Tax Rate and Tax Base Competition for Foreign Direct Investment

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Abstract

This paper examines international tax competition for multinational enterprises (MNEs). Governments compete in two policy instruments: the rate at which they levy a source-based corporate tax, and the base on which this tax is levied. We construct a model to derive testable hypotheses concerning the strategic interaction between governments, and then estimate the governments' policy reaction functions. The model predicts, among other things, that economic integration induces governments to lower their corporate tax rates and to raise depreciation allowances so that the effective marginal tax rate on the MNE's capital stays constant. The predictions are supported by the data.

1 Introduction

Corporate tax systems in industrialized countries have changed substantially over the last decades. Statutory tax rates have fallen nearly across the board to 35% on average by the late 1990s from 48% in the early 1980s (see Devereux, Griffith and Klemm (2002). This trend appears to be unbroken. Germany, for example, reduced its corporate tax to 25% in 2001, and recently announced another reduction of the statutory tax rate. This fall in the tax rate has been accompanied by a widening of the tax base. However, while there does not seem to have been a systematic change in the effective marginal tax rate, the effective average rate seems to have fallen slightly from the early 1980s to the late 1990s.

This downward trend in the effective average tax rate is consistent with an increase in tax competition for mobile multinational enterprises (see Devereux and Griffith 2002), since the profitability of a plant location depends on the average rather than the marginal rate. Tax competition for portfolio capital, by contrast, would have suggested a fall in the effective marginal tax rate.

The current paper examines tax competition for multinational enterprises. We consider the location choice of a firm that wants to establish a plant to supply goods to a region consisting of two countries, A and B. Set-up costs of a plant are implicitly assumed to be so large compared to market size and trade costs between the countries that the multinational will establish at most one plant in the region. The location choice depends on the tax liability faced in each country, as well as geographic factors such as relative market size and transportation costs. The tax liability has two determinants: the country's corporate tax rate, and a parameter determining the share of costs that can be deducted from taxes (such as a depreciation allowance). The governments of A and B simultaneously choose corporate tax rates and depreciation allowances to influence the multinational's location decision.

In this scenario we derive the Nash equilibrium in the two policy instruments, and consider how the equilibrium policies change with regional integration, modeled here as a reduction in trade costs between the two countries. We find that regional integration induces competition in statutory tax rates, with these tax rates being strategic complements. At the same time, countries adjust their depreciation allowances to keep the effective marginal tax rate unchanged, so as to not distort the investment/output choices of the firm. With corporate tax rates decreasing due to lower trade costs depreciation allowances have to increase.

How well do these predictions match the stylized facts of regional integration? There is considerable empirical evidence that regional integration affects FDI flows. For instance, the creation of the European customs union in 1968 and especially the Single European Act of 1986/87 were associated with significant inflows of U.S. and Japanese FDI [see, for instance, Motta and Norman (1996) and Pain (1997)]. Inflows were particularly strong in relatively low-cost locations, such as Ireland. Similar effects were observed in the case of the North American Free Trade Agreement (NAFTA), which particularly boosted FDI into Mexico. Some authors, including Ethier (1998), have argued that attracting FDI was in fact one of the main reasons why some countries have pursued integration. Many preferential trade agreements, including NAFTA, explicitly stipulate the removal of FDI review procedures and other barriers to direct investment. Another possible effect of the removal of internal trade barriers is that companies may rationalize and concentrate production in low-cost locations within the preferential trade area. This was pointed out, for instance, by the Royal Commission (1985) and Pain (1997). Empirical evidence of this effect for NAFTA is found by Niosi (1994).

Given the potential of preferential trade agreements to affect the location choices of foreign investors, governments have found it indeed tempting to intervene to try to attract new firms or to prevent existing firms from leaving. Competition for FDI especially on an intra-regional basis is well documented, and there is some evidence that it has increased in line with regional integration [Bond and Guisinger (1985)]. Benassy-Quere et al. (2000) find that nominal and effective corporate tax rates in the EU have decreased in the process of European integration. According to UNCTAD [(1996), Table III.1], the use of fiscal incentives, such as tax holidays, to attract FDI has increased in Europe between the mid-1980s and early 1990s.[1] The study reports a similar trend in the United States and Canada. The main objectives pursued with these incentives appear to have changed as well during this period. UNCTAD [(1996), Table III.4] argues that in the EU as well as in the United States and Canada more incentives were given to stimulate FDI and exports and fewer were given for sectoral development and restructuring, priority industries, and research and development.

The paper follows in the tradition of the growing literature on FDI and recent papers on tax competition for FDI, which stress the discrete nature of firms and location choices. This literature also views multinational enterprises as possessing firm-specific assets that allow them to penetrate foreign markets but also confer market power [see Markusen (1995) for a survey of the FDI literature]. A number of papers, including Motta and Norman (1996), Donnenfeld (2003) and Neary (2002), examine how CUs affect FDI decisions in monopoly or oligopoly. However, these papers do not consider how governments may adapt other policy instruments to influence FDI flows. Papers on tax competition for FDI typically examine the effects of removing internal trade barriers, but do not consider how countries would change their external tariffs; hence they also do not distinguish between FTAs and CUs. Haufler and Wooton (1999), for instance, analyze how a reduction in transport costs affects tax competition between two countries for a foreign monopolist. They consider countries of different size, whereas Davies (2000) examines a similar situation allowing for differences in production costs. Barros and Cabral (2000) examine tax competition for a foreign investor, but do not allow for exports. Tax competition between two countries in the case of

[1] Of the 20 European countries surveyed, 16 provided reductions of standard income-tax rates, 7 provided tax holidays, 10 offered accelerated depreciation, 5 gave investment and reinvestment allowances, 5 offered deductions from social security contributions, 9 granted specific deductions on gross earnings for income tax purposes or reductions in other taxes, 7 provided exemptions from import duties and 6 offered duty drawbacks. The only instrument that appears to have been used less was accelerated depreciation.

a duopoly is studied by Janeba (1998); but this paper also does not consider the role of preferential trade agreements.

We examine tax competition in two instruments in a set of 43 economies over the period 1982-2005, employing a heteroskedasticity and spatial as well as serial autocorrelation-consistent (SHAC) estimator of the variance covariance matrix. Our empirical findings support the hypotheses drawn from our theoretical model: domestic statutory corporate tax rates are strategic complements to their foreign counterparts; similarly, domestic and foreign depreciation allowances are strategic complements; by way of contrast, domestic depreciation allowances are strategic substitutes to foreign statutory corporate tax rates.

The rest of the paper is organized as follows. Section 2 presents the model, and Section 3 some preliminary results. Equilibrium taxes and depreciation allowances are derived in Section 4. Section 5 contains the empirical analysis. Section 6 concludes, and the Appendix contains proofs and data sources.

2 Model

Consider a multinational firm that seeks to locate a production plant in a region consisting of two countries, labeled A and B. The multinational firm is owned by residents outside the region; any profit earned by the firm is repatriated to these owners. Households in A and B have identical preferences. Each household consumes two types of goods: the good supplied by the multinational, and a numeraire good that is competitively provided in each country. The utility function of a household residing in country $i = A, B$ is given by

$$U_i = q_i - \frac{1}{2}q_i^2 + z_i, \tag{1}$$

where q_i and z_i denote the consumption of the multinational's good and the numeraire, respectively.

Capital is the only factor of production, and technologies are identical across countries. Production of a unit of the numeraire good requires exactly one unit of capital. Hence the price of capital is equal to one. Production of the multinational's good requires $c < 1$ units of capital per unit of output, so that c can be interpreted as the marginal cost of production. It is implicitly assumed that there is a sufficiently large set-up cost for a plant (relative to the cost of transporting goods between A and B) that it does not pay the multinational to have a plant in each country; rather, the multinational will choose one location from which to supply the whole region. The per-unit transport cost between countries is denoted by $s < 1-c$. The numeraire good can be transported freely across countries, so that trade is always balanced.

