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

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Abstract

Tax rates on corporate income have declined in most industrialized countries since the mid 1980s. Tax competition between countries 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 an overview of 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. Given the empirical evidence surveyed, it appears that tax rates indeed fall due to tax competition between countries, in particular due to competition for profits and new firms. Besides summarizing the substantive implications of the existing empirical literature the paper also addresses the question of whether the existing studies can convincingly isolate tax competition as a driver of falling corporate income tax rates.

1. Introduction

Statutory corporate income tax rates (STRs) have declined in most industrialized countries since the mid 1980s. Tax competition between countries for mobile capital is frequently stressed as an explanation for this development. Tax competition between countries (horizontal tax competition) can be defined as 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). Horizontal tax competition therefore implies the strategic interdependence of government tax policies.

A vast empirical literature dealing with horizontal tax competition for mobile capital as a driver of falling tax rates has emerged. The main aim of this paper is to categorize and summarize the existing empirical studies on this issue. Particular focus is placed 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.

A semi-elasticity shows the percentage change in the endogenous variable when the exogenous variable changes by one unit (e.g. Wooldridge 2009, p. 46).[i] Semi-elasticities are frequently used in the tax policy literature to isolate the substantive implications of estimated regression coefficients (see e.g. De Mooij and Ederveen 2008; Feld and Heckemeyer 2009). However, it is important to note that semi-elasticities depend on the unit of measurement of the independent variable. Thus, any study deriving and comparing semi-elasticities should make sure that only values are aggregated which are based on comparable units of measurement of the independent variables (see *Section 4* for further details).

Besides summarizing the substantive implications of the existing empirical literature the paper also addresses the question of whether the surveyed studies can convincingly isolate tax competition as a driver of falling corporate income tax rates. This is a relevant policy issue as 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 on corporate income.

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

paired with tax base broadening but also to the increased integration of corporate and personal income taxation (Musgrave 1990) and concerns with the deadweight loss of taxation resulting from high STRs (Griffith and Klemm 2005).

Furthermore, changes in the political climate 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 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 2* contains a brief discussion of what types of capital (investments) countries may compete for with different tax rates. *Section 3* provides a broad classification of the available empirical studies. *Sections 4* and *5* present the results derived based on the empirical studies surveyed and *Section 6* discusses the results. Finally, the main findings are summarized in *Section 7*.

2. Types of capital and corporate income tax rates

Governments may compete for new firms, for the investment of existing firms and for profits generated in one country but shifted by firms to another country, for instance, via favourable transfer pricing agreements with related firms (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 (see e.g. Devereux 2007): Conceptually, new firms are located where after tax profits are highest. The latter crucially hinge upon the average tax rate levied on corporate income. Put differently, tax induced incentives to establish a new firm are exerted by a low effective average tax rate on a firm's pre-tax profit.[ii] In contrast, the investment of already established firms is driven by the cost of capital and thus by the effective marginal tax rate. Finally, the incentive to shift profits is crucially determined by the STR.[iii]

To empirically analyze the presence of tax competition, it is crucial to know how the mentioned tax rates can be operationalized. This is comparatively simple for the STR which can be directly taken from tax codes. Measuring effective tax rates is more complicated, not least because different concepts of effective tax rates are proposed in the literature. 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 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. Besides MA-AETR in some cases the ratio of corporate income tax revenues to GDP or to total tax revenues (AETR) is used to proxy the average corporate income tax burden at the macro-level. Data used to calculate these rates come from National Accounts and Revenue Statistics. In contrast, micro-level backward looking average tax rates (MI-AETR) are based on firms' balance sheet information. A widely cited study deriving MI-AETRs is Nicodème (2001).[iv] 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 over time.[v]

Forward looking effective tax rates measure the tax burden levied on a hypothetical, prospective investment project of a firm. The calculation of forward looking tax rates is based on a present value framework (see Devereux and Griffith 1998). The tax rate and tax base information used in the calculations is directly taken from current and future (expected) tax laws. Forward looking effective average tax rates (EATR) as well as forward looking effective marginal tax rates (EMTR) can be derived for domestic and international investments.

EATRs measure the tax burden on a hypothetical infra-marginal investment project, that is, on one which earns a positive economic rent. EMTRs, 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 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.

Due to their forward looking nature EATRs and EMTRs are of use when analyzing the incentive effects taxes exert on firms' investment and financing decisions. Hence, these tax rates are a suitable choice for analyzing tax competition for new firms (the EATR) and the investment of established firms (the EMTR). Thereby domestic forward looking effective tax rates are more appropriate than bilateral tax rates as the latter also contain stipulations which represent steps to coordinate tax laws. For instance, double tax agreements are a form of tax coordination by explicit agreement between countries and supranational tax law is a type of tax coordination by delegation (Wildasin 2002). Thus, bilateral forward looking effective tax rates can fall over time due the coordination of corporate income taxation. For instance, the adoption of the Parent Subsidiary Directive of the EU by new EU member states in 2004

leads to a substantial simultaneous drop in bilateral effective tax rates (see e.g. Bellak and Leibrecht 2007) which is not triggered by tax competition for mobile capital.

Finally, note that the STR might be considered being a special type of forward looking tax rate which is not effective. As previously mentioned, this tax rate is relevant for analyzing tax induced incentives to shift profits and hence for exploring the presence of tax competition for 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 various types of capital (cf. *Table 1*). Corporate income tax rates are contained in the set of independent variables. Numerous indirect studies have emerged and comprehensive reviews are already available (see DeMooij and Ederveen 2003 and 2008; Devereux and Griffith 2002; Devereux 2006 and 2007; Feld and Heckemeyer 2009). These surveys suggest an empirically significant relationship between taxes and various types of capital. Specifically, Devereux (2007, p. 41) concludes in his survey of indirect studies that corporate income taxes play a significant role for the location of new firms and for profits. A "precondition" for tax competition to exist is thus fulfilled, at least for capital in form of new firms and profits.[vi]

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. Thus, 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 capturing a country's degree of openness. In this case an increase in a country's openness leading to a decrease in the level of tax rates 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. These 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 averaged tax rates of competitor jurisdictions (e.g.

