Follow the Leader?
Evidence on European and U.S. Tax Competition

by

Rosanne Altshuler
Rutgers University
altshule@rci.rutgers.edu

and

Timothy J. Goodspeed
Hunter College and CUNY Graduate Center
timothy.goodspeed@hunter.cuny.edu

Abstract: This paper contributes to the small empirical literature that attempts to estimate tax reaction functions of national governments competing with other national governments. After presenting a simple theoretical model, we estimate reaction functions for European countries for a pure Nash model and for a model in which the U.S. can act as a Stackelberg leader while the European countries compete with each other in a Nash way. We initially find a positive Nash reaction function for European countries with respect to capital taxes, but no reaction with respect to labor taxes. Further investigation of the capital tax response results in our main finding, that the European countries behave as if the U.S. is a Stackelberg leader in setting corporate taxes after the U.S. 1986 Tax Reform Act but not before. We also test whether the United Kingdom or Germany played a leadership role and find that they did not. These regression results are reinforced by our Granger causality tests, and are somewhat stronger when we exclude certain tax havens. Over time, European countries seem to have become more intensely competitive with the U.S. in corporate taxes, but less intensely competitive among themselves.

We thank Julian Alworth, Austan Goolsbee, Roger Klein, Edward Outslay, John Landon-Lane, Michael Smart and participants at the 2003 University of Illinois Tax Research Symposium, 2002 NBER Summer Institute, the 2002 IIPF Meetings, Tulane University, and the University of Rennes 1 for helpful comments and suggestions.

1. Introduction

It is often alleged that countries will compete in setting tax rates on mobile factors such as capital. If true, tax competition could have a profound impact on fiscal systems worldwide, possibly altering revenue, progressivity, the mix of taxes and the overall efficiency of the tax system. Many argue that global tax competition will lead to less reliance on taxes on capital and more reliance on taxes on labor, possibly reflecting more closely the benefits that different groups receive in terms of public services.

A large theoretical literature on tax competition has developed beginning with papers such as Zodrow and Mieszkowski (1986), Wilson (1986), Wildasin (1988), Bond and Samuelson (1989), Kanbur and Keen (1993) and surveyed in Wilson (1999) and Fuest, Huber, Mintz (2003). The basic argument is that countries recognize that taxes can be avoided by relocation in the case of capital taxes or cross-border purchases in the case of consumption taxes. Consequently, the tax rates set by other countries can influence the tax rate set by a given country. Most of the theoretical models of tax competition that have been developed consider a Nash game. Gordon (1992) provides an interesting exception to this by considering a Stackelberg game. He suggests that the United States may have been large and influential enough to have played the role of a Stackelberg leader. Moreover, it has sometimes been suggested that the Tax Reform Act of 1986 in the United States (hereafter TRA'86) stimulated European tax reforms in the ensuing years. In this paper we investigate empirically the role of the United States vis-à-vis Europe in the setting of tax rates.

Empirical examination of tax competition has lagged behind the development of theoretical models and is quite recent. Moreover, most of the empirical work, surveyed by Brueckner (2003),

concentrates on tax competition between governmental units within a country.[1] Several recent papers in this literature such as Besley and Rosen (1998), Goodspeed (2000, 2002), Hayashi and Boadway (2001), and Esteller-Moré and Solé-Ollé (2001) investigate Stackelberg behavior of the central government vis-à-vis lower level governments within a country. A recent paper in the environmental economics literature, Fredriksson and Millimet (2002), studies whether California has played a leadership role in setting automobile emissions standards at the state level. A small empirical literature has recently begun that attempts to estimate tax reaction functions of national governments competing against other national governments. For instance, Devereux, Lockwood, and Redoano (2002) and Besley, Griffith, and Klemm (2001) estimate Nash reaction functions for OECD countries. Both studies find a positively sloped Nash reaction function, but do not consider the possibility of Stackelberg behavior.

Our primary goal in this paper is to provide evidence on global tax competition by estimating the reaction of countries to tax changes of other countries with particular attention to the possibility of a large and dominant country acting as a Stackelberg leader in capital tax policy.[2] We empirically test both a pure Nash model between European countries and a model in which the U.S., the U.K., or Germany can act as a Stackelberg leader while the other European countries also compete with each other in a Nash way. With respect to Nash competition, we find that European countries did not compete with each other over labor taxes, but did compete with each other over corporate taxes. Our main findings are with respect to a Stackelberg leader in capital taxes. We find that the European countries behaved as if the U.S. was a Stackelberg leader in setting corporate taxes after TRA'86 but not before. We also test whether Germany or the United Kingdom played a leadership role and find that they did not. These

[1] Goodspeed (1998) discusses the similarities between the fiscal federalism and international tax literatures on tax competition.

