Economic Modelling

Volume 28, Issues 1–2
January/March 2011

ISSN 0264-9993

CONTENTS

(contents continued on outside back cover)

Economic Modelling 28 (2011) 13–21

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Equilibrium conditions in corporate tax competition and Foreign Direct Investment flows

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ARTICLE INFO

Article history:
Accepted 2 October 2010

JEL classification:
H21
H25
F21
H8

Keywords:
Corporate tax competition
FDI inflows
Corporate Income Tax Revenue
Effective Average Tax Rates

ABSTRACT

We consider a collection of countries which attempt to maximize their corporate tax revenue, the latter being viewed as a function of Foreign Direct Investment (FDI) inflow and the Effective Average Tax Rate (EATR) which each country sets for itself. Under a model that assumes a direct influence of tax differentials on the flow of FDI, each country's decisions are naturally 'coupled' to those of others, leading to a non-cooperative game in which countries–players compete for FDI inflows by sequentially altering their tax rates. Their decisions are made via a differential equation-based model used to predict the effect of tax rate changes on a player's share of FDI inflows. Our model, calibrated using empirical data from 12 OECD countries for the period 1982–2005, combines FDI inflow and tax-rate differentials to arrive at a "steady-state" FDI inflow share for each player, given its competitors' corporate tax rates. We explore the game's equilibrium, including the question of whether equilibrium necessarily implies a 'race to bottom', with low corporate tax rates for all players.

1. Introduction

The elimination of trade barriers in the world economy during the last decade has resulted in the liberalization of capital flows, making corporate profit taxation and Foreign Direct Investment (FDI) important factors in the tax competition which exists among economies. This has created opportunities for multinational firms, which transfer prices and benefit from intra-firm debt and profit shifting practices to countries with lower taxes. Thus, tax differentials among countries may play a role in distorting the optimal global allocation of resources and, consequently, international trade. Adherents of the view that tax differentials heavily affect the allocation of international capital flows could be roughly categorized into two groups. One supports coordinated action in order to reach a common corporate tax basis. The other advances open market rules as a means of arriving at "optimal" tax differentials. In the context of EU tax regulation actions, corporate tax coordination has been debated most actively during the last two decades. Viewpoints range from the Ruding Report (1992), to the Code of Conduct for business taxation (European Communities,1998) and Formula Apportionment (European, 2001), with the last two deviating significantly from the tax-rate harmonization proposals advanced in the first.

This work extends the literature on corporate tax differentials and FDI, with an eye towards corporate tax competition and Nash-style games. Our main contribution centers on a computational model for tax competition, in which a collection of self-interested countries attempt to maximize corporate tax revenue by manipulating their corporate tax policy in order to attract FDI. We describe a non-cooperative multiplayer game for the distribution of FDI inflow, which captures the competition within the group. The game's equilibrium corresponds to the optimal Effective Average Tax Rates (EATRs) and FDI inflow levels for the group in a particular year. This allows us to study the game's equilibria for various amounts of FDI to be distributed, and to explore alternative scenarios, e.g., whether it is advantageous for some players to collude, and whether the competition leads everyone to very low tax rates.

The computational game described above will require us to define along the way i) an objective function based on which the countries–players make decisions on their EATR, and ii) a model for how FDI "distributes itself" among countries, given their EATR and other parameters. These two component models will be developed and calibrated using data for a group of 12 OECD countries during the period 1982–2005. Corporate tax revenue, determined by EATR and FDI inflow, will play the role of the objective function. We will construct such a function by empirically replicating the Laffer curve for the countries under consideration, based on an OLS panel model. One of the novelties of our approach will be the assignment of a unique Laffer curve for each competing country, as determined by the country's individual "characteristics". The second component in our game will be a differential equation-based model for how FDI inflow reacts to tax differentials. We will develop this based on the strand of

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doi:10.1016/j.econmod.2010.10.005

the literature which advocates the existence of nonlinear reaction functions of FDI inflows to tax-rate differentials, with EATR, EATR^2 and GDP ratios used as control variables. Unlike the standard view in the literature where countries are competing in pairs for bilateral FDI inflows, competition in our setting takes place against the entire group simultaneously, and not "pairwise". This scenario is viewed as more realistic, and may thus be more useful in terms of policy making.

The remainder of the paper is organized as follows. The next section reviews the literature on corporate taxes, corporate tax competition and FDI. Section 3 discusses the two basic components needed to formulate our game. These include a model for the behaviour of competing countries, with empirical analysis and data for the specification of objective functions (i.e., corporate tax revenue), and also the response of FDI inflows to tax differentials. Section 4 formulates a computational corporate tax competition game, whose equilibria under alternative scenarios for FDI flow levels are then examined in Section 5. In particular, the game's equilibria suggest that, ultimately, tax competition does not lead to zero (or very low) corporate tax rates for all players, and that collusion (either among "large" or "small" players) does not seem to be preferable over free competition. Section 6 summarizes our results and discusses some policy implications.

2. Literature review

2.1. Direct versus indirect tax competition studies

Following the viewpoint in Griffith and Klemm (2004) the tax competition literature can be divided into so-called direct versus indirect studies. The first examine the responsiveness of investment incentives to tax rates. Examples from this group include Hines (1999) and De Mooij and Ederveen (2003), both of which surmise that foreign capital is very sensitive to taxation.[1] It is difficult to extract any policy implications from the concluding remarks of these studies, and there is only a vague reference to the ongoing process of tax competition. Representative studies from the second category include those of Devereux et al. (2002a,b), and Haufler and Schjelderup (2000). These attempt to estimate whether one jurisdiction's tax rate reacts to changes in the tax rate of another, and conclude that an interdependence does exist, with ambiguous conclusions regarding its driving process.

2.2. Capital tax competition

The idea of an international capital tax competition was the first in the field of tax competition to be investigated theoretically, initially by Tiebout (1956), Oates (1972), and later by Zodrow and Mieszkowski (1986), Gordon (1986), and Wildasin (1988). The "standard" model in the tax competition literature was that of Zodrow and Mieszkowski (1986) which investigated the effects of capital mobility on capital income taxation in a quite restrictive framework. New contributions thereafter were based on a relaxation of that model's restrictive assumptions, and the examination of additional aspects of capital mobility, such as governments being either Leviathan or Benevolent, economies of agglomeration, and differential economic rents across countries.

