ELSEVIER

Journal of Public Economics 92 (2008) 1210–1235

JOURNAL OF PUBLIC ECONOMICS

www.elsevier.com/locate/econbase

Do countries compete over corporate tax rates? ☆

Michael P. Devereux [a,*], Ben Lockwood [b], Michela Redoano [b]

[a] Oxford University Centre for Business Taxation, Oxford OX1 1HP, UK
[b] University of Warwick, Coventry CV4 7AL, UK

Received 20 May 2006; received in revised form 11 September 2007; accepted 11 September 2007
Available online 16 September 2007

Abstract

This paper investigates whether OECD countries compete with each other over corporation taxes, and whether such competition can explain the fall in statutory tax rates in the 1980s and 1990s. We develop a model in which multinational firms choose their capital stock in response to an effective marginal tax rate (EMTR), and simultaneously choose the location of their profit in response to differences in statutory tax rates. Governments engage in two-dimensional tax competition: they simultaneously compete over EMTRs for capital and over statutory rates for profit. We estimate the parameters of their reaction functions using data from 21 countries between 1982 and 1999. We find evidence that countries compete over both measures, and moreover, that the estimated slopes of reaction functions are consistent with our theoretical predictions. We find that – consistent with our model, but not some other forms of competition – evidence of strategic interaction is present only between open economies (i.e. those without capital controls in place). The Nash equilibrium average statutory rates implied by the empirical model fall substantially over the period, in line with falls in actual statutory rates. The reductions in equilibrium tax rates can be explained almost entirely by more intense competition generated by the relaxation of capital controls.

JEL classification: H0; H25; H77
Keywords: Tax competition; Corporate taxes; Transfer pricing

1. Introduction

Statutory rates of corporation tax in developed countries have fallen substantially since the early 1980s. The average rate amongst OECD countries in the early 1980s was nearly 50%; by 2001 this had fallen to under 35%. In 1992, the European Union's Ruding Committee recommended a minimum rate of 30%, then lower than any rate in Europe (with the exception of a special rate for manufacturing in Ireland). But only ten years later, one third of the members of the European

☆ The research reported here received financial support from the ESRC, and from the CSGR at Warwick University. We would like to thank Rachel Griffith and Lucy Chennells for help in assembling corporate tax data. We would also like to thank the editor, Joel Slemrod, two anonymous referees and participants at the World Tax Competition conference at the IFS, the conference on Strategic Interaction among Local Governments at the Catholic University of Milan, the Workshop on Taxation and Public Debt at the University of Warwick's London Office, and seminar participants at EPRU, University of Copenhagen, and the Universities of Exeter, Edinburgh, Keele, Oslo, Newcastle, Nottingham and Warwick for helpful comments.
* Corresponding author.
E-mail address: michael.devereux@sbs.ox.ac.uk (M.P. Devereux).

0047-2727/$ - see front matter
doi:10.1016/j.jpubeco.2007.09.005

Union had a rate at or below this level. It is commonly believed that the reason for these declining rates is a process of tax competition: countries have increasingly competed with each other to attract inward flows of capital by reducing their tax rates on corporate profit. Such a belief has led to increased attempts at international coordination in order to maintain revenue from corporation taxes. Both the European Union and the OECD introduced initiatives in the late 1990s designed to combat what they see as "harmful" tax competition.

The notion that there is increasing competitive pressure on governments to reduce their corporation tax rates has been the subject of a growing theoretical literature — surveyed by Wilson (1999), and Fuest et al. (2005). But there have been no detailed attempts to examine whether there is any empirical evidence of strategic international competition in taxes on corporate income, nor whether such competition has become more intense.[1] In this paper we extend the theoretical literature to provide testable predictions about country reaction functions in corporation taxes, and we provide a rigorous test of those predictions.

Existing theory, in our view, suffers from important weaknesses. First, the vast majority[2] of existing theory does not adequately deal with the fact that governments have two instruments for determining corporate income taxes: the rate and the base. In the standard model in the literature, developed by Zodrow and Miezkowski (1986) and Wilson (1986), denoted here the ZMW model, governments have only one instrument, a tax on capital income. However, as shown below, if a corporate tax of the simplest possible form – with a statutory rate and a capital allowance – is introduced in the ZMW model, this is equivalent to a tax on capital income *plus* a tax on rent accruing to the fixed factor. More precisely, the fixed factor is taxed at the statutory tax rate, and capital income is taxed at a rate which depends on both the statutory rate and the value of capital allowances (usually called the effective marginal tax rate, or EMTR).[3] In this version of the ZMW model, there is no strategic interaction in the setting of the statutory tax rate since it is effectively a lump sum tax. Moreover, if countries are symmetric, and demand for the public good is not too high, the EMTR at equilibrium is zero[4], which is of course, highly unrealistic.

So, some – preferably realistic – extension[5] of the ZMW model is needed to generate both competition in statutory rates and EMTRs. In this paper, we pursue such an extension, by introducing mobility of corporate profit to the ZMW model. Profit mobility is empirically important: conditional on where real activity takes place, multinational firms are able to shift profits from one country to another in order to reduce overall tax liabilities.[6] There are a number of opportunities for doing so, including appropriate use of financial policy (in the simplest case, lending by an affiliate in a low tax country to an affiliate in a high tax country) and setting appropriate transfer prices on intermediate goods exchanged within the corporation. The fundamental incentive for profit-shifting is a difference in the statutory rate between jurisdictions. Moreover, there is considerable empirical evidence of multinational firms taking advantage of differences in statutory tax rates to shift profits between countries.[7]

[1] In an unpublished paper, Altshuler and Goodspeed (2002) investigate competition between countries, and test whether the US is a Stackelberg leader, using data on tax revenue.

[2] An exception is Haufler and Schjelderup (2000), in the context of a model which incorporates mobile capital and profit shifting. This paper is discussed further below.

[3] A tax on the fixed factor only could be achieved through a cash flow tax, which would generate revenue with a zero effective marginal tax rate.

[4] This is shown in Section 2.3 below.

[5] A third form of mobility, which we do not consider in this paper is mobility of firms. Multinational firms make discrete choices as to where to locate their foreign affiliates, and these choices depend on how taxes affect the post-tax level of profit available in each potential location; the impact of tax on such decisions is measured by the *effective average tax rate* (EATR). Devereux and Griffith (1998, 2003) provide evidence of the impact of the EATR on discrete location decisions. We neglect this issue here for two reasons. First, including three forms of mobility simultaneously would make the theoretical model intractable. Second, the EATR is strongly correlated with the statutory rate; it is therefore difficult to identify separately competition in these two forms of tax rate.

[6] There is a considerable theoretical literature on multinational firms shifting profit through the misuse of transfer prices, although not usually in the context of tax competition. Recent relevant papers include Elitzur and Mintz (1996), Haufler and Schjelderup (2000), Raimondos-Moller and Scharf (2002), Nielsen et al. (2003), and Mintz and Smart (2004).

[7] For example, two recent papers use different approaches and data to investigate international profit shifting. Bartelsman and Beetsma (2003) use OECD industry level data to infer profit shifting by relating rates of value added to corporate tax differences between countries. Their baseline estimate is that more than 65% of the additional revenue which would otherwise result from a unilateral tax increase is lost because of profit shifting. Clausing (2003) tests the impact of taxes on transfer pricing directly with data on prices used in US intra-firm trade. She finds that a statutory tax rate 1% lower in the destination country is associated with intra-firm export prices 1.8% higher, and that a statutory tax rate 1% lower in origin country is associated with intra-firm import prices 2% higher. A number of earlier papers also provide evidence of profit shifting. See, for example, Hines and Hubbard (1990), Grubert and Mutti (1991), Hines and Rice (1994), Grubert and Slemrod (1998) and the survey by Hines (1999).

We develop a model which combines mobile capital with profit-shifting via transfer pricing, and we study competition in corporate tax systems in this model. The model is related to contributions by Eliztur and Mintz (1996) and Haufler and Schjelderup (2000), in that at the first stage, the governments choose taxes, and at the second, firms choose a transfer price for an input given the choice of taxes. Our contribution differs from the other two, however, in several ways. First, we allow for an endogenous price of capital, which is in fact a precondition for strategic interaction in the setting of the EMTR across countries. Second, we explicitly characterize both the Nash equilibrium in the two taxes[8], *and* the slopes of the reaction functions in the neighborhood of the Nash equilibrium, in order to obtain testable predictions. Finally, our modelling of transfer-pricing incentives has some micro-foundations.[9]

In our model, we show that the statutory rate, rather than being lump-sum, is used competitively by each country to shift profits into its jurisdiction. This generates strategic interaction in the setting of statutory rates. Moreover, because the statutory rate is no longer a lump-sum tax, the tax on capital income (EMTR) is positive in equilibrium. Finally, in an advance on the previous literature (see e.g. Brueckner, 2006), we are able to establish some quite precise predictions about the properties of reaction functions. In particular, the model has *two-dimensional* reaction functions: in the home country, the optimal choice of both statutory rate and the EMTR react to changes in each of these taxes in the foreign country, and vice-versa. We evaluate these responses in the neighborhood of symmetric Nash equilibrium. We are able to prove generally that the response of the home statutory rate (EMTR) to the foreign statutory rate is positive (negative), and for a calibrated version of the model, the response of both the home EMTR and statutory rate to the foreign EMTR rate is positive, although the response of the statutory rate to the foreign EMTR is numerically very small.

Having developed this model, we confront it with data. Part of the reason for the lack of empirical evidence to date on this topic may be the difficulty in developing appropriate measures of the EMTR. Although there have been striking changes to statutory tax rates, there have also been important changes to the definitions of tax bases; very broadly, tax bases have been broadened as tax rates have fallen. Our measure of the EMTR is based on applying the rules of the tax system to a hypothetical investment project (Devereux and Griffith, 2003). We use information on tax rules from 21 OECD countries over the period 1982 to 1999. This type of measure has been used for other purposes[10], but not for investigating strategic interactions between countries: this paper is the first, to our knowledge, to estimate tax reaction functions based on detailed measures of corporate taxes.

Our empirical work builds on two small, but growing empirical literatures. The first, mostly in political science, has regressed either corporation tax revenues or rates on measures of capital controls and other control variables, primarily to test whether relaxation of exchange controls, especially on the capital account, lowers either corporate tax revenues or rates.[11] Slemrod (2004) uses a similar approach to investigate whether corporate tax rates and revenues rise in response to greater revenue needs and a degree of openness of the economy. However, this literature has not directly tested for strategic interactions between fiscal authorities.

Second, a pioneering study by Case et al. (1993) has stimulated a growing empirical literature on estimation of tax reaction functions, surveyed recently by Brueckner (2006). However, existing empirical work has employed data on local (business) property tax rates,[12] or on local or state income taxes,[13] rather than investigating competition at a national level. This is significant, because, while local property taxes may determine business location within a region, corporate taxes are the most obvious taxes in determining location of investment between countries.

Our findings are as follows. We find evidence consistent with our prediction that countries compete over the statutory tax rate (to attract mobile profit). The size of this effect is both large and consistent with theoretical predictions. For example, a 1 percentage point fall in the weighted average statutory rate in other countries tends to

[8] Eliztur and Mintz (1996) only consider statutory tax rates: there is no taxation of capital in their model. Haufler and Schelderup (2000) assume that allowances are residually determined by a fixed government revenue requirement.

[9] Haufler and Schjelderup (2000) assume an ad hoc cost of transfer pricing of a discrete input, which is increasing and convex in the difference between the true cost of the input and the price.

[10] For example, constructed measures of the EMTR have been used elsewhere to make international comparisons of corporate income taxes (see, for example, King and Fullerton (1984), OECD (1991), Devereux and Pearson (1995), Chennells and Griffith (1997), European Commission (2001)). Devereux and Freeman (1995) provide evidence that flows of foreign direct investment depend on differences in the EMTR across countries.

[11] See Hallerberg and Bassinger (1998), Garrett (1998), Quinn (1997), Rodrik (1997), Swank and Steinmo (2002), and Slemrod (2004).

[12] See Brueckner (1998, 2001), Brett and Pinkse (2000), Heyndels and Vuchelen (1998).

[13] See Besley and Case (1995), Heyndels and Vuchelen (1998).

reduce the tax rate in the home country by just under 0.7 percentage points. There is rather weaker evidence to support the prediction that countries compete over the EMTR (to attract capital). Also the evidence suggests that these two forms of competition are distinct in the sense that we do not find an effect of the EMTR in country j on the statutory rate in country i, nor do we find an effect of the statutory rate in country j on the EMTR in country i. This is broadly consistent with our theoretical model in the sense that theoretical analysis of reaction function slopes suggests that these "cross-tax effects" will be smaller than the "own-tax effects".

It is of course possible that observed strategic interaction in tax setting may also be due to yardstick competition. The latter occurs when voters in a tax jurisdiction use the taxes (and expenditures) set by their own political representative relative to those in neighboring jurisdictions to evaluate the performance of their representative (Besley and Case, 1995; Besley and Smart, 2007; Bordignon et al., 2003). It is also possible that countries follow each other in setting tax policy, not because of any kind of competition, but because of common intellectual trends. Finding an empirical relationship between tax rates in different countries may not necessarily therefore imply competition of the kind analysed in our theoretical model.

We address this as follows. In our model, there is mobility of capital and profit between countries, and governments compete over these mobile flows. However, the yardstick model does not require any flows between the two competing countries — it is as likely to take place between two completely closed (but otherwise similar) countries as between two open economies. Similarly, common intellectual trends can apply to countries which are closed. We therefore differentiate observations in our data depending on whether countries had significant capital controls in place at that time. We take the existence of significant capital controls as severely restricting mobility of capital and profit. Specifically, we would only expect tax competition between two countries when neither country had significant capital controls in place. We find evidence for strategic interaction is much stronger in the cases where none of the countries analysed have capital controls in place. In fact, arguably interaction is present *only* in this case. Our findings thus strongly support the predictions of the theoretical model, and are not consistent with the main alternatives.