[2] Throughout the paper we use Stackelberg to mean the standard dynamic setting in which the leader moves first and the follower second. See, for instance, Fudenberg and Tirole's (1991, p. 67) chapter 2 on "Dynamic Games of Complete Information" where they state, "The difference is that we now suppose that player 1, the 'Stackelberg leader,' chooses her output level q1 first, and that player 2 observes q1 before choosing his own output level."

regression results are reinforced by our Granger causality tests, and are somewhat stronger when we exclude certain tax havens. Over our sample period, European countries seem to have become more intensely competitive with the U.S. in corporate taxes, but less intensely competitive among themselves.

The case of the U.K. is particularly interesting for our analysis. The U.K. government enacted a major tax package in 1984 which, among other changes, reformed the corporate income tax by lowering the statutory rate and broadening the base. Later that same year, the U.S. Treasury Department proposed a rate-cutting, base-broadening reform which paved the way for the eventual passage of TRA'86. A wave of similar tax reforms in OECD countries followed. While many commentators have pointed to the U.K. as playing the leading role, our methodology allows us to empirically test whether OECD countries responded to the U.K. reform of 1984 or the later U.S. reform.

The remainder of the paper is organized as follows. The next section presents a simple theoretical model. Section 3 discusses our empirical methodology and data. Section 4 presents our results. Section 5 concludes.

2. Theoretical Background

A number of game-theoretic models of tax competition have been developed. Most of these consider governments competing against each other in a Nash game. For instance, Zodrow and Mieszkowski (1986) model governments operating in small open economies which take the return to capital as given. Wilson (1991) also considers a Nash game among large governments who realize that they impact the return to capital. An interesting departure from the Nash game is explored in Gordon (1992). Gordon considers a game in which one country is a Stackelberg leader and finds that in certain cases capital income taxes can be sustained when countries use a tax-credit system to alleviate double-

taxation.

We develop below a simple and standard model of tax competition except that one country is assumed to be large and act as a Stackelberg leader in setting it's capital taxes. Our focus will be the effect that a change in the leader's choice of tax rate has on the follower's optimal tax rate. Suppose that there are n countries and consider country i. The representative consumer of country i is endowed with perfectly mobile capital and a fixed factor labor. Capital and labor are combined to produce output according to a constant returns to scale production function. Income from the endowment of capital, K_i^*, and from the fixed factor can be used to consume a private good, X_i, or a public good, G_i. The public good is financed by levying a per-unit tax on capital; we also introduce a tax-credit system for taxation of foreign income as discussed further below. Profit-maximization by perfectly competitive firms implies that a firm's demand for capital satisfies:

$$\frac{\partial f_i}{\partial K_i} = r + t_i \tag{1}$$

where r is the after-tax return to capital and t_i is the per unit tax on capital. The capital market equilibrium condition is:

$$\sum_i K_i(r + t_i) = \sum_j \sum_i K_{ji} = \sum_i K_i^* \tag{2}$$

where K_i is the demand for capital in country i and K_{ji} is the demand for country i's capital in country j.

As mentioned above, we will assume that one of the n countries is large and acts as a Stackelberg leader when choosing its tax rate. Other countries are assumed to be small and act as Nash competitors with each other and as Nash followers with respect to the Stackelberg leader. Since the leader is a large country, its actions will impact the before-tax rate of return necessary to attract capital according to the capital market equilibrium condition. In particular, total differentiation of the capital market equilibrium condition indicates $\partial r/\partial t_L < 0$ where t_L denotes the leader's tax rate. Although a follower is small and does not directly affect the after-tax return when it changes its tax rate, it recognizes that the return to capital depends on the tax rate

chosen by the leader.

Suppose that a country taxes all capital located within its borders and also taxes domestic capital located overseas in conjunction with a tax-credit system to alleviate double taxation. The tax-credit will be assumed to be limited to the domestic tax rate. Tax revenues are:

$$T_i = t_i K_i + \sum_{j \neq i} \max(t_i - t_j, 0)(K_{ji}) \quad (3)$$

The first term is the revenue collected within country *i*'s borders. If country *i*'s tax rate is less than country *j*'s tax rate, no additional revenue is collected. If country *i*'s tax rate is greater than country *j*'s, country *i* will collect additional revenue equal to the difference between the tax rates times the amount of overseas capital. As noted above, the demand for capital located in country *i* depends on the tax rate of country *i*. For simplicity, the demand for country *i*'s capital located in country *j* is assumed to depend on country *j*'s tax rate even when the tax rate for country *j* is less than that for country *i* and country *i* uses a tax credit system. Thus we assume that the residual home country tax has no impact on firms' investment decisions.[3] Note that a territorial tax system corresponds to the case in which country *i*'s tax rate is less than country *j*'s tax rate, so we do not consider this as a separate problem.