Households inelastically supply one unit of capital each. Denoting the consumer price of the multinational's good in country i by p_i , per-capita tax revenue (revenue is redistributed by the government in lump-sum fashion) by R_i, a household's budget constraint is

$$p_i x_i + z_i = 1 + R_i. \tag{2}$$

Maximizing utility subject to the budget constraint yields the household's demand in country i

$$q_i = 1 - p_i. \tag{3}$$

We assume that country A has a measure $n \geq 1$ of households, whereas the measure of households in B is normalized to one. Denoting total sales in country i by Q_i we can write inverse market demand in the two countries as

$$p_A = 1 - \frac{Q_A}{n} \quad \text{and} \quad p_B = 1 - Q_B. \tag{4}$$

Markets in the two countries are segmented so that the multinational can set prices independently in each market.

The governments of A and B choose tax policy to maximize the utility of the households under their jurisdiction, or social welfare for short. Social welfare consists of the sum of tax revenue and consumer surplus. Each government has two policy instruments: a source-based corporation tax on profits, where t denotes country A's and τ country B's statutory tax rate;

and a depreciation allowance d (δ) in the case of country A (B) that determines the tax base. Hence the tax paid by the multinational when it locates a plant in country A and sells its output in A and B is

$$t\left[\left(1-\frac{Q_A}{n}-dc\right)Q_A+\left(1-Q_B-dc-s\right)Q_B\right].$$

The multinational's after-tax profit is therefore equal to

$$\begin{aligned}
\Pi &= (1-t)\left[\left(1-\frac{Q_A}{n}\right)Q_A+\left(1-Q_B-s\right)Q_B-c(Q_A+Q_B)\right] \\
&\quad -(1-d)tc(Q_A+Q_B) \\
&= (1-t)\left[\left(1-\frac{Q_A}{n}\right)Q_A+\left(1-Q_B-s\right)Q_B-c(Q_A+Q_B)\right] \\
&\quad -(a-1)(1-t)c(Q_A+Q_B) \\
&= (1-t)\left[\left(1-\frac{Q_A}{n}\right)Q_A+\left(1-Q_B-s\right)Q_B-ac(Q_A+Q_B)\right]
\end{aligned}$$

where

$$a-1=\frac{(1-d)\,t}{1-t}=\frac{1-dt}{1-t}-1 \tag{5}$$

is the effective marginal tax rate (EMTR) on capital. The corporation tax is hence equivalent to a pure profit tax, if $d=1$ and therefore $a=1$. If $d>1$ ($a<1$), more than the true capital cost can be deducted for tax purposes; hence capital use in production is implicitly subsidized (EMTR<0). If $d<1$ ($a>1$), the taxable cost is less than the actual cost, and the capital input is implicitly taxed (EMTR>0). In the following it turns out to be convenient to work with a (α) instead of d (δ). However, given the statutory tax rate and the EMTR we can easily compute d (δ).

The reason why the governments will want to use two instruments to tax the firm is that there are two "distortions": (i) the multinational is owned by foreign residents and will repatriate its profit unless the government captures this profit with a tax; and (ii) as a monopolist the multinational produces too little output, giving the government an incentive to subsidize production. Governments are assumed to be able to commit to the policies they announce. For instance, if country i offers a low tax rate to attract investment, it does not rescind its offer once the firm has made its investment.[2] The strategic interaction between the governments and the firm can be represented by a sequential game with the following order of moves:

Stage 1: A and B choose their policy instruments simultaneously and non-cooperatively.

Stage 2: The firm observes these policies and decides in which country to locate.

Stage 3: The firm chooses output for each country.

The subgame perfect equilibria of this game (equilibria for short) can be characterized using backward induction; we focus on pure-strategy equilibria.

3 Optimal Policies for Fixed Locations

Before analyzing the equilibrium policy choices when the firm is mobile, it is helpful to first examine policy responses if the multinational's location is fixed. These policies can then serve as a reference point for the subsequent analysis. Without loss of generality suppose that the multinational locates a plant in A. The after-tax profit generated by selling its output in both A and B is:

$$(1-t)\left[\left(1-\frac{Q_A}{n}-ac\right)Q_A+\left(1-\frac{Q_B}{n}-ac-s\right)Q_B\right]. \tag{6}$$

The profit-maximizing output choices are

$$Q_A=\frac{n\,(1-ac)}{2},\ \text{and } Q_B=\frac{(1-ac-s)}{2},$$

which implies consumer surplus in A and B of:

$$S^A=\frac{n\,(1-ac)^2}{8},\ \text{and } S^B=\frac{(1-ac-s)^2}{8}.$$

[2]The commitment problem and its effect on FDI has been extensively discussed in the literature [see, for instance, Bond and Samuelson (1988), and Doyle and van Wijnbergen (1994)]. The current paper has nothing new to add to this literature, and we avoid the commitment problem by abstracting from sunk investment costs.

The maximized after-tax profit is given by:

$$\Pi^A = (1-t)\,\frac{n\,(1-ac)^2 + (1-ac-s)^2}{4}. \tag{7}$$

Taking into account the implicit subsidy/tax on the multinational's output, the tax revenue accruing to A is equal to:

$$t\frac{n\,(1-ac)^2 + (1-ac-s)^2}{4} - \frac{(1-a)c\,(n\,(1-ac) + (1-ac-s))}{2}. \tag{8}$$

Now it is straightforward to compute the social welfare of country A, which equals the sum of consumer surplus and tax revenue:

$$W^A(a,t) = \frac{n\,(1-ac)^2}{8} + t\frac{n\,(1-ac)^2 + (1-ac-s)^2}{4} - \frac{(1-a)c\,(n\,(1-ac) + (1-ac-s))}{2}.$$

The government maximizes this function subject to the multinational's participation constraint. If the firm were mobile between countries, then A would obviously have to offer a policy combination that would make the firm prefer to stay in the country rather than to relocate to B. For now let us assume that the firm requires a minimum profit of $k \geq 0$, so that the participation constraint becomes:

$$(1-t)\,\frac{n\,(1-ac)^2 + (1-ac-s)^2}{4} \geq k. \tag{9}$$

Consider first the case where $k = 0$ so that A can set $t = 1$ and the participation constraint will hold with equality. Using $t = 1$ in the welfare function and taking the derivative with respect to a, the optimal a can then be shown to equal:

$$a^* = \frac{(2c - n + 2cn)}{(n+2)\,c}. \tag{10}$$

Note that $a^* < 1$; that is, the government implicitly subsidizes production to reduce the monopoly distortion and increase consumer surplus. The implicit subsidy payment to the firm does not matter, since the government recaptures this payment through the profit tax. However, since part of the output is exported to B, the subsidy falls short of the level needed to reduce the domestic price in A to marginal cost c.[3]

For higher k, the government has to reduce t to keep the participation constraint of the firm binding. If the participation constraint is binding, we can use it to eliminate t in the welfare function:

$$W^A(a) = \frac{n(1-ac)^2}{8} + \frac{n(1-ac)^2 + (1-ac-s)^2}{4} - \frac{(1-a)c\left(n(1-ac) + (1-ac-s)\right)}{2} - k.$$

Obviously, setting a^* is still the optimal policy. That is, the government responds to an increase in the multinational's outside profit by keeping a unchanged and reducing t to satisfy the participation constraint.

4 Equilibrium Policies

In this section we characterize the countries' best response functions/correspondences and the Nash equilibrium tax policies. Consider the multinational's location choice for given tax policies in A and B. The multinational will choose to locate in A, if the profit of locating there exceeds the profit of locating in B:

$$(1-t)\frac{n(1-ac)^2 + (1-ac-s)^2}{4} - (1-\tau)\frac{(1-\alpha c)^2 + n(1-\alpha c-s)^2}{4} \geq 0 \tag{11}$$

Note that (11) is a generalization of the multinational's participation constraint (9). If A and B impose the same policies and $s > 0$, then the firm strictly prefers to locate in A, since A has the larger domestic market. This locational rent is strictly increasing in n and s. (11) offers additional insights regarding the strategic interaction between A and B. Suppose that country B lowers τ and/or lowers α, so that the profit the firm may earn when locating in B rises. This forces A's government to adjust its policies to

[3] However, it is easy to show that if the trade cost is prohibitive so that the entire subsidy falls on local output, the optimal implicit subsidy, $a^* = (2c-1)/c$, indeed induces the multinational to set a price equal to c.

keep the firm from relocating. As we saw in the previous section, there are two possible best-response patterns, depending on whether the level of t is unconstrained (participation constraint binds) or constrained (participation constraint does not bind). If t is free to adjust, then A will hold a fixed at a^*, given by (10), and reduce t so as to keep (11) satisfied. In this case, t is a strategic complement to both τ and α.