Finally, we return to our motivation in the first paragraph of this paper: does our empirical model explain the significant reduction in statutory rates of corporation tax over the last twenty years? To investigate this, we use the estimated coefficients from the empirical model and the values of the control variables, to infer the change over time in the mean of the Nash equilibrium statutory rates for our sample of countries. We show that the estimated average Nash equilibrium rate falls substantially over the period considered, and in fact, it falls very closely in line with the reduction in observed tax rates.

What has created this more intense competitive pressure leading to a reduction in equilibrium tax rates? In our model, the answer is the relaxation of capital controls. If capital controls had not been relaxed over this period, we estimate that there would have been almost no change in the average Nash equilibrium tax rate. The relaxation of capital controls has generated competition between an increasing number of countries; it is this more intense competition which has driven down equilibrium tax rates.

The layout of the rest of the paper is as follows. Section 2 provides a theoretical framework for the empirical approach. Section 3 presents the empirical specification and data, and Section 4 presents the results. Section 5 briefly concludes.

2. A theoretical framework

2.1. A model of corporate tax competition

There are two countries, home, and foreign. Following the usual convention in the international trade literature, home country variables are unstarred, and foreign country variables are starred. Each country is populated by a unit measure of agents, each of whom owns (i) an endowment of capital, κ, and (ii) a share (normalized to unity) of a multinational firm whose parent is located in that country. That is, the home (foreign) multinational is 100% owned by agents in the home (foreign) country, although nothing important depends on this.

Every agent resident in the home country has preferences over consumption of a private good produced by the two firms and of a country–specific public good of a linear form:

$$u(x,g) = x + v(g) \tag{2.1}$$

where x and g are the consumption levels of the private and public goods, and v is a strictly increasing and concave function. The government can transform one unit of the private consumption good into one unit of the public good. We assume that $v'(0) \geq 1$ which implies that some provision of the public good is (weakly) desirable if lump-sum taxation is available. Preferences in the foreign country are of the same form, over consumption levels x^* and g^*. For future reference, note that $v(g)$ will also depend on a vector of variables X, such as demographics, which will affect the demand for the public good.

In both countries, governments finance the provision of a public good though a source-based corporation tax levied on the profit of both firms. We now describe the operation of the corporation tax in more detail. Consider first the parent company of the home multinational, which is located in the home country. It produces output $f(k)$ using k units of the capital input, and a discrete input which it purchases at price q from an affiliate located in the foreign country.[14] The capital input is purchased from households at price r. So, tax paid by the parent in the home country is $\tau(f(k)-ark-q)$, where $0 \leq \tau \leq 1$ is the statutory rate of tax, and $a \geq 0$ is the rate of allowance on the cost of capital.[15] In addition, the cost to the affiliate of producing the input is equal to c, so the foreign affiliate of the home parent makes a pre-tax profit of $q-c$ and is taxed at the foreign tax rate τ^*.

The overall post-tax profit of the multinational is therefore

$$\begin{aligned} \Pi &= f(k) - rk - q - \tau(f(k) - ark - q) + (1-\tau^*)(q-c) \\ &= (1-\tau)(f(k) - zrk - q) + (1-\tau^*)(q-c) \end{aligned} \tag{2.2}$$

where the effective marginal tax rate (EMTR) is $z-1=(1-a\tau)/(1-\tau)-1=\tau(1-a)/(1-\tau)$. Given τ, the government can choose a in order to set a value of this EMTR. In what follows, we treat the government as choosing z directly.

Now consider the foreign multinational whose parent is located in the foreign country. It has an affiliate in the home country which also sells a discrete input, again produced at cost c, at price q^* to the parent in the foreign country. The parent combines this input with capital input k^* to produce revenue $f(k^*)$. So, global post-tax profits of the foreign multinational are

$$\Pi^* = (1-\tau^*)(f(k^*) - z^*rk^* - q^*) + (1-\tau)(q^*-c). \tag{2.3}$$

In our model, the price of r is determined competitively in the market for the capital input. On the other hand, we assume that there is no competitive market for the discrete inputs: this is realistic in many circumstances, for example where the input is a commercial intangible, such as a patent or trademark (OECD, 2001). Rather, we suppose that the multinationals themselves choose q and q^* to maximize global profits Π and Π^*. If they do so in an unrestrained way, however, it is clear that the multinationals will choose corner solutions[16] for q and q^*. This is both unrealistic and unhelpful for generating testable predictions, as it generates discontinuities in the tax reaction functions.

In practice, the scope of firms for transfer pricing is limited by financial penalties for transfer pricing. In practice, these penalties depend on deviations from the "arm's length" principle — that a transfer price should be the same as if the two companies involved were indeed two independents, not part of the same corporate structure (OECD, 2001). We model this in a tractable way as follows.[17] Consider the home country multinational. If $q>c$, so that transfer pricing penalizes the home government, this government imposes a fine with probability $p=q-c$, and this fine is proportional to the reduction in the tax base i.e. $F=\alpha(q-c)$. Similarly, if $q<c$, so that transfer pricing penalizes the foreign government, this government imposes a fine with probability $p^*=c-q$, and this fine is proportional to the reduction in the tax base i.e. $F^*=\alpha^*(q-c)$. Moreover, to ensure that tax equilibrium is symmetric, we assume $\alpha=\alpha^*<1$. So, for any q, the expected fine of the home multinational is $EF=\alpha(q-c)^2$. Similarly, the expected fine of the home multinational is $EF^*=\alpha(q^*-c)^2$. The multinationals then choose their transfer prices q, q^*, taking EF, EF^* as given, as well as the structure of corporate taxation in both countries.

[14] The use of a discrete input follows Haufler and Schjelderup (2000). In their model the firm faces a quadratic cost of concealing the true value of the input. Below we generate a similar model by instead considering fines imposed by each government. We also analyse the implied reactions functions in more detail in order to inform the empirical work.

[15] The allowance rate a partly reflects relief for the cost of finance: for example, in the case of a wholly debt-financed investment (and in the absence of depreciation) the interest payment would be deductible from tax, and hence $a=1$. More generally, although we do not model depreciation explicitly, a might also reflect the value of depreciation allowances. A cash flow tax would imply that $a=1$ We do not impose $a \leq 1$.

[16] For example, the home multinational will choose $q=0$ if $\tau<\tau^*$, and $q=f(k)-zrk$ if $\tau>\tau^*$.

[17] Optimal transfer pricing rules in the presence of such asymmetric information have been analysed by Gresik and Nelson (1994).

So, to summarize, we have assumed the following order of events. First, governments choose their corporation tax parameters. Second, firms choose investments k, k^* and transfer prices q, q^*. Third, the price of capital, r, is determined, and production and consumption take place. As is usual, we solve the model backwards.

2.2. Choice of investments and transfer prices

We deal with the second and third stages together in this section. The home multinational chooses q and k to maximize profit Π, defined in Eq. (2.2), less the expected fine EF. The first order condition for q is thus $\tau-\tau^*=2\alpha(q-c)$ which easily solves to give the profit-maximizing value of q as a linear function of the difference between the two statutory tax rates, $\tau-\tau^*$:

$$q = c + \frac{\tau - \tau^*}{2\alpha}. \tag{2.4}$$

Thus, the home firm's optimal transfer price shifts profit in the usual way: when τ rises, q rises to shift profit to the foreign affiliate, and when τ^* rises, q falls to shift profit to the parent company. The foreign firm's choice of q^* is entirely symmetric. In particular, the foreign multinational chooses a transfer price

$$q^* = c + \frac{\tau^* - \tau}{2\alpha}. \tag{2.5}$$

Now consider the home multinational's choice of capital input, k. This choice maximizes Π in Eq. (2.2), implying a first order condition for k

$$f'(k) = zr. \tag{2.6}$$

which simply says that the marginal value product of capital is equal to the cost of capital, given the corporate tax system[18]. This solves to give demand for capital by the home multinational of $k(zr)$, and in the same way, $k(z^*r)$ is demand for capital of the foreign multinational. So, the capital market equilibrium condition is

$$k(zr) + k(z^*r) = 2\kappa \tag{2.7}$$

It is easily seen that an increase in z, z^* depresses the demand for capital and thus reduces r. Note from (2.4), (2.5), (2.7) that q, q^* only depend on the statutory tax rates, and r only on the EMTRs.

2.3. Choice of corporate taxes

Here, we characterize the symmetric Nash equilibrium in the corporate tax game between countries. This is the first step in studying the reaction functions, as due to the non-linearity of the model, we cannot study the reaction functions generally, but only linear approximations to these reaction functions around the Nash equilibrium.

The home country government is assumed to choose τ and z to maximize the sum of utilities of its residents, given τ^* and z^* fixed. Given linearity of preferences, the government maximand is thus just the total expected surplus

$$W = r\kappa + \Pi - EF + v(g). \tag{2.8}$$

which is simply the total income[19] $r\kappa+\Pi-EF$ of a resident plus his utility from expected public good supply. Now define the profit function $\pi(zr)=\max_k \{(f(k)-zrk\}$.

[18] We are implicitly assuming here that each multinational takes the price of capital r as given when choosing k. This assumption is made for analytical tractability: treating multinationals as oligopsonistic buyers of capital would considerably complicate the analysis, without adding any new insights. The assumption could be justified (without much change to the details of the model) by supposing that there are large numbers of multinationals of each "type".

[19] Note that each resident in the home country receives the post-tax global profit of the home multinational Π, Eq. (2.2), net of expected fines as the home multinational is 100% owned by home residents.

In the home country, total revenue is the sum of tax revenue, plus any revenue from fines, net of costs of administration of the fine system. To avoid technical complications[20], we will assume that the policing of transfer pricing is self-financing i.e. the costs are equal to the revenue raised from fines. This can be done formally by supposing that the cost of the system is quadratic in the probability p that a fine is imposed i.e. $\psi(p)=cp^2$. As this p captures the costs of auditing and prosecuting firms, this seems a reasonable assumption. Then, we suppose that the government sets the fine $\alpha=\psi$. Under this assumption, the level of public good provision is just equal to the revenue from taxes, which can be written

$$g = \tau(\pi(zr) - q) + (z-1)rk(zr) + \tau(q^* - c) \tag{2.9}$$

This formula for g has two components: (i) the tax revenue from the home multinational, $\tau(\pi(zr)-q)+(z-1)rk(zr)$; (ii) the tax revenue from the foreign multinational, $\tau(q^*-c)$. Note also that tax revenue from the home multinational is expressed as the sum of the statutory tax base $\pi(zr)-q$ times the rate, τ, plus the EMTR base $rk(zr)$ times the rate, $z-1$.

The home government chooses τ, z to maximize Eq. (2.8) above, subject to the government budget constraint (2.9), and given $\mathrm{EF}=\alpha(q-c)^2$ and the definition of Π in Eq. (2.2) above. In the optimization, the home country government is assumed to take τ^*, z^* as fixed, but takes into account the fact that the equilibrium input prices r, q, q^* depend on τ, z via Eqs. (2.4), (2.5), and (2.7). We analyse this choice at symmetric tax equilibrium i.e. $(\tau, z)=(\tau^*, z^*)$. This choice is characterized by first-order conditions, which are denoted

$$W_\tau = 0, \;\; W_z = 0 \tag{2.10}$$

where W_x denotes the partial of W with respect to $x=\tau$, z taking into account all the effects on the input prices. These first-order conditions for τ, z simplify considerably, mainly because q, q^* only depends on τ, and r only depends on z. Indeed, after some manipulation, we can prove (proofs of all propositions are in the Appendix):

Proposition 1. *At a symmetric Nash equilibrium, ($\tau=\tau^*=\hat{\tau}$, $z=z^*=\hat{z}$), then assuming an interior solution for $\hat{\tau}$, $\hat{\tau}$, $\hat{z}$ satisfy the conditions*

$$\hat{\tau} = \frac{\alpha(v'-1)(\pi-c)}{v'} \tag{2.11}$$

$$\frac{\hat{z}-1}{\hat{z}} = \frac{(v'-1)(1-\hat{\tau})}{v'\varepsilon} + \frac{\partial W}{\partial r}\left(\frac{z\partial r}{r\partial z}\right)\frac{1}{v'k\varepsilon} \tag{2.12}$$

where

$$\varepsilon = -\frac{k'r\hat{z}}{k}>0, \frac{z\partial r}{r\partial z} = -\frac{1}{2}, \frac{\partial W}{\partial r} = -\frac{\kappa(v'-1)}{2}<0. \tag{2.13}$$

In the Proposition, primes denote derivatives, π and k' are $\pi(zr)$ and $k'(zr)$ evaluated at the equilibrium values of z and r. So, $\pi-c$ is the base of the statutory tax in equilibrium i.e. revenue minus the cost of capital.

These are interesting and easily interpretable formulae for $\hat{\tau}$, $\hat{z}$. First, as is standard in the optimal tax literature, $(v'-1)/v'$ is a measure of the benefit of public consumption relative to private consumption. Second, note from Eq. (2.4) that $1/\alpha$ measures the sensitivity of the tax base to the statutory tax. So, Eq. (2.11) says that $\hat{\tau}$ is inversely proportional to this. Second, Eq. (2.12) says that the optimal EMTR, $\hat{z}-1$, is set with regard to both revenue-raising incentives (the first term), and with regard to any incentive the government has to manipulate the price of capital (the second term). Note that generally, the second term is positive, as, at equilibrium, an increase in the price of capital reduces welfare, and an increase in z reduces the price of capital.

[20] The complication here is that if the fines generate some net revenue for the government, this complicates the calculation of equilibrium and also the slopes of reaction functions. In practice, revenue from these fines are negligible relative to overall revenue from corporate taxation, so can reasonably be ignored.

