Tax competition as a cause of falling corporate income tax rates: A literature survey

Abstract

Tax rates on capital and corporate income tax rates in particular, have declined in most industrialized countries since the mid 1980s. International tax competition for mobile capital has been frequently mentioned as an explanation for this development. A vast empirical literature dealing with tax competition for mobile capital has emerged. This paper provides a comprehensive overview of these empirical studies. Particular focus is placed on studies modelling strategic interaction in tax policies of competing jurisdictions – which is at the heart of the competition concept. The paper also addresses the question of whether existing studies convincingly isolate tax competition as a driver of falling capital/corporate income tax rates. Given the empirical evidence surveyed, it appears that tax rates indeed fall due to tax competition, in particular due to competition for new firms and paper profits. However, a closer look at the empirical approaches applied in the papers surveyed suggests that there is still no fully convincing evidence to establish tax competition as a driver of falling tax rates.

1. Introduction

Statutory corporate income tax rates (STRs) have declined in most industrialized countries since the mid 1980s. Tax competition between countries (horizontal tax competition) for mobile capital, firms and paper profits is frequently stressed as an explanation for this development. Accordingly, horizontal tax competition reflects any non-cooperative tax setting by governments under which each government's policy choices influence the allocation of mobile tax bases among the 'regions' represented by these governments (see Wilson and Wildasin 2004, p. 1067). Tax competition therefore implies the strategic interdependence of government tax policies.

Issues concerning the presence of tax competition for mobile tax bases, capital in particular, are of high relevance in the academic and political discussion. It is frequently argued that tax competition for mobile capital eventually leads to an inefficient low provision of public consumption goods, government redistribution in particular, and / or to a shift in the composition of tax burden away from capital to more immobile factors.[1] A vast empirical literature tries to shed light on the role of tax competition for mobile capital as a driver of falling tax rates. These studies widely differ in terms of empirical approaches applied, operationalizations of the variables of main interest or control variables used. For this reason, this paper categorizes and summarizes the existing empirical studies with a particular focus on the isolation of the substantive implications the quantitative study outcomes convey. This is done by deriving a comparable tax-rate sensitivity measure: the semi-elasticity of tax rates with respect to different explanatory variables, based on the information given in the papers surveyed.[2] Hence, the article updates and extends existing surveys on the topic (e.g. Brueckner 2003).

The paper also addresses the question of whether the existing studies can convincingly isolate tax competition as a driver of falling capital/corporate income tax rates. This is a relevant policy issue, as one must bear in mind that, aside from tax competition between independent jurisdictions, the decline in tax rates might – at least partly – have other economic, institutional and political causes. Policy recommendations, for instance, with respect to enhanced tax coordination efforts, may differ across the various causes of falling tax rates.

In particular, besides tax competition, tax rates may fall due to the implementation of "common intellectual trends" (Griffith and Klemm 2005 Slemrod 2004; and Nicodème 2006). Examples of common intellectual trends are the move towards the implementation of the Schanz-Haig-Simons concept of income taxation, leading not only to a fall in tax-rate-cum-base-broadening but also to the increased integration of corporate and personal income

taxation (Musgrave 1990) or concerns with the deadweight loss of taxation resulting from high marginal tax rates (Griffith and Klemm 2005).

Furthermore, changes in the political climate (Musgrave 1990) towards a less egalitarian view of distributive justice or a more business friendly environment due to a shift to more right-wing parties may contribute to declining capital/corporate income tax rates (Persson and Tabellini 2000; Musgrave 1990). Moreover, yardstick competition (Brueckner 2003) may lead to falling tax rates if voters react to differences in tax rates, inducing policy-makers to follow tax rate changes in neighbouring jurisdictions. Thus, yardstick competition is based on a taxpayer's "voice" option in contrast to the "exit" option as in the case of tax competition (see Hirschman 1970).

The paper is structured as follows. Section two contains a brief discussion of what types of capital countries may compete for with different tax rates. Section three provides a broad classification of the available empirical studies. Sections four and five present the results derived based on the empirical studies surveyed and section six discusses the results. Finally, the main findings are summarized in section seven.

2. Targets and instruments of tax competition: Conceptual aspects

Mobile capital for which countries might compete is rather heterogeneous. Specifically, governments may compete for new firms, for the investment of existing firms and for paper profits shifted by firms from one jurisdiction to another (see Devereux 2007). Thus, countries compete for three different types of capital which are highly correlated and integrated.

A crucial point here is that these three types of capital may react to differences and changes in distinct tax rates: conceptually, new firms are located where after tax profits are highest. Hence, this decision is determined by the effective average tax rate on firms' profit which directly shows the impact taxes have on after tax profits. In contrast, the investment of already established firms is driven by the cost of capital and thus by the effective marginal tax rate. These tax rates are effective, as they also capture the effects exerted by stipulations concerning the tax base. Finally, the location of paper profits is determined by the STR. In this case, tax base regulations are not relevant (e.g. Weichenrieder 2009).

To empirically analyze the presence of tax competition, it is crucial to know how the mentioned tax rates can be operationalized. This is comparatively easy for the STR which can be directly taken from tax codes. Measuring effective tax rates is more complicated, not least because these rates are available as different types. Specifically, backward and forward

looking effective tax rates are distinguished. The former may further be separated into macro- and micro-level tax rates. Macro-level backward looking average effective tax rates (MA-AETR) in the spirit of Mendoza et al. (1994) are based on accrued capital or corporate income tax revenue data in the nominator and a suitable measure for the tax base (e.g. a corporation's net operating surplus) in the denominator. Data used to calculate these rates come from National Accounts and Revenue Statistics. In contrast, micro-level backward looking average tax rates are based on firms' balance sheet information (MI-AETR). A widely cited study deriving MI-AETRs is Nicodème (2001).[3] Backward looking rates reflect outcomes from past saving, investment and financing decisions, which are *inter alia* made based on past tax laws. Thus, these tax rates are not primarily relevant for analyzing current and future financing and investment decisions of firms as tax laws may change, making backward looking rates somewhat "outdated". However, these rates are a possible starting point for analyzing the formal incidence of taxes (e.g. Devereux 2003).

Forward looking effective tax rates measure the tax burden levied on a hypothetical, prospective investment project of a firm. These rates are based on current and future tax law, as well as certain assumptions concerning macroeconomic variables like the inflation rate. Their calculation is based on a present value framework (see Devereux and Griffith 1998). Both forward looking effective average tax rates (EATR) and forward looking effective marginal (EMTR) tax rates can be derived for domestic and international investments. In this derivation, average tax rates measure the tax burden on an infra-marginal investment project, that is, on one which earns a positive economic rent. Marginal tax rates, in contrast, measure the impact of taxes on the cost of capital. Thus, the focus is on an investment which exactly breaks even. Domestic tax rates only capture the tax laws of a prospective host country of investment. International (bilateral) tax rates additionally include stipulations contained in double taxation agreements, unilaterally binding tax laws towards foreign investment and supranational tax laws. Forward looking effective tax rates are of use when analyzing the incentive effects taxes exert on firms' investment and financing decisions. Hence, due to their reliance on current and future tax laws, forward looking tax rates are suitable measures when analyzing tax competition for new firms (EATR) and the investment of established firms (EMTR). Finally, note that the STR is a special type of forward looking tax rate which is not effective. As previously mentioned, this tax rate is relevant for analyzing tax competition for paper profits.