Devereux et al. 2008). Here, a positive relationship between a country's tax rate and the competitors' 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 on horizontal tax competition

Study type	**Explained variable**	**Independent variable of main interest**	**Outcome in favour of tax competition**
Indirect	Foreign capital in country i or capital from country j in country i	Tax rate of country i or bilateral tax rate for countries i and j	Significant negative impact of an increase in the tax burden on foreign capital
Direct 1st generation	Tax rate of country i	Openness of country i	Significant negative impact of an increase in a country's openness on tax rates
Direct 2nd generation	Tax rate of country i	Averaged tax rates of competitor countries	Decrease in the averaged tax rates of competitor countries leads to a statistically significant decrease in the tax rate of country i

Notes: Capital = (Foreign Direct Investment (FDI), Property, Plant Equipment, 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).

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 horizontal tax competition between countries to set in. First generation direct studies are based on this "precondition" of horizontal tax competition and model the relationship between tax rates on corporate income and a country's degree of openness.

A variety of definitions of a country's openness are used in the first generation 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 or the number of bilateral investment treaties. In contrast, *de facto* measures are based on observable interactions between countries, such as trade and FDI flows or the importance of

foreign ownership of firm assets. Mixed openness indicators combine *de jure* and *de facto* aspects into a summary measure (e.g. the KOF globalization index used by Dreher 2006).

Table 2 contains characteristics of 12 studies surveyed.[vii] 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. Five studies apply forward looking effective tax rates. Thereof four studies apply domestic and one study uses bilateral forward looking effective tax rates which also capture measures of tax coordination (see above). With respect to the proxy variable for a country's openness considerable heterogeneity is given. Furthermore, the econometric estimators applied vary substantially across studies. However, the majority of studies show a negative relationship between a country's openness and the level of capital income taxation (see column seven of *Table 2*). Only four studies report positive coefficients.

To elaborate on the substantive importance of a country's openness for the development of tax rates, 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*. As noted above the semi-elasticity depends on the unit of measurement of the independent variable, here an openness variable.[viii] To cope with this issue we first have separated the presentation of semi-elasticities with respect to *de facto* openness variables in the two most frequently used measures of a country's *de facto* openness: GDP based (e.g. FDI or trade to GDP) and firm asset based (percent of foreign ownership in firm assets) openness variables. This ensures that the respective mean semi-elasticity shows the mean percentage change in the endogenous variable (a tax rate) when the independent variable changes by one percentage point of GDP or firm assets, respectively. Second, we have excluded the study of Garretsen and Peeters (2007) from the analysis as these authors apply FDI flows, not normalized by GDP or assets but by gross fixed capital formation, as *de facto* measure for openness. Note however that Garretsen and Peeters (2007) find support for a negative impact of the degree of *de facto* openness on the EATR (cf. *Table 2*).

Table 3 displays the main results of our descriptive analysis. The table is structured across several dimensions. First, means, standard deviations, 25th, 50th and 75th percentiles, minima and maxima as well as the share of significant underlying regression coefficients are reported.[ix] Second, a separation between single-openness models which contain only one openness proxy per regression and multi-openness models containing several openness variables is made. This separation aims to consider that the simultaneous usage of more than one openness variable may affect the significance, size and sign of the underlying regression coefficients and in succession also of the derived semi-elasticities. Interrelationships in multi-openness models may arise, for instance, due to multi-collinearity which *inter*

alia might lead to "wrong signs" of coefficients (see Kennedy 2005 for further details). Third, the information contained in *Table 3* is structured by the various types of openness variables used in the surveyed studies. Thereby the *de facto* measures are further separated into GDP based and asset based measures. Fourth, results are separated by the type of tax rate used (EATR, EMTR, STR, MI-AETR, MA-AETR) to isolate differences in the marginal effects of changes in a country's openness across tax rates.

Starting with single-openness models *Table 3* implies that the mean and median semi-elasticities are negatively signed in each case but those for regressions based on MI-AETR. The latter rates are only used in papers using asset based *de facto* openness measures. In most instances the majority of underlying regression coefficients is also statistically significant different from zero (see the last column of *Table 3*). Thus, the surveyed evidence is in favour of a negative impact of an increase in a country's openness on tax rates on capital income. This conclusion is particularly valid for studies explaining variations in STRs, MA-AETRs and EATRs. For EMTRs as dependent variable only one regression coefficient, which is statistically insignificant, enters our calculations. Thus, the results from single-openness models are consistent with the presence of tax competition for profits (STR) and firms (EATR and MA-EATR).

However, studies using MI-AETR come up with a mean semi-elasticity of about 1.14. These results imply that, when using firm-level data, an increase in the country's openness by one unit increases the micro-level average effective tax rate by 1.14 percent. This somewhat surprising positive mean semi-elasticity has to be evaluated against the specific proxy variable for a country's openness used in the empirical analysis - the share of foreign ownership in total firm assets. An increase in the share of foreign ownership increases tax rates. Thus, the studies based on the MI-AETR support the view that governments try to "export" corporate income tax burden rather than to reduce the tax burden on foreign capital.[x]

Turning to multiple-openness models the results are qualitatively similar even if the size of mean semi-elasticities derived is different, which stresses that results from single- and multi-openness models should not be aggregated. However note that in case of regressions based on mixed openness measures the mean and median semi-elasticities derived are positively signed. A closer look at the last two columns of *Table 3*, section multi-openness models and mixed measures reveals that these values are based on few regression coefficients (six), mainly driven by the positive results from one study (Dreher 2006).