It is helpful to write Eq. (2.12) more explicitly, using Eq. (2.13). After simple rearrangement, we get

$$\frac{\hat{z}-1}{\hat{z}}=\frac{(v'-1)}{v'\varepsilon}\left(\frac{5}{4}-\hat{\tau}\right) \tag{2.14}$$

So, we can make the following observations. First and foremost, if there is a revenue raising objective, $(v'>1)$ then the EMTR will generally be positive, and inversely related to the elasticity of the "base" of the EMTR i.e. ε. This result was first noted (in a slightly different setting) by Haufler and Schjelderup (2000), and the intuition is a second-best one: as the statutory tax is distortionary via its effect on transfer pricing, it is best to also use the other tax instrument, the EMTR. Second, as expected, conditional on $\hat{\tau}$, $\hat{z}$ is increasing in the relative benefit of public consumption $(v'-1)/v'$, and decreasing in the elasticity of the tax base, as measured by ε.

Third, somewhat less obviously, $\hat{z}$ is deceasing in $\hat{\tau}$, given other parameters fixed. So, for example, an increase in α, which does not affect $\hat{z}$ directly, would increase $\hat{\tau}$ and reduce $\hat{z}$. This is because τ, z are strategic complements: that is, an increase in z lowers the marginal benefit from an increase in τ, and vice-versa. To see this, note from Eq. (2.9) that an increase in z lowers $\pi(zr)$ and thus the base of the statutory tax (a formal proof of strategic complementarity proof is in the Proof of Proposition 3).

Fourth, we can compare Eq. (2.14) with the EMTR that would occur if each country was small in the sense that it could not manipulate the price of capital (set $\frac{z\partial r}{r\partial z}=0$ in Eq. (2.12)). It is easily seen, comparing Eqs. (2.14) and (2.12) with $\frac{z\partial r}{r\partial z}=0$ imposed, that a "small" country would set a lower tax, as $\frac{5}{4}>1$. Intuitively, this is because of the reason already stated: a "large" country can lower the price of capital – which it wants to do – by raising the EMTR.

2.4. Reaction functions

Our main objective in developing this theoretical model is to generate testable predictions about the nature of reaction functions. This is complicated by the fact that each government has two instruments, τ and z, and (in principle) reacts to both τ^*, z^*, so generally, the reaction functions are of the form $\tau=T\,(\tau^*, z^*)$, $z=Z\,(\tau^*, z^*)$. Nevertheless, we can linearize the reaction functions around the Nash equilibrium by totally differentiating Eq. (2.10) to get:

$$\begin{pmatrix} W_{\tau\tau} & W_{\tau z} \\ W_{\tau z} & W_{zz} \end{pmatrix}\begin{pmatrix} \mathrm{d}\tau \\ \mathrm{d}z \end{pmatrix}=-\begin{pmatrix} W_{\tau\tau^*} & W_{\tau z^*} \\ W_{z\tau^*} & W_{zz^*} \end{pmatrix}\begin{pmatrix} \mathrm{d}\tau^* \\ \mathrm{d}z^* \end{pmatrix}. \tag{2.15}$$

Our general strategy is then to solve the system (2.15) for the four reaction function "slopes" $\frac{\mathrm{d}\tau}{\mathrm{d}\tau^*}$, $\frac{\mathrm{d}z}{\mathrm{d}\tau^*}$, $\frac{\mathrm{d}\tau}{\mathrm{d}z^*}$, $\frac{\mathrm{d}z}{\mathrm{d}z^*}$ and then to sign these four slopes, at least under certain conditions. A useful simplification is that the first-order condition for z, $W_z=0$, is independent of τ^*, as shown in the Appendix. Hence we can set $W_{z\tau^*}=0$ in Eq. (2.15).

Following the game-theory literature, say that $x=\tau$, z and $y=\tau^*$, z^* are *strategic complements* if $W_{xy}>0$, and *strategic substitutes* if $W_{xy}<0$. So, for example, τ, τ^* are strategic complements if (holding z, z^* fixed, but allowing all endogenous variables q, q^*, r to vary) an increase in the foreign statutory rate τ^* would induce the home country to raise its own statutory rate. In games with two players, each with only one strategic variable, it is well-known that the two variables being strategic complements (substitutes) is *equivalent* to positively sloped (negatively sloped) reaction functions.

In games with more than one strategic variable, this equivalence no longer holds. Generally, this is because following (say) a change in τ^*, the home government re-optimizes z as well as τ, meaning that $W_{\tau\tau^*}$ is now not sufficient to sign the reaction of τ to τ^*: the effect of a change in z is now also relevant. Call this the *indirect effect* of a change in z. Moreover, it is possible to show – see the Proof of Proposition 3 – that $W_{\tau z}<0$. The intuition for this is simply that an increase in z will lower $\pi(zr)$, the base of the statutory tax, and this in turn reduces the marginal revenue from τ.

Because of this complication, we need to impose additional conditions on utility and production functions in order to obtain results on strategic complementarity, as the following proposition shows:

Proposition 2. *Assume that $v(g)=\gamma g$, $\gamma \geq 1$. Then, $W_{z\tau^*}=0$ i.e. z and τ^* are strategically independent. Moreover, taxes τ, τ^* and τ, z^* are strategic complements ($W_{\tau\tau^*}$, $W_{\tau z^*}>0$). If in addition, the production function is quadratic i.e. $f(k)=\frac{1}{\beta}\left(\sigma k-\frac{k^2}{2}\right)$, and, in equilibrium, the elasticity of demand for capital is sufficiently high i.e. $\varepsilon=\frac{\sigma-\kappa}{\kappa}>\frac{\gamma-1}{2\gamma}$, then z, z^* are strategic complements i.e. $W_{zz^*}>0$.*

It is helpful to have some intuition at this point. The intuition for why τ, τ^* are strategic complements is simply that an increase in τ^* will decrease the transfer price q, thus increasing the base $\pi-q$ of the statutory tax in the home country, and thus increasing the incentive for the government to raise the statutory rate, τ. The intuition for why τ, z^* are strategic complements is equally simple. An increase in z^* only affects home country welfare because it lowers the world price of capital. In turn, this increases gross profit $\pi(zr)$ and thus the base of the home country tax on pure profit, τ.

The reason why z and τ^* are strategically independent is that a change in τ^* will simply change the input prices q, q^*, and the effect of changes in the input prices on profit and public good provision are independent of capital employed in the home country, $k(zr)$, and also of gross profit $\pi(zr)$ generated in the home country. In turn, z only affects home country welfare via capital employed and gross profit.

Finally, there is a more complex relationship between z and z^*. This may appear in contradiction to the existing literature, where is it known[21] that in the ZMW model with specific taxes on the use of capital, reaction-functions are upward-sloping (i.e. capital taxes are strategic complements). This apparent contradiction is due to the fact that here, the taxes z, z^* are, by the nature of the profit tax, ad valorem, rather than specific. This makes a qualitative difference, for the following reason[22]. When capital taxes are specific, the home tax base is k, and thus an increase in the foreign tax has an unambiguously positive impact on the tax base. But, when capital taxes are ad valorem, the home tax base is rk, and an increase z^* raises k but decreases r, and thus has an ambiguous effect overall. The larger the elasticity of demand for capital, the more likely the first effect is to dominate, and make the overall impact on the tax base positive; specifically, $\varepsilon>1$ is required. Finally, this condition needs to be modified when the government maximizes welfare, not tax revenue: that is the explanation for the condition on ε in Proposition 2.

We can now move to the slopes of reaction functions. Combining Proposition 2 with Eq. (2.15), and with a little more calculation, we can establish:

Proposition 3. *Assume that $v(g)=\gamma g$, $\gamma>1$. Then $\frac{d\tau}{d\tau^*}>0$, $\frac{dz}{d\tau^*}<0$, for all production functions.*

So, we find an unambiguous prediction about the responses of the home country's taxes τ, z to the *statutory* tax in the foreign country τ^*: τ responds positively, and z negatively. The result that $\frac{d\tau}{d\tau^*}>0$ extends the finding of Haufler and Schjelderup (2000) to an environment where governments compete in two tax instruments.[23] Moreover, the explanation for $\frac{d\tau}{d\tau^*}>0$ is simply that τ, τ^* are strategic complements — as in shown in the Proof of Proposition 3, $\frac{d\tau}{d\tau^*}$ is signed by $W_{\tau\tau^*}$, because the fact that $W_{z\tau^*}=0$ eliminates any indirect effect from τ^* to z to τ. Similarly, the explanation for $\frac{dz}{d\tau^*}<0$ is that an increase in τ^* increases τ, and τ and z are strategic substitutes ($W_{\tau z}<0$), as shown in the Proof of Proposition 3.

However, we do not find an unambiguous prediction about the response of the home country statutory rate τ and EMTR z, to the foreign EMTR, z^*. In the case of τ, we know from Proposition 2 that τ and z^* are strategic complements i.e. $W_{\tau z^*}>0$, but this is not enough to sign $\frac{d\tau}{dz^*}$ generally due to indirect effects. In the case of z, again from Proposition 3, we only have strategic complementarity for a subset of parameter values, even assuming a quadratic production function as above, but again, this is not sufficient to sign $\frac{dz}{dz^*}$. In fact, for $\frac{dz}{dz^*}>0$ strategic complementarity has to be "strong enough" to offset the indirect effect of z^* on τ and then on z, which is negative.[24]

[21] See for example, Wildasin (1991).

[22] See also Lockwood (2004) for an analysis of how the Nash equilibrium taxes differ when taxes change from specific to ad valorem.

[23] Haufler and Schelderup (2000) assume that there is a fixed revenue requirement, so that allowances (effectively, our z) is residually determined via the government budget constraint.

[24] To see this, note that holding z constant, an increase in z^* by the foreign country will increase τ, as they are strategic complements. But then, as $W_{z\tau}<0$, this induces the home government to lower z.

Finally, although $\mathrm{d}z/\mathrm{d}z^*$, $\mathrm{d}\tau/\mathrm{d}z^*$ cannot be signed analytically, we can investigate their signs in a calibrated version of the model.[25] For a range of simulations we found that $\mathrm{d}\tau/\mathrm{d}z^*$, $\mathrm{d}z/\mathrm{d}z^*$ are both positive. Given Proposition 3 and the robustness of these calibration results, we regard our theoretical predictions as being the following. First, the "own-tax" effects are positive i.e. $\mathrm{d}\tau/\mathrm{d}\tau^*>0$, $\mathrm{d}z/\mathrm{d}z^*>0$. Second, the "cross-tax" effects generally tend to be smaller in absolute value than the own-tax effects. Finally, the cross-effects $\mathrm{d}z/\mathrm{d}\tau^*$ and $\mathrm{d}\tau/\mathrm{d}z^*$ are negative and positive respectively.

2.5. Discussion

At this point, several issues, particularly possible extensions of the model, are worth raising. First, how would allowing for asymmetric countries affect the analysis? The main complication here is that at equilibrium, one country would be a net exporter, and the other, a net importer, of capital. How would this affect our key results on reaction functions? The strategic interaction terms $W_{\tau\tau^*}$ and the counterpart for the foreign country, $W^*_{\tau^*\tau}$, will now generally be different from each other. But, under the assumption of linear utility over the public good, $v(g)=\gamma g$, both $W_{\tau\tau^*}$, $W^*_{\tau^*\tau}$ will continue to be independent of the capital stock in each country, so Proposition 3 will continue to hold.

Second, how would a move to n countries affect the nature of the results? An n-country version of the model can easily be specified. The key part of the extension is to specify how the parent and subsidiary(ies) interact with n countries. The simplest way to do this, while maintaining complete symmetry, is to suppose that each country i has a parent company located there, which produces output from the fixed factor in i, mobile capital, and $n-1$ discrete inputs from the other $n-1$ countries, each produced at some cost $c/(n-1)$. The simplest case[26] is where each of these separate inputs is necessary for production, so the parent needs to buy all of them. Then, the key Eqs. (2.4) and (2.7) are much like before. In particular, the analog of Eq. (2.4) would say that the transfer price or the input from country j used by the multinational with a parent in i would be $q_{ij}=(\tau_i-\tau_j)/2\alpha$, and the analog of Eq. (2.7) would simply say that the sum of demands for capital, $\sum_i k(z_i r)$ is equal to the supply, $n\kappa$. The features of the optimal taxes and reaction functions in this case are as follows as n becomes large. First, the statutory taxes remain strict strategic complements even as $n\to\infty$ i.e. $\lim_{n\to\infty} W_{\tau\tau^*}>0$. On the other hand, as $n\to\infty$, the EMTRs become strategically independent i.e. $\lim_{n\to\infty} W_{zz^*}=0$, as does the home statutory rate and the foreign EMTR i.e. $\lim_{n\to\infty} W_{\tau z^*}=0$. In both cases this is because the impact of any country's EMTR on the demand for capital goes to zero. But then from Eq. (2.15), $\lim_{n\to\infty} \mathrm{d}z/\mathrm{d}z^*=0$ i.e. when the number of countries is large, the interaction between EMTRs becomes very weak.

Third, looking ahead to the empirical specification, if there are n countries, *and* countries are asymmetric, how does the sensitivity of the optimal taxes in country i to those in country j depend on the characteristics of country j? A full formal model of this case is clearly beyond the scope of this paper. But, we can make some informal remarks about what we might find. First, we might expect taxes in j, especially the EMTR, to have more impact on i's decision if j is large. Second – although this would also involve relaxing in some way the assumption of perfect capital mobility – we might expect statutory taxes in j to have more impact on i's statutory tax if trade in inputs is large between the two countries. A proxy for this trade in inputs might be bilateral FDI flows between the two countries.

3. Testing the theory

3.1. Empirical specification of the tax reaction functions

The theoretical analysis in Section 2, which assumed two symmetric countries, generated symmetric reaction functions of the form $\tau=T(\tau^*, z^*)$ and $z=Z(\tau^*, z^*)$ for the home country, and similar ones for the foreign country. Note that τ, z depend also on a $k\times 1$ vector of variables $\mathbf{X}$ that affect the demand for public goods (or more generally, public spending), so that reaction functions can be written $\tau=T(\tau^*, z^*, \mathbf{X})$ and $z=Z(\tau^*, z^*, \mathbf{X})$. We now allow for n countries that may be different, so country i's reaction functions are $\tau_i=T_i(\boldsymbol{\tau}_{-i}, \mathbf{z}_{-i}, \mathbf{X}_i)$, $z_i=Z_i(\boldsymbol{\tau}_{-i}, \mathbf{z}_{-i}, \mathbf{X}_i)$, where as is usual, $\boldsymbol{\tau}_{-\mathrm{i}}$ etc. denotes a

[25] The calibrations are available on request from the authors.