2.3. Corporate taxation and FDI flows

There is generally no dispute that the rapid growth of FDI in the recent past has led to a subsequent use of tax differentials as a tool for attracting FDI. The recent analysis of corporate tax-rate competition and investment capital mobility by Hines (2005) has its roots in the study of Diamond and Mirrlees (1971) who conclude that small, open economies should avoid taxation of income earned by foreign investors as an incentive to attract international investment capital. This seems to "mirror" the common practice of multinational firms to use debt to finance foreign affiliates in high-tax countries, and to use equity to finance the affiliates in low-tax countries, in other words to accumulate income in low tax-rate countries and tax deductions in high tax-rate countries. This is described by Desai et al. (2004) and others, who report that affiliates belonging to the same US parent companies tend to adjust their debt levels lower or higher according to the lower or higher corporate tax rates of the host countries.

Other studies which are relevant to the present work have examined the relationship between FDI, corporate tax rates, and corporate tax revenues. Studies such as Hartman (1984), Boskin and Gale (1987), Young (1988), Slemrod (1990), and Swenson (1994) concerned themselves with time series estimation of the correlation between the level of FDI and the annual variation of after-tax rate of return, focusing mainly on the US. An alternate approach has been to explore the location of FDI based on cross-sectional estimations, as is done in Grubert and Mutti (1991), Hines and Rice (1994), Desai et al. (2004), and Altshuler and Grubert (2004), among others.

The relationship of corporate taxation to FDI has also been studied by Slemrod (1990) who is critical of previous works, e.g., Hartman (1984), and marks a point of departure for subsequent studies by considering pooled bilateral FDI flows in aggregate time series data and quantifies tax rates by means of the Effective Marginal Tax Rate (EMTR, proposed by Auerbach and Hines (1988)). Thereafter, Cassou (1997) explored bilateral FDI flows for individual countries for the period 1970–1989 and found tax effects on FDI to be statistically non-significant for the most part. Other pooled bilateral FDI flow studies include Jun (1994), and Devereux and Freeman (1995), which examined a group of OECD countries, also finding statistically non-significant effects. Pain and Young (1996) focused on FDI flows from Germany and the UK into 11 countries for the period 1977–1992, and found elasticities which were significant (and negative) for the UK but non-significant for Germany. Bénassy-Quéré et al. (2005) using a panel of bilateral FDI flows among 11 OECD countries investigated further agglomeration-related factors, with nonlinearities in the impact of tax differentials on FDI location. Finally, Razin and Sadka (2006), in their study of bilateral FDI inflows in a two-country tax competition model with asymmetric Nash equilibrium noted the importance of tax differentials in determining the direction and magnitude of FDI flows.

In this paper, we will consider countries that attract FDI inflow by adjusting their tax rates, the latter being expressed in terms of the Effective Average Tax Rate (EATR). The EATR was first proposed as an appropriate measure of the tax rate in the context of investment and mobile profit allocation among countries by Devereux et al. (2002b). That work used nonlinear tax reaction functions to make the case for an asymmetric competition in which countries that have set their EATR above the total average seem to react more evidently to changes in the "opponent" countries' tax rates. Devereux (2006), in his survey of empirical studies on the influence of taxes on discrete capital and profit location choices, concluded that the EATR (as opposed to the alternative, EMTR) tends to play a significant role in discrete location choices, and hence in the overall allocation of capital. The same study suggests that statutory tax rates appear to significantly affect financial policy, the location of taxable income, the repatriation of income, and transfer.

A meta-analysis of the empirical literature on the impact of corporate taxes on the allocation of FDI performed by De Mooij and Ederveen (2003), estimated that the median tax-rate elasticity of foreign capital was negative (−3.3) and found FDI to be more responsive to EATR than to statutory tax rates, with no systematic differences between the responsiveness of investors to tax credit versus tax exemption countries. In later extensions, De Mooij and Ederveen (2005) studied the effects of openness and agglomeration tendencies on the tax-rate elasticity values, and explored (De Mooij

[1] De Mooij and Ederveen (2003) reach this conclusion via meta-analysis.

and Ederveen, 2008) the extent to which existing studies reveal differences in size effect between the intensive and extensive margins of international investment. Views contrary to those of De Mooij and Ederveen (2003) are advanced in the OECD-stated goals for such treaties, and in studies such as Dickescheid (2004) and Davies (2004), which consider bilateral tax treaties an important tool for international tax cooperation. Davies surveyed the existing literature and highlighted the reasons for the difference between the standard view that tax treaties increase FDI, and the majority of the empirical findings that show little support for this. In this work, we do not account for the effect of tax treaties on FDI allocation and corporate tax competition.

2.4. Corporate tax revenues and the Laffer curve

It is true, of course, that tax revenues and related policy by local governments are influenced by a great many factors besides corporate tax rates, including tax base breadth, tax avoidance, aggressiveness of tax planners, and tax authorities' enforcement power. Other, less obvious influences come from the use of corporate taxes as a “backstop” for the individual income tax (Slemrod, 2004), the effect of a country's size and initial statutory tax rate (Mutti, 2003), and the effect of corporate taxes on the quality of an FDI flow (Becker and Fuest, 2007). Here, we will look for a model that captures the reaction of corporate tax revenues to corporate tax rates, while differentiating between countries, but without explicitly accounting for the factors listed above.

We are particularly interested in approaches such as Clausing's (2007), who studied the variation in size of Corporate Income Tax Revenues relative to GDP, among OECD countries during the period 1979–2002. That work found a parabolic relationship between corporate tax rates and Corporate Income Tax Revenues, implying the existence of a revenue-maximizing corporate income tax rate. In particular, Clausing (2007) empirically replicates the Laffer curve according to which, changes in tax rates have a double sided-effect: when tax rates decrease, there is an “immediate” decrease in tax revenues, but also an economic effect with a positive impact on work, output and employment (and thereby on the tax base) which provides incentives for a country to increase these activities. The parabolic relationship between tax revenues and tax rates is steeper for small-open economies compared to large-closed ones. Nevertheless, that work refrains from assigning corporate tax revenue curves to specific countries because doing so would be sensitive to inclusion or exclusion of certain control variables.

The discussion on the Laffer curve is of course not complete, and ranges from extensions of the basic model (e.g., Brill and Hassett, 2007) to studies that question its existence, as in Gravelle and Hungerford (2007). For our purposes, the Laffer curve will provide a reduced model for the reaction of corporate tax revenue to corporate tax rates, while allowing us to account for countries' individual features on some “lumped” level.

3. Modeling the behaviour of countries competing for FDI — empirical analysis and data

Our goal is to explore computationally the competition for FDI among countries in a non-cooperative tax policy game where each country acts to optimize its own objective function. In our case, the competition will be on corporate taxation, and players will try to maximize their Corporate income Tax Revenue (CTR). We will consider FDI inward flows and Effective Average Tax Rates (EATR) to be the major determinants of CTR. The basic decision that each player will have to make is how to adjust its EATR and attempt (or not) to attract higher FDI inward flows, in order to maximize its overall CTR. Of course, any change in the EATR of one country may lead others to also alter their policies, and we would like to be able to find the game's equilibria.

