Testing the Tax Competition Theory: How Elastic are National Tax Bases in OECD Countries?

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Abstract

To what extent do countries' corporate income tax (CIT) rates attract foreign tax bases? What are the revenue implications of a unilateral tax reduction when tax bases are internationally mobile? These questions are explored using a panel of annual data from 17 OECD countries spanning the period 1982 to 2005. We find significant international fiscal externalities in the form of CIT-induced resource flows. The magnitude, however, indicates that the extent of international corporate tax base mobility is rather modest. Moreover, we find that, on average, a unilateral CIT reduction results in a less-than-proportional increase in the CIT base, thus reducing CIT revenues. The results are robust across a wide range of specifications and point to potential gains from international tax policy coordination.

JEL Code: H71, H77, H87, C23.

Keywords: tax competition, corporate income tax base elasticity, instrumental variables, international fiscal externalities, Laffer curve, panel data estimation.

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1 Introduction

Based on the early theoretical models of Zodrow and Mieszkowski (1986) and Wilson (1986), it has been recognized that national authorities are increasingly affected by policy measures in neighboring countries. The rise in international investment opportunities as well as the growing role of multinational corporations and their tax planning have placed the spotlight on corporate income taxation as a strategic instrument used by policymakers to attract mobile capital. Theoretical models of tax competition predict that countries mutually undercut each others' tax rates on mobile tax bases in order to avoid an outflow of taxable income. As the chart on the left in figure 1 shows, both the statutory and the *effective average* corporate income tax rate (EATR) have declined sharply in a large selection of OECD countries. [1]

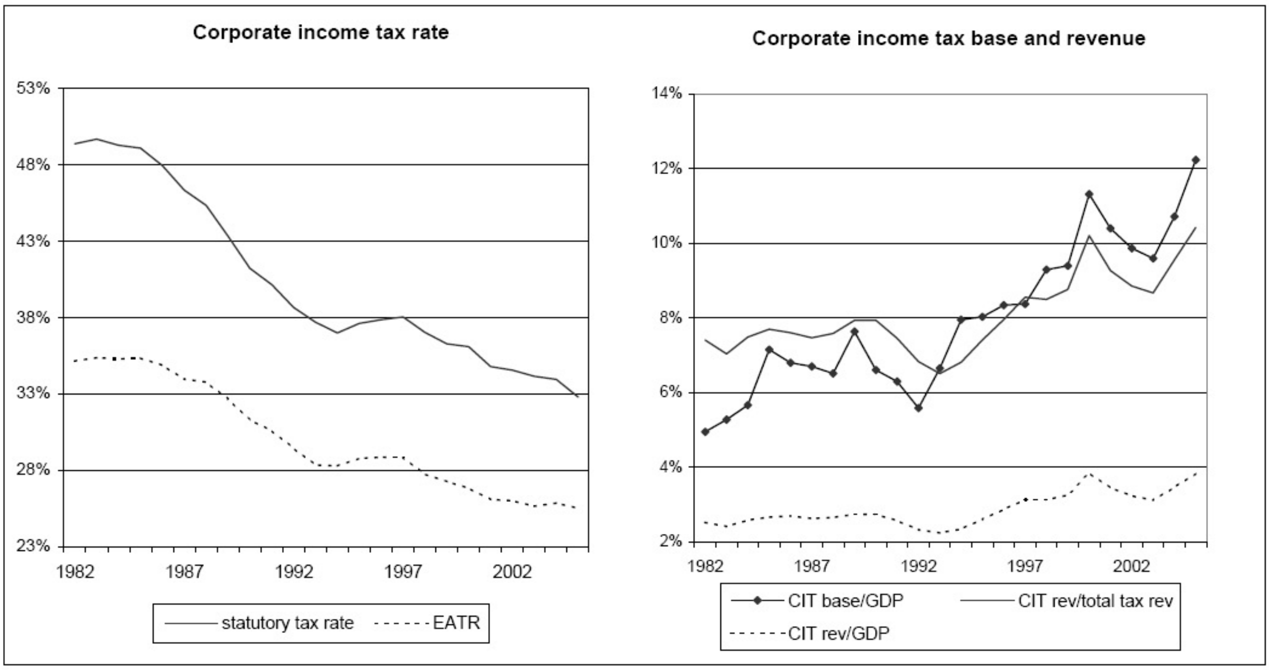

Fig. 1. Yearly average corporate income tax (CIT) rate, base, and revenue (rev) in 17 OECD countries, 1982-2005. The EATR corresponds to the base case measure in Devereux and Griffith (2003). Data sources: See appendix C.3.

The observed downward trend is often regarded as a reflection of governments' mutual responses to tax reductions. Indeed, for a sample of 21 OECD countries, Devereux et al. (2008) find evidence of strategic interaction among governments' CIT policies between 1982 and 1999. Their approach involves estimating a reaction function, which reflects how a given country's tax

[1] The countries in question are listed in section 3.

policy responds to neighboring countries' tax policies. Yet, as Brueckner (2003) rightly points out, "reliable estimates of reaction-function parameters [...] do not directly reveal the nature of the behavior underlying the observed interaction".[2] In particular, it is not clear whether the driving force behind the trend in tax rates is a consequence of tax competition or whether tax mimicking behavior motivated by yardstick competition (Besley and Case, 1995) is at the heart of this development.[3] Brueckner (2003) demonstrates that a nonzero slope for a tax reaction function could reflect either of these strategic incentives. In order to address this issue, Devereux et al. (2008) show that the slope of the tax reaction function parameter is only significant for open economies (i.e. those without capital controls in place), which can be seen as an indication for the existence of tax competition.

This paper goes one logical step backwards and asks the more fundamental question of whether, as assumed in tax competition models, domestic tax bases do vary with foreign tax rates at all. More precisely, if governments' budgets are indeed affected by each other's taxes on mobile resources, we should find that the domestic tax base is negatively affected by the domestic tax rate and positively affected by neighboring countries' tax rates. Based on a panel of annual data from 17 OECD countries spanning the period 1982 to 2005, our results clearly confirm these predictions. As such, the observed tax rate interdependence among OECD countries, which has been measured in the form of tax reaction functions in recent empirical papers, can be explained in part by the existence of fiscal externalities as stated in classic tax competition theory.

Our work also contributes to the small and controversial body of empirical literature on the relationship between corporate tax rates and corporate tax revenues. One key result in the theory of tax competition is that strategic tax setting behavior leads to an equilibrium with inefficiently low tax rates and revenues, and thus to an underprovision of public services. At first sight, the data seems to contradict this idea. The chart on the right in figure 1 shows that between 1982 and 2005 average CIT revenues rose by 52% as a share of GDP and by 41% as a share of total tax revenues. Obviously, changes in tax revenues depend not only on changes in tax rates but also on changes in the level of taxable reported income, that is, the tax base. As shown in the same plot, the average CIT base increased by 147% as a portion of GDP.[4] In order to assess the extent to which tax competition affects individual countries' tax revenues, it is necessary to estimate the sensitivity of reported taxable profits to the domestic tax rate, while controlling for the effects of fiscal policies pursued in neighboring countries.

[2] Griffith and Klemm (2004) and Revelli (2005) also discuss this issue.

[3] Yet another reason for the trend in falling tax rates, albeit not necessarily related to strategic interaction, could be the presence of dominant economic thinking (i.e. a "common intellectual trend") among policymakers, leading to a convergence in economic structures.

[4] For a definition of the corporate income tax base measure, refer to section 3.1.