3. Classification of empirical tax competition studies

Following Griffith and Klemm (2005), empirical studies dealing with tax competition issues may be separated into indirect and direct studies. Studies are classified as indirect if they do not explicitly analyze the presence of tax competition but explore a precondition for tax competition, namely the tax sensitivity of capital. Indirect studies try to explain the tax-rate sensitivity of foreign capital of various forms (e.g. Foreign Direct Investment (FDI) or investments in Property, Plant and Equipment). Capital/corporate tax rates are part of the independent variables. Capital owners structure their various investment decisions by assuming these tax rates as given. Numerous indirect studies have emerged and comprehensive reviews are already available (see DeMooij and Ederveen 2003, 2005, 2008; Devereux and Griffith 2002; Devereux 2006, 2007 and Feld and Heckemeyer 2009). The main finding of these studies is that foreign capital is indeed sensitive to tax rate cuts and differences in tax rates between countries. A "precondition" for tax competition to exist is thus fulfilled.[4]

In contrast, direct studies capture tax rates and their most important determinants within an empirical model. These studies can be further separated into first and second generation direct studies, depending on whether or not they model strategic interaction in tax policies. Therefore, direct studies deal with the tax competition issue more explicitly by explaining the development in tax rates. First generation direct studies explain the development in tax rates by changes in various independent variables, most importantly measures of a country's openness to FDI and trade. An increase in a country's openness leading to a decrease in the level of the tax rate is seen as an indication for the presence of tax competition.

A conceptual drawback of the first generation direct studies is that they do not model the strategic interaction in tax policies which is at the heart of the tax competition concept. This shortcoming is overcome by direct studies of the second generation, which explicitly model and test strategic interaction in tax policies between jurisdictions via estimation of tax reaction functions. Specifically, the strategic interaction in tax policies is modelled by defining a country's tax rate as a function of the weighted average tax rate of all competitor jurisdictions (e.g. Devereux et al. 2008). Here, a positive relationship between a country's tax rate and the weighted average tax rate is seen as an indication of the presence of tax competition. *Table 1* summarizes the different approaches to analyzing tax competition.

Table 1: Classification of studies

Study type	Explained variable	Right-hand side variable of main interest	Outcome in favour of tax competition
Indirect	Capital	Tax rate	Significant (negative) impact of an increase in the tax rate on capital
Direct 1st generation	Tax rate of country i	Openness of country i	Significant negative impact of an increase in the openness variable on tax rates
Direct 2nd generation	Tax rate of country i	Weighted average tax rate of competitor countries	Significant positive impact of an increase in the weighted average tax rate of competitor countries on the tax rate of country i

Notes: Capital = (FDI, Property, Plant Equipment, paper profit, number of foreign affiliates, etc); In case of indirect studies, usually a negative coefficient on the tax variable is indicative of the fulfilment of the precondition for tax competition; yet, in some cases – e.g., when analyzing the profit-shifting behaviour of firms – a positive coefficient is also compatible with this precondition (see e.g. Weichenrieder 2009 for an example of relating the home country's STR to declared net of tax profits in the host country).

4. First generation direct studies

Tax competition between countries implies that capital can react to differences and changes in tax rates. Thus, countries need to be sufficiently open for tax competition to set in. First generation direct studies are based on this "precondition" of tax competition and model the relationship between tax rates on capital/corporate income and a country's degree of openness.

A variety of definitions of a country's openness are used in these studies. On a fundamental level, *de jure*, *de facto* and *mixed* openness measures can be distinguished. *De jure* measures focus on a country's laws with respect to capital, goods and service mobility, such as current account convertibility, the number of bilateral double taxation agreements and the number of bilateral investment treaties or the level of import duties. In contrast, *de facto* measures are based on observable interactions between countries, such as trade and FDI-flows. *Mixed* openness indicators combine *de jure* and *de facto* aspects into a summary measure (e.g. the KOF variable of Dreher 2006).

Table 2 contains characteristics of 12 studies surveyed.[5] It is obvious that the vast majority of studies are based on a type of average tax rate, usually the MA-AETR, and on OECD countries. With respect to the proxy for a country's openness, some heterogeneity is given. The empirical approaches applied in the studies also vary. However, the majority of studies show a significant negative relationship between a country's openness and the level of capital/corporate income taxation. Only three studies report significant positive results.

To elaborate on the substantive importance of a country's openness for the development of tax rates, the semi-elasticities of tax rates with respect to changes in the openness variables are derived based on the information given in the various studies contained in *Table 2*. These semi-elasticities show the percentage change in the tax rate if the openness variable changes by one unit. Taking into account the different empirical designs, three main categories can be used to differentiate the tax rate semi-elasticities with respect to openness: (i) the openness variables used; (ii) the tax rates used and (iii) the model properties (i.e. static or dynamic models).

Table 3 summarizes the means, medians, standard deviations, minima and maxima, as well as the number of significant/insignificant[6] semi-elasticities overall and separated by the three categories mentioned. The surveyed studies apply different strategies to implement openness variables in their models. Most of them use only one openness variable per regression (single-openness models). Others employ different openness measures to cover different effects and/or additionally include a lagged openness variable (multi-openness models).

Starting with the first block of *Table 3*, it is evident that the semi-elasticities range from -9.05 to 15.29 with a mean of -0.45 and a median of -0.28. This implies that the effect of an increase in a country's openness by one unit decreases its tax rate by about 0.45 percent on average. In order to evaluate the overall effect of openness on tax rates, the various semi-elasticities derived from multi-openness models are summed here.

Table 2: Summary of first generation direct studies

Author(s)	Tax rate definition	Tax base definition	Openness definition	Estimation technique[1]	Sample	Results for openness
Adam and Kammas (2007)	MA-AETR, EATR and STR	Corporate income	Quinn (1997) index on capital market integration, (Exp+Imp)/GDP size corrected	OLS with fixed country and time effects and PCSE	1970 - 1997 17 OECD countries	Negative significant
Bretschger (2008)	MA-AETR	Corporate income	Combined measure of capital market restrictions after Dreher and Siemens (2005) and (Exp+Imp)/GDP	2SLS, SURE, OLS with PCSE with time trends, 3SLS	1965 - 1999 12 OECD countries	Negative significant
Bretschger and Hettich (2002)	MA-AETR	Corporate income	Quinn (1997) index on capital as well as on capital and goods market integration, (Exp+Imp)/GDP size corrected	OLS with PCSE and fixed time effects, static and dynamic models	1967 - 1996 14 OECD countries	Positive and negative significant (-++)
Clausing (2008)	STR	Corporate income	FDI outflows	OLS	1979 - 2002 36 OECD countries	Negative significant
Dreher (2006)	MA-AETR	Capital income	Own globalization index according to the method of Gwartney et al. (2000)	OLS with fixed country and time effects, GMM ala Arellano and Bond (1991) with fixed time effects, static and dynamic models	1970 - 2000 OECD countries	Positive significant
Garretsen and Peeters (2007)	EATR	Corporate income	FDI flows (instrumented by the Golub index (Golub, 2003))	2SLS with fixed time effects	1981 - 2001 19 OECD countries	Negative significant
Huizinga and Nicodème (2006)	MI-AETR (accrued taxes to firm assets)	Corporate income	Foreign-ownership share firm and country level	OLS and WLS both with fixed country or/and time effects	1996 - 2000 34 countries	Positive (strong) significant