Our analysis considers a group of 12 OECD countries over the period 1982–2005 using FDI inflow data, EATR and corporate tax revenues. The group includes: Canada, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, the UK and the US, which account for more than 60% of the worlds' total FDI inflow in the year 2005.[2] We will not attempt to account for welfare considerations, investment capital profit maximization criteria, country agglomeration factors, public goods and individual characteristics. Rather, we assume that in the short/medium run these factors vary slowly compared to the changes FDI inflow may undergo.

As we have alluded to in the previous discussion, in order to make the FDI competition game precise we must specify two important components. The first is the objective function of each player; in our case, this will be CTR, viewed as a function of EATR and FDI inward flow. The second component is a model for how FDI inward flows “respond” to the decisions made by each country to lower or raise its own EATR. We go on to discuss each component in turn.

3.1. Specification of the corporate tax revenue objective function

To calibrate the dependence of CTR on EATR and FDI, we obtained tax revenue, EATR and FDI inflow data for countries in our sample, for the years 1982–2005.[3] Following the literature “in favour of” the Laffer curve (e.g., Clausing, 2007, Becker and Fuest, 2007), we tested a parabolic corporate tax revenue reaction curve as a function of EATR (raised to the first and second powers) and FDI inflow. The inclusion of a squared-term is in line with the view that nonlinearities are likely to arise due to the response of the corporate tax base to changes in corporate tax rates. The variable FDI inflow was included, in order to capture the effect of firm mobility on corporate tax revenue maximization. Thus, the basic regression to be estimated involves the following static model:

$$C_{it} = \gamma_0 + \gamma_1 E_{it} + \gamma_{2i} E_{it}^2 + \gamma_3 F_{it} + u_{it}, \;\; i = 1, \ldots, 12 \tag{1}$$

where C stands for corporate tax revenue,[4] E stands for EATR, as determined and calculated in Devereux and Griffith (2003), F is FDI inflow, the γs are regression coefficients, and u is white noise. The subscripts i and t indicate the particular country and year, respectively.

We tested for the appropriateness of model (1), and several variations of it, including some with E raised to higher powers, and then proceeded to identify the most suitable among them. The specification tests we ran involved pooled OLS models (instead of Fixed Effects, or GLS). In a departure from existing empirical literature on the subject, we allowed the sensitivity of EATR, γ_{2i}, to vary among competing economies. We do so in order to account for the heterogeneity across countries in our sample, as determined by the concavity of the corporate tax revenue curve that, in the relevant literature, is typically attributed to economy-specific characteristics like size and market openness. Because countries are assumed to act selfishly during tax competition, it makes sense for them to have their “private” objective function, as opposed to acting according to some “average” criterion. In our model, this is effected via the coefficients γ_{2i}. We specifically avoided aggregating the data (that is, and assigning a common γ_2 coefficient) because tax revenue characteristics vary considerably across the sample, and because by doing so one would “homogenize” the players' behaviour and make the

[2] See Table A1 and Table A2 in the Appendix. For FDI data specification refer to: http://www.unctad.org/Templates/.

[3] There were eight years of missing data for Portugal (1982–1987 and 2005).

[4] Corporate tax revenues are not scaled by GDP as is done in other studies in the field, because this work focuses on the change in CTR attributed to EATR. Including GDP in a nonlinear relationship with corporate tax is beyond the scope of the paper.

competition meaningless, at least on the basis of CTR. Of course, one could also consider letting every coefficient of Eq. (1) be country-specific. We will have more to say about this shortly.

Table 1 summarizes the results of four reduced-form Corporate Income Tax Revenue models (estimated by pooled OLS), that will serve as candidate objective functions for competing countries. All four are built on a quadratic relation between CTR and EATR and replicate the Laffer curve. Before we proceed to discuss the characteristics and appropriateness of each of them, we note that all parameters have the expected sign and magnitude of coefficients, and are statistically significant. We also tested the determining power and robustness of the models involved.

Model 1 in Table 1 was obtained via a pooled OLS model and considers corporate tax rates as being determined by E (EATR), E^2 and F (FDI inflows). The specification is White cross-section standard errors and covariance corrected. We notice that the coefficients of E and F have the expected positive sign, and a high statistical significance. E^2 has a negative sign, also expected, for all countries, which implies a concave CTR curve. Finally, Model 1 is of a quite sufficient determining power of 0.780, and the results cited are robust with respect to the exclusion of individual country or year data. Model 2 has the same specification as Model 1 without White cross-section standard errors and covariance corrections, and exhibits similar signs and magnitudes, with a slightly higher statistical significant in the E^2 term for the US. Model 3 omits FDI as a control variable, and also yields positive signs for E, negative for E^2 and a relatively high R-squared value, although not as high as Model 1. Finally, the log-linear Model 4 included the logarithms of the regressors E, E^2, and F over GDP. This model yielded no statistically significant F/GDP regressor, and a lower R-squared compared to the other models.

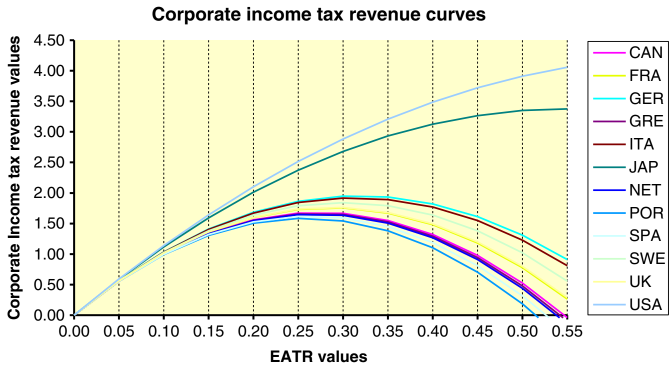

Fig. 1. Plots of the Corporate Income Tax Revenue curves for the twelve countries of the group. The curves were produced from model (1) after removing the FDI and constant terms, for the sake of drawing comparisons with the Laffer curve.

Based on the results shown in Table 1, Model 1 was selected as the most appropriate to serve as the objective function for individual countries in the group. Noticeably, EATR elasticities in this model are in line with the mainstream related empirical literature replicating Laffer curve (see Clausing (2007)). Fig. 1, shows the relationship between CTR and EATR for each country in our sample, considering FDI to be fixed, using Model 1, with the FDI and constant terms removed, so that all curves meet at the origin. We notice an evident replication of the Laffer curve.