To our knowledge, only two studies have estimated aggregate CIT base elasticities with respect to domestic CIT rates. Both focus on a single country. Specifically, Gruber and Rauh (2007) use accounting data of publicly traded US C corporations between 1960 and 2003 and report an elasticity of of -0.2 for taxable corporate profits with respect to a measure of the domestic marginal effective CIT rate. Dwenger and Steiner (2008) construct a pseudo-panel from German corporate tax return micro data and estimate an elasticity of approximately -0.5 for corporate taxable income with respect to a backward-looking measure of the average effective domestic CIT rate for the years 1998-2001. Roughly speaking, the common implications of these results are that a reduction in the domestic tax rate results in a less-than-proportional increase in the tax base, thus, leading to lower tax revenues.

These estimates are challenged to a certain extent by Clausing (2007), who uses a sample of 29 countries between 1979 and 2002 and reports a revenue-maximizing statutory CIT rate of 33%, implying that tax rate reductions from levels above 33% should, on average, have led to higher tax revenues. [5]

It is worth noting that the studies mentioned so far ignore tax rate externalities across countries. The economic literature mainly discusses three forms of international tax base mobility, namely foreign direct investment (e.g. Hines, 1999), foreign portfolio investment (e.g. Desai and Dharmapala, 2007), and income shifting. Income shifting, in turn, may occur at the domestic level through the choice of legal form – specifically through the choice of incorporation – (e.g. Gordon and MacKie-Mason, 1995) or at the international level, for example via the manipulation of transfer prices (e.g. Clausing, 2003) or via debt shifting (e.g. Huizinga et al., 2008).

Using sectoral data for a group of OECD countries from 1979 to 1997, Bartelsman and Beetsma (2003) develop a novel method for isolating the pure effects of tax-induced income shifting by controlling for the effects of taxes and unobserved productivity on the scale of real economic activity. They identify considerable international profit shifting and thus conclude that a unilateral reduction in the statutory corporate tax rate leads to an *increase* in corporate tax revenues. Yet, as the authors suggest, the reported findings are likely to overestimate the extent of income shifting at the aggregate level because their estimates are based only on the manufacturing sector, which is largely dominated by multinational enterprises (MNEs).

In contrast to Bartelsman and Beetsma, we do not analyze particular sectors nor a particular channel through which revenue might leak away in the wake of a tax rate increase. Instead, we take a macro-economic perspective, focusing on the impact of domestic and foreign corporate income taxation on the *aggregate* domestic level of corporate taxable profits. Such an approach

[5] This result is derived from the estimation of CIT revenues on the domestic statutory CIT rate and its square, as well as other determinants for the overall economic and corporate activity that serve as a proxy for the CIT base.

implicitly accounts for the fact that not all companies have the opportunity to engage in international activities intended to circumvent higher taxes and allows to draw conclusions on how tax rate reductions affect governments' budgets. In doing so, we build upon previous work by Devereux and Griffith (2003), Devereux et al. (2002) and Devereux et al. (2008) who develop various effective CIT rate measures for a large group of OECD countries over the period from 1982 to 2005. Among other important features, these tax rates allow to control for tax base broadening reforms.

Our baseline estimation results reveal that in the long run a 1% reduction in the effective average domestic CIT tax rate leads to a 0.7% increase in domestic reported corporate taxable profits.[6] In an extensive robustness analysis, we show that, depending on the definition of CIT rates and the econometric specification applied, CIT base elasticities range between −0.6 and −0.9. We thus conclude that, for the time period 1982 to 2005, CIT rates on average have not been on the downward-sloping part of the Laffer curve. In other words, we do not find a negative relation between CIT rates and CIT revenues. Thus, we can conclude that the trend toward falling CIT rates did not contribute to the rise in the average CIT revenues observed in OECD countries between 1982 and 2005.

The remainder of the paper is organized as follows. In the next section, we review the theoretical background and present the econometric model. In section 3, we describe the data and the motivation for its use. Section 4 discusses relevant estimation issues. Finally, in section 5 we present the main results, which are followed by a thorough robustness analysis. We discuss our conclusions in section 6.

2 The model

2.1 Fiscal externalities

Since the primary purpose of this study consists in empirically identifying the presence and magnitude of horizontal fiscal externalities predicted by the classic tax competition theory (e.g. Zodrow and Mieszkowski, 1986), we review those aspects of the underlying theory that are directly relevant to our subject, namely the mechanism by which tax competition affects an internationally mobile tax base.

The standard model describes a situation in which small and identical countries within a union

[6] Expressed in terms of semi-elasticity, this translates into a 1% increase in the CIT base in response to a 1 percentage point cut in the CIT rate.

compete for capital by setting their tax rates in a strategic manner. In each country, competitive firms produce a homogeneous good, whose price is normalized to unity, using internationally mobile capital and inelastically supplied, immobile labor as inputs. The output is partly intended for private consumption and partly transformed into a public good. Each government in country i, $i = 1, ..., n$, maximizes its residents' welfare by independently setting a source-based tax rate, τ_i, on each unit of capital employed within its jurisdiction in order to finance the public good. Let k_i represent capital per worker in i and $f(k_i)$ denote the intensive form of the production function with the usual properties $f'(k_i) > 0$ and $f''(k_i) < 0$. Profit maximization by producers implies that the marginal product of capital corresponds to the producer price of capital, that is, the sum of the interest rate and the tax rate. One central assumption is that the worldwide level of capital, K^*, is fixed, that is, $\sum_{i=1}^{n} k_i = K^*$, but at the same time it is mobile across jurisdictions. In effect, perfect capital mobility implies that the arbitrage behavior of investors results in an equalization of net-of-tax returns across countries. Assuming a two-country world, the distribution of capital must therefore satisfy

$$f'(k_i) - \tau_i = f'(k_j) - \tau_j = \rho, \qquad i \neq j \tag{1}$$

where ρ is the net return. Therefore, the national capital stock is a function of a country's own national tax rate and the tax rate in the neighboring country, that is, $k_i = k(\tau_i, \tau_j)$. Specifically, implicit differentiation of equation (1) yields

$$\frac{\partial k_i}{\partial \tau_i} = \frac{1}{f''(k_i) + f''(k_j)} < 0 \qquad i \neq j \tag{2}$$

and

$$\frac{\partial k_i}{\partial \tau_j} = -\frac{\partial k_i}{\partial \tau_i} > 0 \qquad i \neq j \tag{3}$$

Hence, the distribution of the world's capital stock among countries is affected by the tax policies of all national governments: an increase in the domestic tax rate raises the cost of capital, leading to a capital outflow, while an increase in a neighboring country's tax rate leads to a higher domestic capital stock.

2.2 Implications for tax revenues

In order to assess how a unilateral change in the tax rate affects a country's tax revenue within the context of tax competition, it is crucial to use an estimate of the tax sensitivity of the capital stock, as given by equation (2). Given that the revenues from capital taxation in country i are

$rev_i = \tau_i k_i$, the effect of a change in the tax rate on tax revenues is

$$\frac{\partial rev_i}{\partial \tau_i} = k_i \Big[1 + \frac{\partial k_i}{\partial \tau_i} \frac{\tau_i}{k_i} \Big] \tag{4}$$

Clearly, the magnitude of the tax base elasticity, $\epsilon_i \equiv \frac{\partial k_i}{\partial \tau_i} \frac{\tau_i}{k_i}$, determines the sign of expression (4): If the capital stock is inelastic with respect to the domestic tax rate ($-1 < \epsilon < 0$), a unilateral tax reduction leads to a less-than-proportional increase in the capital stock, and therefore lower tax revenues; on the other hand, elastic capital implies that a corresponding tax reduction increases tax revenues, that is,

$$\frac{\partial rev}{\partial \tau_i} \left\{ \begin{matrix} > \\ = \\ < \end{matrix} \right\} 0 \quad \text{for} \quad \epsilon_i \left\{ \begin{matrix} > \\ = \\ < \end{matrix} \right\} -1 \tag{5}$$

2.3 The econometric specification

The empirical setting aims to test the predictions given in equations (2) and (3), namely that a country's capital stock is negatively influenced by the domestic capital tax rate and positively affected by competing countries' tax rates.[7] Moreover, based on the estimated elasticity of the tax base, we will assess the influence of domestic tax policy on tax revenues (equation (4)), while controlling for international fiscal externalities.