						(-++)
Krogstrup (2006a)	EATR	Corporate income	Quinn (1997) index on capital and goods market integration	OLS on first differences, 2SLS	1980 - 2001 13 EU countries	Negative significant (-++)
Loretz (2007)	Bilateral EMTR and EATR	Corporate income	(Exp+Imp)/GDP, intra EU dummy for economic integration	OLS with fixed country-pair effects and a time trend, Hausman-Taylor estimator	1991 - 2004 27 OECD countries	Negative significant
Slemrod (2004)	STR and tax revenues to GDP	Corporate income	(Exp+Imp)/GDP, Sachs-Warner openness indicator (Sachs and Warner (1995))	OLS with fixed country and time effects	1980 - 1995 Unknown number of developed and developing countries	Positive significant (-+)
Swank and Steinmo (2002)	STR and MA-AETR	Corporate and capital income	Quinn (1997) index on capital market integration, (Exp+Imp)/GDP*	OLS with PSCE with fixed country and time effects	1981 - 1995 13 countries	Negative significant (++)
Winner (2005)	MA-AETR and EMTR	Capital income	Quinn (1997) index on capital and goods market integration	Static models via FGLS with fixed country and time effects, and dynamic models via GMM ala Arellano and Bond (1991) with fixed time effects	1965 - 2000 23 OECD countries	Negative significant

Notes: (-++) more than half of the results (=regression coefficients) is significant. (-+) half of the results is significant. Significance level: 20% with two-sided test statistic and 10% with a one-sided test statistic. [1] PCSE: Panel corrected standard errors, 2SLS: two stage least squares estimator, SUR: seemingly unrelated regression estimation, 3SLS: three stage least squares estimator, GMM: generalized method of moments estimator, WLS: weighted least squares estimator, and FGLS: feasible general least squares estimator.

In the second block of *Table 3* studies are structured according to the type of openness variables used: *de jure*, *de facto* or *mixed* measures. Here, for a better evaluation of the type of openness measure, the semi-elasticities are not summed when different measures are used in one regression. The results derived based on all regression models imply that, no matter which type of openness measure is used, a negative impact of an increase in a country's openness on tax rates can be expected. This is also broadly the case when results from single-openness models are evaluated. The positive mean of the semi-elasticities for *de facto* measures is driven by some large positive values which skew the distribution to the right. The corresponding median value is negative.

In multi-openness models, *de jure* and *de facto* measures of openness lead to larger negative semi-elasticities, on average, than one finds in single-openness models. However, the standard deviations of these measures are higher if they are used in multi-openness models compared to those in single-openness models, pointing towards greater heterogeneity in derived coefficients from multi-openness models. Using *mixed* measures in multi-openness models leads to a positive relationship between taxes and openness. However, it should be noted that this somewhat unexpected result is based on a rather low number of regression coefficients and is mainly driven by the positive results of Dreher (2006). Overall, the picture given in the second block of *Table 3* strongly supports a negative relationship between a country's openness to FDI and trade and its taxes on capital/corporate income.

The third block of *Table 3* is structured by the tax rate type used as an endogenous variable. A total of 78 percent of the investigated regressions are based on the AETR (either micro or macro) as dependent variable, 13 percent use the forward looking EATRs or EMTRs and the rest employs STRs. Those papers applying the MA-AETR show a negative tax rate semi-elasticity of -0.82 on average. Studies using MI-AETR come up with a mean semi-elasticity of 1.17. These results imply that, when using firm-level data, an increase in the country's openness by one unit increases the average effective tax rate by 1.20 percent, whereas the effect according to MA-AETR measures would indicate a decline in the average effective tax rate by about 0.80 percent.

Turning to the conceptually superior forward looking tax rates, *Table 3* shows that using EATRs leads to a relatively large negative impact of a country's openness on tax rates (average semi-elasticity of about -3.00). The EMTR is only applied in two regressions, whereby one coefficient is insignificant. Thus, although the mean value is negative, the few results based on the EMTR provide only weak evidence supporting the negative impact of a country's openness on its capital/corporate income tax rates. With respect to the impact of open-

ness on STRs, *Table 3* shows that a one-unit increase in a country's openness has a negative impact of -1.70 percent on this tax rate type.

The last block of *Table 3* divides the models used by the investigated studies into static, semi-dynamic and dynamic properties. Here, those regressions including a dynamic part in the form of the one-period lagged dependent variable are denoted as semi-dynamic. Dynamic models also include a lag of the openness variable.

Static models come up with a negative relationship between a country's openness and its tax rate on capital/corporate income. On average, if the country's openness increases by one unit, its tax rate decreases by 0.90 percent. Including a lagged dependent variable in the regressions captures the smoothing or inertia behaviour of governments in changing tax rates. Semi-dynamic models yield a positive mean semi-elasticity. However, the median is approximately-0.16, indicating that some extreme positive values skew the entire distribution to the right. Both the mean semi-elasticity and the corresponding median value are negative for dynamic-specifications (about -1.00).

Comparing the medians and minima of the static and dynamic models, one may conclude that the effects of openness on tax rates are smaller in the case of dynamic models than they are in the case of static models. This may be a sign that static models overestimate the openness effect due to an omitted variable bias (i.e. omitted inertia in tax setting).

To summarize, the first generation direct studies analyze the presence of tax competition for mobile capital by modelling the relationship between a country's openness and its capital/corporate income tax rates. Overall, a negative relation between a country's openness and its tax rate is supported by these studies, raising the fear of a "race-to-the-bottom" if worldwide market integration moves forward. Thus, first generation direct studies are in favour of tax competition as a driver of falling tax rates on capital/corporate income. Importantly, the most striking evidence for the role of tax competition in this respect is found in cases when EATRs and STR are used as dependent variables. This points towards the presence of tax competition for new firms and paper profits (see *Section 2* above).

However, although the first generation direct studies are quite intuitive, they do not model strategic interactions in tax settings which are at the heart of the entire tax competition concept. This provides the starting point for the second generation direct studies.

Table 3: Summary information on semi-elasticities of the openness variable(s) (without extreme outliers[1]).

	Mean	Median	Std.dev.	Min.	Max.	Number of semi-elasticities: All	Number of semi-elasticities: Significant[2]
Overall							
All regression models							
	-0.447	-0.282	4.259	-9.051	15.291	125	79%
1. Openness[3]							
All regression models							
De jure	-0.985	-0.036	3.197	-13.676	2.878	35	57%
De facto	-0.404	-0.057	3.183	-17.500	5.307	118	72%
Mixed	-0.896	-6.219	8.377	-9.051	12.907	24	86%
With only one openness variable in the regression model							
De jure	-0.594	-0.823	0.513	-0.952	-0.007	3	67%
De facto	0.257	-0.043	1.756	-8.000	5.307	67	67%
Mixed	-3.437	-6.684	7.981	-9.051	12.907	18	100%
With more than one openness variable in the regression model							
De jure	-1.021	-0.034	3.344	-13.676	2.878	32	56%
De facto	-1.272	-0.107	4.277	-17.500	4.167	51	78%
Mixed	6.726	5.617	3.641	3.270	12.301	6	50%
2. Tax rates							
MI-AETR	1.167	1.158	1.288	-0.900	5.307	46	65%

MA-AETR	-0.821	-0.495	5.897	-9.051	15.291	51	86%
EATR	-3.046	-1.417	2.943	-16.382	0.610	14	100%
EMTR	-2.168	-2.168	1.706	-17.500	4.167	2	50%
STR	-1.729	-0.595	2.567	-8.000	-0.018	12	83%
3. Model properties[4]							
Static model	-0.927	-0.390	3.730	-9.051	12.907	101	78%
Semi-dynamic model	5.208	-0.142	7.122	-0.495	15.291	10	100%
Dynamic model	-1.027	-1.052	2.026	-5.201	2.833	14	71%

Notes: All semi-elasticities – except those which are separated by their measurement specification *de jure*, *de facto* and *mixed* – are derived by summing up all the openness-semi-elasticities within one regression (see Huizinga and Nicodème 2006). [1] Semi-elasticities which are two times the standard deviation of the overall sample (9.705) are treated as outliers and are not used for comparison. [2] Significance level: the significance level is that of the underlying regression coefficient; 20% with two-sided test statistic and 10% with a one-sided test statistic. [3] *De jure* measures are trade restriction measures like the Quinn indexes, EU integration dummies, and the Sachs-Warner index. *De facto* measures are FDI flows, trade flows, and other measures of real interactions between countries. Dreher's (2006) Index of Globalization and Bretschger's (2008) openness measure which combines the IMF measure (*de jure*) with trade flows (*de facto*) are both categorized as *mixed* openness measures. [4] Static models do not include time lags on openness or independent tax variables. Semi-dynamic models include lags of the dependent variable. Dynamic models include lags of both the openness and dependent variables.