[26] If each input is not necessary – but say, one is – then the MN would produce this input in the country where the tax is lowest, creating a discontinuity in the reaction function.

vector of variables with the ith country variable deleted. Taking a linear approximation to each of these reaction functions at the Nash equilibrium (denoted by "^" superscripts), we get

$$\tau_{i,t} = \hat{\tau}_i + \sum_{j \neq i} \frac{\partial T_i}{\partial \tau_j} \boldsymbol{\tau}_j + \sum_{j \neq i} \frac{\partial T_i}{\partial z_j} \mathbf{z}_j + \boldsymbol{\eta}_1' X_i \qquad i = 1, \ldots n \tag{3.1}$$

$$z_{i,t} = \hat{z}_i + \sum_{j \neq i} \frac{\partial Z_i}{\partial \tau_j} \boldsymbol{\tau}_j + \sum_{j \neq i} \frac{\partial Z_i}{\partial z_j} \mathbf{z}_j + \boldsymbol{\eta}_2' X_i \qquad i = 1, \ldots n \tag{3.2}$$

where $\boldsymbol{\eta}_1$, $\boldsymbol{\eta}_2$ are $k \times 1$ vectors of coefficients.

However, Eqs. (3.1) and (3.2) cannot be estimated as they stand. The first issue is that of degrees of freedom. In principle, each country could respond differently to the tax rates in every other country, leading to a large number of parameters to be estimated. We follow the existing literature by assuming that

$$\frac{\partial T_i}{\partial \tau_j} = \beta_1 \omega_{ij}, \frac{\partial T_i}{\partial z_j} = \gamma_1 \omega_{ij}, \frac{\partial Z_i}{\partial \tau_j} = \beta_2 \omega_{ij}, \frac{\partial Z_i}{\partial z_j} = \gamma_2 \omega_{ij} \tag{3.3}$$

where the weights $w_{ij} > 0$ are not freely estimated, but imposed ex ante. Substitution of Eq. (3.3) into Eqs. (3.1), (3.2) gives a specification

$$\tau_{i,t} = \hat{\tau}_i + \beta_1 \overline{\tau}_i + \gamma_1 \overline{z}_i + \boldsymbol{\eta}_1' \mathbf{X}_i, \qquad i = 1, \ldots n \tag{3.4}$$

$$z_{i,t} = \hat{z}_i + \beta_2 \overline{\tau}_i + \gamma_2 \overline{z}_i + \boldsymbol{\eta}_2' \mathbf{X}_i, \qquad i = 1, \ldots n \tag{3.5}$$

That is, by imposing Eq. (3.3) we are assuming that every country i responds in the same way to the weighted average tax rates $\overline{\tau}_i$, $\overline{z}_i$, of other countries in the sample. What does our theory suggest about β_1, γ_1, β_2, γ_2? Proposition 3 predicts that $\beta_1 > 0$, $\beta_2 < 0$. We do not have any unambiguous theoretical results for γ_1, γ_2, but our simulations suggest that γ_1, $\gamma_2 > 0$.

Moreover, the appropriate choice of weights $\{\omega_{ij}\}$ is informed by the discussion in Section 2.5. That discussion suggests that ω_{ij} is likely to be large when country j is large, and/or when FDI flows between i and j are strong. In our empirical work, we focus on these size and openness weights, but also report results using uniform weights[27].

A final issue is whether the current or lagged value of other countries' tax rates should be included in the empirical model. Following most[28] of the existing applied work in this area (Brueckner, 2006) we use the current values of $\overline{\tau}_i$ and $\overline{z}_i$ in Eq. (3.4). The restriction of this approach is that it effectively assumes that taxes are at their Nash equilibrium values in every year. The advantage of this approach is that is consistent with the theory: at Nash equilibrium, every country correctly predicts the current tax rates of the other countries.

Replacing the unobservable Nash equilibrium values in equations (3.4), (3.5) with country fixed effects, introducing country-specific time trends, and adding in error terms, the system of equations estimated is:

$$\tau_{i,t} = \beta_1 \overline{\tau}_{i,t} + \gamma_1 \overline{z}_{i,t} + \boldsymbol{\eta}_1' \mathbf{X}_{it} + \phi_{1i} + T_{1it} + \varepsilon_{1it}, \qquad i = 1, \ldots n \tag{3.6}$$

$$z_{i,t} = \beta_2 \overline{\tau}_{i,t} + \gamma_2 \overline{z}_{i,t} + \boldsymbol{\eta}_2' \mathbf{X}_{it} + \phi_{2i} + T_{2it} + \varepsilon_{2it}, \qquad i = 1, \ldots n \tag{3.7}$$

where ϕ_{1i} and ϕ_{2i} are country-specific fixed effects, and T_{1it} and T_{2it} are country-specific time trends, discussed below. The theoretical predictions are that β_1, γ_1, $\gamma_2 > 0$, and $\beta_2 < 0$, with β_1, γ_2 large relative to γ_1, β_2. Also, in the estimation, w.l.o.g., we will interpret $z_{i,t}$ as the EMTR, rather than one plus the EMTR, as in the theoretical section. Finally, even if

[27] In the case of local property taxes, the obvious choice (and one that works well in practice, see e.g. Brueckner, 2000) is to use geographical weights, where ω_{ij} is inversely related to the distance between jurisdictions i and j. However, in our case, the degree of tax competition between two countries may depend not on geographic proximity of countries, but on their relative size and the degree to which they are open to international flows.

[28] An alternative approach used, by a few authors, for example by Hayashi and Boadway (2001), is to use lagged values, say $\overline{\tau}_{i,t-1}$ and $\overline{z}_{i,t-1}$. We do not follow this approach on the grounds that this is a further step away from the theory. In effect it assumes a particular form of myopic behavior in which each country responds to the tax rates set in the previous period by other countries.

X_{it} includes a variable that is very likely to raise the demand for government spending (such as the dependency ratio), we cannot be sure that the corresponding component of $\boldsymbol{\eta}_1$ or $\boldsymbol{\eta}_2$ is positive, because the indirect effects due to the two-dimensional nature of tax competition as discussed in Section 2.4.

3.2. Data

The empirical approach in this paper is to estimate Eqs. (3.6) and (3.7) using data on the corporation tax regimes of 21 OECD countries over the period 1982 to 1999. Data definitions, sources, and summary statistics are given in Table A1 of the Appendix. We first comment on our measures of corporate tax rates.

There are two broad approaches to the measurement of effective tax rates on capital income. One, proposed for example by Mendoza et al. (1994), is based on the ratio of tax payments to a measure of the operating surplus of the economy. This approach is not ideal for analysing the competition between jurisdictions over taxes on corporate income described in our theoretical model, for several reasons. First, at best it is a measure only of an effective average tax rate, and so does not measure either the statutory rate or the EMTR. Second, it does not necessarily reflect the impact of taxes on the incentive to invest in a particular location, because tax revenues depend on the history of past investment and profit and losses of a firm, and also the aggregation of firms in different tax positions. Third, this measure can vary considerably according to underlying economic conditions, even when tax regimes do not change; the variation is therefore due to factors outside the immediate control of the government.

The tax rate measures used in this paper are therefore based instead on an analysis of the legislation underlying different tax regimes. In our dataset, the statutory rate is typically the headline rate of corporation tax, with an adjustment for “typical” local statutory rates of taxes where appropriate. For the EMTR, we use the measure proposed by Devereux and Griffith (2003), which is the additional tax paid following a hypothetical unit perturbation to the capital stock. The cost of the increased capital stock is offset by tax allowances, defined by the legislation, and the additional revenue is taxed under the statutory tax rate. Using this approach, we have derived our measure of the EMTR. Further details are available on request from the authors, but here we describe some of the main issues involved.

First, this approach gives several measures of the EMTR, depending on the source of finance (equity, debt) and the type of asset (plant and machinery, industrial buildings). To avoid working with four different measures of this tax variable, we take an average of the four rates, using standard weights[29].

Second, from Eq. (2.6), in the theory, the EMTR can be written $z-1=(f'(k)-r)/r$, which is indeed a standard definition of the EMTR. However, in our main empirical work below, we do not use this measure, because there are cases where the value of r is close to zero, which generates very high values of the EMTR. Instead, we therefore use the numerator of this expression, which refer to as the *tax wedge*, $f'(k)-r$. Clearly, this is a simple transformation of z, multiplying it by r. In the case where r is held constant across all observations, this clearly makes no difference to the results. However, there is a difference when r varies across observations. We have run regressions using the tax wedges and the full EMTR. In general, larger standard errors arise in the second case due to the large variation in $z-1$. Below we present results using the tax wedge, although again to economize on notation, we denote this z.

Third, another issue is that in constructing the EMTR or the tax wedge, some assumption must be made about economic parameters (the interest rate and the inflation rate) by country and year in order to calculate the post-tax return to a hypothetical investment project (and thus the EMTR). In the data we use[30], we allow the interest rate and the inflation rate to vary both across years and countries; this approach is gives a best estimate of the EMTR for each observation.[31]

We have constructed the EMTR and the tax wedge, using data[32] on the statutory tax rate, τ, and allowance rules, between 1982 and 1999 for 21 high income OECD countries. Figs. 1–4 below show key features of our tax rate variables. As shown in Fig. 1, which presents the statutory rate for each country in both 1982 and 1999, almost all

[29] Following Chennells and Griffith (1997), the proportions of each are assumed to be: plant and machinery 64% and industrial buildings 36%; equity 65%, debt 35%.

[30] However, we have also rerun the regressions for the case in which these parameters are fixed over all observations, so that the only variation in the EMTR is due to changes in tax parameters; this does not affect the qualitative results.

[31] Interest rate and inflation rate data are from World Development Indicators of the World Bank. We use the “lending interest rate” and the “GDP implicit deflator”.

[32] These data were collected from a number of sources. Chennells and Griffith (1997) provide information for 10 countries up to 1997. These data have been extended to other countries and later years using annual summaries from accounting firms, notably Price Waterhouse tax guides (Price Waterhouse, 1983 to 1999).

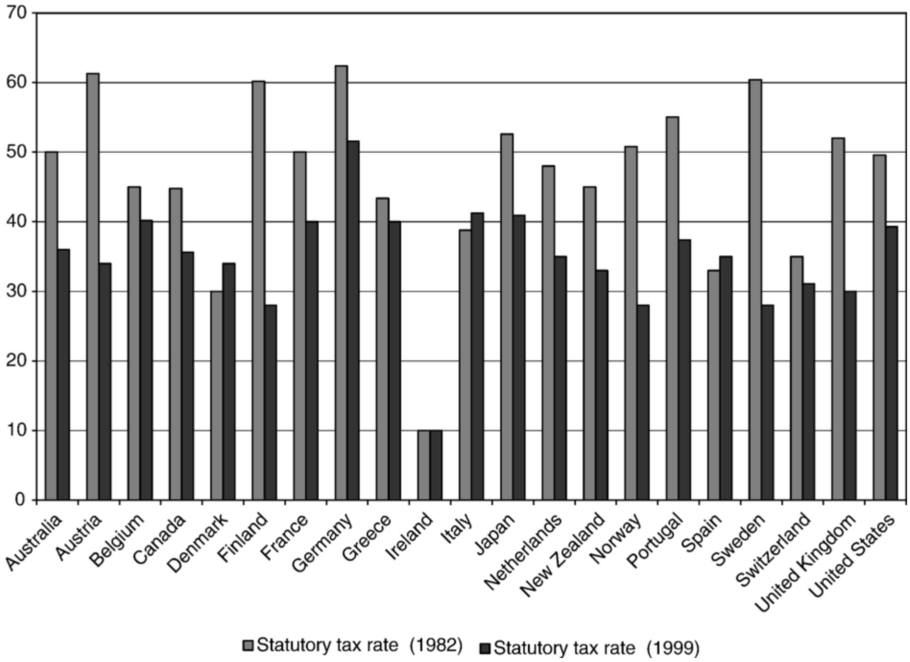

Fig. 1.

countries have reduced their statutory rates, many significantly. It is interesting to note that Germany, essentially the last country in 1999 with a high tax rate, has subsequently cut its tax rate substantially. Ireland is the only country which stands out from the others — here we have used the special 10% rate for manufacturing used in Ireland throughout the period analysed.

Fig. 2 presents data on our estimated tax wedges in the same format. In contrast to Fig. 1, the tax wedge has risen in several countries as a result of a broadening of the tax base. For example, the 1984 tax reform in the UK substantially reduced capital allowances on both types of asset analysed here; in computing the tax wedge this outweighs the very substantial reduction in the statutory rate which occurred at the same time. In general, these two figures suggest that the statutory rate and the tax wedge are not highly correlated. This is indeed the case. Out of 20 countries for which there is variation in both forms of tax rate, 7 have a negative correlation between the statutory tax rate and the tax wedge; the average correlation coefficient over these 20 countries is 0.13. The overall correlation between the statutory rate and the EMTR is 0.36.

Figs. 3 and 4 present time series for the mean statutory rate and tax wedge. The upper and lower lines in each figure show the mean plus and minus one standard deviation. Overall, the mean statutory rate fell from 46.5% in 1982 to 34.7% in 1999. At the same time the dispersion of rates also fell substantially; the standard deviation fell from 12.3% to 8.0%. By contrast, the mean tax wedge actually rose slightly over the same period, from 4.3% to 4.5%. However, there was also a reduction in the dispersion of tax wedges — the standard deviation fell from 2.2% to 1.1%.[33]

Finally, it is worth noting that we do not incorporate international aspects of tax, such as taxes levied by the residence country of the multinational on repatriation of profit. One reason is that such taxes vary with the residence country and so to do so would introduce variation in the tax rates which would need to be applied to activity arising in any country. A more fundamental reason is that there is plenty of evidence that multinational companies are skilled at tax planning (some of the evidence is discussed in the Introduction). This implies that the straightforward calculation of effective tax rates taking into account additional taxes at an international level may be seriously misleading. We believe that a more reasonable approach is to assume that multinational firms typically avoid any further tax at an international level: so, we include only the taxes levied in the source country.