Obviously, the same reasoning applies to country B's best responses to A's policies. However, before considering mutual best responses in both policy instruments, it is useful to first examine Nash equilibria in t and τ, setting $a = \alpha = 1$.

4.1 Nash Equilibrium Taxes for $a = \alpha = 1$

The tax competition game between A and B, where A has a locational advantage, is similar to a Bertrand competition game between firms with different constant marginal costs. The government of B chooses the τ that makes it just indifferent between attracting the multinational (so that its welfare is the sum of consumer surplus and tax revenue) and having it locate in A, in which case it only receives consumer surplus:

$$\frac{(1-c)^2}{8} + \tau\frac{(1-c)^2 + n(1-c-s)^2}{4} = \frac{(1-c-s)^2}{8} \tag{12}$$

B's equilibrium tax hence is:

$$\bar{\tau}(s,n) = \frac{(2c+s-2)\,s}{2\left(n-2c-2cn-2ns+2cns+c^2+c^2n+ns^2+1\right)},$$

where $\bar{\tau}(0,n) = 0$ and

$$\frac{\partial\bar{\tau}}{\partial s} = \frac{-(1-c-s)(n+1)(1-c)^2}{\left(n-2c-2cn-2ns+2cns+c^2+c^2n+ns^2+1\right)^2} < 0.$$

That is, in free trade B sets a zero tax and for positive trade costs it offers the multinational a subsidy, i.e, $\bar{\tau} < 0$.

A's government sets t such that the multinational is indifferent between locating in A or in B:

$$(1-t)\frac{n(1-c)^2+(1-c-s)^2}{4}-(1-\bar{\tau})\frac{(1-c)^2+n(1-c-s)^2}{4}=0$$

Hence the equilibrium tax rate is

$$\bar{t}(s,n)=\frac{(2-2c-s)(2n-3)s}{2(n-2c-2s-2cn+2cs+c^2+s^2+c^2n+1)},$$

with $\bar{t}(0,n)=0$, and

$$\frac{\partial t}{\partial s}=\frac{(1-s-c)(2n-3)(n+1)(1-c)^2}{(n-2c-2s-2cn+2cs+c^2+s^2+c^2n+1)^2}\quad(>0 \text{ for } n>1.5).$$

Hence A also sets a zero profit tax in free trade, but a positive profit tax for $s>0$, provided that $n>1.5$.

4.2 Nash Equilibrium Policies

The point of the previous section is to show that the participation constraint for the firm will hold simultaneously in both countries for given levels of a and α, if the governments are able to adjust t and τ, respectively. This makes computing the Nash equilibria of the game simple, because we know from our previous analysis that in this case each country has an optimal level of a (α) that is independent of its profit tax. Hence in the Nash equilibrium A will choose $a=a^*$, and B will set $\alpha=\alpha^*$, where

$$a^*=\frac{2c-n+2cn}{(n+2)c}\text{ and }\alpha^*=\frac{2c+2cn-1}{(1+2n)c}. \tag{13}$$

The appropriate profit taxes can now be computed as in the previous subsection using $a=a^*$ and $\alpha=\alpha^*$. That is, the government of B chooses the τ that makes it just indifferent between attracting the multinational and having it locate in A:

$$\frac{(1-\alpha^*c)^2}{8}+\tau\frac{(1-\alpha^*c)^2+n(1-\alpha^*c-s)^2}{4}$$
$$-\frac{(1-\alpha^*)c((1-\alpha^*c)+n(1-\alpha^*c-s))}{2}=\frac{(1-a^*c-s)^2}{8}$$

Denote B's equilibrium tax by $\tau^*(c,n,s)$. A's government sets t such that the multinational is indifferent between locating in A or in B:

$$(1-t)\,\frac{n\,(1-a^*c)^2+(1-a^*c-s)^2}{4} \\ -(1-\tau^*)\,\frac{(1-\alpha^*c)^2+n\,(1-\alpha^*c-s)^2}{4}=0$$

We denote the equilibrium tax rate by is $t^*(c,n,s)$.

It is straightforward to compute explicit solutions for $t^*(c,n,s)$ and $\tau^*(c,n,s)$, but the expressions are complicated. To examine the comparative static properties of the Nash equilibrium we therefore focus on two special cases: (i) free trade and country size differences; and (ii) positive trade cost and symmetric countries. In free trade we have

$$\begin{aligned} t^*(c,n,0) &= \frac{4n+3n^2-1}{2\,(2n+1)\,(n+1)}>0. \\ \tau^*(c,n,0) &= \frac{8n+5n^2+5}{16n+10n^2+2n^3+8}>0. \end{aligned}$$

That is, in free trade A and B set positive statutory tax rates together with $a^*<1$ and $\alpha^*<1$.

Given the equilibrium levels of t and a (τ and α) we use (5) to solve for the depreciation allowance d (δ). For A (and similarly for B) we obtain

$$d^*=\frac{1-a^*(1-t^*)}{t^*}>1,\text{ since } a^*<1 \text{ and } t^*>0. \tag{14}$$

Totally differentiating (5) we can derive how d^* has to be adjusted following changes in t^* so that a remains fixed at a^*:

$$\frac{dd^*}{dt^*}=\frac{1-d^*}{t^*(1-t^*)}<0.$$

That is, an increase in the statutory tax rate has to be accompanied by a reduction in the depreciation allowance to hold the EMTR fixed at the opimal level.

Using (**??**) and (14) we may state the following testable hypotheses concerning the strategic relationship between A's and B's policy parameters:

Hypothesis 1 The domestic statutory tax rate t (τ) is a strategic complement to the foreign statutory tax rate τ (t), and a strategic substitute to the foreign depreciation allowance δ (d).

Hypothesis 2 The domestic depreciation allowance d (δ) is a strategic substitute to the foreign statutory tax rate τ (t), and a strategic complement to the foreign depreciation allowance δ (d).

The key to these hypotheses is that (i) the statutory tax rates are strategic complements, and (ii) the EMTR is strategically independent of the statutory tax rate. Hence if the foreign country raises its statutory tax rate or lowers its depreciation allowance, thereby reducing the multinational's profit from locating there, the home country will react by raising its own statutory tax rate. However, when it raises its statutory tax rate, the home country is forced to lower its depreciation allowance to keep the EMTR fixed at the optimal level.

The comparative statics of the Nash equilibrium evaluated at free trade yield the following testable hypotheses (see Appenidix for proof):

Hypothesis 3 Evaluated at free trade ($s = 0$), and assuming that n is sufficiently big, an increase in the trade cost raises each country's statutory tax rate ($\frac{\partial t^*}{\partial s} > 0$, $\frac{\partial \tau^*}{\partial s} > 0$) and reduces its depreciation allowance ($\frac{\partial d}{\partial s} < 0$, $\frac{\partial \delta}{\partial s} < 0$).

Hypothesis 4 Evaluated at free trade ($s = 0$), and assuming that n is sufficiently big, an increase in the size of country A relative to that of B, raises the statutory tax rate in A ($\frac{\partial t^*}{\partial n} > 0$), and reduces the statutory tax rate in B ($\frac{\partial \tau^*}{\partial n} < 0$); it raises the depreciation allowance in A ($\frac{\partial d^*}{\partial n} > 0$), and reduces the depreciation allowance in B ($\frac{\partial \delta}{\partial n} < 0$).