The empirical specification deviates from the theoretical model in two aspects. First, given our special interest in the driving force behind the trend toward lower CIT rates, we consider only that part of the capital stock that is subject to domestic corporate income taxation. Hence our independent variable is the CIT base per capita, κ_{it}. Second, we specify a dynamic rather than a static framework in order to account for the persistence of CIT bases as well as the potentially complex timing of tax payments (cf. section 3.1). This allows us to assess the long-run impact of tax rate changes on the CIT base, which is likely to deviate from the short-run impact as firms may not adjust to new policies immediately. We estimate the following tax base equation:

$$\ln\kappa_{it} = \lambda_0 + \rho \ln\kappa_{it-1} + \lambda_1 \ln\tau_{it} + \lambda_2 \ln\overline{\tau}_{it} + X_{it}\,\lambda_x + Z_i\,\mu + \Theta_i\,\psi + \epsilon_{it} \tag{6}$$

[7] The econometric specification is related to the approach in Brett and Pinkse (2000) and Buettner (2003), who investigate tax competition between jurisdictions at the subnational level.

where the subscripts i and t denote the country dimension $i, j = 1, 2, ...n$ and the time dimension $t = 1, 2, ..., T$, respectively. Our main objective is to assess whether and to what extent the CIT base depends on the domestic tax rate, τ_{it}, and all competing countries' tax rates, $\overline{\tau}_{it}$, where the latter variable is the average of all but i's countries' tax rates. [8] Formally,

$$\overline{\tau}_{it} = \sum_j \omega_{ij}\tau_{jt} \quad \text{with} \quad \omega_{ij} = \begin{cases} \frac{1}{n-1}, & \text{for } j \neq i \\ 0, & \text{otherwise.} \end{cases}$$

If taxable profits are indeed mobile and attracted by lower CIT rates, a fall in a neighboring country's tax rate would result in a decrease in the domestic tax base. This should be reflected by a significantly positive coefficient on $\overline{\tau}_{it}$. By contrast, the CIT base effect of an increase in the domestic tax rate, τ_{it}, is expected to be negative. The tax base as well as both tax rate variables are employed in logarithmic form, so that the coefficients λ_1 and λ_2 can be interpreted as elasticities. Given our specification, the long-run impact of the domestic tax rate on the CIT base is given by $\widetilde{\lambda_1} = \frac{\lambda_1}{1-\rho}$, while the respective impact of the foreign tax rate is $\widetilde{\lambda_2} = \frac{\lambda_2}{1-\rho}$. [9]
In addition to tax rates, we include other country-specific time-varying factors (X_{it}) that are likely to influence the CIT base. These and all other employed variables are discussed in section 3.

Our specification includes unobserved individual effects (Z_i) that are specified to be fixed parameters, as we are interested in exploiting the *within*-country dimension of the data, that is, the impact of tax rate changes on each country's tax base over time. [10] This is crucial because any cross-section variability would relate country i's tax base, κ_{it}, to country j's tax rate, τ_{jt}, — a link that is only supposed to be reflected by the weighted neighboring countries' tax rate variable $\overline{\tau}_{it}$. Thus, in order to separately identify the impact of the domestic tax rate and the weighted neighboring countries' tax rate on the domestic CIT base, any cross-section variability (exploited by the random-effects estimator, for example) is ruled out. Following the same line of argument, we do not implement time dummies, but instead employ individual country time

[8] Since the number of individual tax base elasticities with respect to each neighboring country's tax rate exceeds the degrees of freedom available, we follow the literature (see e.g. Anselin, 1988; Buettner, 2003; Devereux et al., 2008) and posit a weighting structure of dependence between countries. In the baseline setting we assume symmetry between all countries and assign equal weights to each competing country's tax rate (see e.g. Devereux et al., 2008). In the robustness analysis we will deviate from this assumption and employ another weighting concept frequently employed in the tax competition literature.

[9] For a detailed study on long-run dynamics in panel data, see e.g. Hendry, 1995.

[10] We accomplish this by applying the Least Squares Dummy Variable (LSDV) estimator. Details on the estimation technique are provided in section 4.

trends to capture unobserved effects varying over time (see e.g. Devereux et al., 2008).[11]

3 Variables and sampling data

We use annual data from 1982 to 2005 for a panel of 17 OECD countries for which effective CIT rate and CIT revenue data is available, namely, Australia, Austria, Belgium, Canada, Switzerland, Germany, Spain, Finland, France, Greece, Ireland, Italy, Japan, The Netherlands, Norway, Sweden, the United Kingdom and the United States of America.[12] Unfortunately, we cannot include eastern European countries in our sample because data on CIT revenues is not available for the time period in question. However, in a robustness check (section 5.2), we address the presumption that these countries may have influenced tax competition in western Europe after the fall of the Iron Curtain. Summary statistics are provided in appendix C.1.

3.1 The dependent variable

The dependent variable is the CIT base, that is, the amount of firms' profits subject to the nominal CIT rate. Since tax revenues are the product of the effective tax base and the applicable statutory tax rate, we follow Buettner (2003) and calculate the CIT base by dividing tax revenues from corporate profits by the relevant statutory tax rate. The revenue data was retrieved from the OECD's Revenue Statistics and is reported partly on a cash basis and partly on an accrual basis. According to the cash principle, tax revenues are recorded at the time at which the tax liability is paid. Since tax liabilities are usually paid with a one-year delay (Devereux and Klemm, 2004), we specify the tax base as $\kappa_{it} = CITrev_{it+1}/\tau_{it}$ when the data is based on the cash principle. Tax revenues reported on an accrual basis are recorded when the liability is created. In that case, we define the tax base as $\kappa_{it} = CITrev_{it}/\tau_{it}$.[13] Despite the

[11] Note also that in a setting where equal weights are assigned to each country's tax rate, time dummies cannot be identified separately (see Devereux et al., 2008).
[12] We had to exclude Ireland from our sample because its CIT rate has hardly changed over the observed time period. Specifically, Ireland stands out from the other countries in that it introduced a low CIT rate in 1981 which remained virtually unchanged thereafter, suggesting that it has not actively engaged in competition for capital via tax rates. Technically, the low tax rate variability over time creates collinearity problems within a fixed-effects setting. However, we do consider Ireland's tax rate in the vector of neighboring countries' tax rates throughout all specifications in order to control for its impact on the CIT bases of the remaining 17 countries.
[13] Note that by applying a dynamic panel approach, we also account for more complex timing peculiarities of tax payments, such as payments in advance, losses carried forward and refunds.

fact that the OECD recording system has changed in some countries during the time period in question, a visual inspection shows that no structural breaks are present in the constructed tax base series. Moreover, the inclusion of an appropriate dummy variable that controls for the time of the change in the recording system proves to be insignificant and does not alter our results.

In line with the theoretical model, we specify the CIT base in per capita terms. Due to several missing data points for tax revenues, the panel comprises a total of 393 observations.