5. Second generation direct studies

Second generation direct studies explicitly model the strategic interaction in tax settings by – in tax policy – independent jurisdictions via tax reaction functions. Strategic interdependencies arise "whenever the actions of some unit(s) affect the marginal utility of alternative actions for some other unit(s)" (Franzese and Hays 2009, p. 234). From a theoretical viewpoint strategic interactions in tax settings are modelled in the form of "Nash games" and as "Stackelberg-leader games". Models of the first type are based on the idea of simultaneous tax setting strategies, while those of the second sort are based on the tax setting of a large and dominant tax setting jurisdiction (e.g. the US) to which other countries react. The basic cause leading to interdependencies is the existence of externalities. In the case of tax competition models these externalities comprise, for instance, the non-compensated effects exerted by a reduction in the relevant tax rate in country j on the level of capital located (invested) in country i and in turn on the level of real wages and welfare in country i. Put differently, the tax rates of competing countries are strategic complements. This implies that tax policies towards capital move in the same direction: a decrease in the tax rate of a competitor country would induce country i to also lower its corresponding tax rate (Devereux et al. 2008; Franzese and Hays 2009).

From a more empirical viewpoint, modelling strategic interdependencies means that, among the right-hand side variables determining the level of the tax rate (Tax_i) in country i, the weighted average tax rate of all competitor countries ($WTax_{-j}$) is included. Thus, a "spatial lag" is part of the empirical models. If tax rates are strategic complements, then the estimated coefficient on $WTax_{-j}$ is positively signed.[vii] Moreover, the coefficient should be lower than 1 in magnitude to preclude "an explosive pattern of spatial dependence." (Anselin 1988, p. 86). The definition of the weighting matrix (W) is crucial as it determines which competitor countries are considered to have an impact on Tax_i and how the competitors' tax rates are averaged. The form of weighting matrix used also discriminates between Nash and Stackelberg-leader type models.

Redoano (2007) summarizes the six most common operationalizations of W: (i) uniform weights; (ii) geographic distance weights; (iii) GDP per capita weights; (iv) GDP-level weights; (v) openness weights and (vi) EU (or US) "weights" (also see *Table 4*). Uniform weights mean that each competitor country gets equal weight in W. Using this type of weighting matrix assumes that countries' geographic and economic ties have no impact on the tax setting decision. This, in turn, is consistent with the view that tax rate cuts are not predominantly driven by tax competition forces, but rather by common intellectual trends like tax-rate-

cum-base-broadening strategies. The geographic and GDP per capita distance weights cover the idea of similar movements and developments in the tax policies of close neighbours (geographic distance) and countries with similar capital endowment (GDP per capita distance). The GDP-level weights intend to capture size effects assuming that large countries are more likely to take the role of leaders in tax setting. EU (US) weights imply that changes in a country's tax rate are predominately determined by changes in the corresponding tax rates of EU countries (or the US). Note that GDP-level weights and EU (US) "weights" are used to model Stackelberg-leader competition. Moreover, one could combine GDP per capita distance weights or GDP-level weights with an EU dummy variable (see e.g. Chatelais and Peyrat 2008; Crabbé and Vanderbussche 2009 and Davis and Voget 2008 for GDP per capita weights; Redoano 2007 for GDP-level weights). In such a case, for example, only countries within the EU are weighted (by GDP per capita distance or GDP-level) and non-EU countries have zero-weights. Finally, openness weights account for the idea that more open economies are more likely to engage in strategic competition, as interdependencies grow when countries become more economically dependent.

Table 4: The most common weighting schemes

Hypothesis of interaction type	**Weight(s)**
Common intellectual trend	Uniform weight
Similar economic development of close geographic and "economic" neighbours	Geographic distance (contiguity, distance decay function, etc.) and GDP per capita distance
Openness strengthens strategic competition	FDI to GDP, trade to GDP, bilateral FDI and trade linkages
Stackelberg-leader concept	GDP-level and EU (or US) "weights"

Table 5 gives an overview of the various second generation direct studies.[viii] Among the seminal papers estimating tax reaction functions is Devereux et al. (2008). Devereux et al. (2008) model interactions in the setting of statutory as well as effective marginal tax rates on corporate income (i.e. STRs and EMTRs). Hence, the authors are directly concerned with the competition for paper profits and investments of already established firms.[ix] They provide a theoretical model of corporate income tax competition from which tax reaction functions are derived. These are then estimated using data on STRs and EMTRs of 21 OECD countries from 1982 until 1999. The authors use uniform, size and openness weights and find evidence that countries compete over both statutory and marginal tax rates. They also find that strate-

gic interaction in STRs is present only if none of the countries considered has significant capital controls in place. The authors use this last finding to discriminate tax competition from other causes of falling tax rates. They conclude that "[...] strategic interaction in statutory rates is not well-explained by other theories (such as yardstick competition or common intellectual trends), since it is generally present only between open economies without significant capital controls: thus, it is best explained in terms of competition over mobile profit […]" (Devereux et al. 2008, p. 1231). The basic point here is that (horizontal) tax competition between countries is an "open economies issue", whereas other causes of falling tax rates may influence tax policies, even in the case of closed economies (see *Section 6*).

In line with Devereux et al. (2008) many other authors (e.g. Davis and Voget 2008; Overesch and Rincke 2009; Redoano 2003, 2007; Pitlik 2005 and Swank 2006, 2007) also control for a country's openness. These studies usually support the finding of Devereux et al. (2008) and find that tax rates are strategic complements. However, in these studies it becomes evident that omitting a country's openness to FDI and trade would bias the coefficient on $WTax_{-j}$ downwards. This finding is not unexpected given the results derived from first generation direct studies, which show that the level of a country's openness has a negative impact on a country's tax rates.[x] Nevertheless, similar conclusions can be drawn from the studies which do not account for a country's openness (see Altshuler and Goodspeed 2002; Brueckner and Saarvedra 2001; Charlot and Paty 2008; Chatelais and Peyrat 2008; Crabbé and Vandenbussche 2009; Hayashi and Boadway 2001; Hill 2008; Rork 2003 and Ruiz and Gerard 2008).