Because the optimal (maximizing) points and the shape of curves for each country may possibly be altered by the inclusion of additional parameters, we regard Fig. 1 with caution and mainly for purposes of relative comparisons among the countries included in the study. There is an obvious trend where revenue curves are generally more or less concave according to the country's individual characteristics. What we have here is in line with Clausing (2007), where small and open economies[5] (e.g., Portugal, Spain, and Greece) appear to have higher concavity than large-closed economies[6] (e.g., US, Japan, Germany, UK, France, and Canada), and with Baldwin and Krugman (2004) on the so-called core–periphery tax gap, who conclude that core industrialized nations tend to keep their tax rates relatively high while periphery nations tend to lower theirs.

As we have mentioned previously, in Model 1 country-specific heterogeneity is "expressed" through the squared-term coefficient only. We also tested for the possibility of having all coefficients of Eq. (1) vary with i (i.e., and preformed individual regressions using OLS time series models) for each country in the group. Tests on these models indicated thin robustness and low statistical significance. In addition to the models considered in Table 1, we also estimated and tested models with a variety of other distinct control variables, including: GDP, EATR to the third power, FDI inward stock, FDI inflow and FDI outflow, and FDI aggregate flow. The statistical significance of these terms and the determining power of the estimated models were low.[7]

Finally, we note that our purpose here is to specify a statistically significant reduced-form corporate tax revenue model for use in the

Table 1
Baseline Corporate Income Tax Revenue models. Variable names are as defined in Eq. (1).

Dependent variable: central government Corporate Income Tax Revenue				
Explanatory variables	Model 1	Model 2	Model 3	Model 4 (log-linear)
γ_0 (constant)	−1.547	−1.547	−1.687	−2.853
	(2.981)**	(3.317)**	(2.897)**	(30.428)**
E (EATR)	12.296	12.296	14.328	582.651
	(3.549)**	(3.847)**	(3.693)**	(2.617)**
F (FDI)	0.488	0.488		
	(8.380)**	(3.872)**		
F/GDP				−0.004
				(0.193)
E^2 (CAN)	−22.485	−22.485	−27.162	−291.616
	(3.797)**	(4.044)**	(4.104)**	(2.619)**
E^2 (FRA)	−21.482	−21.482	−25.591	−291.513
	(3.674)**	(3.864)**	(3.912)**	(2.618)**
E^2 (GER)	−19.351	−19.351	−22.921	−291.344
	(3.647)**	(3.943)**	(3.860)**	(2.617)**
E^2 (GRE)	−22.674	−22.674	−27.497	−291.465
	(3.934)**	(4.242)**	(4.271)**	(2.618)**
E^2 (ITA)	−19.680	−19.680	−24.399	−291.649
	(3.409)**	(3.583)**	(3.783)**	(2.620)**
E^2 (JAP)	−11.193	−11.193	−15.284	−291.897
	(2.067)*	(2.065)*	(2.524)*	(2.622)**
E^2 (NET)	−22.830	−22.830	−27.182	−291.644
	(3.930)**	(4.239)**	(4.185)**	(2.620)**
E^2 (POR)	−23.845	−23.845	−29.142	−291.573
	(4.024)**	(4.346)**	(4.406)**	(2.619)**
E^2 (SPA)	−23.314	−23.314	−28.033	−291.488
	(3.972)**	(4.250)**	(4.275)**	(2.618)**
E^2 (SWE)	−20.511	−20.511	−24.598	−291.531
	(3.868)**	(4.261)**	(4.150)**	(2.619)**
E^2 (UK)	−21.399	−21.399	−24.695	−291.639
	(3.667)**	(3.697)**	(3.778)**	(2.620)**
E^2 (USA)	−8.939	−8.939	−9.568	−291.526
	(1.519)#	(1.426)#	(1.448)#	(2.619)**
Total pool (unbalanced) observations (NxT)	280	280	280	280
Adjusted R-squared	0.780	0.780	0.723	0.498

Notes: Absolute value of t-statistics in parentheses. * Significant at 5%. **Significant at 1%.
#Significant at 15%.

[5] Economies are categorized as small vs. large based on their population size; they are categorized as open or closed based on the magnitude of their FDI inflow–outflow stock as a proportion of their GDP (as in Clausing (2007)).

[6] Variables that capture market openness and population size are not included in models considered here, but may interfere with the parabolic shape of the corporate tax revenue curves, as discussed in Clausing (2007).

[7] All tests on alternative models mentioned in the text are not included here because of space considerations; they are available from the authors upon demand.

Table 2
FDI inflow differential responsiveness to EATR differentials.

Dependent variable: logarithm of FDI inflow differentials ($LFDI_{ijt}$)					
Explanatory variables	Model 1b	Model 2b	Model 3b	Model 4b	Model 5b
c_0 (constant)	9.140 (167.161)**	8.803 (147.41)**	8.936 (189.274)**	8.616 (164.477)**	8.614 (165.045)**
$E_{it}-E_{jt}$	−0.220 (0.359)	−2.140 (3.511)**	3.517 (3.524)**	−0.249 (0.248)	−0.535 (0.956)
$(E_{it}-E_{jt})^2$	−35.610 (7.12)**	−30.235 (6.275)**			
$(E_{it}-E_{jt})^3$			−82.747 (2.061)*	−13.345 (0.343)	
$\ln(G_{it}/G_{jt})$		0.306 (11.786)**		0.320 (12.098)**	0.321 (12.287)**
Total pool (balanced) observations (NxT)	1584	1584	1584	1584	1584
Adjusted R-squared	0.038	0.115	0.008	0.092	0.093

Notes: Absolute value of t-statistics in parentheses. * Significant at 5%. **Significant at 1%.

tax competition game to be formulated in the next section. Testing for other, extended models of corporate tax revenue with additional possible determinants was outside the scope of the present work. This is not to say, however, that a more complete model could not be considered as a replacement for the one used here.

3.2. Modeling the response of FDI to EATR differentials

We will assume that the response of FDI inflows to tax differentials follows a nonlinear model with a functional form which is similar to that of Bénassy-Quéré et al. (2005),[8] but deviates from the spirit of the bilateral viewpoint of FDI flow competition (as in, for example, Bénassy-Quéré et al. (2005) and Razin and Sadka (2006)) and considers the effects of all FDI inflow differentials simultaneously for the entire group of countries. The basic nonlinear equation to be estimated is the following:

$$\ln\left(F_{it}-F_{jt}\right) = c_0 + c_1\left(E_{it}-E_{jt}\right) + c_2\left(E_{it}-E_{jt}\right)^2 + c_3\ln\left(G_{it}/G_{jt}\right) + e_{ijt}, \quad (2)$$

where G is GDP, $i,j=1,\ldots,N$ indicate countries, with $i\neq j$, t indicates year, and e_{ijt} is a random disturbance. To estimate our basic FDI inflow distribution model (2), we used the same data set as in Section 3.1, excluding years with negative FDI inflow differential values.[9] Using OLS panels, we estimated the following five models — variants of Eq. (2).