Our main focus in the empirical section is in estimating the followers' reaction function. We therefore consider here the maximization problem faced by a follower, country *i*. Country *i*'s problem will be to select a tax rate to maximize the utility of the representative consumer:

[3] The irrelevance of any residual home country tax on corporate decisions concerning foreign investment follows from both the 'new view' of dividend taxation and more recent models that take into account the ability of firms to avoid repatriation taxes. Hartman (1985) was the first to apply the 'new view' of dividend taxation to the case of foreign income. His insight was that since the repatriation taxes are unavoidable, they decrease both the opportunity cost of investment and the return to investment by the same amount. As a result, repatriation taxes do not affect the choice between further investment in foreign subsidiaries or the repatriation of profits. Sinn (1993) and Hines (1994) considered the Hartman result within multi-period models and showed that residual taxes on foreign income due upon repatriation induce firms to "underinvest" initially in order to obtain the benefits of deferral until a "target" capital stock is reached. This underinvestment result does not obtain, however, in more realistic models that allow for alternatives to repatriation (see Weichenreider 1996 and Altshuler and Grubert 2002).

$$\begin{aligned} &\max_{t_i} u(X) + v(G_i) \\ &s.t. \quad X_i = f(K_i) - (r + t_i)K_i + rK_i^* \\ &G_i = t_i K_i + \sum_{j \neq i} \max(t_i - t_j, 0)(K_{ji}) \end{aligned} \tag{4}$$

where utility is assumed to be additively separable. The first order condition for this problem, which defines the reaction function, is

$$-\frac{\partial u}{\partial X_i} K_i + \frac{\partial v}{\partial G_i}\left(K_i + t_i \frac{\partial K_i}{\partial t_i} + \sum_{j \in \{t_j < t_i\}} K_{ji} \right) = 0 \tag{5}$$

where we have substituted for $\partial f_i / \partial K_i$ using the fact that profit-maximization by perfectly competitive firms implies that a firm's demand for capital satisfies (1) above. Rewriting the first order condition yields

$$\frac{\frac{\partial v}{\partial G_i}}{\frac{\partial U}{\partial X}} = \frac{1}{1 + \varepsilon_{K,t} + \sum_{j \in \{t_j < t_i\}} \left(\frac{K_{ji}}{K_i} \right)} \tag{6}$$

The tax rate will be chosen to equate the marginal rate of substitution between public and private goods to the tax-price. The tax price depends on the degree to which capital flees a jurisdiction as it increases its tax rate, the elasticity of capital with respect to the tax rate denoted $\varepsilon_{K,t}$. The greater is the response of capital to an increase in the tax rate, the higher is the tax-price and the lower is the optimal tax rate. If there are no countries whose tax rate is less than the tax rate of country *i* (or equivalently under a territorial system), the summation in the denominator is zero and the tax-price reduces to the standard first order condition of the tax competition literature.

If country *i* operates under a tax credit system and there are other countries with lower tax rates,

the bracketed term becomes relevant. As country *i* increases its tax rate, it not only loses some revenue as domestically located capital leaves, but also gains some revenue from a higher net tax on domestically owned capital that is located in countries with lower tax rates. This diminishes the capital flight impact on revenues, lowers the tax price, and tends to increase the optimal tax rate.

The empirical work will attempt to estimate the slope of the followers' reaction function with respect to a change in the leader's tax rate, t_L. This slope can be derived by differentiating (5). This yields:

$$\begin{aligned} &- u_{XX} K_i \frac{\partial X_i}{\partial t_L} - u_X \frac{\partial K_i}{\partial r} \frac{\partial r}{\partial t_L} + v_{GG} \frac{\partial G_i}{\partial t_L} \left(K_i + t_i \frac{\partial K_i}{\partial t_i} + \sum_{j \in \{t_j < t_i\}} K_{ji} \right) \\ &+ v_G \frac{\partial K_i}{\partial r} \frac{\partial r}{\partial t_L} + v_G t_i \frac{\partial K_i^2}{\partial t_i t_L} + v_G \sum_{j \in \{t_j < t_i\}} \frac{\partial K_{ji}}{\partial r} \frac{\partial r}{\partial t_L} \end{aligned} \tag{7}$$

Examination of this derivative indicates that it is ambiguous in sign. To give some intuition, we group the terms into four categories: a desire to maintain public spending (term 3), a desire to maintain private consumption (term 1), a change in the elasticity of domestic capital (terms 2, 4, and 5), and a change in the demand for taxed capital overseas (term 6).

