that may cause declines in corporate tax rates.

2.2 The government

The government in country A sets the corporate tax rate to maximise tax revenue R_A. Revenue maximisation is a simplifying assumption to identify the maximum level of revenue loss implied by tax competition. The government of country A takes the tax rates in countries B and C as given. In addition, the government incorporates all firms' optimality conditions as a constraint on its tax-setting behaviour. Country A's objective is:

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

The government has taxing rights over the profits of all three multinational firms generated within its jurisdiction. 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 by 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 (2011), I argue that for empirical identification of the strategic spillover, we require the *relative* responsiveness of one government to another. That is, we compare the response of country A to a tax change in country B against the response of country A to a tax change in country B. I examine the ratio of the two best response functions $d\tau_A/d\tau_B$ and $d\tau_A/d\tau_C$, and consider what determines country A's relative responsiveness to countries B and C.

Proposition 1. 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:

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

The cross partial derivative is:

$$\begin{aligned} \frac{\partial^2 R_A}{\partial \tau_B \partial \tau_A} &= \pi'(k_{aA}) \frac{\partial k_{aA}}{\partial \tau_B} + \pi'(k_{bA}) \frac{\partial k_{bA}}{\partial \tau_B} + \pi'(k_{cA}) \frac{\partial k_{cA}}{\partial \tau_B} \\ &+ \tau_A \left[\pi''(k_{aA}) \frac{\partial k_{aA}}{\partial \tau_A} \frac{\partial k_{aA}}{\partial \tau_B} + \pi''(k_{bA}) \frac{\partial k_{bA}}{\partial \tau_A} \frac{\partial k_{bA}}{\partial \tau_B} + \pi''(k_{cA}) \frac{\partial k_{cA}}{\partial \tau_A} \frac{\partial k_{cA}}{\partial \tau_B} \right] \end{aligned} \tag{11}$$

Each of these partial derivatives can be interpreted as an *observable* flow of capital from one country to the other. For example, ∂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

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

The response of country A to a tax change in country B is 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 $\partial k_{aA}/\partial \tau_C$, $\partial k_{bA}/\partial \tau_C$, and $\partial k_{cA}/\partial \tau_C$. 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 process. Tax rates are adjusted in steps rather than a single jump to equilibrium. Corporate tax rates also 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 recast the model of tax competition as part of a dynamic game. Any change in the corporate tax rate incurs a fixed cost γ. A government is 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:

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

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

Empirically, we do not observe τ_t^R in periods where there is no tax change. Only if there were no changes to the external environment from time $t-1$ to time t would there be no change to the revenue-maximising corporate tax rate. Only when we observe tax changes do we actually glimpse the government's best response to the underlying tax competition stage game. Since it is this response that we are concerned about in the long run, we focus on corporate tax 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 influence of country j on 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 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_{ij} as capital originating in country i but located in country j. 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}. This is empirically measured by cross-border stocks of capital.

3.2 Bilateral foreign direct investment weights

To create an empirical analogy of equation 14, 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 stocks: capital instock from j to i, capital outstock from i to j and the competition between j and i for capital stock from a third country k.

The weight that country i places on country j is given by w_{ij} and uses data on instock x_{ji} from j to i, outstock v_{ij} from i to j, and a measure of their competition for instock 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 instocks is given as the proportion of total instock and that comes from country j:

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

Similarly, the weight for outstocks is calculated as the proportion of total outstock 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 instocks from each third country k to country i's total instock (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 outstock and instock 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 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. 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. This means that the outcome model of interest uses only data on tax reforms.

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).

3.4 Main regression covariates

I include a number of country-specific covariates 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.

3.5 Simultaneity bias

The spatial autoregressive model faces the concern of 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).

3.6 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 to model the network formation process. 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 to create a predicted value for each bilateral capital stock. I estimate a simple version of the gravity model with foreign direct investment expressed in natural logs. Covariates 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 predicted values from the gravity model to construct the weight matrix.

3.7 Data

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

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

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 use the stock of foreign 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. 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 (IMR), 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

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

shown in Table 6. 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 the best responses to the tax competition game. The main estimated model is therefore:

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

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 ρ, 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

These are estimates from the outcome model of a two-stage decision. Only periods where the corporate tax rate was changed are included. All models are estimated using maximum likelihood. The dependent variable is the statutory tax rate τ_i. Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses.

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 consensus estimates are *three times larger* than the central estimate in this paper.