Their statistical properties are shown in Table 2. The panels used to estimate the models were balanced, with 1584 observations.[10] The number of observations included all available data, by exchanging the order of the i- and j-terms in Eq. (2) when necessary, to keep $F_{it}-F_{jt}>0$.

As in the case of the objective function specification, the five models tested here are reduced-form determinant models of FDI log-differentials. They do not include variables such as investment potential, market agglomeration, product and labor market regulation, bilateral tax agreements, language, infrastructure and other quantities which are deemed to also be significant FDI control variables in relevant studies,[11] but vary "slowly" in comparison to EATRs, and will be assumed to be fixed here. As in Section 3.1, we are looking for a reduced model which is acceptable for our purposes in terms of robustness and determining power; however, it will become clear, after we have used Eqs. (1) and (2) to formulate the tax competition game central to this work, that it is also possible to substitute other, more complete models, if one wants to include the role of additional determinants.

The "Model 1b" column in Table 2 corresponds to Eq. (2) without the ratio-of-GDP term. Although variable signs and magnitudes are as expected, the coefficient of the EATR differential $(E_{it}-E_{jt})$ is of low statistical significance and magnitude, while the model's R-squared statistic is also very low. Model 2b corresponds to Eq. (2) itself. Coefficients for the tax variables have the expected negative sign, while the coefficient of $\ln(G_{it}/G_{jt})$ exhibits the expected positive sign since the relative size of a country's economy is deemed important and implicitly determines factors such as infrastructure and investment potential. The semi-elasticity of E-differentials in Model 2b is −2.14, while that of $(E_{it}-E_{jt})^2$ is −30.25. These values are generally in line with the mainstream related literature[12] (see, for example, the De Mooij and Ederveen (2003) meta-analysis, according to which the median tax-rate semi-elasticity[13] of foreign capital is −3.3).

In Model 3b, we tested for the presence of an EATR differential term raised to the third power. The corresponding coefficient does not have the expected sign. The magnitude of the tax variables is quite satisfactory but the determining power of the model is very low. In Model 4b, we augmented Model 3b with the regressor $\ln(G_{it}/G_{jt})$. It is clear from Table 2 that, although the determining power of the model increases, the $(E_{it}-E_{jt})^3$ term becomes insignificant. Finally, in Model 5b we tested a reduced-form equation for the linear relationship of FDI differentials with EATR differentials and $\ln(G_{it}/G_{jt})$. In that case, the linear EATR term becomes insignificant, and the statistical significance of the model remains low. These comparisons suggest Model 2b to be the most appropriate among those tested for capturing the reaction of FDI differentials to tax differentials.

4. A computational model for tax competition

Armed with models (1) and (2), we are now ready to describe a sequential, non-cooperative tax policy game, in which players–countries will seek to optimize their corporate tax revenues by altering their EATR in an attempt to attract higher FDI inward flows when that is advantageous. We begin by discussing the mechanics of our model.

The objective function of each country–player, i, will be its corporate tax revenue, as per Eq. (1) where, following the analysis of Section 3.1, the coefficients γ_0, γ_1, γ_{2i}, γ_3, are as in Model 1 of Table 1, and we have used the subscript i in γ_{2i} to indicate the fact that the coefficient of the squared term is different for each player. Each player, acting selfishly, is then faced with the problem of choosing E_i to maximize $C_i=f(E_i,F_i)$, where the function f is shorthand for the relationship in Eq. (1). Of course, once the entire group of players is considered, F_i is no longer an independent variable; the FDI inflow that a player will receive depends on the tax rates set by all players, because FDI inflows are affected by tax differentials between countries (see Section 3.2). This will be an additional source of nonlinearity (besides the presence of the squared term) in the objective function. We will describe this dependence of F_i on everyone's EATR next.

[8] For a fuller discussion on nonlinear models of bilateral FDI flows see also Razin and Sadka (2006) and Devereux et al. (2008).

[9] For data details refer to Section 3 and to Tables A1 and A2 in the Appendix.

[10] There are 12 countries and 24 years of data, which yields $(12\cdot 11)/2\cdot 24=1{,}584$ possible pairings of competing countries.

[11] For more FDI determinant variables in the FDI-tax rates nexus refer to Brill and Hassett (2007, 2003), Bénassy-Quéré et al. (2005), Devereux (2006) and Hajkova et al. (2006).

[12] De Mooij and Ederveen (2003) implemented a meta-analysis of the most important empirical studies on the impact of taxes on the allocation of FDI. The FDI in this meta-analysis is assumed to equal the number of foreign locations multiplied by the average amount of capital invested in each of these locations.

[13] Semi-elasticity is defined as the measure of the percentage change in FDI in response to a 1% point change in the tax rate (e.g. from 25% to 24%).

4.1. A probabilistic model for "global" FDI distribution

Each instance of our model (2) – and others of its kind – for the reaction of FDI inflow to tax differentials between countries is a kind of "local" description only, in the sense that it determines only the difference in FDI inflow received by a pair of countries. The problem of course, is that for N countries there will be $N(N-2)/2$ instances of Eq. (2) – 66 in our case – which, given every country's EATR, must be solved for the N FDI inflows. This gives rise to an over-determined system of equations which in general will not have a solution. We will circumvent this problem by constructing a probabilistic model, based on Eq. (2), in which a fixed total of FDI inflow is to be distributed among the N players. Specifically, for a given time period (e.g., one year), each unit of FDI inflow will have a probability x_i to locate itself in country i. It is reasonable, for example, to think of this probability as being higher if a country has low EATR relative to others. The probabilities x_i will be allowed to fluctuate and "settle" before any FDI is "committed". Our assumption will be that the rate a_{ij} at which the probability of player i receiving a unit of FDI "flows" to player j is proportional to the right-hand side of the deterministic version of Eq. (2) exponentiated, or, equivalently, proportional to the FDI inflow differentials "predicted" by Eq. (2):

$$a_{ij} = ke^{c_0 + c_1(E_i - E_j) + c_2(E_i - E_j)^2 + c_3\left(\ln\left(\frac{C_i}{C_j}\right)\right)}, \quad i \neq j, i, j = 1, \ldots, N. \tag{3}$$

Here, k is a positive constant and the coefficients $c_0, \ldots, c_3$ are taken from Model 2b in Table 2. Intuitively, Eq. (3) could be viewed as a "tendency" of new FDI inflow to decide in favor of player i versus player j. Based on these rates, the probabilities x_i will evolve according to the following N linear differential equations:

$$dx_i / dt = a_{ij}x_j, \tag{4}$$

which can be combined in a single vector equation,

$$\frac{dx}{dt} = Ax, \tag{5}$$

with $x = [x_1, \ldots, x_N]^T$, and A being the matrix whose (i,j)-th element is $[A]_{ij} = a_{ij}$ for $i \neq j$, $[A]_{ii} = -\sum_{j=1, i\neq j}^{N} a_{ji}$, for $i,j = 1,\ldots,N$.