The desire to maintain public spending. Differentiation of the constraint for public spending yields:

$$\frac{\partial G_i}{\partial t_L} = t_i \frac{\partial K_i}{\partial r} \frac{\partial r}{\partial t_L} + \sum_{j \in \{t_j < t_i\}} (t_i - t_j) \frac{\partial K_{ji}}{\partial r} \frac{\partial r}{\partial t_L} - \alpha t_L K_{Li} > 0 \ \textit{for} \ \alpha = 0 \tag{8}$$

where $\alpha = 1$ if $t_L < t_i$ and 0 otherwise. A decrease in the leader's tax rate leads to an outflow of capital from country *i* and countries other than *L* in which country *i*'s capital is located. The after-tax return to capital is raised in equilibrium. This implies that the first two additive terms are positive and public

spending in country *i* must fall if country *i* leaves its tax rate unchanged, so $\partial G_i / \partial t_L > 0$ if $\alpha = 0$. The fall in *G* increases the value of public spending on the margin and country *i* consequently has an incentive to increase its tax rate to maintain public spending. In this case the third term of the comparative static is negative and tends to make the reaction function downward sloping. If the leader has a tax rate less than country *i* ($\alpha = 1$), country *i* gains some revenue on its capital located in the leader country making the sign of (8) and the third term of the comparative static ambiguous.

The desire to maintain private spending. Differentiation of the constraint for private spending yields:

$$\frac{\partial X}{\partial t_L} = \frac{\partial r}{\partial t_L}(K_i^* - K_i) \quad > 0 \text{ if net capital importer, } < 0 \text{ if net capital exporter} \qquad (9)$$

A decrease in the leader's tax rate raises the after-tax return to capital. This raises the capital income of country *i* (rK_i^*) but decreases country *i*'s labor income ($f(K_i) - (r + t_i)K_i$). If the follower is a net capital importer, private consumption falls because its labor income falls by more than its capital income rises.[4] Private consumption becomes more valuable on the margin, but additional consumption of the private good entails a lower tax rate for the follower and term 1 is positive. If the follower is a capital exporter, a fall in the leader's tax rate increases private consumption which becomes less valuable on the margin. The follower would like to consume less of the private good which entails a higher tax rate for the follower and term 1 is negative. Hence, the first term tends to make the reaction function negatively sloped for a capital exporter and positively sloped for a capital importer.

A change in the elasticity of domestic capital. Terms 2, 4, and 5 relate to a change in the elasticity of domestic capital on the right hand side of (6). The elasticity is of course defined as (t_i/K_i) $(\partial K_i / \partial t_i)$. Terms 2 and 4 derive from the fact that a lower tax rate for the leader increases the after-tax

[4] Capital importer and capital exporter are used somewhat loosely to mean the cases for which $K_i^* < K_i$ and $K_i^* > K_i$, respectively.

return to capital which will result in less capital located in country *i*. This implies that the elasticity of capital is higher. In other words, a decrease in the tax rate of the leader increases the tax-price of public spending for country *i*, and there will be an incentive for country *i* to lower its tax rate in response.[5] Thus terms 2 and 4 tend to make the reaction function positively sloped.

Term 5 arises from the possibility that a change in the leader's tax rate changes the response of country *i*'s capital to a change in its tax rate, i.e. that it changes $\partial K_i / \partial t_i$. The sign of this term depends on the sign of the cross-tax derivative. To the extent that a lower leader tax rate increases the response of K_i to change in t_i, the elasticity and tax-price perceived by country *i* is higher and the follower would decrease its tax rate, making this term positive. More generally, the term is ambiguous in sign.

A change in the demand for taxed capital overseas. Term 6 is positive and arises from the fact that a lower tax rate for the leader increases the after-tax return to capital and results in less formerly taxed overseas capital located in countries with tax rates less than country *i*. This loss in revenue increases the tax-price of public spending for country *i*, and there will be an incentive for country *i* to lower its tax rate in response.