Davis and Voget (2008) find that EU member states react more to the tax rate changes of other EU members than to the changes of non-EU members. Chatelais and Peyrat (2008) and Crabbé and Vanderbussche (2009), applying "contiguity weights"[xi], find that countries react to downward revisions of tax rates in neighbouring countries by also reducing their corresponding tax rates. Vis-a-vis non-neighbours, the reaction is not in line with tax competition, as tax rates are not strategic complements in this case. These results stand in contrast to those of Redoano (2007) which imply that countries were more interdependent before joining the EU.[xii]

The quantitative results derived from second generation direct studies are summarized in *Table 6*. The table shows the surveyed semi-elasticities of tax rates with respect to $WTax_{-j}$ separated by different measures of tax rates, weighting schemes and model properties. The overall semi-elasticity ranges from about -10 to 11 with a mean of 1.17 (median of 0.58), indicating that an increase in the weighted average tax rate of competitor countries by one percentage point is associated with an increase in the own tax rate by about 1.17 percent.[xiii]

Separating the studies by their tax rate definition signals that the models applying AETR measures show a negative tax reaction to neighbour's tax changes and seem to identify tax rates of different jurisdictions as strategic substitutes rather than complements. However, this result is mostly driven by estimates from the paper of Ruiz and Gerard (2008).[xiv] Reaction functions for EMTRs yield small, close to zero semi-elasticities which are positive on average. Once more, models using the STR and the EATR seem to explicitly support the tax competition thesis. The mean (median) semi-elasticities are 1.76 (1.39) and 1.76 (0.79), respectively. Thus, the empirical evidence particularly favours tax competition for paper profits and the location of new firms.

The third category of *Table 6* reports the study outcomes separated according to the employed weighting schemes. Mean and median values are all positive, irrespective of the weighting scheme, whereby openness weights and weights supporting the Stackelberg-leader concept (cf. Table 4) give the largest mean semi-elasticities. For instance, the value of 2.11 (Stackelberg-leader concept) implies that a country which follows a leading country (or leading group of countries like the EU) in tax setting will reduce its tax rates on capital/corporate income by about 2 percent if the leading country (group) reduces the corresponding tax rate by one percentage point.

Table 5: Summary of second generation direct studies.

Author(s)	Tax rate definition	Tax base definition	Functional specification	Weights	Measurement units[2]	Estimation technique[3]	Sample used	Results
Studies using a model with tax reaction functions to uncover the mechanism of tax competition ...								
a. ***... without the countries' openness as independent variable.***								
Altshuler and Goodspeed (2002)	AETR	Corporate income	Spatial lag models[1]: Nash and Stackelberg leader	Geographic distance (+1/3 if countries are separated by water) weight	$\%tax_{[t-(t-2)]} - \%tax_{[t-(t-2)]}$	IV approach with first differences and fixed country effects, Newey-West (1987) standard errors	1968 – 1996 17 European countries + US	Positive reaction on neighbor's tax setting
Brueckner and Saavedra (2001)	AETR	Property	Spatial lag model	Contiguity (common border), geographic distance, population-contiguity and population-geographic-distance weights	Log(%tax) – log(%tax)	ML approach	1980, 1990 70 cities in the Boston metropolitan area	Positive reaction on neighbor's tax setting – tax competition exists
Charlot and Paty (2005)	STR	Local business	Spatial lag model	Geographic distance weight	Log(%tax) – log(%tax)	ML approach	2002 French localities, departments and regions	Positive reaction on neighbor's tax setting
Chatelais and Peyrat (2008)	STR	Corporate income	Spatial lag models: Nash and Stackelberg leader (small vs. large countries)	Geographic distance between countries, geographic distance to Belgium-Brussels, GDP distance and population weights	%tax – %tax	IV-GMM (Kejeljian and Procha 1998)	1995 – 2006 25 EU countries + Iceland	Positive tax reaction on neighbors and negative reaction on non-neighbors; stronger reaction on tax setting of small countries
Crabbé and Vandenbussche (2009)	STR	Corporate income	Spatial lag model, differentiate between old and new	Geographic distance, contiguity, export share and economic (similar characteristics) weights	%tax – %tax	IV approach	1993 – 2006 15 EU countries	Positive tax reaction on neighbors and negative reaction on non-neighbors; stronger reaction

			EU countries					on tax setting of new EU member countries
Hayashi and Boadway (2001)	AETR	Corporate income	Dynamic[4] spatial lag models: Nash and Stackelberg leader	Average of tax rates of provinces excl. Quebec or Ontario	Logit transformation of all tax rate variables	SUR system by IFGL	1963 – 1996 10 provinces of Canada	Negative reaction on federal tax changes and some positive reactions on neighbor's tax setting
Hill (2008)	STR	Property and option sales	Spatial lag model with agglomeration effects, also differentiate between rural and urban counties	Contiguity, contiguity-population and economic (similar country income per capita) weights	%tax – %tax	IV approach with county and year fixed effects	1993 – 2003 County governments in Tennessee	Positive reaction on neighbor's tax setting; in urban counties reaction on sales tax increase is negative with contiguity and income weights
Rork (2003)	STR and AETR	Corporate income and sales	Spatial lag model	Contiguity and contiguity-population weights	%tax – %tax	IV approach (Kelejian and Prucha 1998), year and state fixed effects	1967 – 1996 48 US states	Positive tax reaction on neighbor's tax setting
Ruiz and Gerard (2008)	STR, EATR, MA- and MI-AETR	Capital and corporate income	Spatial lag model	Geographic distance (of capitals, distance within a band, real), economic distance (between GDP or GDP per capita) and cluster (similar tax system) weights	%tax – %tax	ML approach with time fixed effects, IV (2SLS) approach	1979 – 2001 15 EU countries	More negative reactions on neighbor's tax setting; positive results with geographic weights; different results depending on the computation of the tax rate
b. ***... also with the countries' openness as independent variable.***								
Davies and Voget (2008)	STR and EATR	Corporate income	Spatial lag models: Nash and Stackelberg leader	Relative market potential of a given country = domestic consumption + exports; also: GDP, distance and average tax rate weights	Log(tax rate) – log(tax rate) and log(openness rate)	OLS, time trend and fixed effects, bootstrapped errors	1980 – 2005 19 countries	Positive tax reaction and tax competition between EU and non-EU members

Devereux, Lockwood and Redoano (2008)	STR and EMTR	Corporate income	Spatial lag model: Nash	Economic distance (between GDP), relative openness (of bilateral (Exp+Imp)/GDP), capital controls (Quinn 1997 0-4 Index) and uniform weights	Tax rate – tax rate and openness rate	IV, clustered by countries and country-specific time trends and fixed effects	1982 – 1999 21 OECD countries	Positive tax reaction on neighbor's with statutory tax rates; negative effect on effective tax wedge or if capital controls are unequal distributed between interacting countries
Overesch and Rincke (2009)	STR, EMTR and EATR	Corporate income	Dynamic spatial lag model	Geographical distance adjusted by population size	Tax rate – tax rate and openness rate	OLS fixed effects, IV fixed effects	1983 – 2006 32 European countries	Positive reactions on neighbor's tax setting
Pitlik (2005)	EATR	Capital income	Dynamic spatial lag model	Uniform, GDP and GDP distance weights	%tax – %tax and IMF-capital-openness rate and log(openness rate)	IV-GMM (Arellano-Bond 1991) with country heterogeneity and time trend	1970 - 1998 15 EU countries	Positive reactions on neighbor's tax rate increase; negative effect of IMF-capital-openness measure on tax rates
Redoano (2003)	STR	Corporate income	Dynamic spatial lag model	Contiguity, economic distance adjusted y population size (between GDP or GDP per capita) and leader (higher GDP) weights	Tax rate – tax rate and openness rate	IV approach	1980 – 1995 13 EU countries (pooled cross-sectional)	Positive reactions on neighbor's tax setting; negative effect of openness
Redoano (2007)	STR	Corporate income	Dynamic spatial lag model	Uniform, geographic distance, economic distance (between GDP per capita), GDP (relative level or average level of EU members) and openness (trade to GDP) weights	Tax rate – tax rate and openness rate	IV-GMM (Arellano-Bond 1991)	1970 – 1999 17 western European countries	Positive reactions on neighbor's tax setting; stronger effect if neighbor is a leader; EU members react more independently than non-EU countries
Swank (2006)	STR and EATR	Capital and corpo-	Dynamic spatial lag model with different	tax rate change weighted by total trade flows, total FDI, correlation	%tax – %tax and	OLS with PCSE and general error correc-	1981 – 1998	Positive reactions on neighbor's tax setting; negative effect of

		rate income	weighting properties (no weights, weights on spatial lag, weights on spatial lag and on dynamic variable)	between cross-national distribution of DI flows and a measure of the similarity of two countries' capital market orientation; lagged tax rates weighted by the mean of past policy changes	%openness and openness-Dummy	tion method	16 countries	openness
Swank (2007)	STR	Corporate income	Dynamic spatial lag model	Competition weights = in- and outflow of merchandise trade relative to GDP	%tax – %tax and %openness and openness-Dummy	OLS with PCSE and general error correction method	1982 – 2002 16 countries	Positive reactions on neighbor's tax setting; negative effect of openness