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, the surveyed studies support a negative relation between a country's openness and its capital income tax rate. Specifically, evidence is in favour of tax competition for profits and new firms. 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 2: Summary of first generation direct studies

Author(s)	Tax rate definition	Tax base definition	Openness definition	Estimation technique[1]	Sample	Results for openness	Number of semi-elasticities
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 (-++)	9
Bretschger (2008)	MA-AETR	Corporate income	Combined measure of capital market restrictions after Dreher and Siemers (2005) and (Exp+Imp)/GDP	2SLS, SURE, OLS with PCSE with time trends, 3SLS	1965 - 1999 12 OECD countries	Negative significant (+++)	9
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 (-++)	39
Clausing (2008)	STR	Corporate income	FDI outflows in percent of GDP	OLS	1979 - 2002 36 OECD countries	Negative significant (-++)	5
Dreher (2006)	MA-AETR	Capital income	KOF globalization index	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 (-+)	7
Garretsen and Peeters (2007)	EATR	Corporate income	Sum of FDI in- and outflows in percent of gross fixed capital formation	2SLS with fixed time effects	1981 - 2001 19 OECD countries	Negative significant (+++)	n.i.[2]

Huizinga and Nicodème (2006)	MI-AETR	Corporate income	Share of foreign ownership in firm assets	OLS and WLS both with fixed country or/and time effects	1996 - 2000 34 countries	Positive significant (-++)	52
Krogstrup (2005)	EATR	Corporate income	Quinn (1997) index on capital and goods market integration	OLS on first differences, 2SLS	1980 - 2001 13 EU countries	Negative significant (-++)	11
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 (-++)	7
Slemrod (2004)	STR and AETR	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 and negative (-)	4
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 (-+)	8
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 t (+++)	8

Notes: (+++) all underlying regression coefficients are significant. (-++) more than half of the underlying regression coefficients significant (but not all). (-+) about half of the underlying regression coefficients significant. (-) less than 50 percent of underlying regression coefficients 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. [2] n.i.: not included in the analysis. .

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

	Mean	Std.dev.	Min.	25 Perc.	Median	75 Perc.	Max.	Share of significant[2] regression coefficients
1. Single-openness models								
a. De facto measures								
i. GDP based								
Overall	-0.9877	1.7258	-8.0000	-0.7317	-0.5833	-0.4440	-0.0575	13 / 19
Tax definitions								
MA-AETR	-0.6288	0.3559	-1.3420	-0.6926	-0.4798	-0.4440	-0.2152	6 / 10
STR	-1.4396	2.6605	-8.0000	-0.7195	-0.5949	-0.4152	-0.0575	7 / 8
EMTR	-0.9619	-	-0.9619	-0.9619	-0.9619	-0.9619	-0.9619	0 / 1
ii. Asset based								
Tax definitions								
MI-AETR	1.1366	1.3571	-0.8996	0.0620	1.1029	1.5327	5.3070	24 / 40
b. De jure measures								
Overall	-0.5938	0.5127	-0.9524	-0.9524	-0.8225	-0.0066	-0.0066	2 / 3
Tax definitions								
MA-AETR	-0.0066	-	-0.0066	-0.0066	-0.0066	-0.0066	-0.0066	0 / 1
EATR	-0.8874	0.0918	-0.9524	-0.9524	-0.8874	-0.8225	-0.8225	2 / 2

c. Mixed measures

Tax definitions								
MA-AETR	-5.4347	4.5935	-8.1508	-7.2993	-6.6133	-6.1660	7.4565	10 / 10

2. Multiple-openness models

a. De facto measures

i. GDP based

Overall	-1.8752	4.7228	-17.5000	-0.5254	-0.1500	-0.0455	4.1667	29 / 39
Tax definitions								
MA-AETR	-0.2949	0.2282	-0.5922	-0.5106	-0.3587	-0.1071	0.0028	19 / 23
EATR	-4.2394	6.0154	-16.3824	-8.7647	-0.0569	0.1197	0.6105	5 / 9
STR	-0.1218	0.0733	-0.2109	-0.1804	-0.1147	-0.0631	-0.0469	3 / 4
EMTR	-9.2361	11.7118	-17.5000	-17.5000	-14.375	4.1667	4.1667	2 / 3

ii. Asset based

Tax definitions								
MI-AETR	0.6863	0.7778	-0.0197	0.0628	0.2243	1.2239	2.3078	11 / 12

b. De jure measures

Overall	-0.2336	1.2766	-4.9906	-0.0678	-0.0333	-0.0043	2.8784	16 / 30
Tax definitions								
MA-AETR	0.0978	0.6545	-0.8327	-0.0362	-0.0285	0.0024	2.8783	10 / 22
EATR	-0.0541	0.0214	-0.0881	-0.0608	-0.0560	-0.0387	-0.0252	5 / 6

STR	-4.4166	0.8118	-4.9906	-4.9906	-4.4166	-3.8425	-3.8425	1 / 2

c. Mixed measures

Overall	6.7260	3.6415	3.2703	3.5958	5.6170	9.9546	12.3013	3 / 6
Tax definitions								
MA-AETR	7.7309	4.0826	3.5958	4.3340	7.5132	11.1279	12.3013	3 / 4
STR	4.7162	2.0449	3.2703	3.2703	4.7162	6.1621	6.1321	0 / 2

Notes: [1] Semi-elasticities which are two times the standard deviation of the overall sample are treated as outliers and are not included in the analysis. [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 or the Sachs-Warner index. *De facto* measures are FDI flows, trade flows, and other measures of real interactions between countries as share in GDP and the share of foreign ownership in firm assets. Dreher's (2006) KOF 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. Perc. = percentile.

5. Second generation direct studies

Second generation direct studies explicitly model the strategic interaction in tax settings by 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). The tax policy towards capital of country i has an impact on the welfare level in country j due to its impact on the capital stock in the latter country. This may trigger a tax policy response in country j. Hence, the optimal tax policy choice of country i depends on country's j policy and vice versa (Franzese and Hayes 2009). Put differently, the tax rates of competing countries are strategic complements in case of horizontal tax competition. This implies that tax policies towards capital move in the same direction: a decrease in the tax rate of country i would induce country j to also lower its corresponding tax rate (Devereux et al. 2008; Franzese and Hays 2009).

From a theoretical viewpoint, strategic interactions in tax settings are modelled in the form of "Nash games" and "Stackelberg 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 (e.g. Altshuler and Goodspeed 2002).