To summarize, the reaction function of a small country with respect to a change in the tax rate of a large leader can be positively or negatively sloped in theory. We have derived four factors that influence the slope: a desire to maintain public spending and private spending, a change in the elasticity of domestic capital, and a change in the demand for taxed capital overseas. Intuitively, the main reason one might observe a negatively sloped reaction function is a desire to maintain public spending (and to

[5] Formally, adding term 2 and term 4 together yields:

$$u_X \frac{\partial K_i}{\partial r} \frac{\partial r}{\partial t_L} \left(\frac{v_G}{u_X} - 1 \right) > 0$$

where the positive sign follows from the first order condition: fearful of capital flight, the tax-price perceived by the follower is greater than 1.

reduce private consumption for a capital exporter) while a positively sloped reaction function is due primarily to a higher elasticity of capital resulting from the leader's tax change. We turn next to the estimation.

3. Empirical Methodology

3.1 Econometric Specification

The theory that underlies the empirical work is a strategic model of tax competition that allows for one large country to act as a Stackelberg leader. Empirically, our goal is to estimate a reaction function for the followers. The few empirical papers that have attempted to estimate national reaction functions (e.g. Besley, Griffith, and Klemm, 2001, and Devereux, Lockwood, and Redoano, 2002) have considered a Nash competition model. We follow this literature in that we allow the followers to be Nash competitors with each other, but we also allow them to react to the actions of a large country. We think that the United States may have played a Stackelberg leader role as it passed TRA'86. Our focus is thus on European countries acting as Nash competitors with each other, and viewing the United States as a Stackelberg leader, although we also test whether the United Kingdom or Germany could have played this role.

Our basic estimating equation is:

$$\tau_{i,t} = \beta \sum_{j \neq i} \omega_{ij} \tau_{j,t} + X_{i,t}\theta + \tau_{L,t-1}\eta + d_i\phi + T_t\psi + \varepsilon_i \qquad (10)$$

where i indexes the follower countries and t indexes time, τ_i is our tax rate measure, $\tau_{L,t-1}$ is the lagged tax rate of the leader, X_i is a vector of exogenous control variables, ω is a weighting matrix discussed further below, $\beta, \theta, \phi, \eta$ and ψ are estimated parameters (θ being a vector of estimates), d_i is a set of country fixed

effects, T is a time trend, and ε_i is an error term.[6] We discuss our exogenous control variables in some detail in the next section. The slope of the reaction function with respect to the Stackelberg leader is the estimated coefficient η. As our theoretical derivation makes clear, this coefficient could be negative (due primarily to a desire to maintain public spending) or positive (due primarily to a higher elasticity of capital resulting from the leader's tax change).

The slope of the reaction function with respect to other Nash competitors is the coefficient β. The weights of the weighting matrix ω are constructed to reflect the influence of each neighbor's tax rate on the "own" country tax rate. A weighting scheme that seems particularly appealing to us is one in which weights are assigned based (inversely) on the distance between the own country and all countries for which interactions are assumed. This equation has been found to explain well trade relations. One such scheme assigns a weight of one to contiguous countries (states, counties, etc.) and zero to all others (see, for example, Besley and Case 1995). These weights are normalized to add to one. We follow this simple weighting scheme in our analysis. However, in assigning weights to neighbors we have ignored relatively small bodies of water separating countries. For example, the neighbors of Norway are Denmark, Finland and Sweden. These three countries each receive a weight of one-third in our weighting matrix.[7] We further test the validity of this weighting matrix by testing whether the weighted average tax rate of the neighbors of the neighbors of country i is significant in our regression specification. We define the neighbors of the neighbors using the same logic that we used to identify the neighbors of country i and we find that this weighted average tax rate is not significant in our regressions.[8] Appendix table 1 shows our

[6] As will become clear shortly, we follow Besley and Case (1993) in allowing a 2-year window for the Nash reaction and we use the lagged value for the leader since our assumption is that the Stackelberg leader moves first.
[7] Another example of a country whose neighbors' are assigned ignoring small bodies of water is the United Kingdom. Instead of assuming that the United Kingdom has no interaction with European countries, we consider the possibility that the federal government strategically interacts with Belgium, France, Ireland and the Netherlands. In our view, this is consistent with assigning countries based on borders.
[8] We thank Austan Goolsbee for this suggestion. We constructed the variable as follows. Assume that country 1 has two neighbors, countries 2 and 3. Assume further that countries 2 and 3 together have three neighbors that are

classification of the geographic neighbors of the countries in our dataset.

We investigate several variations of the basic regression equation. We start by dropping the leader's rate to estimate a simple Nash specification. We estimate this first specification for both capital and personal tax competition. One would expect tax competition to be particularly pronounced for mobile capital and relatively sedate for immobile labor. Second, one might suspect that globalization and increased mobility of capital would lead to steeper reaction functions over time. Indeed, Altshuler, Grubert and Newlon (2001) find that the location of the assets of U.S. multinationals became more sensitive to differences in corporate tax rates between 1984 and 1992. If governments perceive this change, their perceived tax price would increase, lowering the tax rate on capital.