Notes: [1] Spatial lag models are the most common, but not exclusively used, models to specify tax reaction functions. [2] Measurement units indicate how the "dependent variable" or the "independent variables" are measured. "%" stands for percentage measurement units and "rate" means that the variables are measured in levels. [3] Instrumental variable (IV), maximum likelihood (ML), general method of moments estimation with an instrumental variable (IV-GMM), seemingly unrelated regression (SUR), iterated feasible generalized least squares (IFGLS), two stage feasible generalized least squares (2S-FGLS) estimation approach. [4] Dynamic spatial models are spatial lag models which include the own tax rate as a lagged dependent variable in the regression.

Distinguishing the models by their model properties is shown in the last category of *Table 6*. There, the first model properties concentrate on the use of a control variable for a country's openness level. Models which do not include an openness variable seem to underestimate interdependencies in tax policies as the coefficient on $WTax_{-j}$ might capture the negative impact an increase in a country's openness level has on tax rates. Moreover, only about 40 percent of the models without openness controls produce significant semi-elasticities which contrast with the high robustness of the models with openness controls (86 percent of estimated coefficients are significant).

Comparing Stackelberg-leader type models with Nash type models, the former show relatively high semi-elasticities (about 1.98) compared to the latter (about 1.01). Recall that Stackelberg-leader models are models which use either GDP-level weights or EU (US) weights or a combination of both (e.g. Altshuler and Goodspeed 2002; Chatelais and Peyrat 2008; Hayashi and Boadway 2001 or Swank 2007). The relatively larger semi-elasticities derived based on models with Stackelberg-leader properties included could indicate that a follower country reacts more strongly to a change in tax rates by a dominant country than to tax rate changes by other non-dominant neighbours.

Finally, the last part of *Table 6* summarizes the models according to their static or dynamic properties. Dynamic models include at least the lagged endogenous variable in the set of right-hand side variables. Results derived based on dynamic models differ from static models with respect to their narrower range, lower standard deviation and less skewed distribution of the semi-elasticities. This indicates that the dynamic models seem to be more reliable and produce more stable estimates compared to the static models. Furthermore, static models seem to overestimate the tax reactions by negating own tax setting strategies from the past as an additional driving factor.[xv]

Overall, second generation direct studies are again in favour of tax competition for mobile capital as a cause of falling tax rates. According to second generation direct studies – consistently with the findings of first generation models – competition for new firms and paper profits is a particularly likely event. Put differently, STRs and EATRs are strategic complements. Furthermore, the relatively large semi-elasticities derived from models based on weights supporting the Stackelberg-leader concept suggest that the leader-capability of a single country (or group of countries) is important to the reaction of other countries.

Additionally, as the openness weights on average show the highest semi-elasticities, it could be argued that a sufficient level of openness is important to the strength of tax competition.

This is consistent with the view that *de jure* and *de facto* openness to FDI and trade is a pre-condition for tax competition.

6. Discussion

The first and second generation direct studies surveyed find support for tax competition for new firms and paper profits as a driver of falling tax rates. This result also seems plausible when one takes into consideration the political statements of public officials, which often suggest that tax competition forces are at work.[xvi]

First generation direct studies make an effort to mainly explain tax rate changes with changes of a country's openness to FDI and trade. The underlying view is that only sufficiently open economies will use their capital/corporate income tax rates to compete for mobile tax bases. However, these studies do not model strategic interactions in tax setting. Moreover, the majority of first generation direct studies are based on conceptually inferior backward looking tax rates. Thus, their results do not constitute clear cut evidence in favour of tax competition as a driver of falling tax rates.

By employing reaction function ("spatial lag") models to account for strategic interactions between countries, the second generation of direct studies concentrates on neighbours' tax rates as determinants of own tax rates. Yet, as outlined in the introduction, tax rates might also decline for other economic, institutional and political reasons than tax competition. Frequently, second generation direct studies try to discriminate between the various causes of falling tax rates by exploring whether strategic interaction in tax setting is only present in the case of sufficiently open economies. Against this benchmark, second generation direct studies indeed succeed in finding support for tax competition and not yardstick competition or common intellectual trends (see especially Devereux et al. 2008). However, yardstick competition and common intellectual trends may also influence tax policies in open economies.[xvii] It is plausible that in closed economies simply no external forces, such as yardstick type pressures or the emergence of novel theoretical insights, will have an impact on tax policies and these factors are also "open economies issues".

Table 6: Summary information on semi-elasticities of the tax variable(s) derived from second generation models (without extreme outliers[1]).

						Number of semi-elasticities	
	Mean	Median	Std.dev.	Min.	Max.	All	Significant[2]
Overall							
All	1.168	0.580	2.771	-10.101	11.149	204	68%
1. Tax definition							
AETR[3]	-0.778	0.000	3.179	-10.101	11.149	42	50%
EATR	1.758	0.785	2.869	-2.327	9.474	47	51%
EMTR	0.043	0.008	0.065	0	0.157	8	75%
STR	1.757	1.393	2.263	-3.876	9.236	107	81%
2. Weights							
Uniform weights	1.111	0.961	1.256	-0.652	4.531	31	48%
Geographic and economic Distance weights	0.698	0.181	3.045	-10.101	11.149	112	66%
Openness weights	2.864	1.929	2.984	-2.327	7.277	24	83%
Weights supporting the Stackelberg-leader concept	2.107	1.296	2.366	-0.571	8.917	27	78%
3. Model properties							
No openness variable(s)	-0.012	0.000	-2.876	-10.101	11.149	82	40%
With openness variable(s)	1.961	1.427	2.401	-2.330	9.236	122	86%
Nash games	1.014	0.557	2.785	-10.101	11.149	168	66%
Stackelberg-leader games	1.983	1.296	2.498	-1.677	9.236	63	76%