3.2 The tax rate variable

The independent variable of main interest is the tax rate on corporate profits. In order to capture the behavioral responses of firms to a country's and its neighbors' tax policies, we employ tax rate measures which are exclusively based on tax laws rather than implicit tax rates. Since the latter are basically calculated by dividing revenues from taxes on capital income by a measure of capital income, that is, the aggregate operating surplus from national accounts data, implicit tax rates are strongly affected by the business cycle and rarely indicate changes in tax laws (Devereux and Klemm, 2004). For this reason, we employ the forward-looking effective average tax rates (EATR) provided by Devereux et al. (2002). This measure captures both instruments that governments have at their disposal to determine the CIT system, namely the statutory tax rate and the set of rules that specify the extent to which profits are subject to taxation. Specifically, the EATR depends on the assumptions imposed on a hypothetical investment on which the legal parameters of the tax system are applied, such as the profit rate, the form of finance and the type of investment. Importantly, by using the EATR rather than the statutory tax rate, we rule out the possibility that the coefficients λ_1 and λ_2 in equation (6) measure the implications of changes in statutory tax rates while ignoring other alterations in tax code reforms, such as changes in deduction schemes.

As shown in Devereux and Griffith (2003), the EATR covers the full spectrum of effective taxation from investment projects with very low to very high rates of profitability. In the baseline specification we employ the base case measure defined in Devereux and Griffith (2003), which assumes a hypothetical investment in plant and machinery yielding an economic profit rate of 10%.[14] However, in section 5.2 we will check the robustness of our results to a wide scope of definitions of effective taxation, including effective marginal and statutory tax rates. Note that the latter may also be relevant because changes in statutory tax rates may provide a

[14] Additional assumptions: 12.25% true economic depreciation; 10% real interest rate and 3.5% inflation rate. For details, see Devereux and Griffith (2003).

powerful incentive for pure accounting income shifts, which are particularly relevant in the case of MNEs (Bartelsman and Beetsma, 2003). In effect, if MNEs are able to exploit all potential deductions and allowances in each of their affiliates, their excess income is taxed at the statutory tax rate.

3.3 Control variables

In addition to the domestic and foreign CIT rates and the legal parameters of the tax system, we expect countries' reported profits to be positively determined by the volume of sales and negatively affected by input costs. Therefore, we add income per capita and real unit labor costs, denoted by *income* and *rulc*, respectively, to our list of regressors. [15] Note that rulc is the total remuneration (in cash or in kind) payable by an enterprise to an employee in return for work done and hence includes e.g. social contributions, income taxes, cash allowances, overtime pay and bonuses. Furthermore, profitability is likely to be affected by the business cycle (see e.g. de Mooij and Nicodème, 2008), which we control for by including the growth rate of real GDP. In a recent paper, Fryges and Wagner (2008) demonstrate that exporting has a positive causal effect on the profitability of enterprises in the manufacturing sector. In order to capture this potential positive effect on profits, we also consider a country's exports of goods and services as a share of GDP. Moreover, as profits can also increase simply due to an increase in prices, we include inflation as a control variable. Finally, several recent contributions have suggested that the tax gap between the top personal income tax (PIT) and the CIT rate exerts a significant positive effect on the degree of incorporation, thus raising CIT revenue at the expense of PIT revenue (Mackie-Mason and Gordon, 1997; de Mooij and Nicodème, 2008). Hence, we will test whether, all other things being equal, an increase in the top PIT rate has the expected positive effect on aggregate reported profits.

[15] Ideally, one would include a variable measuring the size of the corporate sector. However, reliable and comparable data reflecting the degree of incorporation at the aggregate level is not available. Nevertheless, given the national account definition of GDP, a decrease in the wage share, ceteris paribus, implies an increase in operating surplus. Hence the inclusion of real unit labor costs at least partly captures changes in the size of the corporate sector.

4 Estimation

In order to obtain reliable parameter estimates for the model given in equation (6), three basic econometric issues have to be considered. First, the empirical setting is a dynamic panel specification where the autoregressive variable κ_{it-1} is potentially endogenous. Second, it follows from the theoretical model that the domestic CIT base and both CIT rate variables are simultaneously determined such that the two variables of main interest,τ_{it} and $\overline{\tau}_{it}$, are expected to be endogenous as well. Finally, the disturbances are likely to follow a spatial pattern due to similar geographical conditions in adjacent countries (Brueckner, 2003). This has to be taken into account in order to obtain correct standard errors. We will consider these issues in turn.

The choice of an adequate estimator for a dynamic panel data specification crucially depends on the size of the time (T) and cross-section (N) dimensions. While the one-step and two-step GMM estimators proposed by Arellano and Bond (1991) perform quite well in large N and small T samples, they were found to be a less favorable choice when T increases. In particular, Judson and Owen (1999) use a Monte Carlo simulation to show that the Least Squares Dummy Variable (LSDV) estimator outperforms the common alternatives in panel data sets with T=30, as the Nickell bias becomes negligible (Nickell, 1981).[16] However, the question whether the LSDV estimator is the appropriate choice in our setting (where T=24 and N=17) cannot be answered in a straightforward manner. This is because the performance of the estimator depends on various other characteristics of the data generating process, such as the size of the autoregressive parameter, the relative size of T and N, and the degree of unbalancedness. Furthermore, as we are primarily interested in the long-run estimates, which are non-linear transformations of the original parameter estimates, we perform a corresponding Monte Carlo simulation for a long-run parameter of interest in order to ensure that the LSDV estimator does not suffer from a non-negligible bias. Thus, we sample from a distribution that most closely matches the characteristics of our dataset. For details on the simulation design please refer to appendix A. The results obtained from 2000 sample draws reveal that the LSDV estimator is an appropriate choice for our analysis, as the bias turns out to be extremely small, that is, around 2% of the true value.

A second crucial issue that needs to be addressed is the endogeneity of the CIT rate variables. One standard method for dealing with this problem is to apply instrumental variables

[16] This comparison refers to an unbalanced panel data set where the estimators under consideration are the one-step and two-step GMM estimators proposed by Arellano and Bond (1991), the Anderson-Hsiao (1981) estimator and the LSDV estimator. Moreover, the comparison only refers to the autoregressive parameter, as the bias of the exogenous regressors was too small to be compared between the different estimators.

(IV) techniques to exogenize the fiscal variables in an initial step. Estimates obtained under IV methods are particularly sensitive to the choice of instruments in that their consistency depends heavily on the degree of instrument relevance, that is, the correlation between instruments and explanatory variables (see e.g. Staiger and Stock, 1997, and Stock and Yogo, 2002). A commonly used instrument which might explain a large part of the variation is the lag of the endogenous variable. As the CIT rate is highly persistent, we employ one-year lags of the domestic and foreign countries' tax rates (see e.g. Buettner, 2003). In addition, we consider the unemployment rate as a potential instrument for the domestic tax rate, since policymakers frequently justify tax reduction reforms as a means of attracting physical capital in order to combat unemployment. Accordingly, a rise in the fraction of jobless residents may strengthen a government's motivation to lower the corporate tax rate so as to stimulate investment and to reduce firms' incentives to relocate abroad. Unfortunately, tests for weak instruments are not available for the case of non-iid errors. We therefore report the rk Wald F-statistic proposed by Kleibergen and Paap (2006) as the robust analog of the Cragg-Donald statistic and rely on the rule of thumb proposed by Staiger and Stock (1997) that the F-statistic should exceed 10 to avoid weak identification problems. Employing only the lagged tax rates and the unemployment rate results in fairly large F-statistics, indicating a high partial correlation.[17] Additionally, we report the Hansen J-statistic of overidentifying restrictions which indicates that the applied instruments are uncorrelated with respect to the remainder error in equation 6.