We also explore whether the reaction function of the follower European countries became steeper with respect to the U.S. lead. The U.S. TRA'86, which significantly lowered the U.S. statutory corporate tax rate while broadening the base, was a defining moment for U.S. tax policy. Our argument is that it was also a defining moment for Europe. It is thus possible that the TRA'86 combined with the relaxation of capital controls in Europe and technological advances that eased capital mobility resulted in European nations treating the U.S. as a Stackelberg leader after 1986. Previous work has presented suggestive evidence of this dynamic in tax competition. For instance, tax return data shows that the average foreign effective tax rates faced by U.S.-based multinationals abroad have declined substantially between 1983 and 1992 (see, for example, Grubert, Randolph and Rousslang 1996 and Altshuler, Grubert, and Newlon 2001).[9] Grubert, Randolph and Rousslang (1996) find this trend is primarily due to reductions in country

---

not neighbors of country 1. The "neighbor's neighbor" rate would be a weighted average of the three neighbors corporate tax rates (where each receives a weight of 1/3).

[9] More recent work with tax return data finds that effective tax rates faced by U.S. multinationals investing abroad continued to decline after 1992 (see Altshuler and Grubert 2005).

average tax rates that closely paralleled the decrease in the U.S. statutory rate in 1986.[10] During this same period, U.S.-based multinationals have increased outbound investment and become more sensitive to differences in local tax rates abroad.[11] Desai (1999) argues that taken together these trends suggest that changes in the tax rates of large countries such as the United States "…can trigger a transitional period of tax competition (p. 176)." Our work directly tests whether TRA'86 initiated a period of more intense European tax competition at two levels: first, whether European countries became more responsive to their neighbor's tax changes and second, whether these same countries "followed" the U.S. reforms.

3.2 Data and Variables

We use data for 1968 to 1996 from the OECD Revenue Statistics. This data source provides us with a relatively long time-series of country tax revenue detail that is comparable across countries. We calculate a measure of average corporate and individual tax rates by dividing revenues from each tax by gross domestic product.[12] This is one common average tax rate measure and has been used by, among others, Besley, Griffith and Klemm (2001) to estimate Nash fiscal reaction functions for OECD countries. Although this is not a perfect measure, it accounts for the large variety of tax concessions that determine

[10] Desai (1999) finds similar patterns using data from the Bureau of Economic Analysis. He finds that the ratio of foreign income taxes to profit-type return fell significantly between 1982 and 1995. The data show that there was a substantial period of adjustment to the 1986 U.S. tax reform.

[11] See Desai (1999) for a concise discussion of U.S. MNC investment growth over this period and Desai (2002) and Altshuler, Grubert, and Newlon (2001) for evidence of increased tax sensitivity of U.S. multinational investment abroad.

[12] Corporate tax revenues are class 1200 "taxes on income, profits and capital gains of corporations." Personal tax revenues are class 1100 "taxes on income, profits and capital gains of individuals." The OECD data breaks tax revenues down by level of government. We calculate corporate and personal tax rates at the overall level (federal, state, and local tax revenues). Our theoretical model assumes that the "agent" setting taxes controls the federal tax rate. Whether tax rates at lower level of governments are inputs into the agent's decision is, in our opinion, an open question. By including local and state level taxes in our tax measure we allow for the possibility that the federal government takes both the overall and federal tax burden into account when setting its tax parameters. We repeated our analysis using tax rates calculated using federal tax revenues as the numerator and found little difference in the empirical estimates.

the true tax burden. This is a big advantage over statutory tax rates, for instance, which do not account for the major changes embodied in TRA'86 other than the change in the tax rate. Our measure is also available from the 1960s so that a long time-series can be used. We try to control for certain problems measures such as ours may encounter, such as cyclical effects.

Alternative measures of corporate tax burdens, such as those calculated by considering the tax burden of marginal investments in different asset classes, are problematic since they rely on some arbitrary assumptions and do not consider certain aspects such as enforcement, as pointed out by Slemrod (2004).[13] These hypothetical tax rates also do not account for differences in international double taxation relief across countries. Moreover, a true effective marginal tax rate would be at least firm-specific and more likely project-specific within a firm, so it is unclear a-priori whether a particular country effective tax rate calculated in the usual way offers any advantage over our average tax rate measure. In any case, these measures are available for a relatively short time frame, having only been calculated from the 1980s onward, which makes them of dubious use for the focus of our analysis.