Hypothesis 5 Evaluated at free trade ($s = 0$), an increase in the marginal cost has no effect on statutory tax rates, but reduces depreciation allowances ($\frac{\partial d}{\partial c} < 0$ and $\frac{\partial \delta}{\partial c} < 0$). However, evaluated at $n = 1$ (symmetry across countries) and $s > 0$, an increase in the marginal cost reduces the statutory tax rate ($\frac{\partial t}{\partial c} < 0$), provided that s is close to zero.

5 Empirical analysis

5.1 Profit tax data features

We use an unbalanced panel data-set of 43 European and also non-European economies which covers the period 1983-2005.[4]

5.2 Specification

The theoretical model in Section 2 suggests that governments may use two instruments to compete for multinational plant location: statutory tax rates and cost deduction parameters (referred to as depreciation allowances in the empirical analysis). The empirical data-set allows inference from panel data. Therefore, we use a time (year) index $y = 1, ..., Y$ to refer to a cross-section of countries in a specific period. Let us collect the determinants of the (Nash) equilibrium in these two instruments for year y into the $N \times K$ matrix $\mathbf{X}_y$, where N denotes the number of countries in the sample. According to the theoretical model, country size (n), production costs (c), and transportation costs (s) belong in $\mathbf{X}_y$. We approximate country size by the logarithm of a country's real GDP (using the year 2000 as the base year) and refer to the corresponding $N \times 1$ vector for all countries in year y as $\mathbf{n}_y$. Furthermore, we use the logarithm of GDP per capita as a measure of costs and collect the observations for year y into the $N \times 1$ vector $\mathbf{c}_y$. Finally, we approximate a country's trade costs by a trade barrier index which is annually published

[4]Note that we refer to this data-set as a balanced panel even though some of the countries (namely the Central and Eastern European ones) are not included before the fall of the iron curtain. From the perspective of tax competition, the opening of the borders to both goods transaction as well as capital flows was equivalent to an increase in the 'size of the world' in terms of the number of relevant competitors. Hence, the rising cross-section over time entails a very specific kind of unbalancedness, reflecting the increase of world size in terms of the number of politically independent and at least partially integrated economies.

by the World Economic Forum.[5] We refer to the corresponding $N \times 1$ vector of trade costs for year y as $\mathbf{s}_y$. Furthermore, with panel data we are able to control for a comprehensive set of time-invariant determinants by accounting for fixed country-specific effects. With matrix notation, for year y this involves an $N \times N$ identity matrix $\mathbf{I}_y$. With these definitions at hand, we may define $\mathbf{X}_y = [\mathbf{n}_y, \mathbf{c}_y, \mathbf{s}_y, \mathbf{I}_y]$ so that $K = 3 + N$. Note that the variables in $\mathbf{X}_y$ matter for the Nash equilibrium in both the $N \times 1$ vector of statutory tax rates $\mathbf{t}_y$ and that one of depreciation allowance parameters $\mathbf{d}_y$. However, the marginal effects of these variables (hence, the corresponding parameters in the econometric model) may differ. Let us refer to the $K \times 1$ vector parameters for statutory tax rates as δ_t and to that one for depreciation allowances as δ_d.

Moreover and most importantly, strategic interaction among governments leads to interdependence in the setting of the two instruments. The empirical modeling of the corresponding surface faces two challenges: the domestic statutory tax rate ($\mathbf{t}_y$) is a function of the foreign statutory tax rate (τ_y) and the foreign depreciation allowance parameter (δ_y). Similarly, the domestic depreciation allowance parameter ($\mathbf{d}_y$) is a function of τ_y and δ_y. Of course, with a data-set of more than two countries, for each country τ_y and δ_y reflect a weighted average of the tax parameters ($\mathbf{t}_y$) and ($\mathbf{d}_y$) of all other countries. Let us define an $N \times N$ weighting matrix $\mathbf{W}$ whose elements correspond to weights. Two important properties of $\mathbf{W}$ are that it contains zero diagonal elements and that its row sums are bounded, e.g., due to normalizing entries by their row-sum. Hence, domestic tax instruments are (strategically) related to average foreign ones. For instance, for country i the corresponding weighted average of foreign statutory tax rates in year y would be $\tau_{iy} = \mathbf{w}_i \mathbf{t}_y$, where $\mathbf{w}_i$ is a $1 \times N$ row vector of $\mathbf{W}$ whose elements sum up to unity. For all countries, we may write $\tau_y = \mathbf{W}\mathbf{t}_y$. Similarly, we may write $\delta_y = \mathbf{W}\mathbf{d}_y$. Let us refer to the slope parameters of the reaction function (with two instruments,

[5]For instance, this index has been employed as a measure of trade costs in Carr, Markusen, and Maskus (2001) and Markusen and Maskus (2002). We gratefully acknowledge provision of the data by Keith Maskus.

we should refer to this as a surface) of $\mathbf{t}_y$ with respect to τ_y as β_t and to that one of $\mathbf{d}_y$ with respect to δ_y as β_d. Furthermore, let us denote the slope parameter of the reaction function of $\mathbf{t}_y$ with respect to δ_y as γ_t and that one of the reaction function of $\mathbf{d}_y$ with respect to τ_y as γ_d. Then the econometric model capturing profit tax competition in both $\mathbf{t}_y$ and $\mathbf{d}_y$ may be written as

$$\mathbf{t}_y = \beta_t \mathbf{W}\mathbf{t}_y + \gamma_t \mathbf{W}\mathbf{d}_y + \mathbf{X}_y \xi_t + \mathbf{u}_{t,y} \quad (15)$$

$$\mathbf{d}_y = \beta_d \mathbf{W}\mathbf{d}_y + \gamma_d \mathbf{W}\mathbf{t}_y + \mathbf{X}_y \xi_d + \mathbf{u}_{d,y}. \quad (16)$$

According to our theoretical model, we expect domestic and foreign statutory tax rates to be strategic complements ($\beta_t > 0$, Hypotheses 1). Similarly, domestic and foreign depreciation allowances should be strategic complements ($\beta_d > 0$, Hypotheses 2). Moreover, we hypothesize that the domestic statutory tax rate is a strategic substitute to the foreign depreciation allowance and vice versa ($\gamma_t < 0$, Hypothesis 1; $\gamma_d < 0$, Hypothesis 2). For the parameters of the country size variable, we expect $\xi_{1,t} > 0$ (because $\frac{\partial t^*}{\partial n} > 0$, Hypothesis 4) and $\xi_{1,a} > 0$ (because $\frac{\partial d^*}{\partial n} > 0$, Hypothesis 4). Moreover, with costly trade and symmetric countries, for the parameters of the cost variable we expect $\xi_{2,t} < 0$ (because $\frac{\partial t}{\partial c} < 0$) and $\xi_{3,a} < 0$, respectively. Finally, for the parameters of the trade cost variable, we expect $\xi_{3,t} > 0$ (because $\frac{\partial t^*}{\partial s} > 0$, Hypothesis 3), and $\xi_{3,a} < 0$ (because $\frac{\partial d}{\partial s} < 0$, Hypothesis 3).

5.3 Methodology

Cross-sectional interdependence through the inclusion of $\mathbf{W}\mathbf{t}_y$ and $\mathbf{W}\mathbf{d}_y$ in (15) and (16) renders the least squares dummy variable estimator of the parameters (i.e., OLS with fixed country effects) inconsistent. This can be avoided by instrumental variable two-stage least squares (IV-2SLS) with instruments $\mathbf{W}\mathbf{X}_y$, $\mathbf{W}^2\mathbf{X}_y$, $\mathbf{W}^3\mathbf{X}_y$, etc., see Kelejian and Prucha, 1999). If the instruments are relevant and uncorrelated with the disturbances, IV-2SLS will be consistent. Yet, it still might be inefficient. The latter may be due to heteroskedastic and cross-sectionally and/or serially correlated disturbances $\mathbf{u}_{t,y}$ or $\mathbf{u}_{t,y}$. One may avoid efficiency losses by correcting the estimate of variance-covariance matrix, accordingly. We do so by employing a version of the variance-covariance matrix estimator for spatially and/or serially correlated data following Driscoll and Kraay (1998).