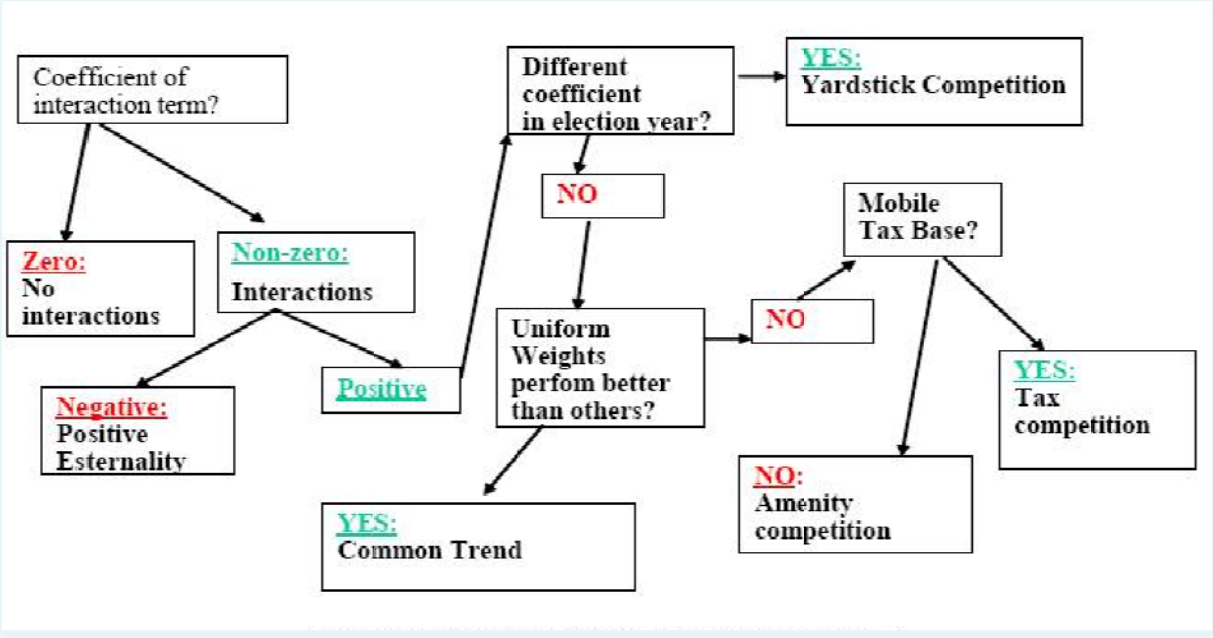
Static	1.285	0.683	3.297	-10.101	11.149	136	67%
Dynamic	0.935	0.563	1.132	-0.328	4.531	68	69%

Notes: All semi-elasticities are derived by summing up all tax-semi-elasticities on neighbors within one regression (see Huizinga and Nicodème, 2006). [1] Semi-elasticities which are 2-times the original standard deviation. [2] Significance level: the significance level is that of the underlying regression coefficient; 20% with two-sided test statistic and 10% with a one-sided test statistic. [3] MA-AETR and MI-AETR are not separated, because only Ruiz and Gerard (2008) use MI-AETR for some regressions.

Thus, establishing strategic interdependence based on the openness of countries is consistent with tax competition forces, but it does not unambiguously isolate the underlying cause. Put differently, establishing strategic interaction as only present in the case of open economies also does not provide clear cut evidence in favour of tax competition.

So how could the procedure to isolate the role of tax competition as a driver of falling tax rates look? One approach is outlined in Redoano (2007) who uses various definitions of the weighting matrix (W) to distinguish different causes of falling tax rates within a second generation direct studies framework. *Figure 1* summarizes Redoano's reasoning.

Figure 1: About the nature of interactions



Source: Redoano (2007, p. 8)

According to Redoano (2007), tax competition is correctly identified if (a) the coefficient on the interaction term (which is the weighted tax rate; i.e. $WTax_{-j}$) is i) non-zero, ii) positive and iii) not sensitive to election years; if (b) results are not only present in case of uniform weights; and if (c) the study is concerned with a mobile tax base.

The sensitivity to election years would refer to yardstick competition as the government tries to react or imitate the neighbour's tax policy to stay in office. Well performing uniform weights indicate that no matter how distant the neighbouring countries are, how similar their economies are or how intensive their economic integration is, the own tax rate depends on the

neighbours' tax rate to an equal strength. Such results would support the presence of common intellectual trends in tax setting which are incorporated in all countries independently.

If yardstick competition and common intellectual trends can be excluded as the causes of the investigated interaction, strategic tax competition is then only correctly identified if the tax base is mobile, which is a precondition of (horizontal) tax competition (compare the aim of indirect studies).

Among the studies surveyed Redoano (2003, 2007) and Rork (2003) control for election years. No significant relationship is established. Thus, yardstick competition could be excluded as a cause of falling tax rates. Moreover, based on our survey the presence of positive externalities (i.e. a negative coefficient on $WTax_{-j}$) is unlikely, as the semi-elasticities derived are positive on average (0.763; cf. *Table 6*). Furthermore, only 15 out of 31 semi-elasticities are significantly different from zero when uniform weights are employed (about 50 percent). Overall, the proportion is about 76 percent (cf. *Table 6*). Thus, non-uniform weights find more frequently statistically significant strategic interactions in tax setting, which points towards a relatively lower importance of common intellectual trends as drivers of falling tax rates. Thus, applying the approach of Redoano (2007) offers additional evidence in favour of tax competition as a driver of falling tax rates.

However, in our opinion, a fully convincing approach should model the political aim behind tax rate cuts more directly than via different weighting matrixes and election year dummies. An approach in this respect could be based on the definition of tax competition given above, which follows Wilson and Wildasin (2004). This definition may be used to derive preconditions for the existence of tax competition. In turn, these preconditions – as well as variables indicating alternative causes of falling tax rates – can be captured within a multi-equation empirical model aiming to explore the causes of falling capital/corporate income tax rates.

Bellak and Leibrecht (2007) derive four preconditions for corporate income tax competition for mobile capital based on the Wilson and Wildasin (2004) definition. The four preconditions are (1) capital mobility is technically possible and Multinational Enterprises (MNEs) make use of this possibility; (2) governments reduce relevant tax rates on capital/corporate income; (3) one explicit motivation of tax rate cuts is to attract mobile capital or to react to downward revisions of other countries' capital/corporate income tax rates to avoid losing investment; and (4) capital/corporate income taxes are a significant determinant of capital investment decisions.

Note that precondition (4) represents the indirect approach to analyzing tax competition briefly outlined above and precondition (3) captures the argument of second generation di-

rect studies for analyzing the presence of tax competition. Thus, one way to model tax competition as a driver of falling tax rates could be to combine indirect and direct studies in a, say, two-equation model. Precondition (1) can be incorporated into this model by including *de jure* and *de facto* openness measures, such as, for example, the FDI a country receives, in the set of regressor which is also the main point behind first generation direct studies. Precondition (2) can be operationalized by using the relevant tax rates, for instance the EATR in case of tax competition for new firms, as a dependent variable in the equation capturing second generation direct studies and as regressors in the equation capturing indirect studies. This makes the two-equation model a simultaneous model. Moreover, the impact of common intellectual trends on capital/corporate tax rates can be captured following Slemrod (2004) who uses the tax rate on personal income as a determinant of the tax rate on capital/corporate income. Changes in the political climate can be captured via the inclusion of institutional variables pinpointing a country's attitude towards a more (less) egalitarian society. In addition, following Redoano (2007), different weighting matrices and an election year dummy can be used in the equation, capturing the second generation direct studies.

However, it is crucial to include a variable capturing the governments' reason for changing tax rates in this equation (precondition 3). Of course, this is not an easy task. Following Altshuler and Grubert (2004) one may assume that "If countries are engaging in tax competition we would expect those that are losing market share (those with the most to gain) to lower their effective tax rates more than the average." (p. 5) Thus, the inclusion of a variable capturing a country's share in world FDI as a regressor could pinpoint the aim of tax rate changes.

7. Summary

This paper provides a comprehensive overview of empirical studies dealing with tax competition for mobile capital. It places particular focus on studies modelling strategic interaction in tax policies of competing jurisdictions – which is at the heart of the competition concept. Furthermore, it addresses the question of whether existing studies convincingly isolate tax competition as a driver of falling capital/corporate income tax rates.