Lastly, we need to address the estimation of standard errors. A Breusch-Pagan LM test (see e.g. Greene, 2000) rejects the hypothesis of cross-sectional independence between the error terms. Hence, for the sake of obtaining reliable standard errors, we have to consider the spatial structure of the innovations. The conventional method of accounting for interdependence in the errors across individuals involves imposing a spatial covariance structure by means of a weighting matrix specified a priori (see e.g. Anselin, 1988). However, as we have no information on the nature of interactions across space concerning the innovations, we obtain robust standard errors using bootstrapping techniques. In this way, we control for heteroscedasticity and contemporaneous correlation of arbitrary form.[18] This method also enables us to calculate the standard errors of the long-run parameter estimates, where the calculated statistic from

[17] Note that in several studies on tax competition various other instruments for tax rates such as budget deficits, lagged population and lagged employment have also been employed. Including these variables in our list of instruments would cause severe finite sample biases in our two-stage least squares procedure, as it increases the number of overidentifying restrictions (see e.g. Wooldridge, 2003).

[18] Specifically, we resample the data set 200 times (random drawing with replacement) and apply the standard formula for the sample standard deviation given in Hall and Wilson (1991). The formula is given by $\widehat{se} = \left\{ \frac{1}{k-1} \sum (\widehat{\theta}_i - \overline{\theta})^2 \right\}^{1/2}$, where $\widehat{\theta}_i$ is the calculated statistic of the ith bootstrap sample, k equals the number of replications and $\overline{\theta} = \frac{1}{k} \sum \widehat{\theta}_i$.

the ith bootstrap sample in this case is a ratio of the respective tax rate parameter and the autoregressive parameter, that is, $\widetilde{\lambda_1} = \frac{\lambda_1}{1-\rho}$ and $\widetilde{\lambda_2} = \frac{\lambda_2}{1-\rho}$.

5 Results

5.1 Baseline model

The estimation results reported in table 1 are based on the specification outlined in section 2.3. Column (1) presents the CIT base elasticities with respect to the domestic and the competing countries' CIT rates when no control variables are considered. The remaining columns include the estimation results when the proposed control variables are added one at a time. Note that, as argued in section 3.2, our specification is estimated using the base case measure of the EATR defined in Devereux and Griffith (2003). Moreover, the coefficients presented reflect long-run estimates, that is, a variable's cumulative impact on the CIT base over the entire time period. In order to get an idea of the short-run tax base elasticities, we report the untransformed estimates of specification (5) in appendix B. At the bottom of table 1 we report the p-values from Hansen J tests and rk Wald F values, indicating that the instruments in question are exogenous and do not suffer from a weak instrument problem.

As predicted by standard tax competition theory, the CIT base is negatively affected by a country's own tax rate, τ, whereas the coefficient on the weighted neighboring tax rate, $\overline{\tau}$, is positive. Hence, the results confirm that corporations clearly undertake efforts to compare national tax policies and that they react to international tax differentials. The estimated elasticities are statistically significant regardless of whether we control for potential influences on the CIT base other than tax rates. However, as column (3) reveals, the coefficients decrease in absolute value as we increase the number of regressors, especially when we consider real unit labor costs as a determinant of corporate profits. In general, a clear picture arises with respect to the impact of the control variables on the tax base. As expected, income per capita, growth and exports have a positive effect, whereas labor costs have a negative effect on the national tax base. Contrary to expectations, the top PIT rate is negatively, though insignificantly, related to the level of reported profits. Hence, while controlling for CIT rates, we find that the effect of the PIT has no apparent impact on incorporation activities – at least not to the extent that it could influence reported corporate profits at the aggregate level. Finally, inflation is also shown to be insignificant, which is not surprising given that the rise in prices is likely to be captured by the individual time trends employed. Consequently, we choose the specification in column

Table 1
Baseline estimates. Dependent variable: ln CIT base per capita

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln τ	-1.287*	-1.202**	-0.710*	-0.747**	-0.708**	-0.694*	-0.683**
	(0.689)	(0.481)	(0.384)	(0.358)	(0.349)	(0.355)	(0.338)
ln $\overline{\tau}$	4.968**	4.506***	2.758***	2.195**	2.142**	2.146**	1.994**
	(2.065)	(1.315)	(0.924)	(0.986)	(0.957)	(0.971)	(1.013)
ln income		0.320***	0.353***	0.350***	0.430***	0.427***	0.398***
		(0.068)	(0.046)	(0.044)	(0.063)	(0.063)	(0.068)
rulc			-0.026***	-0.020***	-0.020***	-0.020***	-0.019***
			(0.006)	(0.005)	(0.005)	(0.005)	(0.004)
growth				0.019**	0.016*	0.016*	0.028*
				(0.008)	(0.008)	(0.009)	(0.016)
ln exports					0.191*	0.189*	0.241**
					(0.105)	(0.105)	(0.117)
infl						-0.002	-0.003
						(0.006)	(0.005)
ln PIT							-0.100
							(0.076)
Constant	1.488	0.428	2.363***	1.481**	1.707***	1.737***	1.596***
	(1.129)	(0.700)	(0.723)	(0.645)	(0.609)	(0.616)	(0.605)
N	361	361	361	361	361	361	361
rk Wald F	67.093	77.077	81.533	78.619	77.141	71.756	71.426
Hansen J	0.484	0.599	0.843	0.590	0.778	0.861	0.847

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Notes: The estimates presented in columns (1) to (7) are based on a two-step LSDV procedure where the reported coefficients represent long-run results. In each specification, country-fixed effects as well as individual time trends are included. Standard errors are reported in parentheses and are based on bootstrapped samples. The tax rate variables correspond to the base case EATR measure in Devereux and Griffith (2003).

(5) as our preferred estimation, which will serve as a basis for our robustness analysis in section 5.2. Note that country-fixed effects and time trends are jointly highly significant in all models (not reported).

According to our preferred estimation, the long-run CIT base elasticity with respect to the domestic CIT rate is -0.71. This value implies that a country's unilateral CIT rate reduction of 1% boosts its corporate reported profits by 0.71% on average, thus ultimately leading to a *reduction* in its CIT revenues. Rephrased in terms of the semi-elasticity of the corporate tax base, a 1 percentage-point reduction in the CIT rate is associated with an increase in the corporate tax base by 1%.[19] The coefficient on the weighted neighboring countries' tax rate is 2.14. Taken literally, this value reflects the average percentage response of a country's tax base if *all* 16 neighbors simultaneously increase their tax rates by 1%. In order to obtain an estimate for the effect of an *individual* neighboring country j's tax rate on the tax base of country i, the estimated parameter must be multiplied with the respective weight, i.e., $\partial\kappa_{it}/\partial\tau_{jt} = \widetilde{\lambda_2}\,\omega_{ij}$ (Brueckner, 2003). Evaluated on the basis of the results reported in column (5), the elasticity

[19] The semi-elasticity is obtained by re-estimating our specification and employing tax rate variables in percentage-points rather than on a lograthmic scale.

amounts to $\frac{2.1420}{16} = 0.134$. Hence, on average, the impact on a country's tax base due to a change in any individual neighboring country's tax rate is comparatively modest.