Note that our data-set covers the period $1982 - 2005$, hence, there are 24 consecutive periods. In this case, IV-2SLS with fixed country dummies obtains valid estimates not only of the parameters of the covariates but also of the fixed effects (and, hence, the disturbances $\mathbf{u}_{t,y}$ and $\mathbf{u}_{t,y}$).[6]

For the definition of the IV-2SLS GMM estimator and its heteroskedasticity and spatial as well as serial autocorrelation-consistent (HAC) estimator of the variance-covariance matrix in the spirit of Driscoll and Kraay (1998), it will be useful to introduce some further notation. Recall that we indicate countries by $i = 1, ..., N$ and time periods by $y = 1, ..., Y$. For convenience, let us use the running index $\ell = t, a$ to refer to the two equations (15) and (16), respectively. Furthermore, define the $N \times (K + 2)$ matrix $\mathbf{Z}_y = [\mathbf{W}\mathbf{t}_y, \mathbf{W}\mathbf{d}_y, \mathbf{X}_y]$ and refer to the $NY \times (K + 2)$ stacked version of this matrix (covering all years) as $\mathbf{Z}$. IV-2SLS potentially involves sets of instruments which differ across equations. Define the number of instruments in equation ℓ as $P_\ell \geq K + 2$ and collect the instruments for equation ℓ and all years into the $NY \times P_\ell$ matrix $\mathbf{D}$.[7] Then, we may define the projection $\hat{\mathbf{Z}} = \mathbf{D}(\mathbf{D}'\mathbf{D})^{-1}\mathbf{D}'\mathbf{Z}$. Later on, we will refer to one row of $\hat{\mathbf{Z}}$ by the $1 \times (K + 2)$ vector $\hat{\mathbf{z}}_{iy}$. Finally, collect the IV-2SLS parameters for equation ℓ into the $(K + 2) \times 1$ vector θ_ℓ. Let us refer to the (inefficient) estimate of the $(K + 2) \times (K + 2)$ variance-covariance matrix of the parameters as $\hat{\mathbf{V}} = (\mathbf{Z}'\mathbf{D}_\ell\mathbf{D}_\ell'\mathbf{Z})^{-1}$.

Driscoll and Kraay (1998) suggest averaging the moment conditions to obtain $\mathbf{h}_y(\theta_\ell) = \frac{1}{N}\sum_{i=1}^{N} \mathbf{h}_{iy}(\theta_\ell)$. Let us use the notation $\mathbf{h}_{\ell y} = \mathbf{h}_y(\theta_\ell)$ to write

$$\mathbf{h}_{\ell y} = \frac{1}{N}\sum_{i=1}^{N} \mathbf{d}_{\ell iy}\mathbf{u}_{\ell iy}; \quad \mathbf{h}_{\ell y'} = \frac{1}{N}\sum_{i=1}^{N} \mathbf{d}_{\ell iy'}\mathbf{u}_{\ell iy'}. \tag{17}$$

[6]With a very small number of periods but a large number of countries N, it would not be possible to obtain valid estimates of these residuals due to the relatively large number of fixed country effects.

[7]Of course, the $NY \times K$ matrix $\mathbf{X}$ of exogenous variables in (15) and (16) is part of $\mathbf{D}$.

with $y, y' = 1, ..., Y$. Furthermore, let us define the matrix

$$\mathbf{S}_{\ell Y} = \frac{1}{Y} \sum_{y=1}^{Y} \sum_{y'=1}^{Y} E[\mathbf{h}_{\ell y} \mathbf{h}'_{\ell y'}] \tag{18}$$

and note that $E[\mathbf{h}_{\ell y} \mathbf{h}'_{\ell y'}] = \frac{1}{N^2} \sum_{i=1}^{N} \mathbf{d}_{\ell i y} \mathbf{d}'_{\ell i y'} E[u_{\ell i y} u_{\ell i y'}]$.

A HAC estimator of the variance-covariance matrix with IV-2SLS in the spirit of Driscoll and Kraay (1998) is then defined as

$$\hat{\mathbf{V}}_{HAC} = (\mathbf{Z}' \mathbf{D}_\ell \hat{\mathbf{S}}_{\ell Y}^{-1} \mathbf{D}'_\ell \mathbf{Z})^{-1}. \tag{19}$$

Driscoll and Kraay (1998) prove that such a Newey and West (1987)-type estimator of the variance-covariance matrix relies on fairly weak assumptions.

5.4 Results

We summarize IV-2SLS parameter estimates in the benchmark models for statutory tax rates and depreciation allowances in Table 1. With each of the models, we report two sets of standard errors: ones that are based on the Huber-White sandwich estimator of the variance-covariance matrix (ignoring any spatial or serial correlation) and ones that are based on the above described SHAC estimator (considering serial correlation of the disturbances with their counterparts in up to three periods in the past).

−− Table 2 −−

Let us briefly describe the general model characteristics before turning to the parameter estimates. First of all, the explanatory power of the second stage models is generally high. As expected, country-specific characteristics are important and abandoning the country dummies likely would lead to biased parameter estimates for the covariates. Indeed, it turns out that treating third-country tax variables as exogenous would be harmful, given the chosen specification. This points to strategic interaction in tax parameters among governments as hypothesized. Moreover, the incremental explanatory power of the identifying instruments for the third-country averages of the taxation variables is relatively high.[8] The latter renders the insignificant over-identification tests meaningful. Overall, we may conclude that the IV-2SLS models work well.

Regarding the covariates determining the Nash equilibrium in tax parameters, we find that larger countries tend to set insignificantly higher statutory tax rates but significantly lower depreciation allowances. Higher production costs are associated with significantly lower statutory rates but significantly higher depreciation allowances. Higher trade costs lead to significantly higher statutory tax rates but insignificantly lower depreciation allowances. Of the six point estimates for the covariates (i.e., the determinants of the Nash tax rates), only two contradict the theoretical hypotheses (namely the effects of country size and costs on depreciation allowances).[9] There is support across the board for the determinants of statutory corporate profit tax rates.

The parameters determining the slope of the reaction function in the two dimensions are highly significant throughout. In particular, they indicate that domestic and foreign statutory tax rates are strategic complements, while domestic statutory tax rates and foreign depreciation allowances are strategic substitutes. In contrast, domestic and foreign depreciation allowances are strategic substitutes while domestic depreciation allowances and foreign statutory tax rates are strategic complements. Hence, all the slope parameters of the reaction function are consistent with the above theoretical model.

However, interdependence across economies is quite complicated in that model. Therefore, it is useful to study its mechanics in terms of policy scenario simulations. We will do so by simulating the effects of hypothetical harmonization scenarios: in one of them, we will study the impact of a simultaneous reduction of statutory tax rates by one percentage point in all countries in the sample; then, we will illustrate the impact of a simultaneous

[8] In matrix notation, we use $\mathbf{WX}$, $\mathbf{W}^2\mathbf{X}$, and $\mathbf{W}^3\mathbf{X}$ as instruments.

[9] Half of the statistically significant parameters of the covariates are in line with the model predictions.

reduction in depreciation allowances by one percentage point; and, finally, we will analyze the consequences of a hypothetical harmonization of the two tax parameters in the European Union (EU) on outsider countries. However, it is useful to illustrate the robustness of our findings before turning to the simulation.

5.5 Sensitivity analysis

We assess the sensitivity of our findings in qualitative terms along two general lines: measurement of some of the right-hand-side variables and the aggregation concept for construction of foreign tax instruments (i.e., the spatial weighting scheme). With respect to the former we pay particular attention to country size, production costs, and trade costs.

In the benchmark models summarized in Table 2, we used log real GDP as a measure of country size. In the theoretical model, we referred to country size as the number of households/workers in the economy. While log GDP might generally be a better measure for aggregate demand, log population size would be closer to our model. However, replacing log GDP by log population size has little influence on the reaction function parameters. This becomes obvious from the set of parameters in the upper block of results reported in Table 3.