Given the empirical evidence surveyed, it appears that tax rates indeed fall due to tax competition, in particular due to competition for new firms and paper profits. However, a closer look at the empirical approaches applied in the papers surveyed suggests that, in any case, the isolation of the role tax competition plays in the drop in capital/corporate tax rates is demanding. Even if existing empirical studies have made considerable progress in recent years

in this respect, there is still room for further research, such as the identification and adequate modelling of important preconditions for tax competition within an empirical model.

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Appendix:

1. Derivation of semi-elasticities

The semi-elasticity of variable y with respect to variable x is given by $\in_S = \frac{\left(\Delta y / y^{*100}\right)}{\Delta x}$ which gives the percentage change in variable y when variable x changes by one unit. The derivation of semi-elasticities from published regression coefficients crucially depends on the measurement of the dependent variable and the exogenous variable of main interest. The studies surveyed are based on four different operationalizations: (i) log-level models; (ii) level-level models; (iii) log-log models and (iv) level-log models. Here, "log-" means that the dependent variable is used in logarithmic form and "level-" implies that it is used untransformed. The same applies to "-log" and "-level" but in this case it captures the measurement of the independent variable of main interest.

a. Log-level models:

Semi-elasticities are easily derived from log-level models by multiplying the regression coefficient ($\hat{b}$) by 100: $\epsilon_S = 100 * \hat{b}$. Note, however, that in the case of second generation direct studies the independent tax variable and, in the case of first generation direct studies, the *de facto* openness variable (e.g. FDI + trade in percent of GDP) have to be measured in percent. If it they are measured as proportions then the semi-elasticity simply is the regression coefficient ($\hat{b}$). Moreover, if the independent variable is a binary dummy variable then the semi-elasticity is derived as $\epsilon_S = 100 * (\exp^{\hat{b}} - 1)$.

b. Level-level models:

In this case $\epsilon_S = 100 * \frac{\hat{b}}{\bar{y}}$. Thereby $\bar{y}$ is the sample overall-mean of the dependent variable. The papers surveyed measure the tax and the de facto openness variables in percent or in proportions. Combinations of percent and proportions are also frequently used (i.e. y and x in percent; y and x in proportions; y in percent and x in proportion and vice versa). The formula given above is suitable when y and x are measured in percent. In the remaining cases the regression coefficient ($\hat{b}$) has to be transformed (i.e. multiplied or divided by 100) before applying the formula. In any case $\bar{y}$ has to be measured in percent.

c. Log-log models:

The coefficients from log-log models are elasticities ($\hat{\epsilon}$) of variable y with respect to variable x. Thus, semi-elasticities can be derived by $\epsilon_S = \frac{100*\hat{\epsilon}}{\bar{x}}$. Thereby $\bar{x}$ is the sample overall-mean of the independent variable. In the case of second generation direct studies $\bar{x}$ is the sample overall-mean of the weighted average tax rate of competitor countries measured in percent. In the first generation direct studies, $\bar{x}$ is the sample overall-mean of the various openness measures used, whereby de facto measures are also used in percent (e.g. FDI + trade in percent of GDP).[1]

d. Level-log models:

In this case $\epsilon_S = 100 * \frac{\hat{b}}{\bar{y}*\bar{x}}$. Thereby $\bar{y}$ and $\bar{x}$ are the sample overall-means of the dependent and the independent variables both measured in percent (if x is a tax rate variable or *de facto* openness variable). If the endogenous variable is measured in proportion instead of percent than the regression coefficient is multiplied by 100 before the given formula is applied.

2. Derivation of the statistical significance of the underlying regression coefficients

To derive the statistical significance of the underlying regression coefficients for studies where t-statistic values are not given, we proceed in two steps. First, the t-statistics are derived by dividing the regression coefficients through its standard deviation. Then, the t-statistic values are used to identify the significance level from standard t-distribution tables. Semi-elasticities with t-statistics equal or greater than 1.282 are identified as being significant.

[1] One study uses the dependent variable in logit-transformed form. In this case, the implied marginal effects are derived in a first step and then we proceed as we do in the case of level-level models.

Notes:

[1] It has to be stressed that the Leviathan-view of governments foresees positive efficiency effects of tax competition due to the avoidance of tax cartels and increased policy interventions (see Wilson 1999 for an overview).

[2] The appendix sketches how regression coefficients are turned into semi-elasticities and how the statistical significance of the underlying regression coefficients is derived.

[3] A backward looking marginal effective tax rate is proposed by Gordon et al. (2003).

[4] As such studies do not explicitly deal with the presence of tax competition they have not been included in our survey.

[5] Note that both published and unpublished papers are included in the table.

[6] A frequency distribution of the semi-elasticities of openness on the tax rates shows that an exclusion of insignificant coefficients has no dramatic effect on the distribution of semi-elasticities. We therefore do not distinguish the reported tables by significance levels. Extreme values which are greater than twice the standard deviation are excluded from the analysis (only three regressions).

[vii] This is unambiguously so if only one strategic variable is included in the model. When more strategic variables are used, indirect effects have to be considered which determine the sign of the coefficient on $WTax_{-j}$ (see Devereux et al. 2008, p. 1217f for more details).

[viii] Again, published and unpublished work is included in the survey. Note, that studies using as dependent variable the tax base rather than a tax rate (e.g. Brett and Pinske 2000; and Riedl and Rocha-Akis 2007 and 2008) are not included in the survey.

[ix] The latter type of investments is summarized as "capital" in Devereux et al. (2008).

[x] Thus, excluding an openness variable would lead to an omitted variable bias (see also Franzese and Hays 2009).

[xi] Contiguity weights imply that countries having the same border could be assumed to have more economic interactions and therefore governmental decisions have a stronger impact on bordering than on non-bordering countries.

[xii] Redoano (2007) argues that her result "is possibly due to the fact that countries who want to join the EU want to show to other EU members that they have 'aligned' policies for being accepted and also because the EU as an Institution provides a safer environment where countries need to compete less with the outside and more among themselves." (p. 23)

[xiii] Note that these values above 1 do not *per se* imply an explosive pattern of spatial dependence. These values are conditional upon the transformation of the semi-elasticity computation. For example, given an estimated coefficient (elasticity) of 0.5 - which is well below 1 - and given a mean of the independent variable of 33 percent the semi-elasticity is computed as follows: (0.5*100)/33=1.51. See the Appendix for details.

[xiv] Note, Ruiz and Gerard (2008) also find that STRs and EATRs are strategic complements. However, using backward looking tax rates they find a negative relationship between capital/corporate income tax rates of EU countries. They argue that this finding is consistent with the view that "countries are mimicking *tax codes* (as captured by STRs and EATRs; the authors) main reforms of their close neighbors, but at the time of considering tax burdens effectively paid (as captured by backward looking tax rates; the authors) and supported by enterprises, national states still differ by large, not interacting between themselves." (p. 23)

[xv] Moreover, including the own tax rate, one period lagged is rather intuitive as governments are assumed to conduct predictable, reliable and relatively stable tax policy. Therefore, they are not assumed to make dramatic changes in their tax policy and tend to orientate their strategy towards their own past tax levels.

[xvi] See, for example, Bellak and Leibrecht (2007) for a survey of such political statements in the case of Central and Eastern European Countries which have markedly reduced their tax rates during the last decade.

[xvii] Note, Anselin (2002) points out that the basic spatial lag models suffer from a lack of identifying the underlying economic mechanism which causes the spatial interaction (inverse problem).