From a more empirical viewpoint, modelling strategic interdependencies within a Nash game framework implies that, among the right-hand side variables determining the level of the tax rate in country i (Tax_i), the weighted average tax rate of all competitor countries ($WTax_{-j}$) is included. Models containing $WTax_{-j}$ are frequently termed "spatial lag models" as the spatial correlation modelled pertains to the dependent variable. Specifically, "a spatial lag [...] constructs a new variable that consists of the weighted average of neighboring observations" (Anselin et al. 2008, p. 629).

Modelling strategic interdependencies within a Stackelberg game framework means that $Tax^{L}_{(t-1)}$, the "leader's" lagged tax rate, is among the set of independent variables. The lagged tax rate is used to capture the fact that the Stackelberg leader moves first in the tax game (Altshuler and Goodspeed 2002). Frequently $Tax^{L}_{(t-1)}$ is included together with $WTax_{-j}$ in an empirical model (henceforth "mixed Nash and Stackelberg models").

Presence of horizontal tax competition is signalled by a positive sign of the estimated coefficients on $WTax_{-j}$ and $Tax^{L}_{(t-1)}$.[xi] Moreover, the coefficient on $WTax_{-j}$ should be lower than 1 in magnitude to preclude "an explosive pattern of spatial dependence." (Anselin 1988, p. 86)

In case of Nash game models 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. Based on Redoano (2007) the most common operationalizations of *W* can be summarized as follows: (i) uniform weights; (ii) geographic and economic distance weights; (iii) size weights; (iv) weights capturing economic ties between a country pair and (v) openness weights (cf. *Table 4*).

Uniform weights mean that each competitor country gets equal weight in the averaging of tax rates. Put differently, the development in taxes of geographically or economically close countries has no enhanced impact on a particular jurisdiction's tax policy. Thus, a statistical significant relationship between Tax_i *and* $WTax_{-j}$ in case uniform weights are applied is consistent with the view that tax rate cuts are *inter alia* driven by common intellectual trends like tax-rate-cum-base-broadening strategies (see Redoano 2007, p. 9). In contrast, the geographic and economic 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).

GDP-level weights intend to capture size effects assuming that large countries are more likely to take the role of "leaders" in tax setting. Specifically, 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). Size weights are thus capable to incorporate the concept of leadership also into Nash game models.

Weighting matrixes based on bilateral FDI and trade linkages (economic ties weights) capture the fact that economic ties between countries also strengthen their strategic interaction in tax policies. Finally, openness weights account for the idea that more open economies are more likely to engage in strategic tax competition.

Table 4: The most common weighting schemes

Weight(s)	**Hypothesis of interaction type**
Uniform weight	Common intellectual trend in tax setting
Geographic distance (e.g. contiguity, distance decay function) and **economic distance** (e.g. GDP per capita distance) **weights**	Enhanced influence of close geographic and economic neighbours on a jurisdiction's tax policy
Size weights (e.g. GDP-level or EU (US) weights)	Size of countries matters for strategic interactions in tax settings (leadership concept in Nash models)

Economic ties weights (e.g. bilateral FDI and trade linkages)	Economic ties strengthens strategic interaction in tax policies
Openness weights (e.g. FDI or trade to GDP)	Openness strengthens strategic interaction in tax policies

Table 5 gives an overview of the various second generation direct studies surveyed.[xii] An often cited paper estimating tax reaction functions is Devereux et al. (2008). These authors 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 profits and investments of already established firms.[xiii] They derive a theoretical Nash game model of horizontal 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. Devereux et al. (2008) state that they "found strong evidence that they [taxes, the authors] do respond to changes in other countries' taxes." (p. 1231)

In particular, in their basic specification (Table 2 in Devereux et al. 2008) the authors establish that STRs respond to changes in other countries' STRs. This result is present across different definitions of the weighting matrix (e.g. uniform and GDP-level weights). However, for the EMTR a significant response is given only in the case of uniform weights. In their preferred empirical specifications (see Table 3 in Devereux et al. 2008) they find that strategic interaction in STRs is present only if (a) none of the countries considered has significant capital controls in place and (b) only in case uniform weights are used.[xiv]

The authors use the first 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* for further discussion). Yet, the finding of a significant interrelationship mainly in case of uniform weights points towards the importance of common intellectual trends as determinants of STRs (cf. *Table 4*) rather than the working of tax competition between countries.

In line with Devereux et al. (2008) several other authors (e.g. Davis and Voget 2008; Dreher 2006; Overesch and Rincke 2009; Redoano 2003, 2007; Swank 2006, 2007) also control for a country's openness. Indeed, given the results derived from first generation direct studies which imply that the level of a country's openness has a significant negative impact on a country's tax rates, the inclusion of an openness proxy should be standard to reduce the likelihood of a biased coefficient on $WTax_{-j}$ (also see Franzese and Hays 2009 on this issue).

From a European perspective of particular interest is the study of Davis and Voget (2008). They find that EU member states react more to tax rate changes of other EU members than to the changes of non-EU members. Therefore, they conclude "that expansion of the EU may lead to more aggressive tax competition." (p. 22) This result is plausible as the internal market in the EU offers free movement of goods, services, persons and capital. Restrictions on cross-border movements of capital are of relatively lower importance within the EU as they are with respect to third countries. However, the results of Davis and Voget (2008) contrast to those derived by Redoano (2007). She finds that countries are more interdependent with each other before joining the EU. Once countries are EU members they act more independently.[xv] Moreover, Crabbé and Vanderbussche (2009) find that neighbouring countries of the new EU member states react to downward revisions of tax rates in these states by also reducing their corresponding tax rates. In addition Crabbé and Vanderbussche (2009) find that countries not neighbouring the new EU member states not only react less to tax rate changes of the latter country group but also that they do not react to tax rate alterations of old EU member states. These findings indicate that the geographic distance to new EU members is important for competing with them, whereas there seem to be no reaction between the old EU members.

Table 5: Summary of second generation direct studies.