In order to enable a comparison of the relative impact of the explanatory variables on the CIT base, we calculate standardized coefficients which represent the estimated average change in equal units (i.e. standard deviation units; see e.g. Wooldridge, 2003). In table 2, we report the transformed coefficients for our preferred specification and their corresponding rank, with the value 1 assigned to the most important variable. Clearly, income per capita dominates as a determinant of reported profits; this is followed by real unit labor costs, whereas taxes rank only third. Therefore, we can conclude that a large share of the increase in corporate reported profits over the last two decades is attributable to the increase in per capita income and the fall in labor costs.

Table 2
Beta coefficients. Dependent variable: ln CIT base per capita

Variable	Coeff.	Rank
ln τ	-0.167	4
ln $\overline{\tau}$	0.325	3
ln income	0.595	1
rulc	-0.374	2
growth	0.095	5
ln exports	0.094	6

Calculation based on specification (5) in table 1.

5.2 Robustness analysis and extensions

We now proceed to investigate the robustness of our baseline estimation result reported in column (5) of table 1 to several important variations. First, we rerun the regression using a number of different CIT rate measures. Second, we use a more complex weighting scheme to capture the linkages between countries. Thirdly, we address potential sources of endogeneity concerning the control variables. Fourth, we evaluate the sensitivity of our results to the inclusion and exclusion of countries; a particularly appropriate robustness check is to see whether we underestimate the magnitude of the tax base elasticities if we ignore the tax policies in eastern Europe after the fall of the Iron Curtain. Next, we change the nature of competition by allowing countries to affect each others' tax bases additionally through channels other than tax policy. Furthermore, we consider whether changing our model specification from a dynamic to a static setting affects our basic findings.

Columns (1) to (3) in table 3 present the results when we use different CIT rate measures. Not surprisingly, employing the statutory tax rate yields a higher coefficient on the domestic tax rate (see column 1). As discussed in section 3.2, the statutory tax rate is only one policy parameter that governments have at their disposal to affect the burden of taxation. Given the tax-broadening reforms enacted in most OECD countries, we can safely conclude that the use of the statutory tax rate gives rise to an omitted variable bias and leads to an overestimation of the CIT base elasticity with respect to the domestic CIT rate. Nevertheless, the relationships shown in the baseline model remain similar, the coefficients of interest being highly significant. Next, we experiment with several alternative definitions of effective CIT rates presented and discussed in Devereux and Griffith (2003). Probably the most salient assumption underlying the derivation of effective tax rates is the degree of profitability of an investment. In effect, the effective average tax rates developed by Devereux and Griffith are weighted averages of the effective marginal tax rate (EMTR) and the statutory tax rate, where the weight attributed to the latter rises with the assumed profitability of the underlying investment project. Intuitively, the role of allowances decreases with the profitability of the real investment. Conveniently, the effective average tax rates thus cover the full spectrum of effective taxation from the profitability of a marginal investment that just earns a net rate of return equal to the going interest rate, in which case the EATR corresponds to the EMTR, to very high rates of profitability, in which case the EATR corresponds to the statutory tax rate.[20] Indeed, as shown in column (2), assuming a rate of profit of 40% instead of the implied 10% in our baseline regression yields tax base elasticities very similar in magnitude to those obtained when employing the statutory tax rate (column (1)). In fact, the estimated coefficients on the domestic tax rate range from -0.10 for investments that earn zero economic rents, where the EMTR applies (see column (3)), to -0.92 for the most profitable investment projects (i.e. infinite economic profits), where the statutory tax rate applies. Interestingly, the coefficient on the domestic EMTR is insignificant, which might be related to the fact that the EMTR has not exhibited a clear trend throughout all countries. In Italy, for example, the EMTR shows a somewhat erratic development, increasing most of the time. In fact, rerunning the regression without Italy yields a tax base elasticity with respect to the EMTR of -0.4 which is significant at the ten percent level. This is close to the estimate in Gruber and Rauh (2007) who employ a marginal CIT rate and report a CIT base elasticity of -0.2 for the. In summary, the absolute size of a country's own tax elasticity monotonically increases with the assumed profitability and is highly significant for EATRs based on profit rates of 10%, 20%, 30% and infinity (statutory tax rate).[21] Coming back to our discussion on the drawbacks of using statutory rather than effective average tax rates, we conclude that the omitted variable bias mentioned above is decreasing in the profitability of a country's investment projects. On the other hand, as we commented in section 3.2, the statu-

[20] For a detailed discussion of the various tax rate measures, please refer to Devereux et al. (2002).
[21] For the sake of brevity, we do not report all estimations (all results are available upon request).

tory tax rate is the relevant indicator for profit shifting since it affects the MNEs' incentives to reduce their tax burdens by using (for example) accounting techniques and internal pricing to manipulate their country-specific levels of reported profit without actually changing their levels of real investment. Hence, another interpretation of the higher coefficient on the statutory tax rate in column (1) is that it might reflect the additional impact of such tax avoidance strategies on a country's tax base.

Let us now turn to the definition of the variable capturing the weighted neighboring countries' CIT rates. Because of the potential complexity in the linkages that determine the degree of competition between any two countries, it is not a trivial task to construct a more detailed weighted neighboring CIT rate vector. In the regressions so far, we have followed core theoretical tax competition literature in its assumption of symmetry between all countries, thus assigning equal weights to each competing country's tax rate. From gravity models, it is well established that distance plays a major role in determining trade and investment relations (Navaretti and Venables, 2004). In order to examine whether the choice of weights affects our qualitative findings, we redefine the neighboring tax rate variable by applying a weighting scheme based on geographic proximity between countries. The idea is to attribute a weight to every other individual country's CIT rate on the basis of the extent to which that country is likely to be perceived as a substitute investment location by corporations. Specifically, we assign higher values to countries that are relatively close in geographical terms by defining the distance weight, ω_{ij}, between some country i and a country j as the inverse of the relative distance[22] ($dist_{ij}$) between the capital cities of i and j, that is:

$$\omega_{ij} = \frac{1}{dist_{ij}} / \frac{1}{\sum_j dist_{ij}}$$

One possible economic motive for this measure is given by the fact that the costs of transportation between two countries usually increase along with the distance between them. Moreover, the availability of investment-relevant information on country-specific characteristics decreases (or, alternatively, the cost of such information increases) with distance. Therefore, geographical proximity weights may capture the ease with which corporations can circumvent higher CIT rates in a particular country by relocating assets to some other country. In order to interpret the coefficient on the weighted neighboring countries' tax rate in terms of averages, the weighting matrix is row standardized. Column (4) shows that the basic result is not altered. In column (5) we additionally control for the possibility that corporate profits might affect income per capita and real unit labor costs.

[22] The data source is given in appendix C.3.