4.1 Decomposing the difference relative to previous studies

There are two main differences relative to existing studies: the choice of the weight matrix, and using only tax rate changes. In this section I consider how these contribute to the difference in results.

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 geographical 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).

4.1.1 All observations

I begin with the model that approximates the estimation method of previous works most closely. I consider four alternative weight matrices: uniform weights, GDP weights, total

Table 2: All Observations as Best Responses for Alternative Weight Matrices

	Uniform	GDP	Aggregate FDI	Distance	Bilateral FDI
$w \cdot \tau_J$	0.653***	0.623***	0.475***	0.511***	0.379***
	(0.050)	(0.051)	(0.051)	(0.035)	(0.045)
R^2	0.447	0.434	0.424	0.458	0.427
Obs.	1620	1620	1508	1620	1356

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 4 of Table 1. Models include all observations without using the Heckman sample selection method. For each model estimated, the specified weight matrix is given by the column name.

inward plus outward foreign direct investment weights (aggregate foreign direct investment), and inverse geographical distance weights. I include all observations, including periods where the tax rate did not change, and I do not model the decision to change the tax rate. The results from this estimation are presented in Table 2. The central estimate in this table is the estimate using uniform weights as in Devereux et al. (2008). I almost match their main estimate of tax competition of 0.678. My approximation gives an estimate of 0.653 using the maximum likelihood method and an updated dataset including a larger number of countries. They use data for 21 OECD countries from 1982 to 1999 giving 378, compared to the 76 countries from 1984 to 2015 I use in this paper giving 1,620 observations. This suggests that the choice of dataset or estimation method does not significantly alter the results relative to Devereux et al. (2008).

Devereux et al. (2008) also include a model that weighs each country by their aggregate foreign direct investment, producing a smaller coefficient of 0.34. However, they reject these estimates on the grounds of endogeneity. This is smaller than the estimate of 0.475 using aggregate FDI in Table 2. The estimate of 0.69 in Overesch and Rincke (2011) is based on geographical distance weights. Similarly, Redoano (2014) use distance weights in their 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. Compared to Redoano (2014) I take a more direct approach, and simply use cross-border investment 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 only slightly smaller than the 0.511 estimated here using a similar distance weight.

To examine the immediate impact of using the theoretically-derived weight matrix, I also re-estimate the model with the proposed bilateral foreign direct investment weights using all observations. As above, this now includes periods where the corporate tax rate did not change. This estimate is now directly comparable to the existing estimates in the literature. I find an estimate of 0.379. This is around 42 percent smaller than the central estimate from Devereux et al. (2008) using uniform weights. This evidence suggests that the choice of the weight matrix contributes substantially to the size of the estimate of strategic spillovers.

4.1.2 Only tax changes

I now compare alternative weight matrices to the central estimate of this paper using the Heckman two-stage approach. In the main outcome model I include only periods where the corporate tax rate was changed. I estimate a similar model using the alternative weight matrices: uniform, GDP, aggregate FDI, and distance weights. The results of these estimates are presented in Table 3.