[33] A thorough description of the development of these taxes is provided in Devereux et al. (2002).

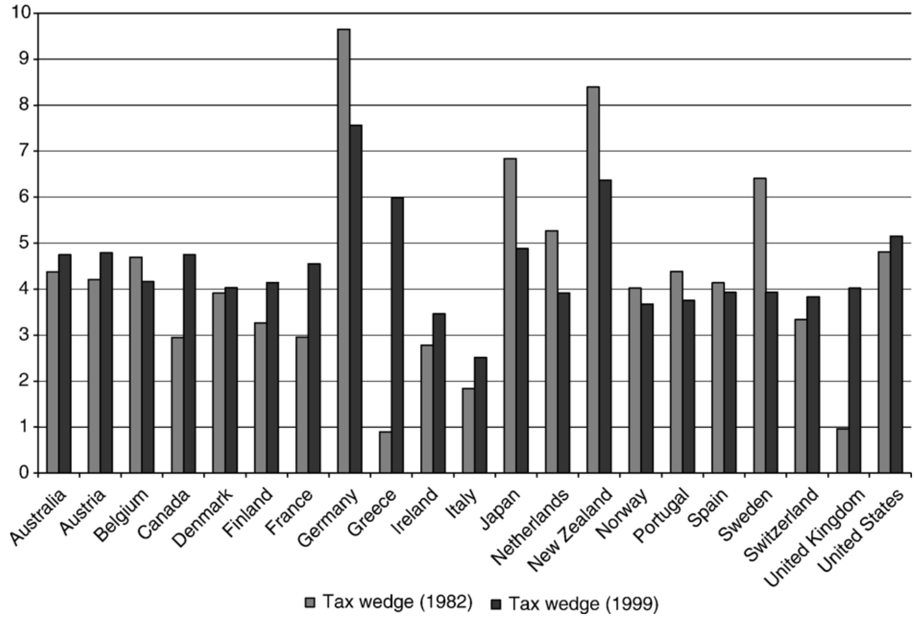

Fig. 2.

Table A1 also lists and defines the country-specific control variables that we included in the regressions determining the tax rate variables. The control variables chosen which we use are based on existing theoretical and empirical literature. It has frequently been argued that corporation tax is a necessary "backstop" for income tax: that is, in the absence of corporation tax, individuals could potentially escape tax on their earnings by incorporating themselves. One important control variable is therefore the highest domestic income tax rate, TOPINC_{it}. A second potentially important factor is the revenue need of the government; we proxy this using the proportion of GDP accounted for by public consumption. In addition, we control for the openness of each country using lagged data on inward and outward foreign direct investment, and size, using GDP. We also allow for the political persuasion of the governing party. We include a dummy variable indicating whether the party of government is to the right of centre. We also interact right-wing and left-wing dummies with the majority in parliament to account for the possibility that

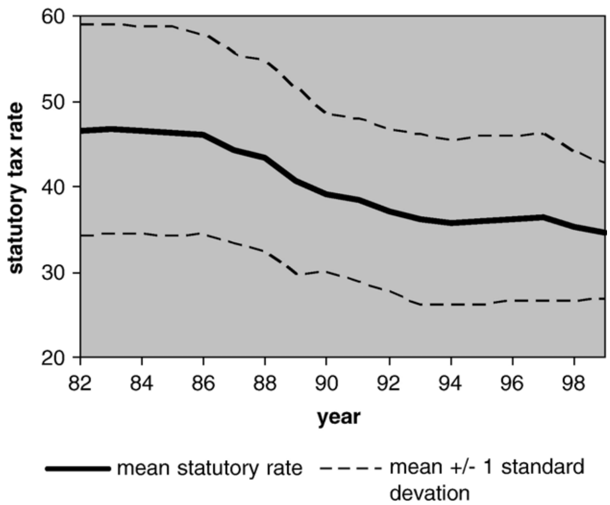

Fig. 3.

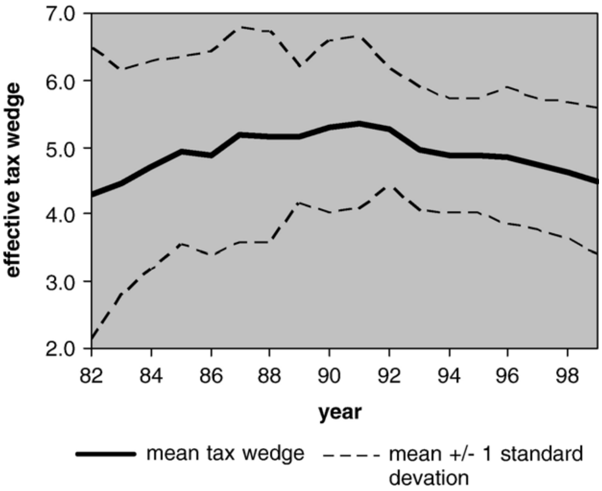

Fig. 4.

parties only have a decisive influence on tax rates if their majority is strong enough. Finally, we also include some demographic variables.

3.3. Econometric issues

The system to be estimated is Eqs. (3.6), (3.7). Since the model predicts that all tax rates are jointly determined, it clearly indicates endogeneity of $\overline{\tau}_{i,t}$ and $\overline{z}_{i,t}$. We use an instrumental variable approach to address this. As is common in this literature, we generate instruments as the weighted average of the control variables in other countries. That is for each element of $\mathbf{X}_{it}$, denoted x_{it}, it is possible to construct a weighted average for other countries: $\overline{x}_{i,t} = \sum_{j\neq i} \omega_{ij} x_{jt}$. These weighted averages can be used directly as instruments for $\overline{\tau}_{i,t}$ and $\overline{z}_{i,t}$. We test the validity of these instruments using a standard test of over-identifying restrictions.

A closely related issue is which variables should be considered as endogenous. If countries do respond to each other in setting tax rates, then we would expect $\overline{\tau}_{i,t}$ to be endogenous in the statutory rate equation, and $\overline{z}_{i,t}$ to be endogenous in the tax wedge equation. Whether $\overline{z}_{i,t}$ is endogenous in the statutory rate equation, and vice versa, depends on the statistical significance of the relationship between the two tax rates. In addition, if all tax rates are set simultaneously it is possible that the home country income tax rate – which we would like to use as a control variable – is also endogenous. We test for all of these possibilities using a version of the Hausman test which allows us to identify the endogeneity of one variable, assuming the others are exogenous.[34] In constructing this test, we use same control variables and instruments as in the main regressions.

A second issue is that in practice, our tax rates are serially correlated, perhaps because abrupt changes in the tax system are likely to be costly to governments, either because such changes impose costs of adjustment on the private sector, or because such changes may be blocked at the political level by interest groups who stand to lose from the change. We present t-statistics based on standard errors clustered by country which are robust to serial correlation.

A third issue is that while we would want to include time dummies, to capture shocks in each period which are common to all countries, this is not generally feasible. To see this, consider for example the case of uniform weights. Then Eq. (3.6) can be rewritten[35] as an equation where τ_{jt} it depends on only the average of *all* statutory rates $\overline{\tau}_t = \frac{\sum_{j=1}^{n} \tau_{jt}}{n}$, plus $\overline{z}_{i,t}$, $\mathbf{X}_{it}$, and thus the effect of $\overline{\tau}_t$ cannot be identified separately from a time dummy. However, we do allow for unobserved factors varying over time as far as possible by also including country-specific time trends. We also include country-specific fixed effects.

[34] The test is described in Maddala, 2001.

[35] To see this, note that we can write $\overline{\tau}_{i,t}$ in the uniform weighted case, for example, as $\overline{\tau}_{i,t} = \frac{\sum_{j\neq i} \tau_{jt}}{n-1} = \frac{\sum_{j=1}^{n} \tau_{jt}}{n-1} - \frac{\tau_{it}}{n-1}$. Substituting into Eq. (3.6) and rearranging yields the result.

4. Empirical results

4.1. Tests of endogeneity

We begin by constructing a Hausman test to test for the endogeneity of the income tax rate. We also test for the endogeneity of $\overline{\tau}_{i,t}$ in the tax wedge regression and $\overline{z}_{i,t}$ in the statutory rate regression. The results are presented in Table 1. This table contains three columns (1 to 3) with the statutory rate as the dependent variable and three columns (4 to 6) with the effective tax wedge as the dependent variable. For each form of tax rate, we present results based on three weighting schemes: (a) uniform weights, (b) weights based on the size of the economy, measured by GDP, and (c) weights intended to capture the openness of the economy, measured by the sum of inward and outward FDI over the three preceding years, expressed as a proportion of GDP. The columns in Table 1 mirror those which present the main results in Table 2.

The values shown in Table 1 are *p*-values corresponding to the probability that the adjusted residual from a first stage regression of the variable of interest is not significant in a regression-based Hausman test. Throughout, the other control variables are assumed to be exogenous. In the first section of the table we investigate the significance of the top income tax rate in three cases: (a) in both equations, where $\overline{\tau}_{i,t}$ and $\overline{z}_{i,t}$ are both endogenous; (b) in the statutory rate equation where $\overline{z}_{i,t}$ is assumed exogenous and (c) in the tax wedge equation, where $\overline{\tau}_{i,t}$ is assumed exogenous. In no case is there evidence of endogeneity of the top income tax rate at the 5% level.[36]

In the lower parts of the table, we then test the endogeneity of $\overline{\tau}_{i,t}$ and $\overline{z}_{i,t}$, assuming either endogeneity or exogeneity of the top income tax rate. Again, there is no evidence of endogeneity. That is, it appears that $\overline{\tau}_{i,t}$ is exogenous in the tax wedge equation and $\overline{z}_{i,t}$ is exogenous in the statutory rate equation. We therefore treat them as exogenous in the main regressions below, although doing so makes very little difference to the results. As will be seen below, these results mirror those in Table 2.

4.2. Regression results

The results for our base case are presented in Table 2. This contains the same columns as Table 1, corresponding to the two dependent variables and three weighting schemes. In the case of the statutory rate equation, we instrument $\overline{\tau}_{i,t}$ with the weighted average of each of the control variables, $\overline{x}_{i,t}$. Similarly, in the EMTR equation, we instrument $\overline{z}_{i,t}$, using the same instrument set. We treat all other variables as exogenous. The first stage regressions explain a considerable amount of the variation in the endogenous variables; the R^2 for each of the first stage statutory rate equations are all around 0.99, and those for the tax wedge equations vary from 0.87 to 0.97. The instruments themselves are also highly jointly significant in the first stage regressions.

First consider the control variables. The top income tax rate has a significant effect on the statutory rate, but not on the tax wedge. This is exactly what would be expected if the corporation tax were being used as a "backstop" to income tax.[37] This form of income shifting does not depend on the EMTR or tax wedge; consistently with this, we find that the top income tax rate is not significant in the tax wedge regressions. These results mirror those in Slemrod (2004). So, too, do the results for the role of public spending on the statutory rate. There is some evidence that country size has a positive effect on the statutory rate (only in the case of uniform weights), but again, not on the effective tax wedge. This may reflect the possibility that in a larger economy, a higher proportion of economic activity is purely domestic. If the government prefers to tax such activity at high rates, it would be effectively constrained by competitive pressures from abroad. It is plausible that the more important the domestic part of the economy, the higher the government would set the overall tax rate. By contrast, however, our measure of the openness of the economy plays no role in determining either form of tax rate, conditional on the other variables in the model.

Next, consider variables that may proxy for the demand for public spending. First, we find that increases in public consumption relative to GDP – which require at some stage a higher tax revenue – do not affect the statutory rate (or

[36] At lower significance levels, there is some evidence of endogeneity in the uniform-weighted statutory rate equation. We therefore estimated this equation allowing for the endogeneity of the top income tax rate; there was no qualitative difference from the case in which it is assumed to be exogenous (shown in the first column of Table 2). The main difference is that the top income tax rate itself loses significance, probably due to weak instruments.

[37] The further the statutory rate from the income tax rate, the greater the incentive to classify income in the lower-taxed form.

Table 1
Tests of endogeneity

Dependent variable:	Statutory rate, τ_{it}			Effective tax wedge, w_{it}		
Weights	Uniform	GDP	FDI	Uniform	GDP	FDI
1. Income tax rate						
(a) Assuming $\overline{\tau}_{it}$ and $\overline{w}_{it}$ endogenous:	0.069	0.333	0.524	0.392	0.406	0.239
(b) Assuming $\overline{w}_{it}$ exogenous:	0.064	0.570	0.411			
(c) Assuming $\overline{\tau}_{it}$ exogenous				0.918	0.203	0.156
2. $\overline{\tau}_{it}$						
(a) Assuming $\overline{w}_{it}$ and income tax rate endogenous:				0.132	0.987	0.191
(b) Assuming income tax rate exogenous				0.213	0.622	0.576
3. $\overline{w}_{it}$						
(a) Assuming $\overline{\tau}_{it}$ and income tax rate endogenous:	0.504	0.359	0.719			
(b) Assuming income tax rate exogenous	0.477	0.633	0.034			
Observations	378	378	378	378	378	378

Values shown are p-values testing significance of adjusted residuals in Hausman test for exogeneity (see Maddala, p. 499).

the effective tax wedge) at the margin. One of the demographic variables is marginally significant. The political persuasion of the government does not appear to play a very significant role in determining either form of tax. What evidence there is seems conflicting: right wing parties tend to have higher statutory rates, but then higher statutory rates are also associated with left-wing parties which have a significant majority. These findings are, however, consistent with the theory, because as argued in Section 2.4, variables that increase the demand for public spending do not necessarily increase both taxes. Finally, note that the time trends are highly jointly significant in all specifications; and excluding the time trends leads to failure of the test of over-identifying restrictions.