Table 3

Robustness analysis. Dependent variable: ln CIT base per capita

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ln τ	-0.918***	-0.912***	-0.101	-0.920***	-0.962**	-0.779***	-0.723*	-0.699*	-0.555***	-0.621*
	(0.306)	(0.333)	(0.177)	(0.340)	(0.437)	(0.288)	(0.410)	(0.363)	(0.182)	(0.336)
ln $\overline{\tau}$	2.137***	2.203***	1.866*	2.249***	1.884*	3.515***	2.169**	1.684*	1.899***	
	(0.655)	(0.731)	(0.994)	(0.802)	(1.060)	(1.319)	(0.915)	(1.007)	(0.704)	
ln income	0.496***	0.475***	0.335***	0.424***		0.466***	0.397***	0.331**	0.473***	0.407***
	(0.067)	(0.065)	(0.081)	(0.063)		(0.060)	(0.082)	(0.146)	(0.038)	(0.065)
rulc	-0.019***	-0.019***	-0.021***	-0.020***		-0.019***	-0.019***	-0.022***	-0.016***	-0.021***
	(0.004)	(0.005)	(0.005)	(0.005)		(0.005)	(0.005)	(0.005)	(0.003)	(0.005)
growth	0.015*	0.016*	0.015*	0.017**	0.033***	0.014	0.021*	0.017**	0.009*	0.0209***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.009)	(0.012)	(0.008)	(0.005)	(0.007)
ln exports	0.213**	0.204**	0.358	0.154	-0.375	0.236**	0.116	0.125	0.522***	0.461*
	(0.093)	(0.096)	(0.278)	(0.106)	(0.277)	(0.093)	(0.157)	(0.129)	(0.158)	(0.241)
ln income_{t-1}					0.133*					
					(0.074)					
rulc_{t-1}					-0.016**					
					(0.007)					
ln $\overline{\text{income}}$								0.146		
								(0.135)		
$\overline{\text{rulc}}$								-0.054**		
								(0.025)		
$\overline{\text{growth}}$								-0.035		
								(0.022)		
Constant	1.289***	1.403***	2.251***	1.638**	0.924	1.819***	1.726**	7.695**	1.260***	0.927
	(0.479)	(0.516)	(0.613)	(0.663)	(0.902)	(0.462)	(0.752)	(3.100)	(0.371)	(0.564)
N	361	361	359	361	361	361	277	361	376	361
rk Wald F	54.459	64.733	77.930	52.434	48.716	155.923	69.914	72.499	91.722	111.459
Hansen J	0.933	0.938	0.480	0.629	0.665	0.735	0.474	0.947	0.156	0.817

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Notes: The estimates presented in columns (1) to (10) are based on a two-step LSDV procedure. Except for the static specification in column (9) the reported coefficients represent long-run results. In each specification country-fixed effects as well as individual time trends are included. Standard errors are reported in parentheses and are based on bootstrapped samples.

Therefore we employ the latter variables in their one-period lagged form, revealing that our estimation results are not suffering from endogeneity problems.

Next, we address a potentially important aspect of tax competition in Europe which is attracting increasing interest, namely the role of transition countries in eastern Europe. Since effective tax rate data for these countries is not available, we make use of statutory tax rate data and augment the uniformly weighted neighboring tax rate variable. Specifically, for the period from 1982 to 1994, our variable $\overline{\tau}_{it}$ corresponds to the definition given in section 2.3, while for the period where reliable statutory tax rate data for eastern European countries is available, that is, from 1995 onward, $\overline{\tau}_{it}$ consists of the uniformly weighted average of 16 western plus 10 eastern European countries. Column (6) demonstrates that our key results still hold. Although the coefficient on the tax rate of neighboring countries appears to be larger than in the base case estimation, the derived impact on a country's tax base remains virtually unchanged if an individual competing country increases its tax rate: $\frac{3.5}{26} = 0.13$.

In column (7), we examine the structural stability of our preferred specification if we exclude non-European countries from the baseline model, specifically Australia, Canada, Japan, and the US. Evidently, even though one might expect evidence of fiercer competition among the European countries, the pooling across continents does not bias our results.

As a further robustness check we examine whether our core relationships are affected if we deviate from tax competition theory and assume that countries' CIT bases are linked not only through their fiscal policies but also through other country-specific variables. Hence, we augment our basic model by entering all the determinants of a country's CIT base in terms of spatial lags. Specifically, we include growth, per capita income, and real unit labor costs, each weighted as proposed in section 2.3. The respective variables are denoted by $\ln \overline{\text{income}}$, $\overline{\text{rulc}}$, and $\overline{\text{growth}}$.[23] As column (8) shows, the coefficient on the domestic tax rate is not altered while the coefficient on neighboring countries' tax rates is slightly lower. This means that even if we control for various potential spillover channels working through income and labor costs, we still obtain the clear result that governments attract foreign tax bases by means of fiscal policies.

In an additional check, we estimate a static specification, that is, we exclude the lagged tax base variable. Although the coefficients remain robust as reported in column (9), the elasticities are somewhat lower. This suggests that by neglecting lasting effects, the static model may underestimate the sensitivity of the tax base to fiscal policies.

Finally, for the sake of comparability with some of the studies mentioned in the introduction, in

[23] Note that we do not weight the exports variable because it measures the total volume of a country's exports to *all* foreign countries, so that the assignment of bilateral weights has no economic interpretation.

column (10) we re-estimate our baseline regression while excluding the variable of neighboring countries' tax rates. The results reveal that the impact of the domestic tax rate on the CIT base is lower when we ignore international fiscal externalities. In effect, the magnitude of the elasticity -0.6, is comparable to that found in Dwenger and Steiner (2008) for German data, namely -0.5.

6 Discussion and conclusion

In the past two decades, an impressive amount of theoretical literature on tax competition has emerged. A vast majority of empirical research associated with this topic has focused on identifying strategic interactions among governments by means of tax reaction functions (see e.g. Devereux et al., 2008). According to the tax competition theory, tax reaction functions emerge because tax bases are internationally mobile. Indeed, increasing attention has been devoted to the measurement of tax base mobility via income shifting between units of MNEs. By necessity, this requires the use of company-level data, which typically covers only a part of the economy's corporate sector. As such, predictions about the effect of tax rate changes on tax revenues cannot be derived. In order to estimate how tax rate reductions affect governments' budgets, an assessment of the aggregate response of the CIT base to changes in the domestic and foreign CIT rates is required.

Conceptually, the approach of this paper is guided by two distinct purposes. First, we investigate whether countries' corporate taxable income is responsive to foreign countries' tax rates – a prerequisite for the presence of tax competition. Second, we examine how governments affect their national tax revenues when they unilaterally reduce their tax rates taking into account that tax bases may be internationally mobile. Do tax revenues rise or fall? This latter aspect is linked to a large and growing literature devoted to estimating the elasticity of taxable income with respect to *individual* income taxes (for a recent and extensive survey see Saez et al., 2009). As in that literature, the interest in this matter lies in the fact that generally all responses to taxation are indicative of a dead weight loss. Ideally, the sensitivity of taxable income captures the sum of individual behavioral responses aimed at reducing the tax burden, including, for example, spillovers to other tax systems via the choice of incorporation. To the extent that this is the case, the elasticity of taxable income provides a useful measure of the welfare cost of taxation and hence is an indicator for the efficiency of the tax system.

Our key findings can be summarized as follows: The estimates strongly support the existence of fiscal externalities. Thus we can confirm that the trend toward CIT reduction observed over the last two and a half decades is indeed related to governments' competition for mobile resources via tax rates. The magnitude of fiscal externalities, however, indicates that the extent of international corporate tax base mobility is rather modest. To infer the relationship between CIT rates and revenues, we estimate the sensitivity of reported corporate profits with respect to domestic CIT rates, while controlling for such international fiscal linkages. Our estimation results reveal that in the long run a 1% reduction in the effective average domestic CIT rate leads to a less-than-proportional increase in the level of domestic reported corporate profits. Specifically, according to our baseline regression, the CIT base elasticity amounts to -0.7, which is higher in absolute terms but still comparable to the elasticities found in Dwenger and Steiner (2008) for Germany and in Gruber and Rauh (2007) for the United States – the only two related country-level studies of which we are aware.