−− Table 3 −−

Furthermore, we used GDP per capita as a measure of production costs in the benchmark models. Again there are pros and cons for this choice. The fact that expenditures to cover fixed costs will be accounted for in GDP is among the latter. An alternative measure of production costs would be labor compensation (available from the World Development Indicators 2005). Yet, replacing log GDP per capita by labor compensation renders the results qualitatively unaffected, again (see the second block of results in Table 3).

The trade cost index in the benchmark models relies on a survey among managers and CEOs. Managers might find it difficult to distinguish between sheer trade frictions and obstacles to market transactions as such. Accordingly, the index might reflect other barriers than just trade barriers. We address this concern by using the average cost-insurance-freight to free-on-board bilateral trade values by country (across all importers) and year in logs. Again, the signs of the reaction function parameters are unaffected by this choice (see the third block of results in Table 3).

With regard to the weights to aggregate foreign economies' tax parameters, the sensitivity of the results with respect to usage of inverse distance-based weights might be a concern. We suggest sensitivity checks along two general lines to infer this issue, namely using alternative weighting concepts such as contiguity weighting (direct neighbors matter with the same weight for tax competition while non-neighbors do not mater at all), trade weighting (there, tax competition is hypothesized to be tougher among natural trade partners), and foreign direct investment weighting (there, tax competition is hypothesized to be tougher among natural foreign direct investment partners). The Appendix provides more detail on the construction of these alternative weighting schemes. The three blocks at the bottom of the table indicate that common borders, higher natural levels of bilateral international trade flows, or higher natural levels of bilateral foreign direct investment are related to tax competition similar to inverse geographical distances. In qualitative terms, the results for the signs of the slope parameters of the reaction function are unaffected by these alternative choices of the weighting scheme. Therefore, we will shed light on quantitative issues with profit tax competition by using the benchmark estimates from Table 2.

5.6 Tentative quantification of the extent and whereabouts of profit tax competition with some discussion

In the sequel, we are interested in how shocks on statutory tax rates versus depreciation allowances propagate according to (15) and (16). Let us denote the vector of shocks on statutory profit tax rates by ι_t and the one on depreciation allowances by ι_d. Let us assume that all other exogenous variables in the model stay constant. Then, after skipping year indices, the size-N vectors of changes in statutory profit tax rates and depreciation allowances in line with estimates of (15) and (16) are determined by

$$D\mathbf{t} = (\mathbf{I} - \hat{\beta}_t\mathbf{W} - \hat{\gamma}_t\mathbf{W}[\mathbf{I} - \hat{\beta}_d\mathbf{W}]^{-1}\mathbf{W})^{-1}\iota_t \quad (20)$$

$$D\mathbf{d} = (\mathbf{I} - \hat{\beta}_d\mathbf{W} - \hat{\gamma}_d\mathbf{W}[\mathbf{I} - \hat{\beta}_t\mathbf{W}]^{-1}\mathbf{W})^{-1}\iota_d, \quad (21)$$

where D is the difference operator and '^' denotes estimates. Two issues are of interest, here. First, by how much would statutory tax rates (depreciation allowances) respond to a shock captured by an $N \times 1$ vector of ones ι_t (ι_d). Second, it may be relevant to understand how a shock similar to the harmonization of tax parameters within a sub-group of economies propagates (in our example, it will be the member countries of the European Union).

Let us first discuss generally the magnification/compression of shocks on profit tax parameters in a world of interdependent countries. Typically, with strategic interdependence among units shock propagation is inferred by considering the effect of a simultaneous unitary change on each unit (ι_t). The extent to which ι_t is magnified/compressed is referred to as the *spatial multiplier*, acknowledging that the magnification/compression is brought about by cross-sectional interdependence. In our case, the multiplier effect is more complicated than usual (i.e., than with one tax instrument only), since interdependence matters not only across countries but even across instruments.

—— Table 4 ——

Table 4 provides the estimated multiplier effect for all countries in our sample. Column (1) in the table indicates by which factor a common unitary shock of ι carries over into actual statutory tax rate changes in the sample. According to the table, the average magnification of such a shock is small (amounting to about one percent), being largest in the non-EU countries of Europe (where it is about two percent). Non-European countries are comparatively remote and therefore face only a tiny magnification of the shock in their tax rates. The multiplier effect is somewhat bigger with depreciation allowances as can be seen from column (4) in the same table. There, ι generates an additional increase in depreciation allowances of about three percent. The effect is about the same for the average European country in the sample, irrespective of whether we consider EU member countries or non-members. Again, the magnification of shocks on depreciation allowances through cross-sectional shock propagation is negligible for the non-European economies in the sample.

Second, a shock on a sub-group of countries such as the EU-members exerts potentially strongly asymmetric effects. The reason is that some countries (where a shock occurs) will face direct effects, while others will only be affected indirectly (by cross-border shock propagation). Accordingly, the consequences will crucially depend on the whereabouts of shocks. Our example relies on a drastic but not implausible scenario. Let us hypothesize that all members of the European Union faced a shock in the year 2005 that was similar to an adjustment of individual tax parameters towards the EU median. Suppose that no direct change occurred in any other European or non-European economy. The question is, how would tax parameters respond in any of the countries in response to that shock? In contrast to what we have said about the assessment of multiplier effects, the magnitude of the shock is now different across countries, since they differ regarding their initial 'distance' from the median. Not very surprisingly, the consequences vary a lot more than before. However, it seems interesting to point out the geographical pattern of shocks.[10] Harmonization of statutory corporate tax rates would raise tax rates within the European Union for the average country. This effect is due to the large number of Central and Eastern European economies where statutory corporate tax rates are below the median.[11] The

[10]Due to the strong correlation of geographical distance with contiguity, bilateral trade flows, or bilateral foreign direct investment, a similar cross-country pattern would arise with alternative weighting schemes implemented in the sensitivity analysis.

[11]It is the fact of the matter that the latter observation is one of the roots of the EU tax harmonization debate.

original shock would be compressed within the EU. Also the average European non-EU country would increase its statutory tax rate – but only slightly – in response to that. Yet, the harmonization would unlikely propagate outside Europe. The latter holds also true for a harmonization of depreciation allowances. While a shock which is equivalent to the harmonization of depreciation allowance parameters would be amplified within the EU, it would lead to an increase in the tax base (i.e., a reduction in depreciation allowances) among non-EU-member countries in Europe.

6 Concluding remarks

This paper ventures theoretically and empirically into analyzing a government's problem of profit tax competition in two tax instruments rather than a single one: a statutory profit tax rate and a fixed cost deduction parameter. Theoretically, we explore the reaction function in these two dimensions and we investigate how the Nash equilibrium in the two instruments depends on country size, production costs, and trade costs. A characterization of the reaction function obtains two testable hypotheses. First, the domestic statutory tax rate is a strategic complement to the foreign statutory tax rate, and a strategic substitute to the foreign depreciation allowance. Second, the domestic depreciation allowance is a strategic substitute to the foreign statutory tax rate, and a strategic complement to the foreign depreciation allowance.

In the empirical part of the paper, we test these hypotheses among others in a panel data-set of 43 countries over the period 1982-2005. We use the statutory corporate profit tax rate and the depreciation allowance parameter as empirical analogues of the two tax instruments in the theoretical model.