For the statutory rate, there is clear evidence of an effect of other countries' statutory rates. In columns 1 to 3, the size of the coefficients vary from 0.34 to 0.67; that is a one percentage point reduction in the average of other countries' statutory rates would tend to reduce the rate in country i by between 0.34 and 0.67 percentage points. The significance of these effects varies slightly across the different weighting schemes. However, of more concern is the fact that the test of over-identifying restrictions rejects the validity of the instrument set in the case of GDP and FDI weights. Given that only the weighting scheme differs between the three specifications, this seems to indicate that the weights themselves are generating the problem.[38] In the context of Table 2, this suggests focusing on the case of uniform weights, where the instrument set is acceptable. In this case, the coefficient is 0.67 and is clearly statistically significant. By contrast, in none of the specifications does the statutory rate in country i depend on the effective tax wedges in other countries.

The results of the effective tax wedge equation have some differences. In each case, the instrument set is valid at a 5% significance level in all cases. Column 4, with uniform weights, presents clear evidence that the effective tax wedges in other countries have a significant impact on the effective tax wedge in country i, with a coefficient is 0.766. However, this significant effect is not present for the two other weighting schemes. The statutory rates in other countries do not affect the effective tax wedge in country i using uniform and GDP weights, but they appear to have a significant and negative effect in the case of FDI weights.

How do these results relate to our theoretical predictions? First, as predicted, the "own-tax" effects are positive, at least in the case of uniform weights i.e. $\frac{d\tau}{d\tau^*}>0$, $\frac{dz}{dz^*}>0$. Our second prediction was that the "cross-tax" effects are smaller in absolute value than the own-tax effects: this is generally what we find, subject to the obvious qualification that the coefficients measuring the cross-tax effects are imprecisely determined, and except for one case they are not significantly different from zero. Finally, as predicted, although with one exception, the cross-effects $\frac{dz}{d\tau^*}$ and $\frac{d\tau}{dz^*}$ are negative and positive respectively in the case of either GDP or FDI weights, although again these are imprecisely determined.

[38] This view is reinforced by the fact that the problem of invalid instruments remains even when a variety of control variables are used.

Table 2
Basic specification

Weights	Statutory rate, τ_{it}			Effective tax wedge, w_{it}		
	Uniform	GDP	FDI	Uniform	GDP	FDI
$\bar{\tau}_{it}$	0.678	0.357	0.340	−0.012	−0.043	−0.082
	(2.50)	(2.07)	(1.90)	(0.19)	(1.21)	(2.31)
$\bar{w}_{it}$	−1.362	0.123	1.044	0.766	0.703	0.088
	(1.04)	(0.08)	(0.79)	(2.35)	(1.23)	(−0.27)
Income tax rate	0.16	0.20	0.21	0.007	0.005	0.004
	(2.95)	(4.21)	(4.11)	(0.84)	(0.63)	(0.59)
Size	0.54	0.05	0.02	−0.02	−0.02	−0.01
	(2.55)	(0.25)	(0.09)	(0.22)	(0.20)	(0.16)
Dummy=1 if party right	0.05	0.05	0.05	0.005	0.007	0.005
	(1.44)	(1.36)	(1.34)	(0.64)	(0.97)	(0.77)
Majority*right	−0.01	0.005	−0.004	−0.006	−0.006	−0.006
	(0.33)	(0.12)	(0.10)	(0.82)	(0.83)	(0.83)
Majority*left	0.09	0.10	0.10	0.007	0.01	0.008
	(1.3)	(1.4)	(1.39)	(0.66)	(1.03)	(0.81)
Openness	0.06	0.13	0.104	−0.003	0.01	0.01
	(0.64)	(1.31)	(1.12)	(0.27)	(0.87)	(1.12)
Public consumption/GDP	0.007	−0.15	−0.15	0.07	0.08	0.07
	(0.03)	(0.55)	(0.58)	(0.99)	(1.13)	(1.04)
Proportion Young	−2.24	−1.76	−1.94	0.37	0.54	0.43
	(1.75)	(1.54)	(1.62)	(1.56)	(2.36)	(1.94)
Proportion Old	−0.41	−1.20	−1.23	0.30	0.18	0.27
	(0.29)	(1.09)	(1.01)	(0.60)	(0.39)	(0.66)
Proportion Urban	0.23	−0.03	0.13	0.14	0.08	0.01
	(0.34)	(0.05)	(0.24)	(0.76)	(0.28)	(0.06)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country time trends	Yes	Yes	Yes	Yes	Yes	Yes
Test of overidentifying restrictions	0.690	0.021	0.000	0.950	0.087	0.229
Observations	378	378	378	378	378	378
R-squared	0.93	0.93	0.93	0.77	0.77	0.78

Notes.
1. Parentheses contain *t*-statistics robust to serial correlation and heteroscedasticity.
2. $\bar{\tau}_{it}$ and $\bar{w}_{it}$ are the weighted averages of values of other countries' statutory tax rates and effective tax wedges respectively.
3. In each case, only the weighted average of the dependent variable is treated as endogenous. Instruments are the weighted averages of each of the control variables, where the weights are constructed in the same way as the weighted average tax rates. A standard test of over-identifying restrictions is presented; the test statistic is distributed as χ^2 (d) where d is the degrees of freedom — the table presents the p-value. Treating the income tax rate as endogenous in the case of uniform weights has a negligible impact on the results.

4.3. Alternative explanations of strategic interaction

A central question is whether the relationship between tax rates in different countries observed in Table 1 can be attributed to the movements of capital and profit described in our theoretical model. Alternative explanations include yardstick competition and a common intellectual trend.

To investigate this, we run regressions which allow for the reaction function coefficients to vary with the strength of legal controls on capital movements *in both* the country setting the tax *and* the average of such controls across all the other countries with which that country is competing. The purpose of this exercise is the following. If the strategic interaction detected in the regressions already discussed is due to yardstick competition or common intellectual trends, the strength of capital controls should not matter. If on the other hand, the strategic interaction is truly generated by competition over mobile tax bases, then strategic interaction should be stronger, the more mobile these bases are i.e. the weaker are capital controls.

The main source for researchers on legal controls is the information in the International Monetary Fund's Exchange Arrangements and Exchange Restrictions annual. Based on this publication, Quinn (1997) offers a sophisticated coding that measures the intensity of capital controls, and which covers all our countries and observations up to 1997.[39] Quinn distinguishes seven categories of statutory measures, of which two are capital account restrictions. He codes each of these on a 0–4 scale with a higher number denoting a weaker restriction. We use an index based on Quinn's coding of capital account restrictions. We give the two capital controls equal weight, and normalize the index between zero and one, with a higher value denoting weaker control.[40] There is no reason to suppose this constructed variable has any simple (eg. linear) relationship with tax rates — we do not have a model of competition amongst countries which are partially open, but such competition would depend on the nature of the remaining controls. Instead, we aim to use the index to distinguish between economies which are essentially open to flows of capital and those which are not. To make this distinction, we divide observations between those with a value of the index above 0.8 (58% of observations) and those with an index below 0.8 (42% of observations); this allows us to create a dummy variable, $c_{it}=0$ if country i does not have controls in period t, and $c_{it}=1$ if country i does have controls in period t.[41]

We then proceed as follows. Consider first the statutory rate. First, we calculate the weighted average of τ_{jt} across countries other than i which have capital controls separately from those which do not:

$$\overline{\tau}_{i,t}^{C} = \sum_{j\neq i} \omega_{ijt} c_{jt} \tau_{jt} \text{ and } \overline{\tau}_{i,t}^{N} = \sum_{j\neq i} \omega_{ijt}(1-c_{jt})\tau_{jt} \tag{4.1}$$

where the weights $\omega_{ijt} c_{jt}$ and $\omega_{ijt}(1-c_{jt})$ are adjusted to sum to one within each subgroup. We then run the regression

$$\tau_{i,t} = \beta_1^1(1-c_{it})\overline{\tau}_{i,t}^{N} + \beta_1^2 c_{it}\overline{\tau}_{i,t}^{N} + \beta_1^3(1-c_{it})\overline{\tau}_{i,t}^{C} + \beta_1^4 c_{it}\overline{\tau}_{i,t}^{C} + \boldsymbol{\eta}_1'\mathbf{X}_{it} + \eta_{1i} + T_{1it} + \varepsilon_{1it} \tag{4.2}$$

This specification allows a country i to respond differently to other countries depending on whether they have significant controls or not, and moreover, allows this response to differ also depending on whether country i itself has significant controls. If strategic interaction is only being generated by tax competition, we would expect only β_1^1 to be significant: i.e. there should be strategic interaction only between countries without capital controls.

In the case of the tax wedge, we run the regression

$$z_{i,t} = \gamma_1^1(1-c_{it})\,\overline{z}_{i,t}^{N} + \gamma_1^2 c_{it}\overline{z}_{i,t}^{N} + \gamma_1^3(1-c_{it})\overline{z}_{i,t}^{C} + \gamma_1^4 c_{it}\overline{z}_{i,t}^{C} + \boldsymbol{\eta}_2'\mathbf{X}_{it} + \eta_{2i} + T_{2it} + \varepsilon_{2it} \tag{4.3}$$

where $\overline{z}_{i,t}^{N}$ and $\overline{z}_{i,t}^{C}$ are constructed as in Eq. (4.1). Again, if strategic interaction is only being generated by tax competition, we would expect only γ_1^1 to be significant. Note that for simplicity we drop the tax wedge from the statutory tax rate equations, and vice versa; this does not affect the results.

The results of regressions (4.2) are reported in Table 3 below, and provide striking support for the hypothesis that co-movements in statutory tax rates are driven by movements of profit between countries. In each of the three columns in Table 3, the first coefficient – which gives an estimate of β_1^1 for each of the specifications – is positive. It is significant at the 5% level using uniform and GDP weights, but only marginally significant in the case of FDI weights.

By contrast, of the other eighteen coefficients reported in the table, none is statistically significant at normal significance levels. Thus Table 3 strongly supports the hypothesis that there is competition in statutory tax rates only between countries without capital controls is supported. These results are consistent with the model analysed in this paper. They do not appear consistent with either yardstick competition or a common intellectual trend — neither of which requires flows of capital or profit between countries.

We have also estimated the regressions (4.3). However, the results indicate that none of the tax variables were significant in this case. Combined with the results in Table 2, this casts some doubt on the extent to which the proposition that governments compete over the effective tax wedge holds. This is, of course, easily explained in the context of our model. The strategic element in setting the effective tax wedge depends on the country being able to manipulate the world interest rate, r. The smaller a country, the less able it is to exert influence over r and the less likely

[39] Another widely-used coding is a binary one, originally due to Grilli and Milesi-Ferretti (1995).

[40] We have also experimented with a number of other possible measures; some of these results are reported in a companion paper, Devereux et al. (2003).

[41] We have experimented with setting $c_{it}=1$ only for those observations which have a value of 1 (41% of the observations). This does not yield as decisive a difference between groups of countries as shown in Table 3. We interpret this as indicating that countries with values just below 1 are open for the purposes required for competition to be a factor in setting tax rates.

Table 3
Allowing for capital controls

Weights	Statutory rate, τ_{it}		
	Uniform	GDP	FDI
Mean tax rate over countries *without* capital controls; home country *without* capital controls	0.583	1.42	0.682
	(2.01)	(1.98)	(1.49)
Mean tax rate over countries *with* capital controls; home country *without* capital controls	−0.001	−0.93	−0.290
	(0.00)	(1.18)	(0.58)
Mean tax rate over countries *without* capital controls; home country *with* capital controls	0.282	−0.444	−0.119
	(0.90)	(1.26)	(0.36)
Mean tax rate over countries *with* capital controls; home country *with* capital controls	0.413	0.807	0.603
	(1.07)	(1.68)	(0.99)
Control variables	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
Country time trends	Yes	Yes	Yes
Test of overidentifying restrictions	0.73	0.26	0.25
Observations	378	378	378
R-squared	0.93	0.93	0.93

Notes.
1. The full set of controls from Table 2 is included in all regressions.

it is to engage in such competition. However, this element is absent in the case of profit-shifting. Even small countries can attract mobile profit, which of course reflects the concerns of large developed countries in losing tax revenue to small tax havens.[42]

4.4. Can the model explain the evolution of taxes over time?

The original motivation for our work was to investigate whether falls in the statutory rate of corporate tax over the last 20 years can be explained as the outcome of a process of tax competition. We believe that our analysis so far establishes the existence of strategic interaction in tax-setting between countries, which is plausibly explained by tax competition. We now ask the question: can the degree of strategic interaction we have estimated (as measured by slopes of reaction functions), together with changes in the exogenous variables over time, explain a significant part of the observed decline in the statutory rate of tax?

To be more specific, we investigate to what extent the declines in statutory rates can be attributed to changes in capital controls. The results in Table 3 provide evidence that tax competition is only present between pairs of countries that have no significant capital controls. It is therefore interesting to ask whether the gradual abolition of capital controls in the countries considered has generated increased competition which in turn has driven down equilibrium tax rates.

To address this issue, observe that in our empirical model it is implicitly assumed that in any period taxes are at their Nash equilibrium values, as all countries are "on" their tax reaction functions. So, our general approach is to (i) calculate in any time period, the Nash equilibrium tax rates, given the values of the control variables $\mathbf{X}_{it}$, the capital controls and our estimates of the slopes of the reaction functions: and then (ii) take the average of those Nash equilibrium taxes across countries. We can compare the cross-country averages of the Nash equilibrium taxes in each period to the actual cross-country averages. Below we present this comparison for the earliest and latest years for which we have capital control data, 1983 and 1997.