We include GDP per capita, total government spending (as a percentage of GDP) and the value of our personal tax measure as control variables. High corporate tax rates in a country could be a by-product of a relatively high demand for public services. As a result, corporate taxes may vary due to differences in the demand for services. If the demand for government services is correlated with income, then it is important to control for any differences in income across countries. We use per-capita GDP as a measure of country income.

The government budget constraint suggests the inclusion of government spending and the personal tax rate. If government spending is held fixed, an increase in one revenue source such as the personal income tax will need to be matched by a corresponding decrease in another revenue source, such

[13] An interesting paper that estimates Nash reaction functions using three measures of corporate taxes (statutory rates, effective marginal tax rates, and effective average tax rates) is Devereux, Lockwood and Redoano (2002). Their effective tax rate measures are based on those proposed in Devereux and Griffith (2003).

as the corporate tax. Hence, personal and corporate revenues may be negatively correlated. Further, the theoretical model in Gordon (1986) suggests that tax competition will lead to a movement away from taxes on mobile factors toward taxes on immobile factors, also suggesting a negative correlation. If government spending increases, the budget constraint maintains balance through an increase in some revenue source. Part of the increase might result from an increase in the corporate tax, suggesting a positive correlation between government spending and corporate tax. Thus, variation across countries in corporate rates may be correlated with variation in spending levels as well as changes in personal tax rates.

These arguments suggest that we control for differences in the personal tax rate and government spending. However, they also suggest that the personal tax rate and government spending may be endogenous. As explained further below, before proceeding with our estimation of the reaction function we test whether the personal tax rate and government spending are endogenous.

3.3 Econometric Issues

Several econometric issues arise in the estimation of equation (10). First, the tax rates appearing on the right hand side are clearly endogenous in theory if all countries are playing Nash: country *j* responds to a change in country *i*'s tax rate just as country *i* responds to a change in country *j*'s tax rate.[14] Consistent estimates can be obtained through the spatial econometric approach employed by Case, Hines and Rosen (1993) in their study of expenditure competition, or by using an instrumental variable technique. We employ the latter solution, which Kelejian and Prucha (1998) show is also consistent in the presence of a second possible problem, spatial error dependence. In addition, both the personal tax rate and government spending are also potentially endogenous. We explain our endogeneity tests and

[14] In theory the Stackelberg leader's tax rate is exogenous for the follower.

instrumental variables approach more fully below. The use of fixed country effects eliminates a third possible problem, omission of unobserved country characteristics that do not vary over time. Baldwin and Krugman (2004) suggest that agglomeration economies, which tend to be fixed over time if historically determined, may be important for understanding tax competition across countries. We use the method of first-differencing to implement fixed effects.[15] Given our exploitation of the time series nature of our data, we need to be concerned with a fourth possible problem, serial correlation. We tested for serial correlation by augmenting our regression to include the residual (as well as checking the Durbin-Watson statistic) and found serial correlation to be an issue. We correct this by computing and presenting Newey-West (1987) standard errors which also are robust to heteroskedasticity.

As noted, we have good theoretical reasons to suspect that neighbors' tax rates are endogenous. We also suspect that two of our other explanatory variables may be endogenous: spending per capita and our measure of the personal tax rate. We therefore need to carefully test for endogeneity and correct our estimates if we reject the hypothesis that OLS estimates are consistent. To test for endogeneity we employ a Durbin-Wu-Hausman test. The results of this test indicate that the neighbor's tax rate is endogenous and that OLS is inconsistent if not corrected. However, neither spending nor the personal tax rate were found to be endogenous in the sense of leading to inconsistent OLS estimates. Since an attempt to use IV estimates for these variables could lead to greater error and imprecision of the estimates, we proceed by treating the personal tax rate and spending per capita as exogenous.

To explain our instrumental variable approach for neighbors' tax rates more fully, let $\omega_i t_{-i}$ represent the neighbor tax rate for country i. If country 1, for example, has two neighbors, countries 2 and 3, then $\omega_1 \tau_{-1} = \frac{1}{2}\tau_2 + \frac{1}{2}\tau_3$. The neighbor co-variates, $\omega_i X_{-i}$ are defined similarly. The first stage regression used to generate a predicted value for neighbors' tax rates is:

[15] We use two-year intervals in first-differencing since political processes can be slow in practice. At the same time, our two-year window minimizes the loss in data that would result from a longer interval.

$$\omega_{-i}(\tau_{-i,t} - \tau_{-i,t-2}) = C + \gamma\omega_i(X_{-i,t} - X_{-i.,t-2}) + \theta(X_{i,t} - X_{i,t-2}) + \Psi T_t + \varepsilon_i \quad (11)$$

where C is a constant term and, dropping the time subscript for simplicity, $\omega_i \tau_{-i}$ is country i's "neighbor" tax rate, $\omega_i X_{-i}$ is a vector of neighbor explanatory variables, X_i is a vector of own country explanatory variables, and T is a time trend.