As defined, A is a so-called intensity matrix, with all of its off-diagonal elements positive, and column-sums equal to zero, so that the state Eq. (5) preserves probability (i.e., the elements of x remain positive, with a constant sum). It is well-known that A will have a single zero eigenvalue, with all other eigenvalues having negative real parts. As a result, Eq. (5) will have a unique equilibrium for the vector x in the space of probability vectors. Specifically, the solution of Eq. (5), starting from any initial condition, will converge to the probability vector, $\bar{x}$, which is parallel to the eigenvector of A corresponding to the eigenvalue at zero. This equilibrium state will describe how FDI inflow will be distributed on average, once players have decided on their tax rates: if we let F denote the total FDI inflow amount for which countries compete, then the vector $F \cdot \bar{x}$ would correspond to the expected FDI inflow levels that players would receive, given their EATRs. Thus, Eq. (5) brings together all of the "bilateral" instances of Eq. (2) into a single model in which changes in one country's EATR simultaneously affect everyone's probability of receiving each unit of FDI inflow.

We emphasize again that Eqs. (3)–(5) are not meant to capture cross-country migration of investment; rather, they are a model of FDI "deciding" how to distribute itself among the players, according to percentages which are obtained when Eq. (5) is at equilibrium. Note also that we are only interested in the equilibrium state of Eq. (5) even though its complete solution, $x(t)$, is a function of time. The notion of time in Eq. (5) does not have any physical significance in the context of our tax competition game.

4.2. Tax competition game

Let F_{tot} be the sum total of FDI inflow for which the players compete. Given their objective functions C_i, and initial values for their tax rates E_i, for $i = 1,\ldots,N$, the players engage in the following game:

1. `Repeat`
2. `For` each player, $i = 1,\ldots,N$, in random order
3. Given all players' tax rates, E_i, use Eqs. (3) and (4) to determine A and compute the steady-state probabilities, $\bar{x}$, of each player receiving one FDI unit, from Eq. (5), using any initial condition for x. We note that the choice of proportionality constant k in Eq. (3) does not affect the steady-state of Eq. (5).
4. Compute the FDI levels each player is expected to receive, as $F_i = F_{tot} \cdot \bar{x}_i$, $i = 1,\ldots,N$.
5. Find the tax rate E_i that maximizes $C_i = f(E_i, F_i)$ from Eq. (1), treating F_i as fixed.
6. `End for`
7. `Until` all agent's tax rates do not change compared to the last iteration (within some specified tolerance).

When simulating the game, we also apply upper and lower bound constraints to the tax rates E_i, so that no agent could institute either zero or very high tax rates:

$$T_{min} \leq E_i \leq T_{max}, i = 1,\ldots,N. \tag{6}$$

In our simulations, we used $T_{min} = 0.06$ (6%) and $T_{max} = 0.65$ (65%).

As one might expect, and as we shall see in the next section, the game described above may not always have a unique equilibrium. In that case, the order in which the players take turns as well as their initial conditions may play a role as to which equilibrium is reached.

4.3. Finding the game's equilibrium

Given the decisions of its competitors, an agent i maximizes its objective when the following first-order condition is satisfied:

$$\frac{\partial C_i}{\partial E_i} + F_{tot}\frac{\partial C_i}{\partial F_i}\frac{\partial \bar{x}_i}{\partial E_i} = 0, \tag{7}$$

where the last term, $\partial \bar{x}_i / \partial EATR_i$, can be computed from the FDI distribution model (5) by finding the partial derivatives (with respect to each E_i) of the eigenvector that corresponds to A's zero eigenvalue. To find the game's equilibrium, one could solve the first-order conditions after modifying Eq. (7) to account for the constraints (Eq. (6)). Doing this analytically is complicated by the presence of the $\partial \bar{x}_i / \partial E_i$ term. Instead, we chose to directly apply the algorithm given in Section 4.1. We note that, as posed, our game is not zero-sum and therefore may have multiple equilibria, something which we observe in our numerical experiments described next.

5. Results and discussion

We simulated the game described in Section 4.1, where countries were allowed to optimize their tax revenue (Eq. (1)) by adjusting their EATR levels, competing for a total FDI inflow level equal to that for 2005 ($F = 544.533$ mil. USD). When applying the algorithm of Section 4.1, equilibrium was reached typically within two to three turns. Table 3 shows the optimal EATR levels and corresponding fraction of the total FDI captured by each country at the game's equilibrium, where no country was better off by unilaterally changing its tax rate.

Because total FDI inflows were increasing during 1982–2005, we explored alternative scenarios of FDI total inflow values (with the baseline case corresponding to the year 2005). When the FDI inflow amount increased to 150% of its 2005 level, all countries – except the US which keeps its EATR steady – maximize their objective function

Table 3
Optimal EATR for players in the FDI distribution game. Players compete for a total FDI level equal to the 2005 total for countries in the sample. We have included the 2005 EATR and FDI amounts for comparison.

Country	2005 EATR	2005 FDI fraction captured	Optimal EATR at equilibrium	FDI fraction captured at equilibrium	CTR at equilibrium (in 10^{11} USD)
Canada	0.2843	0.0531	0.244	0.1015	0.3847
France	0.2539	0.1489	0.242	0.1526	0.5767
Germany	0.3150	0.0659	0.269	0.1559	0.7752
Greece	0.2061	0.0011	0.261	0.0348	0.2105
Italy	0.2602	0.0367	0.276	0.1134	0.6492
Japan	0.3170	0.0051	0.493	0.0337	1.8842
Netherlands	0.2512	0.0761	0.249	0.0693	0.2838
Portugal	0.2021	0.0073	0.248	0.0329	0.1235
Spain	0.2611	0.0459	0.233	0.1082	0.3403
Sweden	0.2089	0.0187	0.286	0.0406	0.4000
UK	0.2392	0.3557	0.243	0.1548	0.5893
US	0.2904	0.1855	0.650	0.0021	2.6747

by slightly lowering their EATR values compared to the optimal EATR values for the 2005 FDI inflow levels (see Table 4).