Table 3: Estimates Strategic Spillovers Using Alternative Weight Matrices

	Uniform	GDP	Aggregate 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

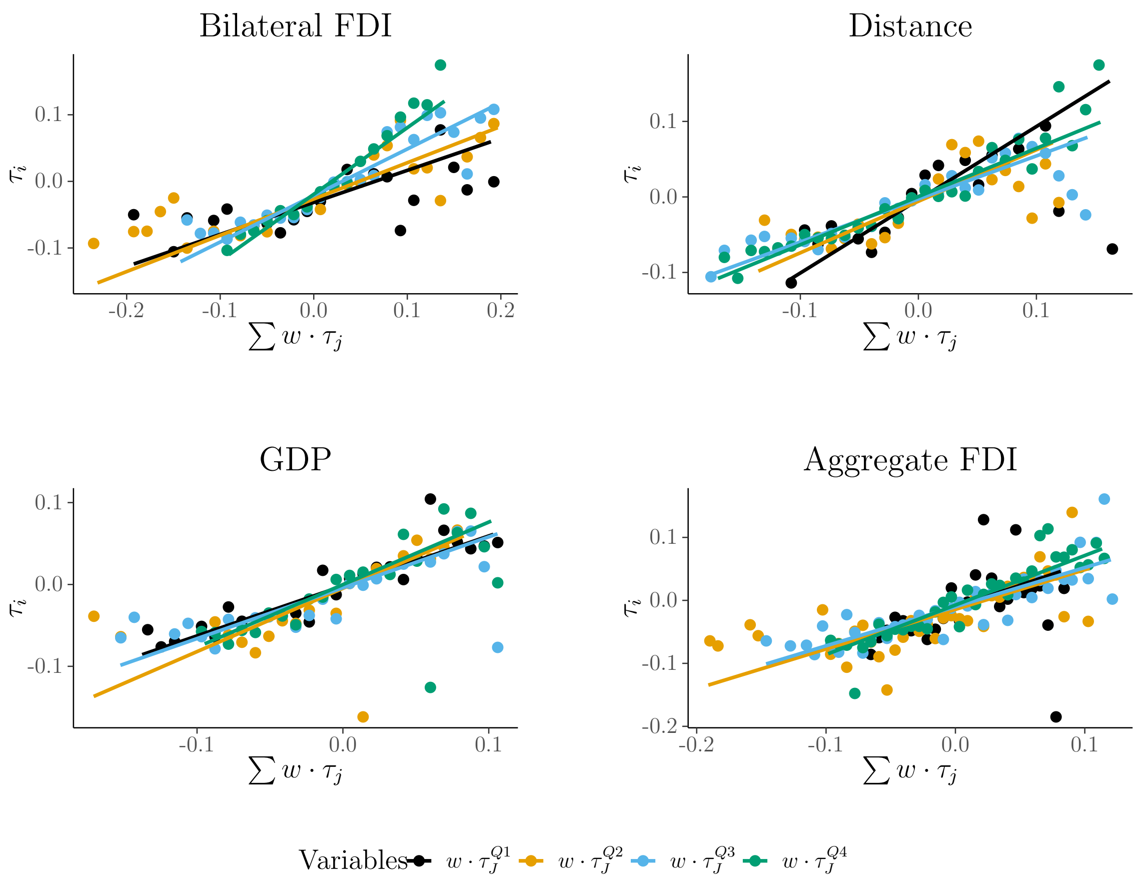
Statistical significance is given by $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors are in parentheses. All models are estimated using maximum likelihood. The models estimated in the table are the same specification as that estimated in Model 3 of Table 1. Models include all controls 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, 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. Note, however, that the exclusion of no-reform periods results in smaller estimates for all weight matrices.

4.2 Graphical Evidence

Tax competition provides 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, τ_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 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

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.

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 in this ad hoc weighting scheme.

5 Policy Implications

The commonly recommended policy solution to the problem of tax competition is tax coordination. Typically this takes the form of governments collectively agreeing to increase their corporate tax rates to increase revenue. This stems from the view that tax competition results in a Nash equilibrium where tax rates are below the social optimal.

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 τ^0 is the counterfactual tax rate were there no tax competition, τ 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 2. The coefficient is 0.653, close to the standard estimate of 0.69 in the literature.

Figure 2 shows the result of this calculation in terms of corporate tax revenue lost due to

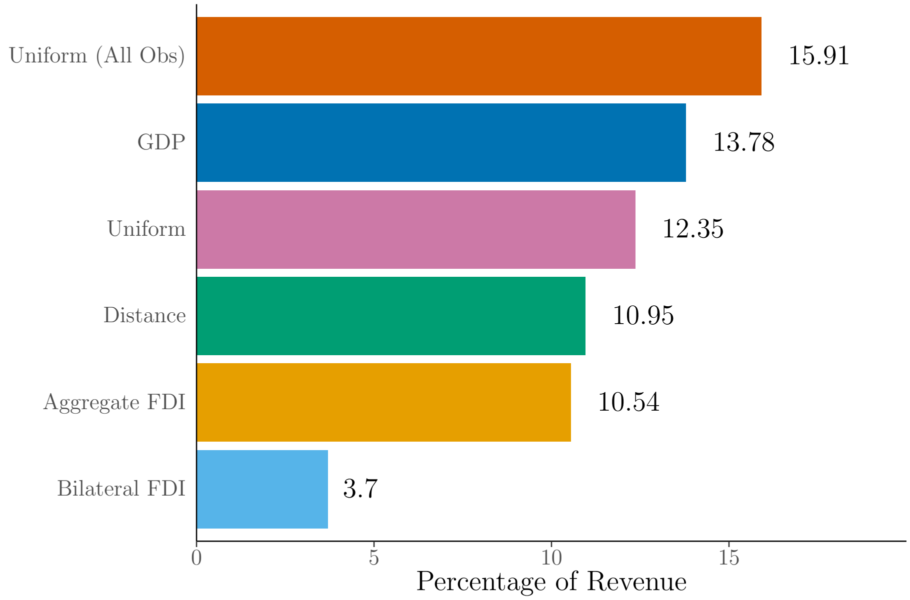


Figure 2: Estimated Tax Revenue Lost Due to Tax Competition for 2012

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 in revenue loss 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. 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.