7 Appendix

7.1 Proof of Hypotheses 3 - 5

Straightforward computation yields the following derivatives, which can be signed assuming $s = 0$ and provided that n is sufficiently big:

$$
\begin{aligned}
\frac{\partial t^*}{\partial s} &= \left(-\frac{1}{2}\right)(c-1)^{-1}(n+1)^{-3}(2n+1)^{-1}\left(2n^2-3n+2n^3-4\right)(n+2)>0\\
\frac{\partial \tau^*}{\partial s} &= \left(-\frac{1}{2}\right)(c-1)^{-1}(n+1)^{-3}(n+2)^{-2}(2n+1)^{2}\left(n^2-2n-2\right)>0\\
\frac{\partial d^*}{\partial s} &= (-2)\left(4n+3n^2-1\right)^{-2}(n+1)^{-1}c^{-1}\left(2n^2-3n+2n^3-4\right)(2n+1)\,n<0\\
\frac{\partial \delta^*}{\partial s} &= (-2)\left(8n+5n^2+5\right)^{-2}(n+1)^{-1}c^{-1}(n+2)^{2}\left(n^2-2n-2\right)(2n+1)<0\\
\frac{\partial t^*}{\partial n} &= \frac{1}{2}(2n+1)^{-2}(n+1)^{-2}\left(10n+n^2+7\right)>0\\
\frac{\partial \tau^*}{\partial n} &= \left(-\frac{1}{2}\right)(n+2)^{-3}(n+1)^{-2}\left(3n+6n^2+5n^3+4\right)<0\\
\frac{\partial d^*}{\partial n} &= (-2)\left(4n+3n^2-1\right)^{-2}(n+2)^{-2}c^{-1}(c-1)\left(2n^4-11n^2-2n^3-4n-3\right)>0\\
\frac{\partial \delta^*}{\partial n} &= 2\left(8n+5n^2+5\right)^{-2}c^{-1}(c-1)\left(10n+n^2+7\right)<0\\
\frac{\partial d^*}{\partial c} &= \left(1-3n^2-4n\right)^{-1}(n+2)^{-1}c^{-2}\left(2n+n^2+3\right)n<0\\
\frac{\partial \delta^*}{\partial c} &= -\left(8n+5n^2+5\right)^{-1}c^{-2}\left(2n+n^2+3\right)<0
\end{aligned}
$$

For $n = 1$ and $s > 0$, one obtains

$$
\frac{\partial t}{\partial c} = \frac{(-6)\left(32(1-c)^2-9s^2\right)s}{\left(24cs-24s-64c+32c^2+9s^2+32\right)^2} < 0 \text{ for } s \text{ close to zero.}
$$

7.2 'Natural' trade and foreign direct investment based weights matrices in the empirical model

As indicated in Section 5.5, in two sensitivity checks we use 'natural' trade and, alternatively, 'natural' foreign direct investment as weights instead of inverse distance. They are derived from cross-sectional empirical models using log bilateral exports and stocks of outward foreign direct investment, respectively, as the dependent variable. Apart from exporter (parent country) and importer (host country) fixed effects, the models include the following trade cost variables on the right hand side: log bilateral distance and a set of dummy variables such as common official language between exporter and importer, common border, European Economic Area membership, and North American Free Trade Area membership.

Since both trade flows and stocks of foreign direct investment take zero values, we follow Santos Silva and Tenreyro and estimate the equations by a Poisson pseudo-maximum-likelihood routine. The associated model predictions are then used to create row-normalized weighting schemes which are positively associated with 'natural' (i.e., predicted) bilateral trade and foreign direct investment, respectively.

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Figure 1 - Evolvement of profit tax instruments in a sample of 43 countries (medians)

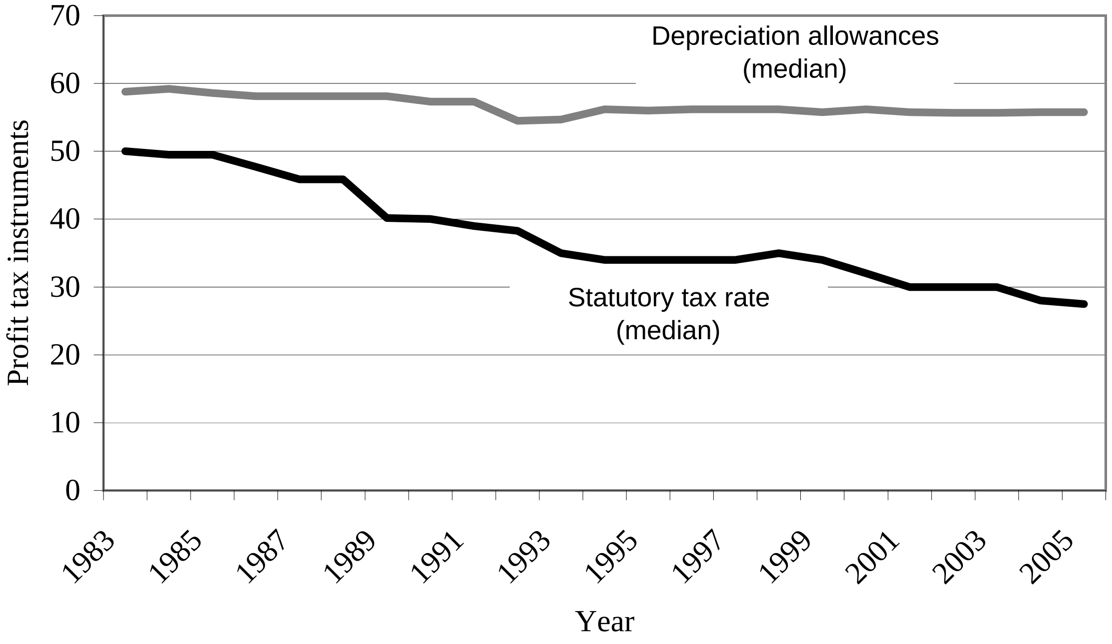

Figure 2 - Evolvement of profit tax instruments in a sample of 43 countries (average change)

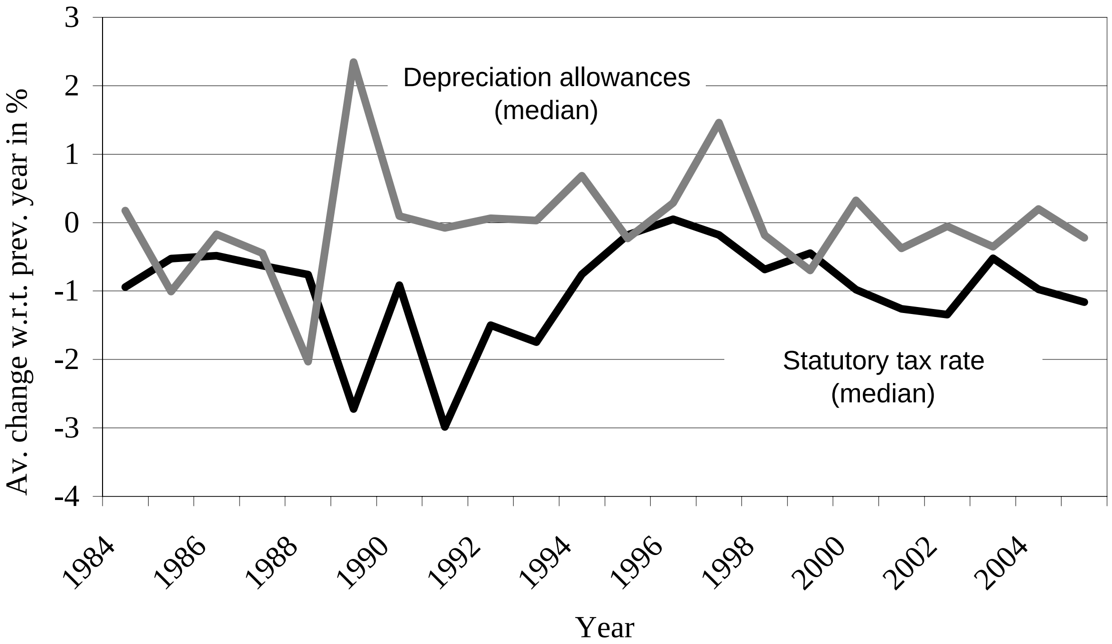

Table 1 - Descriptive statistics

Variable	Mean	Std.	Minimum	Maximum
Domestic statutory tax rate	34.855	10.863	10.000	65.000
Domestic depreciation allowance	43.637	10.585	1.691	98.309
Country size (log GDP)	25.491	1.957	21.322	30.028
Costs (log GDP-per-capita)	2.228	0.112	1.864	2.435
Trade costs (log index value)	-1.375	0.146	-1.688	-0.911

Notes: 749 observations; 43 countries.