Author(s)	Tax rate definition	Tax base definition	Functional specification	Weights	Estimation technique[1]	Sample used	Results	Number of semi-elasticities
1. *Studies using a model with tax reaction functions to uncover the mechanism of tax competition ...*								
a. <u>without a country's openness as independent variable</u>								
Altshuler and Goodspeed (2002)	AETR	Corporate income	Nash and mixed Nash and Stackelberg model	Geographic distance weights	IV approach with first differences and fixed country effects	1968 – 1996 17 European countries + US	Nash type of tax competition present and US is leader in tax policy	17
Brueckner and Saavedra (2001)	AETR	Property	Nash model	Geographic distance weights	ML approach	1980, 1990 70 cities in the Boston metropolitan area	Nash type of tax competition present	n.i[2]
Charlot and Paty (2005)	STR	Local business	Nash model	Geographic distance weights	ML approach	2002 French localities, departments and regions	Nash type of tax competition present	n.i
Chatelais and Peyrat (2008)	STR	Corporate income	Nash and mixed Nash and Stackelberg model	Geographic distance and size weights	GMM (Kelejian and Prucha 1998)	1995 – 2006 25 EU countries + Iceland	Nash type of tax competition present; stronger reaction to tax setting of small countries within the centre	41
Crabbé and Vandenbussche (2009)	STR	Corporate income	Nash model	Geographic, economic distance and economic ties weights	IV approach	1993 – 2006 15 EU countries	Nash type of tax competition present; reaction to new EU-member states' tax cuts is stronger for close neighbours	10

Hayashi and Boadway (2001)	AETR	Corporate income	Nash and mixed Nash and Stackelberg model	Uniform weights	SURE	1963 – 1996 10 provinces of Canada	Negative reaction on federal tax changes (vertical tax competition) and Nash type of tax competition between provinces present	n.i
Hill (2008)	STR	Property and option sales	Nash model	Geographic and economic distance weights	IV approach with county and year fixed effects	1993 – 2003 County governments in Tennessee	Nash type of tax competition present; in urban counties reaction on sales tax increase is negative with contiguity and income weights	n.i
Rork (2003)	STR and AETR	Corporate income and sales	Nash model	Geographic distance weights	GMM approach (Kelejian and Prucha 1998), year and state fixed effects	1967 – 1996 48 US states	Nash type of tax competition present	n.i
Ruiz and Gerard (2008)	STR, EATR, MA- and MI-AETR	Capital and corporate income	Nash model	Geographic and economic distance weights	ML approach with time fixed effects, IV approach	1979 – 2001 15 EU countries	Nash type of tax competition present with geographic distance weights	49
b. <u>with a country's openness as independent variable</u>								
Davies and Voget (2008)	STR and EATR	Corporate income	Nash model	Uniform, geographic and economic distance as well as openness weights	OLS, time trend and country fixed effects	1980 – 2005 19 countries	Nash type of tax competition present; tax competition especially between EU members	59
Devereux, Lockwood and Redoano (2008)	STR and EMTR	Corporate income	Nash model	Uniform, size and openness weights	IV with country-specific time trends and country fixed effects	1982 – 1999 21 OECD countries	Strategic interaction in case of sufficient open economies; however then also only if uniform weights are applied	18
Dreher (2006)	MA-AETR, EATR and	Capital income	Nash model	Uniform and openness weight	OLS with fixed country effects	1970 - 2000 OECD countries	Nash type of tax competition not present	16

	EMTR							
Overesch and Rincke (2009)	STR, EATR and EMTR	Corporate income	Nash model	Geographic distance weight	OLS and IV with country fixed effects and some also with time trends	1983 – 2006 32 European countries	Nash type of tax competition present	8
Pitlik (2005)	EATR	Capital income	Nash model	Uniform and size weights	GMM (Arellano-Bond 1991) with time trend	1970 - 1998 15 EU countries	Nash type of tax competition present; negative effect of openness	10
Redoano (2003)	STR	Corporate income	Nash model	Geographic distance, economic distance and size weights	IV approach	1980 – 1995 13 EU countries (pooled cross-sectional)	Nash type of tax competition present; negative effect of openness	4
Redoano (2007)	STR	Corporate income	Nash model	Uniform, geographic distance, economic distance and openness weights	GMM (Arellano-Bond 1991)	1970 – 1999 17 western European countries	Nash type of tax competition present; EU members act more independently than non-EU countries	42
Swank (2006)	STR and EATR	Capital and corporate income	Nash model	Uniform and economic ties weights	OLS with PCSE	1981 – 1998 16 countries	Nash type of tax competition present; negative effect of openness	35
Swank (2007)	STR	Corporate income	Nash model	Openness and economic ties weights	OLS with PCSE	1982 – 2002 16 countries	Nash type of tax competition present; negative effect of openness	16

Notes: [1] Instrumental variable (IV), maximum likelihood (ML), general method of moments estimation (GMM), seemingly unrelated regression (SURE). [2] n.i. = not included in the analysis as not dealing with horizontal tax competition between countries.

Table 6 includes the quantitative results derived from the second generation direct studies surveyed. Note, that we include only studies which deal with horizontal tax competition between countries (also see notes to *Table 5*).

The table is again structured across several dimensions. First, means, standard deviations, 25thm, 50th and 75th percentiles, minima and maxima as well as the share of significant underlying regression coefficients are reported. Second, studies including an openness variable in their empirical model are separated from those which do not. This separation is made as results from first generation direct studies imply that openness is a relevant driver of tax rates. Third, we distinguish between the type of model used (pure Nash, mixed Nash and Stackelberg and pure Stackelberg model). Fourth, a separation by tax rates is made as this directly shows for which type of capital governments compete (e.g. STR for profits, EATR for new firms). Fifth, a separation by weights is carried out as this conveys valuable information concerning the cause of falling tax rates. In particular, uniform weights are in line with the presence of common intellectual trends determining tax policies (cf. *Table 4*).

Starting with the studies not including an openness measure, *Table 6* implies that the mean semi-elasticities for pure Nash models are all positively signed except for studies explaining MI-AETR. Thus, except for MI-AETR the results indicate that tax rates are strategic complements on average. Tax competition for mobile firms (MA-AETR and EATR) and profits (STR) is signalled. Furthermore, the mean value is positive across all definitions of the weighting matrix considered.[xvi]

The negative coefficient for MI-AETRs implies that these tax rates are strategic substitutes, a result which is at odds with basic horizontal tax competition theory. A negatively signed coefficient on the spatial lag might be indicative for econometric problems - like the omission of unobserved country heterogeneity or another important variable like a country' openness - facing the estimations (also see Davies and Voget 2008 on this issue).