In light of the tax coordination debate, our results suggest that, on average, CIT rates are in the upward-sloping region of the Laffer curve indicating that a simultaneous rise in CIT rates across countries would, on average, result in a less-than-proportional decrease in the CIT base and, therefore, higher CIT revenues. An important caveat is that our data set does not allow us to address distributional issues related to the relative tax burden incurred by different types of corporations in the wake of tax rate changes. We have seen that the CIT base elasticity with respect to the statutory CIT rate – which is likely to reflect the tax burden of highly profitable firms – is close to -1. In other words, a change in the statutory CIT rate has little impact on the CIT revenue, indicating a substantial response to tax changes. Changes in the effective corporate tax burden of less profitable firms, by contrast, imply weaker tax base responses, suggesting that they are less able to react to tax changes. Another potential source of asymmetry not considered in this study arises from country asymmetries (Bucovetsky, 1981 and Wilson, 1981) and the related potential conflicts of interest concerning international tax coordination arrangements. This topic would certainly constitute an interesting field for future research.

Appendix

A Monte Carlo simulation

Our Monte Carlo design closely follows Bruno (2005) who studies approximations of the LSDV bias in dynamic unbalanced panels. The model of the data generating process for the dependent variable y_{it} can be denoted as follows

$$\begin{aligned} y_{it} &= \gamma y_{it-1} + x_{it}\beta + \nu_i + \epsilon_{it} \text{where} \\ x_{it} &= \delta x_{it-1} + \xi_{it} \end{aligned} \tag{A.1}$$

The time $t = 1, ..., T$ and cross-section $i = 1, ..., N$ dimensions are fixed at T=24 and N=17, and we drop the last time period in the first 15 cross-sections to account for the unbalanced structure of our data sample. The explanatory variable x_{it} is also assumed to depend on its one-period lag, with the initial observations x_{i0} and y_{i0} generated according to the procedure suggested in Kiviet (1995).[24] The error terms ϵ_{it} and ξ_{it} are assumed to be $N(0, \sigma_\epsilon^2)$ and $N(0, \sigma_\xi^2)$ respectively, and the individual fixed effects ν_i are generated by assuming $\nu_i \sim N(0, \sigma_\nu^2)$, where $\sigma_\nu = \sigma_\epsilon(1-\gamma)$. The values for the parameters γ and β are set according to the LSDV estimates of our baseline specification for the variables ln κ_{it-1} and ln $\overline{\tau}_{it}$, that is, $\gamma = 0.38$ and $\beta = 1.32$ (see appendix B for the short-run parameter estimates). The parameter δ is set to 0.8 to reflect the high persistence of the tax rate variable $\overline{\tau}_{it}$. As Kiviet (1995) points to the importance of the signal-to-noise ratio of the regression (denoted as σ_s^2) for the size of the LSDV bias, we present the results of the Monte Carlo analysis by varying this ratio from 2 to 8. By determining this value, we ensure that σ_ξ^2 is uniquely determined. Moreover, we set σ_ϵ^2 equal to one. In table A.1 we report the bias, standard deviation (std) and root mean squared error (rmse) of the long-run parameter $\frac{\beta}{1-\gamma} = 2.13$. The results reveal that the bias is rather negligible, varying from 1.8% to 2.9% of the true value, and that the LSDV estimates have very low standard deviations and attractive mean squared errors.

[24] Following Kiviet (1995), the initial observations are kept fixed across replications and are generated in a way that avoids the waste of random numbers. We simulate the data generating process using the Stata Code written by Bruno (2005) available at http://ideas.repec.org/c/boc/bocode/s453801.html, who closely follows Kiviet (1995) and Bun and Kiviet (2003).

Table A.1
Monte Carlo results for $\frac{\beta}{1-\gamma}$

σ_s^2	bias	std	rmse
2	-0.0535	0.1575	0.1663
5	-0.0354	0.1025	0.1084
8	-0.0268	0.0825	0.0867

The results are based on 2,000 replications.

B Short-run results

Table B.1
Dependent variable: CIT base per capita, κ_{it}, in log

Variable	Coeff.	Std.Error
ln κ_{it-1}	0.383***	0.071
ln τ	-0.437*	0.227
ln $\overline{\tau}$	1.323**	0.548
ln income	0.265***	0.053
rulc	-0.012***	0.003
growth	0.010*	0.006
ln exports	0.272*	0.161
Constant	1.054***	0.358

Significance levels: $*$: 10% $**$: 5% $***$:1%. First-stage results of spec. (5) in table 1. Standard errors are based on bootstrapped samples.

C Descriptive statistics and data sources

Table C.1
Descriptive Statistics, baseline specification

Variable	Mean	Std. Dev. between/within	Min	Max	Obs
EATR (base case)	0.301	0.064 0.040/0.050	0.186	0.479	408
statutory tax rate	0.403	0.091 0.052/0.076	0.250	0.627	408
CIT base per capita*	1.946	2.262 1.319/1.865	0.067	27.545	393
income per capita*	21.704	9.814 5.656/8.132	4.382	65.605	408
rulc	104.592	7.291 4.678/5.702	93.430	139.286	408
growth	2.406	1.807 0.490/1.744	-6.244	7.188	408
exports	0.317	0.162 0.160/0.046	0.072	0.862	408
infl	4.043	4.067 2.440/3.305	-11.316	24.321	408
PIT	0.422	0.193 0.169/0.103	-0.051	1.005	408
population**	46.563	62.785 64.416/5.230	4.104	296.259	408
unemployment	7.355	3.966 3.481/2.073	0.175 175	24.118	408

* in USD thousands, ** in million

Table C.2
Correlation coefficients of regressors, baseline specification

	$\ln \tau$	$\ln \overline{\tau}$	ln income	rulc	growth	ln exports	infl
$\ln \tau$	1.00						
$\ln \overline{\tau}$	0.47	1.00					
ln income	-0.37	-0.73	1.00				
rulc	0.34	0.48	-0.46	1.00			
growth	-0.04	0.05	0.05	-0.23	1.00		
ln exports	-0.23	-0.13	0.13	-0.03	-0.03	1.00	
infl	0.25	0.49	-0.66	0.54	-0.24	-0.19	1.00
ln PIT	-0.20	-0.12	0.22	-0.27	0.39	0.75	-0.36

Table C.3
Measurement and sources of variables

Variable	Measure	Source
EATR	Effective average tax rate on corporate profits where the economic rents may vary between 0% (EMTR), 10% (base case), 20%, 30% and 40%	Devereux and Griffith (2003), www.ifs.org.uk/publications.php?publication_id=3210
Statrate	Statutory tax rate on corporate profits	Devereux and Griffith (2003), www.ifs.org.uk/publications.php?publication_id=3210
CIT revenues	Tax revenues from corporate profits in current US dollars	OECD Revenue Statistics (Online database, Vol 2007)
Total tax revenues	Total tax revenues in current US dollars	OECD Revenue Statistics (Online database, Vol 2007)
CIT base	Own calculation: Division of CIT revenues by the statutory tax rate as defined in section 3.1	
income	Gross domestic product in current US dollars divided by country inhabitants	International Monetary Fund (IMF)
rulc	Real unit labor costs	Ameco Online Database, European Commission
growth	Percentage change in real GDP over the previous year	International Monetary Fund (IMF)
exports	Own calculation: exports of goods and services divided by GDP, current prices	Ameco Online Database, European Commission
infl	Annual percentage change of average consumer prices	IMF
PIT	Top personal income tax rate, central and representative subcentral rate	OECD, www.oecd.org/dataoecd/44/3/1942514.xls; www.oecd.org/dataoecd/34/21/2576404.xls
population	Number of country inhabitants	IMF
unemployment	Unemployment in percent of total labor force	IMF
dist	Distances between the capitals in kilometers measured on the basis of data on latitudes and longitudes	www.fallingrain.com/world

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