This effect can be aggregated to the world level. In 2012, global corporate tax revenue was USD $1.9 trillion according to the ICTD/UNU-WIDER Government Revenue Dataset (2019). A 15.9 percent loss in revenue adds up to USD $302 billion in 2012. In comparison a 3.7 percent loss in revenue adds up to only USD $70 billion in 2012. Global corporate tax revenues made up around 2.56 percent of global GDP in 2012. Under the smaller estimates of tax competition in this paper, total revenue lost to tax competition was only 0.1 percent of global GDP in 2012.

6 Conclusion

At the Nash equilibrium of the tax competition game, tax rates are predicted to be below the social optimum and would lead to revenue loss relative to the cooperative equilibrium. But how far below that social optimum? And how much revenue loss does it imply?

This paper answers those questions by estimating the magnitude of strategic spillovers on corporate tax rates between governments. I use a three-country three-multinational firm model of tax competition to propose that the size of government's response to a neighbour's tax cut depends on the size of the base spillover generated by that tax cut. I use the stock of foreign direct investment between two countries to measure the expected 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 geographical distance—suggest revenue loss between 10 and 16 percent of annual revenue. The bilateral foreign direct investment weights suggest that revenue loss is less than 4 percent of revenue. This study finds that strategic spillovers on corporate tax rates between national governments exist and are statistically significant. However, the magnitude of these spillovers is a third of the size of existing estimates, and results in corporate tax revenue losses that are much less economically significant.

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A Data

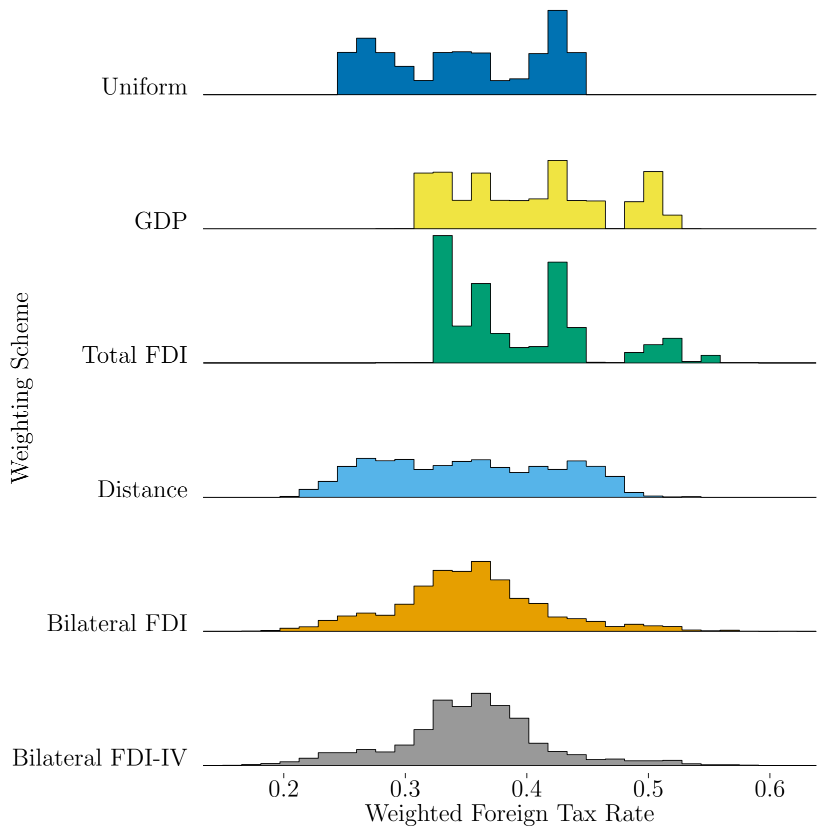

Figure 3: Histogram of Weighted Foreign Tax Rates

Table 4: 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 5: Gravity Model for FDI Instruments

$\ln(\text{GDP}_i)$	0.751^{***}
	(0.082)
$\ln(\text{GDP}_j)$	-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 6: 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 7: 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 τ_i.