Furthermore the table suggests that using uniform weights leads to the largest mean semi-elasticity. The value of 2.3 suggests that a decrease in the averaged tax rates of competitor countries leads to a 2.3 percent decrease in the own tax rate on capital income. However, it should be noted that uniform weights are used only in one study. Thus, the number of underlying regression coefficients (four) driving this result is low.

The last column of *Table 6* shows that the majority of results from the pure Nash models also are statistical significant. Taken at face value these results imply that horizontal tax competition of the Nash type is not unlikely.

Turning to studies applying mixed Nash and Stackelberg models, *Table 6* reveals comparable results. Both parameters, the mean semi-elasticity on the spatial lag as well as that on the leader's lagged tax rate, are positively signed. However, the leaders lagged tax rates frequently is short of statistical significance. Given this result a Stackelberg leader type horizontal tax competition is a rather unlikely event. In contrast, three fourth of the underlying Nash regression coefficients, all based on geographic and economic distance weights, are statistically significant from zero signalling the presence of horizontal tax competition of the Nash type.

Thus, studies excluding an openness variable deliver evidence in favour of Nash type tax competition between countries. However, as implied by the direct studies of the first generation, the results derived in these papers may suffer from an omitted variable bias. This latter bias is avoided by studies which add openness proxies to their empirical model.

Results from pure Nash models containing a country's openness among the set of exogenous variables reveal that EATRs, EMTRs and STRs may be strategic complements and MA-AETRs are strategic substitutes. However, the majority of underlying regression coefficients is insignificant in case of MA-AETR and EMTR.

Mean semi-elasticities are again positively signed across the various definitions of the weighting matrix. An interesting aspect is that uniform weights now result in the lowest mean semi-elasticity. Moreover, the majority of underlying regression coefficients lacks statistical significance. This is in marked contrast to other weighting matrix types where at least 50 percent of the underlying regression coefficients are statistically significant. These results lend further support for the presence of tax competition as driver of falling tax rates. Especially horizontal tax competition for profits and new firms seems to be at force.

Mixed Nash and Stackelberg models are in favour of Nash as well as Stackelberg type tax competition for profits. The mean semi-elasticities based on STRs are positively signed and more than 50 percent of the underlying regression coefficients are statistically significant. In contrast, Nash type tax competition for new firms is not signalled by this model type. The underlying regression coefficients all fall short of statistical significance. Moreover, results for the EATR based on the leader's lagged tax rate are not consistent with Stackelberg leader type of tax competition for new firms as the mean semi-elasticity is negatively signed. However, the number of underlying regression coefficients the calculation is based upon again is low.

Finally, one study applied a pure Stackelberg leader model (i.e. it does not include $WTax_{-j}$). It does not find any evidence in favour for this type of tax competition.

Taken together, second generation direct studies including an openness variable, which are preferred over studies excluding an openness measure indicate the presence of Nash and Stackelberg type of tax competition for profits. Our results suggest that a one percentage point change in the weighted average STR of competitor countries leads to a change in the own STR by about 0.9 to 1 percent (see means values for STR, international studies with openness variable, Nash coefficients). The reaction to a one percentage point change in a leader's tax rate is about 0.21 percent (see mean value for STR, international studies with openness variable, Stackelberg coefficients).

Results are also in favour of Nash type tax competition for new firms although the evidence is somewhat less clear cut due to the results derived from mixed Nash and Stackelberg models. Stackelberg leader type tax competition for new firms is not supported by the results. Moreover, no convincing evidence is provided for the presence of tax competition for investments of already existing firms.

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

	Mean	Std.dev.	Min.	25 Perc.	Median	75 Perc.	Max.	Share of significant[2] regression coefficients
1. <u>Studies without openness variable(s)</u>								
a. Pure Nash models								
i. Tax definitions								
MA-AETR	0.2053	1.0270	-0.3358	-0.0855	-0.0205	0.0073	3.8972	13 / 15
MI-AETR	-0.0251	0.0193	-0.0546	-0.0476	-0.0146	-0.0089	-0.0082	7 / 7
EATR	0.5159	1.1032	-0.0165	-0.0063	0.0064	0.0947	3.4410	14 / 18
STR	0.3778	1.2357	-2.7476	-0.0036	0.0069	0.7225	4.7101	16 / 24
ii. Weights								
Uniform	2.3038	1.1887	1.1897	1.2795	2.2923	3.3282	3.4410	4 / 4
Geographic and economic distance	0.2015	0.9427	-2.7476	-0.0165	-0.0024	0.0088	4.7101	46 / 59
Economic ties	0.1544	-	0.1544	-	-	-	0.1554	0 / 1
b. Mixed Nash and Stackelberg models								
i. Tax definitions								
Nash coefficients:								
MA-AETR	4.3302	0.4034	3.8430	3.9986	4.4046	4.6617	4.6685	3 / 4
Stackelberg coefficients:								
MA-AETR	0.2515	2.1985	-4.5332	-1.2855	1.2585	1.4208	3.7348	4 / 12

ii. Weights

Nash coefficients:

Geographic and economic distance	4.3302	0.4034	3.8430	3.9986	4.4046	4.6617	4.6685	3 / 4