But in addition, we can also ask; to what extent is the change in the average equilibrium tax rate due to changes in capital controls, rather than other exogenous variables? We do so by constructing hypothetical Nash equilibria. First, using the control variables for 1997, we can construct the Nash equilibria which would be implied if the capital controls that were in place in 1983 were still in existence. Comparing these hypothetical Nash equilibria with the "base case" Nash equilibria for 1997, we can identify the impact of the change in capital controls between 1983 and 1997. We can also make a similar comparison using the control variables for 1983.

[42] The finding that there is more strategic interaction in statutory tax rates might also be partly explained if they are more visible to policy-makers.

In more detail, the procedure is as follows. First, we look at the statutory tax only, as it has fallen much more substantially over the sample period, and this fall is of considerable interest. We use the estimated coefficients from Eq. (4.2) using uniform weights — that is, the coefficients presented in the first column of Table 3.

So, the Nash equilibrium statutory taxe rates in period t must solve the n simultaneous equations:

$$\tau_{i,t} = \hat{\beta}_1^1(1-c_{it})\overline{\tau}_{i,t}^N + \hat{\beta}_1^2 c_{it}\overline{\tau}_{i,t}^N + \hat{\beta}_1^3(1-c_{it})\overline{\tau}_{i,t}^C + \hat{\beta}_1^4 c_{it}\overline{\tau}_{i,t}^C + \hat{\boldsymbol{\eta}}_1'\mathbf{X}_{it} + \hat{\phi}_{1i} + \hat{T}_{1it},\ i=1,\dots n \tag{4.4}$$

where $\hat{\beta}_1^1$, $\hat{\beta}_1^2$, $\hat{\beta}_1^3$, $\hat{\beta}_1^4$, $\hat{\boldsymbol{\eta}}'_1$, $\hat{\eta}_{1i}$ and $\hat{T}_{1it}$ are the estimated coefficients from column 1, Table 3. In matrix form, Eq. (4.4) can be written as

$$\boldsymbol{\tau}_t = \hat{\beta}_1^1\boldsymbol{C}_t^1\boldsymbol{\tau}_t + \hat{\beta}_1^2\boldsymbol{C}_t^2\boldsymbol{\tau}_t + \hat{\beta}_1^3\boldsymbol{C}_t^3\boldsymbol{\tau}_t + \hat{\beta}_1^4\boldsymbol{C}_t^4\boldsymbol{\tau}_t + \boldsymbol{\eta}_1'\mathbf{X}_t + \hat{\phi}_1 + \hat{\boldsymbol{T}}_{1t} \tag{4.5}$$

where the ijth element of $\boldsymbol{C}_t^1$ is ω_{ijt} if $i\neq j$ and $c_{it}=c_{jt}=0$, and 0 otherwise; $\boldsymbol{C}_t^2$, $\boldsymbol{C}_t^3$, and $\boldsymbol{C}_t^4$ are defined in an equivalent way, $\mathbf{X}_t$ is the $k\times n$ matrix of controls, $\boldsymbol{\tau}_t$, $\hat{\phi}_1$ and $\hat{\boldsymbol{T}}_{1t}$ are $n\times 1$ vectors of tax rates, fixed effects and time trends. Define matrix Z_t as

$$\boldsymbol{Z}_t = I - \hat{\beta}_1^1\boldsymbol{C}_t^1 - \hat{\beta}_1^2\boldsymbol{C}_t^2 - \hat{\beta}_1^3\boldsymbol{C}_t^3 - \hat{\beta}_1^4\boldsymbol{C}_t^4 \tag{4.6}$$

From Eqs. (4.5), (4.6), matrix inversion then gives

$$\hat{\boldsymbol{\tau}}_t = \boldsymbol{Z}_t^{-1}(\hat{\boldsymbol{\eta}}_1'\mathbf{X}_t + \hat{\phi}_1 + \hat{\boldsymbol{T}}_{1t}) \tag{4.7}$$

The vector $\hat{\boldsymbol{\tau}}_t$ represents the set of *Nash equilibrium statutory tax rates* across countries for year t. Taking the mean across countries gives the *Nash equilibrium average statutory tax rate* for year t. The variation over time in this Nash equilibrium average statutory rate depends on the estimated coefficients, the average values of the control variables $\overline{\mathbf{X}}_t$, and the capital controls dummies, c_{it}. Comparing the estimated Nash equilibrium average statutory rates with the actual average tax rates in each year enables is an indirect test of whether the model can explain the reduction in tax rates over the period considered.

This approach can also be used to consider the impact of changes in capital controls. Expression (4.7) can be modified to consider hypothetical cases. For example, we can consider what the Nash equilibrium statutory tax rates would have been if the capital controls for 1983 had been in place in 1997: they are given by

$$\hat{\boldsymbol{\tau}}_{83,97} = \boldsymbol{Z}_{83}^{-1}(\hat{\boldsymbol{\eta}}_1'\mathbf{X}_{97} + \hat{\phi}_1 + \hat{\boldsymbol{T}}_{1,97}). \tag{4.8}$$

Alternatively we can consider what the Nash equilibrium statutory tax rates would have been if the capital controls for 1997 had been in place in 1983: they are given by

$$\hat{\boldsymbol{\tau}}_{97,83} = \boldsymbol{Z}_{97}^{-1}(\hat{\boldsymbol{\eta}}_1'\mathbf{X}_{83} + \hat{\phi}_1 + \hat{\boldsymbol{T}}_{1,83}). \tag{4.9}$$

The results of these alternative hypotheses are given in Table 4.

The third row of the table shows the actual average tax rates in 1983 and 1997, which fell from 46.6% to 36.3%. The first two columns of the fourth row show our estimates of the Nash equilibrium average statutory rates in 1983 and 1997. These are close to the actual averages, implying that the equilibria implied by the results closely correspond to those observed in practice: the model predicts a reduction in tax rates very similar to that observed in practice.

The last two columns consider the two hypothetical cases and provide even more striking results. Applying the capital control data for 1983 to the control variable data for 1997 yields a Nash equilibrium average statutory rate of

Table 4
Nash equilibrium average statutory tax rates

Control variable data	1983	1997	1997	1983
Capital control data	1983	1997	1983	1997
Actual average tax rates	46.6%	36.3%	n.a.	n.a.
Nash equilibrium average statutory tax rates	44.2%	35.8%	44.5%	36.7%

44.5% — almost identical to the base case estimate for 1983. And applying the capital control data for 1997 to the control variable data for 1983 yields a Nash equilibrium average statutory rate of 36.7% — very close to the base case estimate for 1997. Together, these results imply that effectively the entire fall in average statutory tax rates can be explained by more intense competition induced by relaxation of capital controls. Changes in the other control variables appear to have had little impact on the competitive process and the decline in tax rates.

5. Conclusions

Motivated by significant reforms to corporation taxes in OECD countries over the last twenty years, we have investigated the extent to which governments set such taxes in response to each other. We have found strong evidence that they do respond to changes in other countries' taxes. More specifically, we identify in our theoretical model two possible forms of tax competition: over statutory tax rates for mobile profit and over effective marginal tax rates (EMTRs) for capital. We derived testable predictions about the resulting two-dimensional reaction functions, and took these predictions to the data. In the empirical work, we found strategic interaction in both forms of tax rate, but especially in the statutory tax rate.

Moreover, our results indicate that the strategic interaction in statutory rates is not well-explained by other theories (such as yardstick competition or common intellectual trends), since it is generally present only between open economies without significant capital controls: thus, it is best explained in terms of competition over mobile profit, as described in our theoretical model. We show that the downward trend in the average statutory tax rate across countries in our sample is well explained by our model, in the sense that the average Nash equilibrium tax rate implied by the model falls closely in line with the actual average tax rate. Finally, we identify the reason for the fall in the average Nash equilibrium tax rate as the relaxation of capital controls. As capital controls have been relaxed, more countries have been engaged in tax competition: this intensified competition has been responsible for essentially the whole of the reduction in average Nash equilibrium tax rate over the period considered.

Appendix A. Proofs of Propositions

Table A1
Summary statistics

Variable	Description	Mean	Std. Dev.	Min	Max	Source
τ_{it}	Statutory tax rate	0.402	0.112	0.1	0.627	Prince Waterhouse, Corporate Taxes: a Worldwide Summary
w_{it}	Tax wedge	0.048	.0131	0.009	0.107	Our Calculations, data from Prince Waterhouse, Corporate Taxes: a Worldwide Summary and World Bank WDI
Income tax rate	Highest marginal income tax rate	0.533	0.116	0.280	0.920	Primarily annual guides from accounting firms, and specifically those from Prince Waterhouse
Size	$\mathrm{GDP}_{it}/\mathrm{GDP}_{jt}$ where j=USA	0.122	.217	0.007	1	OECD National Accounts, various years
Right	Dummy=1 if executive right wing, 0 if left or centre	0.548	0.498	0	1	World Bank: Database of Political Institutions
Majority	Fraction of seats held by government in legislature	0.557	0.107	0.255	0.858	World Bank: Database of Political Institutions
Openness	Sum of inward and outward foreign direct investment, as a proportion of GDP_{it}, lagged one year	0.028	0.031	−0.005	0.314	OECD International Direct Investment Statistics Yearbook
Public consumption/ GDP	Total public consumption, as a proportion of GDP_{it}	0.187	0.417	0.088	0.297	OECD National Accounts, various years
Proportion young	Proportion of population below 14 years old	0.196	0.027	0.145	0.302	World Bank — World Development Indicators
Proportion old	Proportion of population 65 years old	0.138	0.020	0.095	0.178	World Bank — World Development Indicators
Proportion urban	Proportion of population living in urban areas	0.747	0.125	0.325	0.972	World Bank — World Development Indicators

Proof of Proposition 1. From Eq. (2.2), the formula for *EF*, and Eq. (2.4), we can write explicitly

$$\begin{aligned}\hat{\Pi} &= \Pi - EF = (1-\tau)(f(k) - zrk - q) + (1-\tau^*)(q-c) - \alpha(q-c)^2 \\ &= (1-\tau)\pi(zr) - (1-\tau^*)0.5 + (\tau-\tau^*)\left(c + \frac{\tau-\tau^*}{2\alpha}\right) - \frac{(\tau-\tau^*)^2}{4\alpha}\end{aligned} \tag{A.1}$$

In the same way, from Eqs. (2.9), (2.4), and (2.5), we obtain:

$$\begin{aligned} g &= \tau\pi(zr) + (z-1)rk(zr) + \tau(q^* - q - c) \\ &= \tau\pi(zr) + (z-1)rk(zr) + \tau\left(\frac{(\tau^* - \tau)}{\alpha} - c\right) \end{aligned} \tag{A.2}$$

So, Eqs. (A.1) and (A.2) give $\hat{\Pi}$, g as a function of just the tax variables τ, τ^*, z, z^* and r. Also, note that r depends only on z, z^*. So, using Eqs. (2.8), (A.1) and (A.2), we see that

$$W_\tau = \frac{\partial\hat{\Pi}}{\partial\tau} + v'\frac{\partial g}{\partial\tau} = -\pi + c + \frac{\tau - \tau^*}{2\alpha} + v'\left[\pi + \frac{(\tau^* - \tau)}{\alpha} - c - \frac{\tau}{\alpha}\right] \tag{A.3}$$

So, using (A.3), we see that at symmetric tax equilibrium, with $\tau=\tau^*$, the first first-order condition for the optimal choice of the statutory rate is therefore

$$W_\tau = -\pi + c + v'\left(\pi - \frac{\tau}{\alpha} - c\right) = 0 \tag{A.4}$$

Solving (A.4) for the statutory rate, we get Eq. (2.11). Next, note that

$$\begin{aligned} W_z &= \frac{\partial\hat{\Pi}}{\partial z} + v'\frac{\partial g}{\partial z} + \frac{\partial W}{\partial r}\frac{\partial r}{\partial z} \\ &= (1-\tau)\pi' r + v'(rk + \tau\pi' r + (z-1)r^2 k') + \frac{\partial W}{\partial z}\frac{\partial r}{\partial z} \end{aligned}$$

where in the second line, we have used (A.1), (A.2). Using $\pi' = -k$ by the envelope theorem, at symmetric tax equilibrium, the first first-order condition for z is therefore

$$W_z = -(1-\tau)rk + v'((1-\tau)rk + (z-1)r^2k') + \frac{\partial W}{\partial r}\frac{\partial r}{\partial z} = 0 \tag{A.5}$$

Rearranging, and using the definition $\varepsilon = \frac{-k'rz}{k}$, we get Eq. (2.12). Finally, note that $\frac{\partial r}{\partial z} = -\frac{r}{2z}$ from Eq. (2.7), so $\frac{z}{r}\frac{\partial r}{\partial z} = -\frac{1}{2}$, as claimed. Finally,

$$\begin{aligned} \frac{\partial W}{\partial r} &= \kappa - (1-\tau)zk + v'\frac{\partial g}{\partial r} \\ &= \kappa - (1-\tau)zk + v'[-\tau zk + (z-1)k + (z-1)rzk'] \end{aligned} \tag{A.6}$$

Now, from Eqs. (A.5), (A.6), we have

$$\begin{aligned} \frac{\partial W}{\partial r} &= \frac{\partial W}{\partial r} - \frac{zW_z}{r} \\ &= -\kappa(v'-1) - \frac{v'}{2}\frac{\partial W}{\partial r} \end{aligned} \tag{A.7}$$

where the second line follows after routine simplification. Solving Eq. (A.7) for $\frac{\partial W}{\partial r}$ gives Eq. (2.13). □

Proof of Proposition 2. First, from Eq. (A.3), using the fact that $v' = \gamma \geq 1$ in the case of linear utility, we get:

$$W_{\tau\tau^*} = \frac{-1}{2\alpha} + \frac{\gamma}{\alpha} > 0 \tag{A.8}$$

Second, again from Eq. (A.3) we have

$$W_{\tau z^*} = -(\gamma - 1)zk\frac{\partial r}{\partial z^*} = \frac{1}{2}(\gamma - 1)rk > 0. \tag{A.9}$$

which establishes that τ, z^* are strategic complements, as claimed in the text. Third, note from Eq. (A.13) and the fact that r is independent of τ^* that $W_{z\tau^*} = 0$.