5.1. Existence of multiple equilibria

When FDI inflow increases to three times its 2005 value, we were able to identify two equilibria, shown in Tables 5a and 5b. We observe that for some players, specifically the US, the corresponding choices made are far apart, i.e., setting its EATR at the minimum and maximum possible levels, respectively. Essentially, as the amount of FDI that can be attracted by a country grows in relation to its GDP, it becomes more advantageous to compete by lowering its EATR. At the same time, the optimum EATR for a country will depend strongly on the choices that other countries have already made, thus the sequence in which players take turns becomes important. In the equilibria shown in Table 5a, France and Germany “move” first, and their choice to minimize their EATR means that the US cannot attract enough FDI to offset its “internal” losses that would be incurred when lowering its EATR, so it decides to effectively ignore the game. On the other hand, if the US is already at a low EATR (Table 5b), it is not advantageous for other “large” players to aggresively compete for FDI.

With respect to the possibility of a “race to bottom”, our results indicate that no such condition occurs with current – or even higher – FDI levels. Of course, as one would expect, and as our numerical experiments show, if the total FDI available were to grow significantly compared to a country's GDP, this would induce that country to lower its EATR to the minimum possible, because even a small fraction of total FDI would be significant. In our setting, it took an FDI level of 50 times that of 2005 in order for all countries to choose the minimum (0.06) EATR (results available upon request).

Table 4
Optimal EATR levels at game equilibrium when players compete for a total FDI level equal to 150% of the 2005 total for countries in the sample.

Country	Optimal EATR at equilibrium	Fraction of FDI captured at equilibrium	CTR at equilibrium (in 10^{11} USD)
Canada	0.232	0.0971	0.4830
France	0.219	0.1548	0.7334
Germany	0.245	0.1591	0.9389
Greece	0.257	0.0320	0.2434
Italy	0.260	0.1110	0.7628
Japan	0.447	0.0493	1.9097
Netherlands	0.241	0.0650	0.3497
Portugal	0.245	0.0300	0.1542
Spain	0.220	0.1039	0.4445
Sweden	0.281	0.0376	0.4386
UK	0.218	0.1588	0.7502
US	0.650	0.0013	2.6744

Table 5a
Optimal EATR levels at game equilibrium when players compete for a total FDI level equal to 3× the 2005 total for countries in the sample.

Country	Optimal EATR at equilibrium	Fraction of FDI captured at equilibrium	CTR at equilibrium (in 10^{11} USD)
Canada	0.202	0.0690	0.5703
France	0.060	0.2451	1.0692
Germany	0.060	0.2891	1.4281
Greece	0.246	0.0194	0.2610
Italy	0.207	0.0886	0.8621
Japan	0.540	0.0008	1.8352
Netherlands	0.221	0.0430	0.3988
Portugal	0.237	0.0183	0.1736
Spain	0.193	0.0731	0.5411
Sweden	0.265	0.0224	0.4500
UK	0.163	0.1312	0.9357
US	0.650	0	2.6691

5.2. Conspiracy scenarios for FDI inflow 1×-to-3× 2005 levels

We considered a “conspiracy” scenario where a few of the larger players (France, Germany, Japan, UK, and US) keep their EATRs at the minimum value allowed. Table 6 shows the corresponding equillibrium for an FDI level of 3× its 2005 value. We selected this FDI level in order to simulate an environment where the amount of FDI is large enough to perhaps entice players to “sacrifice” some tax revenue in exchange for FDI. By comparing the values of the objective functions at equilibrium, we notice that the conspiracy is not a “stable” one. Every conspirator is worse off than if they had competed freely. In addition, simulating a situation where any of the five decides to “betray” the others and compete freely, indicates that the “rogue” conspirator would improve their position (i.e. increase the value of their objective function). In the case where the conspirators decide to simply optimize their EATR by ignoring the FDI terms in Eq. (1), the results for an FDI level equal to the 2005 total (see Table 7) indicate that the US is slightly better off (compared to the free competition scenario in Table 3) but all other conspirators are not.

We also examined the scenario where the same collection of “large” players decide to optimize their EATR by ignoring FDI when competing for a total FDI of 3× the 2005 total FDI inflow for countries in the sample. In that case, the US is indifferent but all other “conspirators” are worse off than if they were competing freely. At the same time smaller countries lowered their rates to gather most of the FDI. The numerical results are not shown here because of space considerations, but are available upon demand.

Finally, we examined the case where some of the “smaller” countries (Greece, Portugal and Spain) collude by minimizing their EATR in order to attract FDI. When competing for a total FDI inflow equal to the 2005 amount the conspirators were not better off, because they were not effective at attracting FDI inflows despite their

Table 5b
Optimal EATR levels at game equilibrium when players compete for a total FDI level equal to 3× the 2005 total for countries in the sample (second equilibrium).

Country	Optimal EATR at equilibrium	Fraction of FDI captured at equilibrium	CTR at equilibrium (in 10^{11} USD)
Canada	0.227	0.0437	0.4341
France	0.212	0.0709	0.6601
Germany	0.225	0.0775	0.8585
Greece	0.255	0.0138	0.2243
Italy	0.247	0.0511	0.6974
Japan	0.537	0.0011	1.8372
Netherlands	0.238	0.0287	0.3151
Portugal	0.244	0.0130	0.1378
Spain	0.218	0.0462	0.3944
Sweden	0.278	0.0157	0.4112
UK	0.211	0.0727	0.6752
US	0.060	0.5657	3.6725

Table 6
Equilibrium values when some "large" players (e.g. France, Germany, Japan, UK, US) conspire to keep their EATR at the minimum allowed. Countries compete for a total FDI level equal to 3× the 2005 total for countries in the sample.

Country	Optimal EATR at equilibrium	Fraction of FDI captured at equilibrium	CTR at equilibrium (in 10^{11} USD)
Canada	0.236	0.0253	0.3047
France	0.060	0.1139	0.0226
Germany	0.060	0.1344	0.1935
Greece	0.258	0.0079	0.1789
Italy	0.260	0.0271	0.5362
Japan	0.060	0.1808	0.5931
Netherlands	0.244	0.0166	0.2266
Portugal	0.247	0.0076	0.0965
Spain	0.227	0.0273	0.2609
Sweden	0.283	0.0081	0.3551
UK	0.060	0.1162	0.0410
US	0.060	0.3348	1.8301

low EATR. An experiment with 3× the 2005 FDI inflow gave similar results; in that case it was optimal for the US to set its EATR at 0.06 and attract over 50% of available FDI away from other players, leaving insufficient amounts for the conspirators to make colusion worthwhile (numerical results available upon request).