2. <u>Studies with openness variable(s)</u>

a. Pure Nash models

i. Tax definitions

MA-AETR	-1.1291	1.2934	-3.8500	-1.6972	-0.5438	-0.2559	-0.1893	1 / 8
EATR	1.4037	1.7622	-2.3275	0.0951	1.1409	2.7498	4.8512	43 / 60
STR	0.8998	1.1387	-1.4417	0.0145	0.6161	1.6696	4.0541	65 / 91
EMTR	0.2470	0.3469	-0.0005	0.0183	0.1133	0.1596	0.8777	1 / 9

ii. Weights

Uniform	0.0769	1.3270	-3.8500	-0.3592	0.0882	0.7418	2.2769	11 / 28
Geographic and economic distance	0.9900	1.2933	-1.3714	0.0045	0.5795	1.9018	4.0541	26 / 34
Size	1.0999	1.3771	-1.1637	0.1321	0.6265	2.0071	4.3846	20 / 30
Openness	1.2179	1.5608	-2.3275	0.1697	0.9478	2.3765	4.8512	52 / 74
Economic ties	0.1830	0.2538	0.0036	0.0036	0.1830	0.3625	0.3625	1 / 2

b. Mixed Nash and Stackelberg models

i. Tax definitions

Nash coefficients:

EATR	0.0584	0.0136	0.0410	0.0503	0.0569	0.0697	0.0738	0 / 5

STR	0.9883	1.4493	-4.3652	0.1222	1.2776	1.8680	3.4602	19 / 36
Stackelberg coefficients:								
EATR	-0.4574	0.3033	-0.7277	-0.5997	-0.5241	-0.4964	0.0610	3 / 5
STR	0.2090	1.0046	-1.7301	-0.6171	0.2422	0.6388	2.6883	22 / 30
ii. Weights								
Nash coefficients:								
Geographic and economic distance	2.4399	0.7004	1.8100	1.8100	2.3157	3.1940	3.1940	3 / 3
Size	1.1818	1.9263	-4.3652	0.1597	1.5172	2.3955	3.4602	10 / 15
Economic ties	0.4706	0.7344	-0.8055	0.0738	0.1225	0.9595	1.9260	6 / 23
c. Pure Stackelberg models								
i. Tax definitions								
EATR	-0.1433	-	-0.1433	-	-	-	-0.1433	1 / 1

Notes: Only studies which focus on horizontal tax competition between countries are used for computing this table. [1] Semi-elasticities which are 2-times the standard deviation of the overall study sample. [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. Perc. = percentile.

6. Discussion

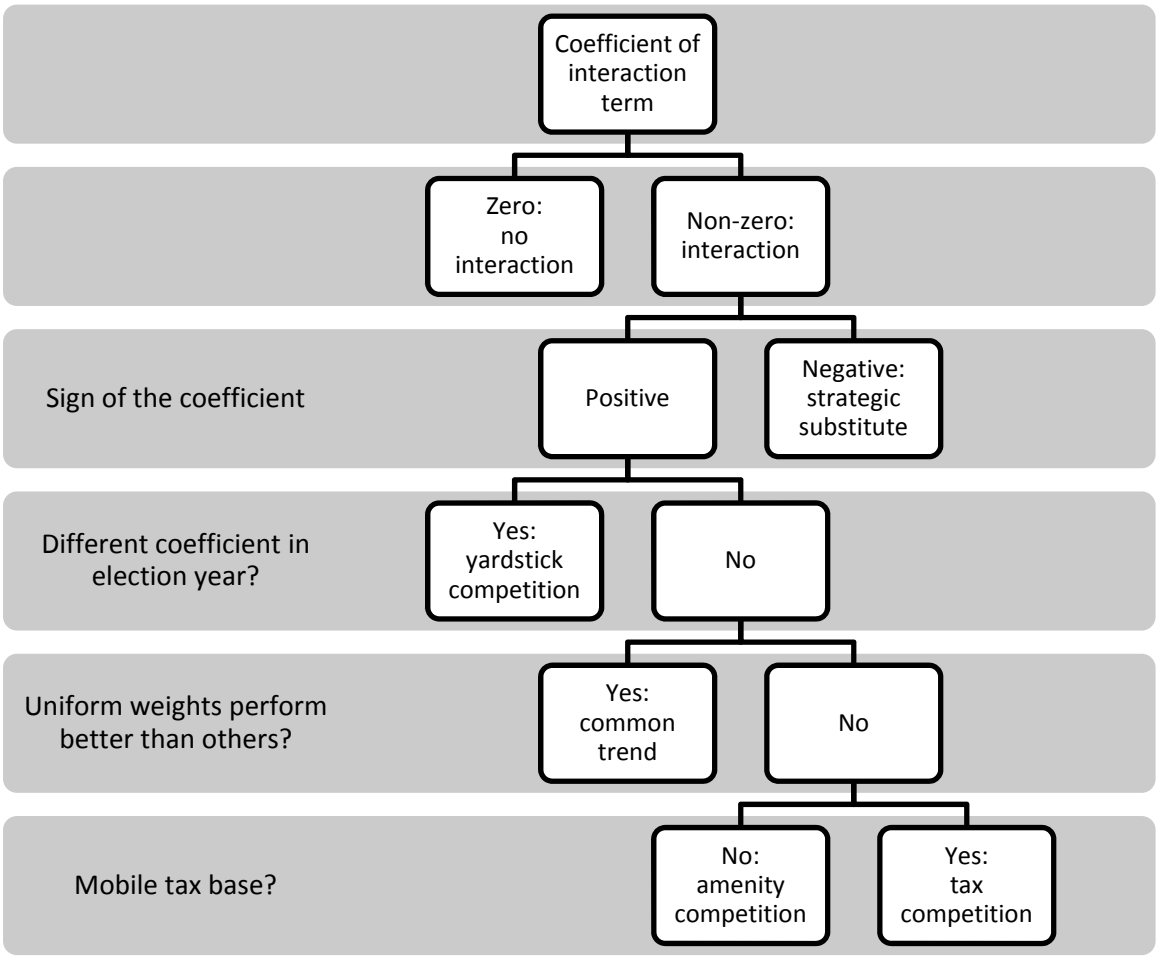
Taken together the first and second generation direct studies surveyed find support for tax competition for new firms and for profits as a driver of falling tax rates. This result also seems plausible when one takes into consideration the political statements of public officials which often suggest that tax competition forces are at work.[xvii] Moreover these findings are consistent with results from indirect studies (see above and Devereux 2007).

However, first generation direct studies do not model strategic interactions in tax setting. Thus, their results do not constitute clear cut evidence in favour of tax competition as a driver of falling tax rates. By employing tax reaction function 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 (Nash games) or on a leader's lagged tax rate (Stackelberg games).