It remains to show that $W_{zz^*}>0$ if $\varepsilon>(\gamma-1)/\gamma$. This is much harder. First, from the assumptions of linear utility and quadratic production functions, we have

$$v'=\gamma, k(zr)=\sigma-\beta zr, k'=-\beta$$

Moreover, combining $k(zr)=\sigma-\beta zr$ with the capital market clearing condition (2.7), we obtain the following formulae for the equilibrium r and its response to z:

$$r=\frac{2(\sigma-\kappa)}{\beta(z+z^*)},\frac{\partial r}{\partial z}=-\frac{r}{(z+z^*)} \tag{A.10}$$

Finally, in equilibrium, recalling $z=z^*$, the elasticity of the demand for capital can be written in terms of the parameters as

$$\varepsilon=\frac{\beta zr}{\sigma-\beta zr}=\frac{\sigma-\kappa}{\kappa} \tag{A.11}$$

Combining Eqs. (A.11) and (2.14) gives

$$\frac{z-1}{z}=\frac{\kappa}{\sigma-\kappa}\frac{(\gamma-1)}{\gamma}\left(\frac{5}{4}-\tau\right) \tag{A.12}$$

Using the results just derived, plus Eqs. (A.5), (A.6), we can proceed to write the derivative W_z as follows:

$$\begin{aligned} W_z &= \frac{\partial W}{\partial z}+\frac{\partial W}{\partial r}\frac{\partial r}{\partial z} \\ &= -(1-\tau)rk+\gamma[(1-\tau)rk-(z-1)r^2\beta] \\ &\quad +\{\kappa-(1-\tau)zk+\gamma[-\tau zk+(z-1)k-(z-1)rz\beta]\}\left[-\frac{r}{(z+z^*)}\right] \\ &= \frac{r}{(z+z^*)}\{-\kappa+(\gamma-1)(1-\tau)z^*k+\gamma k-\gamma(z-1)z^*r\beta\} \\ &\equiv \frac{r}{(z+z^*)}f(z,z^*,r) \end{aligned} \tag{A.13}$$

Now differentiating Eq. (A.13) with respect to z^*, taking into account that r depends on z^*, we get

$$W_{zz^*}=-\frac{r}{(z+z^*)^2}f(z,z^*,r)+\frac{1}{(z+z^*)}f(z,z^*,r)\frac{\partial r}{\partial z^*}+\frac{r}{(z+z^*)}\left(f_{z^*}+f_r\frac{\partial r}{\partial z^*}\right)$$

Evaluating W_{zz^*} at equilibrium, we use the facts that $f(z, z^*, r)=0$, $z=z^*$. This gives us

$$W_{zz^*}=\frac{r}{2z}\left(f_{z^*}+f_r\frac{\partial r}{\partial z^*}\right) \tag{A.14}$$

Now, from Eq. (A.13), recall that

$$f(z,z^*,r)=-\kappa+(\gamma-1)(1-\tau)z^*k(zr)+\gamma k(zr)-\gamma(z-1)z^*r\beta \tag{A.15}$$

Differentiating Eq. (A.15), recalling that $k(zr)=\sigma-\beta zr$, we get, at symmetric equilibrium, that

$$f_{z^*}=(\gamma-1)(1-\tau)\kappa-\gamma(z-1)r\beta \tag{A.16}$$

and as $z=z^*$ in equilibrium, that

$$f_r=-(\gamma-1)(1-\tau)z^*z\beta-\gamma z\beta-\gamma(z-1)z^*\beta=-\beta((\gamma-1)(1-\tau)+\gamma)z^2 \tag{A.17}$$

But now from Eq. (A.14), we are only concerned with signing $\left(f_{z^*}+f_r\frac{\partial r}{\partial z^*}\right)$, which using Eqs. (A.16), (A.17), and $\frac{\partial r}{\partial z}=\frac{r}{2z}$ can be rewritten

$$\begin{aligned}\left(f_{z^*}+f_r\frac{\partial r}{\partial z}\right)&=(\gamma-1)(1-\tau)\kappa-\gamma(z-1)r\beta+\beta((\gamma-1)(1-\tau)+\gamma)z^2\frac{r}{2z}\\&=(\gamma-1)(1-\tau)\kappa-\gamma\left(\frac{z-1}{z}\right)(\sigma-\kappa)+((\gamma-1)(1-\tau)+\gamma)\frac{(\sigma-\kappa)}{2}\\&=-\frac{(\gamma-1)\kappa}{4}+((\gamma-1)(1-\tau)+\gamma)\frac{(\sigma-\kappa)}{2}\\&=\frac{\kappa(\gamma-1)}{2}\left[-\frac{1}{2}+\left(1-\tau+\frac{\gamma}{1-\gamma}\right)\varepsilon\right]\\&>\frac{\kappa(\gamma-1)}{2}\left[-\frac{1}{2}+\frac{\gamma}{1-\gamma}\varepsilon\right]\end{aligned}\tag{A.18}$$

where in the second line we have used $r=\frac{(\sigma-\kappa)}{\beta z}$ in equilibrium from Eq. (A.10), and in the third, Eq. (A.12) and the formula for the equilibrium z from Proposition 2, and in the fourth, Eq. (A.11). We conclude from Eq. (A.18) that if $\varepsilon>\frac{\gamma-1}{2\gamma}$, $W_{zz^*}>0$, as required. □

Proof of Proposition 3. Note first that as none of the terms in Eq. (A.13) depends on τ^*, as claimed. Then from Eq. (2.15), using $W_{z\tau^*}=0$ from Proposition 3, we have:

$$\frac{\mathrm{d}\tau}{\mathrm{d}\tau^*}=\frac{-W_{zz}W_{\tau\tau^*}}{D},\frac{\mathrm{d}z}{\mathrm{d}\tau^*}=\frac{W_{\tau z}W_{\tau\tau^*}}{D},D=W_{\tau\tau}W_{zz}-(W_{\tau z})^2>0.\tag{A.19}$$

where D is positive from the second-order conditions. Combining Eq. (A.19), $W_{\tau\tau^*}>0$ from Proposition 3, and using the fact that $W_{zz}<0$ from the second-order conditions, we see that $\frac{\mathrm{d}\tau}{\mathrm{d}\tau^*}>0$. In addition, from (A.13), at symmetric equilibrium,

$$W_{\tau z}=W_{z\tau}=-\frac{r}{(z+z^*)}(\gamma-1)zk=-\frac{1}{2}(\gamma-1)rk<0\tag{A.20}$$

Combining Eqs. (A.19), (A.20) and $W_{\tau\tau^*}>0$ implies $\frac{\mathrm{d}z}{\mathrm{d}\tau^*}<0$. □

References

Altshuler, R., Goodspeed, T., 2002. Follow the Leader? Evidence on European and U.S. Tax Competition. Rutgers University Economics Department Working 200226.

Bartelsman, E.J., Beetsma, R., 2003. Why pay more? Corporate tax avoidance through transfer pricing in OECD countries. Journal of Public Economics 87, 2225–2252.

Besley, T., Case, A., 1995. Incumbent behavior: vote-seeking, tax setting, and yardstick competition. American Economic Review 85 (1), 25–45.

Besley, T., Smart, M., 2007. Fiscal restraints and voter welfare. Journal of Public Economics 91 (3-4), 755–773.

Bordignon, M., Cerniglia, F., Revelli, F., 2003. In search of yardstick competition: a spatial analysis of Italian municipality tax setting. Journal of Urban Economics 54 (2), 199–217.

Brett, C., Pinkse, J., 2000. The determinants of municipal tax rates in British Columbia. Canadian Journal of Economics 33 (3), 695–714.

Brueckner, J.K., 1998. Testing for strategic interaction among local governments: the case of growth controls. Journal of Urban Economics 44 (3), 438–467.

Brueckner, J.K., 2000. A Tiebout/tax-competition model. Journal of Public Economics 77 (2), 285–306.

Brueckner, J.K., 2001. Do governments engage in strategic property tax competition. The National Tax Journal 54, 203–229.

Brueckner, J.K., 2006. Strategic interaction among governments. In: Arnott, R., McMillen, D. (Eds.), Companion to urban economics. Basil Blackwell, Oxford.

Case, A.C., Rosen, H.S., Hines, J.R., 1993. Budget spillovers and fiscal policy interdependence. Journal of Public Economics 52, 285–307.

Chennells, L., Griffith, R., 1997. Taxing Profits in a Changing World. Institute for Fiscal Studies, London.

Clausing, K.A., 2003. Tax-motivated transfer pricing and US intrafirm trade prices. Journal of Public Economics 87, 2207–2223.

Devereux, M.P., Freeman, H., 1995. The impact of tax on foreign direct investment: empirical evidence and the implications for tax integration schemes. International Tax and Public Finance 2, 85–106.

Devereux, M.P., Griffith, R., 1998. Taxes and local production: evidence from a panel of US multinationals. Journal of Public Economics 68, 335–367.

Devereux, M.P., Griffith, R., 2003. Evaluating tax policy for location decisions. International Tax and Public Finance 10, 107–126.

Devereux, M.P., Pearson, M., 1995. European tax harmonisation and production efficiency. European Economic Review 39, 1657–1681.

Devereux, M.P., Griffith, R., Klemm, A., 2002. Can international tax competition explain corporate income tax reforms. Economic Policy 35, 451–495.

Devereux, M.P., Lockwood, B., Redoano, M., 2003. Capital Account Liberalization and Corporate Taxes. IMF Discussion Paper 03/180.

Elitzur, R., Mintz, J., 1996. Transfer pricing rules and corporate tax competition. Journal of Public Economics 60, 401–422.

European Commission, 2001. Towards an International Market without Tax Obstacles. Communication from the European Commission COM(2001) 582 final.

Fuest, C., Huber, B., Mintz, J., 2005. Capital mobility and tax competition: a survey. Foundations and Trends in Microeconomics 1, 1–62.

Garrett, G., 1998. Partisan Politics in the Global Economy. Cambridge University Press, Cambridge.

Gresik, T., Nelson, D., 1994. Incentive-compatible regulation of a foreign-owned subsidiary. Journal of International Economics 36, 309–331.

Grilli, V., Milesi-Ferretti, G., 1995. Economic effects and structural determinants of capital controls. IMF Staff Papers 42, 517–551.

Grubert, H., Mutti, J., 1991. Taxes, tariffs and transfer pricing in multinational corporate decision making. Review of Economics and Statistics 68, 285–293.

Grubert, H., Slemrod, J., 1998. The effect of taxes on investment and income shifting into Puerto Rico. Review of Economics and Statistics 75, 365–373.

Hallerberg, M., Bassinger, S., 1998. Internationalization and changes in tax policy in OECD countries: the importance of domestic veto players. Comparative Political Studies 31, 321–353.

Haufler, A., Schjelderup, G., 2000. Corporate tax systems and cross country profit shifting. Oxford Economic Papers 52, 306–325.

Hayashi, M., Boadway, R., 2001. An empirical analysis of intergovernmental tax interaction: the case of business income taxes in Canada. Canadian Journal of Economics 34, 481–503.

Heyndels, B., Vuchelen, J., 1998. Tax mimicking among Belgian municipalities. National Tax Journal 51 (1), 89–100.

Hines, J.R., 1999. Lessons from behavioral responses to international taxation. National Tax Journal 52 (2), 305–322.

Hines, J.R., Hubbard, R.G., 1990. Coming home to America: dividend repatriations by US multinationals. In: Razin, A., Hubbard, R.G. (Eds.), Taxation in the Global Economy. University of Chicago Press, Chicago.

Hines, J.R., Rice, E.M., 1994. Fiscal paradise: foreign tax havens and American business. Quarterly Journal of Economics 109, 149–182.

King, M.A., Fullerton, D., 1984. The Taxation of Income from Capital. The University of Chicago Press, Chicago.

Lockwood, B., 2004. Competition in unit vs. ad valorem taxes. International Tax and Public Finance 11, 763–772.

Maddala, G.S., 2001. Introduction to Econometrics. Wiley, Chicester.

Mendoza, E.G., Razin, A., Tesar, L.L., 1994. Effective tax rates in macroeconomics: cross country estimates of tax rates on factor incomes and consumption. Journal of Monetary Economics 34, 297–323.

Mintz, J., Smart, M., 2004. Income shifting, investment and tax competition: theory and evidence from provincial taxation in Canada. Journal of Public Economics 88, 1149–1168.

Nielsen, S.B., Raimondos-Moller, P., Schjelderup, G., 2003. Formula apportionment and transfer pricing under oligopolistic competition. Journal of Public Economic Theory 5, 419–437.

OECD, 1991. Taxing Profits in a Global Economy. OECD, Paris.

OECD, 2001. Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrations. OECD, Paris.

Price Waterhouse (1983 to 1999) Corporate Taxes: a Worldwide Summary, London and New York.

Quinn, D., 1997. The correlates of change in international financial regulation. American Political Science Review 91, 531–551.

Raimondos-Moller, P., Scharf, K., 2002. Transfer pricing rules and competing governments. Oxford Economic Papers 54, 230–246.

Rodrik, D., 1997. Has Globalization Gone too Far? Institute for International Economics, Washington DC.

Slemrod, J., 2004. Are corporate tax rates, or countries, converging? Journal of Public Economics 88, 1169–1186.

Swank, D., Steinmo, S., 2002. The new political economy of taxation in advanced capitalist economies. American Journal of Political Science 46, 642–655.

Wildasin, D., 1991. Some rudimentary “duopolity” theory. Regional Science and Urban Economics 21, 317–331.

Wilson, J.D., 1986. A theory of interregional tax competition. Journal of Urban Economics 19 (3), 296–315.

Wilson, J.D., 1999. Theories of tax competition. National Tax Journal 52, 269–304.

Zodrow, G., Miezkowski, P., 1986. Pigou, Tiebout, property taxation, and the underprovision of local public goods. Journal of Urban Economics 19 (3), 356–370.