Table 2 - Reaction function estimation for coporate tax rates and depreciation allowances

Explanatory variable		Dependent variable is: Domestic statutory tax rate				Domestic depreciation allowances			
		Theory	Coef.	Std.[a)]	Std.[b)]	Theory	Coef.	Std.[a)]	Std.[b)]
Foreign statutory tax rate	(1)	+	0.246	0.166	0.134 *	-	-0.438	0.128	0.157 ***
Foreign depreciation allowance	(2)	-	-0.439	0.119	0.099 ***	+	0.311	0.088	0.105 ***
Country size (log GDP)	(3)	+	0.100	0.037	0.027 ***	+	0.194	0.050	0.035 ***
Costs (log GDP-per-capita)	(4)	-	-0.411	0.130	0.123 ***	-	-0.851	0.223	0.161 ***
Trade costs (log index value)	(5)	+	0.188	0.051	0.048 ***	-	-0.075	0.037	0.062
Observations			749				749		
Countries			43				43		
Estimation method			IV-2SLS				IV-2SLS		
Instrumentation:									
Shea's partial R^2 for identifying instruments to explain (1)			0.408				0.669		
Shea's partial R^2 for identifying instruments to explain (2)			0.384				0.592		
Over-identification (p-value of Sargan's χ^2-statistic)			0.226				0.169		
Exogeneity of (1) and (2) (p-value of Hausman-Wu-test)			0.000				0.000		
Fixed country effects (p-value of F-test)			0.000				0.000		

Notes: *** significant at 1%; * significant at 10%. - a) Newey-West-type standard errors which are robust to heteroskedasticity and autocorrelation. - b) Driscoll and Kraay-type standard errors which are robust to serial and spatial autocorrelation.

Table 3 - Sensitivity analysis

Explanatory variable		Domestic statutory tax rate Coef.	Std.[a)]		Domestic depreciation allowances Coef.	Std.[a)]	
		Using population instead of real GDP to measure country size					
Foreign statutory tax rate	(1)	0.188	0.104	*	-0.419	0.136	***
Foreign depreciation allowance	(2)	-0.440	0.101	***	0.260	0.085	***
		Using wages instead of GDP per capita to measure production costs					
Foreign statutory tax rate	(1)	0.080	0.136		-0.422	0.159	***
Foreign depreciation allowance	(2)	-0.373	0.104	***	0.287	0.104	***
		Using log c.i.f./f.o.b. ratios as a measure of trade costs (s)					
Foreign statutory tax rate	(1)	0.317	0.068	***	-0.226	0.063	***
Foreign depreciation allowance	(2)	-0.645	0.077	***	0.187	0.038	***
		Using contiguity weights to aggregate third-country tax parameters					
Foreign statutory tax rate	(1)	0.326	0.121	***	-0.370	0.047	***
Foreign depreciation allowance	(2)	-0.511	0.077	***	0.105	0.027	**
		Using natural trade weights to aggregate third-country tax parameters					
Foreign statutory tax rate	(1)	0.134	0.052	***	-0.616	0.080	***
Foreign depreciation allowance	(2)	-0.553	0.141	***	0.258	0.054	***
		Using natural FDI weights to aggregate third-country tax parameters					
Foreign statutory tax rate	(1)	0.375	0.094	***	-0.936	0.125	***
Foreign depreciation allowance	(2)	-0.555	0.079	***	0.433	0.049	***

Dependent variable is: Domestic statutory tax rate / Domestic depreciation allowances.

Notes: *** significant at 1%; * significant at 10%. - a) Driscoll and Kraay-type standard errors which are robust to serial and spatial autocorrelation.

Table 4 - Simulation experiments to assess the impact of 'shocks' in profit tax instruments across countries

		Statutory corporate tax rates **t**			Depreciation allowances **a**		
		(1)	(2)	(3)	(4)	(5)	(6)
Country	**Country group**	Competition multiplier effect for 'world-wide' increase in **t**	Shock within EU in % equiv. to harmonization twd. EU median of **t**	Induced change on **t** in %	Competition multiplier effect for 'world-wide' increase in **a**	Shock within EU in % equiv. to harmonization twd. EU median of **a**	Induced change on **a** in %
Austria	European Union	0.83	1.00	0.93	0.91	4.28	3.60
Belgium	European Union	1.02	-7.99	-8.02	1.07	-8.78	-8.34
Bulgaria	European Union	1.02	11.00	10.91	1.05	-1.03	-0.84
Cyprus	European Union	1.00	16.00	16.00	1.00	5.64	5.64
Czech Republic	European Union	0.96	0.00	-0.19	0.98	4.57	4.59
Denmark	European Union	1.00	-2.00	-2.00	1.01	-0.79	-0.79
Estonia	European Union	1.00	2.00	1.87	1.04	55.66	51.06
Finland	European Union	0.98	0.00	0.06	1.03	0.00	6.35
France	European Union	1.00	-7.83	-7.81	1.02	-3.06	-3.21
Germany	European Union	0.99	-10.38	-10.17	1.03	4.08	3.87
Greece	European Union	1.00	-6.00	-6.00	1.00	-3.88	-3.88
Hungary	European Union	0.90	10.00	9.62	0.94	7.41	7.25
Ireland	European Union	1.00	13.50	13.49	1.00	3.16	3.16
Italy	European Union	1.00	-11.25	-11.26	1.00	-1.68	-1.71
Latvia	European Union	1.01	11.00	11.16	1.03	-6.64	-6.31
Lithuania	European Union	1.02	11.00	11.21	1.03	-12.63	-12.77
Luxemburg	European Union	1.00	-4.38	-4.53	1.04	-0.54	-0.78
Malta	European Union	1.00	-9.00	-9.00	1.00	2.38	2.38
Netherlands	European Union	0.99	-4.50	-4.69	1.03	1.92	1.72
Poland	European Union	1.00	7.00	7.05	1.01	9.57	9.49
Portugal	European Union	1.00	-1.50	-1.52	1.00	-2.81	-2.81
Romania	European Union	1.01	10.00	10.12	1.01	11.23	11.20
Slovak Republic	European Union	0.84	7.00	5.91	0.91	-1.71	-0.57
Slovenia	European Union	0.96	1.00	0.62	1.00	-20.09	-19.34
Spain	European Union	1.00	-9.26	-9.26	1.00	3.99	3.98
Sweden	European Union	1.01	-2.00	-1.98	1.01	-2.46	-2.36
United Kingdom	European Union	1.00	-4.00	-3.99	1.01	1.13	1.04
Albania	Other Europe	1.01	0.00	-0.13	1.04	0.00	-0.02
Croatia	Other Europe	0.96	0.00	-0.19	1.00	0.00	-1.81
Iceland	Other Europe	1.00	0.00	0.00	1.00	0.00	0.00
Makedonia	Other Europe	1.05	0.00	0.40	1.08	0.00	-0.07
Norway	Other Europe	1.01	0.00	-0.01	1.01	0.00	-0.02
Russia	Other Europe	1.00	0.00	0.00	1.00	0.00	0.00
Switzerland	Other Europe	1.00	0.00	0.00	1.01	0.00	-0.03
Turkey	Other Europe	1.00	0.00	0.04	1.01	0.00	0.04
Ukraine	Other Europe	1.00	0.00	0.01	1.00	0.00	-0.01
Australia	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
Canada	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
Japan	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
Korea, Rep.	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
Mexico	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
New Zealand	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
United States	Non-Europe	1.00	0.00	0.00	1.00	0.00	0.00
;							
Total		0.99	0.47	0.43	1.01	1.14	1.16
European Union		0.98	0.76	0.69	1.01	1.81	1.91
Other Europe		1.00	0.00	0.01	1.02	0.00	-0.21
Non-Europe		1.00	0.00	0.00	1.00	0.00	0.00