6. Conclusions and policy implications

We have proposed a game-based model for capturing tax competition among countries that seek to maximize corporate tax revenue by adjusting their corporate tax rates in an effort to attract FDI. Numerical experiments using data from twelve OECD countries during 1982–2005 suggest that there will be no "race to the bottom" for the group as a result of tax competition. In our experiments, race-to-bottom conditions did occur for very large (over 50 times the 2005 value) amounts of FDI inflow, ceteris paribus. Our results are in line with the recent literature discussing the existence of a tax rent bonus offered by large countries to mobile investment capital (e.g., in the case of USA, Japan, Germany, Italy, Sweden, UK, France, and Canada). Also, there may be multiple equilibrium positions in which the optimum EATR for the competing countries heavily depends on the prior choices of other countries. With respect to the existence (or not) of a race to bottom, our findings seem to be in agreement with studies such as Haufler and Wooton (1999), Baldwin and Krugman (2004), and others (see, for example the discussion in Loretz (2007)), as opposed to early work in tax competition which predicted (either explicitly or implicitly) a race to bottom for tax rates (e.g. Dhillon et al., 1999, Mintz, 1999, Wilson, 1991).

Our simulations also suggest that there is no room for collusion either among "large" or "small" players. Thus, even if we ignore additional considerations that would direct policy away from minimal EATR values, there would be no incentive, for example, for countries like Portugal, Spain, Netherlands, and Greece to conspire on keeping very low rates, because their difficulties in attracting FDI are in some significant part due to factors other than tax rates, as we have discussed in Section 3.1.

In the case of the EU-25, which follow a strict convergence program, with the intention of eventually leading to a unified level of development and similar political and economic characteristics, the scenario of convergence to zero (or very low) EATR equilibrium levels in an extended time span appears weak. If, in some idealized setting, these uniform conditions were achieved, they would likely drive long-run equilibrium to homogenous EATR levels. However, those levels would not necessarily be low. One reason for this, aside from policy considerations which argue against extreme EATR levels, would be that countries outside the EU-25 are likely to differ from member states in terms of their economic variables. Another reason is that it is unlikely that the objective functions of countries both inside and outside the EU-25 would be similar enough so that the game equilibrium occurs at very low EATRs for all players.

Opportunities for future research include augmenting the FDI distribution model to incorporate dynamic effects in the specification of the intensity matrix which determines the proportion of FDI allocated to each country, and also to account for economic geography gravity variables, such as market investment potential, openness, infrastructure, language, and bilateral tax agreements. In this context, it is also of interest to consider the role of rising economies which may be more likely to fuel a race to bottom with respect to corporate taxation. Our game model is sufficiently flexible so that substituting more advanced CTR objective functions and/or FDI reaction functions would be relatively straightforward. Our findings do not preclude the need for some sort of common EU or OECD tax administration actions intended to facilitate investment capital and profit allocation, in a way that reduces administration costs and economic inefficiencies, but without limiting the governments' taxing power according to the national objectives and constraints. Moreover, given the existence of multiple equilibria found in this work, and in light of recent studies which predict that corporate tax competition will lead to tax rates converging to lower than welfare-optimal levels (e.g., Devereux et al., 2008, Clausing, 2007, Bénassy-Quéré et al., 2005), it would be interesting to determine whether any of these correspond to "harmful" corporate tax competition, in terms of welfare losses. Finally, it might be worth to investigate the likely consequences of tax avoidance through income-shifting from the personal to the corporate tax base.

Table 7
Equilibrium values when some "large" players (France, Germany, Japan, UK, and US) decide to optimize their EATR by ignoring FDI. Countries compete for a total FDI level equal to the 2005 total for countries in the sample.

Country	Optimal EATR at equilibrium	Fraction of FDI captured at equilibrium	CTR at equilibrium (in 10^{11} USD)
Canada	0.237	0.1182	0.4188
France	0.286	0.1340	0.5692
Germany	0.318	0.1326	0.7591
Greece	0.259	0.0392	0.2212
Italy	0.270	0.1300	0.6843
Japan	0.549	0.0168	1.8748
Netherlands	0.245	0.0792	0.3059
Portugal	0.246	0.0372	0.1338
Spain	0.224	0.1283	0.3788
Sweden	0.284	0.0455	0.4119
UK	0.287	0.1360	0.5812
US	0.650	0.0029	2.6768

Appendix. Variables and data sources

Table A1
Descriptive statistics for the period: 1982–2005 (all 12 countries in our data set).

	N	Max	Min	Mean	Median	Std. dev.	Kurtosis
Corporate Income Tax Revenues	280(*)	3.844	0.003	0.443	0.198	0.640	7.948
Foreign Direct Investment inflows	288	3.140	−0.092	0.188	0.063	0.373	28.798
Effective Average Tax Rates	288	0.481	0.202	0.307	0.284	0.068	2.987
Gross Domestic Product	288	124.000	0.241	14.762	6.200	21.467	10.844

Notes: Corporate Income Tax Revenues, FDI inflows, and GDP are in US dollars ($\times 10^{11}$) in current prices.
(*) There was no CTR data available for Portugal for the period: 1982–1987, and the year 2005.

Table A2
Data sources.

Variables	Sources
Corporate Income Tax Revenues (central government level)	OECD Revenue and National Accounts Databases.
Foreign Direct Investment inflows	United Nations Conference of Trade and Development (UNCTAD) Statistical Databases
Effective Average Tax Rates	Institute for Fiscal Studies (IFS) Publications (Base case EATR)
Gross Domestic Product	The World Bank/World Development Indicators Data and Statistics

Tax-related data definitions: EATR and Corporate Income Tax Revenues.[14]

EATR equals a weighted average of an EMTR and an adjusted statutory tax rate. It can therefore be interpreted as summarizing the distribution of effective tax rates for an investment project over a range of profitability. The calculation of countries' EATR[15] from the data set provided by the Institute for Fiscal Studies (updated by A. Kleem in 2005) in the document "tablesIFS.xls", is based on a set of specific assumptions e.g., investment in plant and machinery, financed by equity or retained earnings, taxation at shareholder level not included, rate of economic rent at 10% (i.e., a financial return of 20%), a real discount rate of 10%, an inflation rate of 3.5%, and a depreciation rate of 12.25%.

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[14] http://www.ifs.org.uk/publications.php?publication_id=3210.

[15] For the precise formula applied refer to Devereux and Griffith (2003). In the present study we use EATRs as calculated with the "base case" scenario.