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 (e.g. Devereux et al. 2008). However, yardstick competition and common intellectual trends may also influence tax policies in open economies.[xviii] Moreover 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". 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.

So how could a procedure to isolate the role of tax competition as a driver of falling tax rates look like? 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 of the Nash typ. *Figure 1* basically replicates Redoano's reasoning.

Figure 1: Discrimination among various causes of falling tax rates



Source: Redoano (2007, p. 8)

According to Redoano (2007), horizontal tax competition is correctly identified if (a) the coefficient on the interaction term (which is the weighted average 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. As mentioned above (cf. *Table 4*) 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. Once yardstick competition and common intellectual trends can be excluded horizontal tax competition is correctly identified if the tax base is mobile, which is another precondition of horizontal tax competition.

Redoano (2003 and 2007) includes election year dummy variables in her empirical models. Yet, no significant relationship with the tax rate on corporate income is established. Thus, based on *Figure 1* yardstick competition could be excluded as a cause of falling tax rates. Moreover, based on our survey the presence of a positive coefficient on $WTax_{-j}$ is likely, as the majority of mean semi-elasticities derived is positive (cf. *Table 6*). Furthermore, uniform weights do not outperform other types of weighting matrices (in case of the preferred models containing an openness variable). Hence, applying the approach of Redoano (2007) offers additional evidence in favour of tax competition as a driver of falling corporate income 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 horizontal tax competition. In turn, these preconditions – as well as variables indicating alternative causes of falling tax rates – can be captured within a two-equation empirical model aiming to explore the causes of falling corporate income tax rates.

For instance, Bellak and Leibrecht (2007) derive four preconditions for horizontal 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 MNEs make use of this possibility; (2) governments reduce relevant tax rates on corporate income; (3) one explicit motivation of tax rate cuts is to attract mobile capital or to react to downward revisions of other countries' corporate income tax rates to avoid losing investment; and (4) 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 direct 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 two-equation model. Precondition (1) can be incorporated into this model by including *de jure* and *de facto* openness measures 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 independent variables in the equation capturing indirect studies. This makes the two-equation model a simultaneous model. Moreover, the impact of common intellectual trends on 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 corporate income. Changes in the political climate can be incorporating 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), it could be assumed 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 political aim of tax rate changes.[xix]

7. Summary

This paper provides an 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 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 profits and new firms. 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 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: Derivation of semi-elasticities for this paper

The semi-elasticity of variable y with respect to variable x is given by $\epsilon_S = \frac{(\%\Delta y)}{\Delta x}$ which shows the percentage change in variable y when variable x changes by one unit (see Wooldridge 2009, p. 46). 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 have to be measured in percent (i.e. for instance as 35 percent). If they are measured as proportions (e.g. 0.35) then the semi-elasticity of a one percentage point change 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 applied in all cases except for x being measured as proportion. In this case $\epsilon_S = \frac{\hat{b}}{\bar{y}}$. In any case $\bar{y}$ is 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.

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 proportions instead of percent than the regression coefficient is multiplied by 100 before the given formula is applied. In any case $\bar{y}$ and $\bar{x}$ are measured in percent.

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Notes:

[i] The appendix sketches how regression coefficients are turned into semi-elasticities.
[ii] Tax rates are effective if they capture stipulations concerning the tax base.
[iii] It has to be noted that the profit shifting *opportunities* of firms depend on tax base related aspects like thin-capitalization rules or the availability and tax treatment of hybrid financing instruments which share characteristics of debt and equity (see e.g. Eberhartinger and Six 2009). We are very grateful to the referee who pointed out these issues.
[iv] A backward looking marginal effective tax rate is proposed by Gordon et al. (2003). So far this tax rate has not been used in the empirical tax competition literature.
[v] However, these rates can be used ex-post to explore the distribution of the corporate income tax burden across different firms and sectors (MI-AETR) or the distribution of the tax burden across different types of tax bases (capital, labour, consumption (MA_AETR)). Moreover, these rates can also be used to explore ex-post the extent of tax-planning possibilities of firms as they are based on real data.
[vi] As such studies do not explicitly deal with the presence of tax competition they have not been included in our survey.
[vii] Note that both published and unpublished papers are included in the table.
[viii] Note, that for second generation studies this aspect is of minor importance as the independent variable of main interest in any case is a tax rate.
[ix] Extreme values which are greater than twice the standard deviation are excluded from the analysis.
[x] Indeed the coefficients included in the positive mean value are all taken from studies which explore the presence of tax exporting effects in tax policy (Huizinga and Nicodème 2006).
[xi] In Nash games this is unambiguously so if each government has only one strategic variable to compete for mobile capital. When more strategic variables are given, then indirect effects have to be considered (see Devereux et al. 2008, p. 1217f for more details).
[xii] 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.
[xiii] The latter type of investments is summarized as "capital" in Devereux et al. (2008).
[xiv] In case of GDP-level weights a statistical significant coefficient greater one is found which implies an explosive behaviour of the spatial lag model.
[xv] 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)
[xvi] 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 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.
[xvii] 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.
[xviii] Anselin (2002) points out an identification problem: the basic spatial lag models suffer from a lack of identifying the underlying economic mechanism (tax competition or yardstick competition) which causes the spatial interaction.
[xix] Recent empirical evidence on the determinants of FDI indicates that agglomeration forces play a crucial role for attracting FDI and for the tax rate sensitivity of FDI. This also implies that the incentive to engage in tax competition of those countries which offer substantive agglomeration advantages might be rather low. Hence, the inclusion of agglomeration variables may substantially impact on the estimated strategic interaction in tax setting between countries. Indeed, some papers surveyed here include a proxy variable for agglomeration forces in their empirical model (e.g. Garretsen and Peeters 2007; Krogstrup 2005). For instance, Garretsen and Peeters (2007) find that "compared to more peripheral countries, core countries have a higher corporate tax rate" (p. 22). This indicates that agglomeration effects may matter for the strength of tax competition. Thus, agglomeration forces should also be captured within the above sketched two-equation model.

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