The variables in the "neighbor" matrix ($\omega_i X_{-i}$) are neighbor's GDP per capita, neighbor's spending per capita, neighbor's personal tax rates (tax revenues/GDP), neighbor's percentage of population under 14, neighbor's percentage of population over 65, neighbor's population density, and neighbor's unemployment rate.[16] The variables in the own country matrix (X_i) are similarly defined.[17] The fitted values for the neighbor tax rates are used as instruments in the second stage regression:

$$\tau_{i,t} - \tau_{i,t-2} = C + \beta_1(\tau^*_{-i,t} - \tau^*_{-i,t-2}) + \beta_2(GDP_{i,t} - GDP_{i,t-2}) + \beta_3(S_{i,t} - S_{i,t-2}) + \beta_4(P_{i,t} - P_{i,t-2}) + \beta_5 T_t + \varepsilon_i \quad (12)$$

where $\tau^*_{-i,t}$ is the fitted value of the neighbors' tax rate, $GDP_{i,t}$ is GDP per capita, $S_{i,t}$ is government spending per capita, and $P_{i,t}$ is our measure of the personal tax rate, all for country i and year t. We use an overidentifying restrictions test to judge whether the instruments used in our first-stage regressions are uncorrelated with the error term. The results of this test indicate that we can accept the joint null hypothesis that the instruments we use are uncorrelated with the error term for each regression that we present. Appendix table 3 shows the results of our first-stage regressions.

4. Results

Table 1 presents our basic estimates of reaction functions for European countries. The

[16] Data on country area used to compute population density comes from Eurostat's *Basic Statistics of the Community*, demographic data comes from the World Bank's *World Development Indicators*, and unemployment data comes from the OECD's *Labour Force Statistics*.

[17] Note that we include a constant term in equation (11) to allow for the possibility that the constant term in each yearly regression may vary across time. Our results are not sensitive to including the constant term.

specification of the first column assumes only a Nash tax-setting game between European neighbors; that is, we omit any possible Stackelberg game with the U.S. The coefficient on the neighbors' corporate tax change is positive and significant at a more than five percent confidence level. Using sample means, this suggests that a ten percent decrease in the neighbors' corporate tax rate induces about a 3.6 percent decrease in a country's corporate rate. The magnitude of the effect of an individual neighbor's tax change on a country's tax rate depends on the neighbor's weight. The average number of neighbors for a country in our data set is about four which suggests that, at the sample means, a ten percent decrease in a neighbors' tax rate leads to about a 1 percent decrease in the own country tax rate.

We find that greater levels of spending are positively associated with corporate tax rates. Consistent with the idea that tax rates on different bases are substitutes, the coefficient on the personal tax rate in column 1 is negative and highly significant. Somewhat surprisingly, differences in income, as measured by GDP per capita, do not explain differences in corporate tax rates.

Interestingly, we do not find the same results when we investigate the impact of neighbors' personal tax changes on own country personal tax rates in column 2. The coefficient on the neighbor's personal tax rate is negative and not significantly different from zero. This suggests that countries do not set personal tax rates strategically most likely because labor is less mobile than capital.[18]

In column 3 we continue to assume that European countries behave as Nash competitors with each other, but we further investigate whether they behave as if the U.S. were a Stackelberg leader when setting corporate taxes Column 3 shows estimates of the impact of a change in neighbors' **and** U.S. tax rates on own country corporate tax rates. When we add the lagged value of the U.S. corporate tax rate, the coefficient on the neighbors' tax rate falls from about .45 to .41 but remains significant at a greater than 5 percent confidence level. The U.S. rate (lagged) is also statistically different from zero at a greater

[18] The results of Besley, Griffith, and Klemm (2001) also support the idea that taxes on more mobile factors react more strongly than those on more immobile factors.

than 5 percent confidence level. The results suggest that European countries respond both to their neighbor's and U.S. tax changes.

In the fourth column of table 1, we explore whether the U.S. became a leader after TRA'86. To do this we include a dummy variable that equals one for observations prior to and including 1986 and an interaction term between this variable and the U.S. tax rate. The estimated coefficient shows the difference (if any) between the responsiveness of corporate tax rates to U.S. tax changes before and after TRA'86.

The estimates in the fourth column suggest that the Europeans did act as if the U.S. were a Stackelberg leader following TRA'86, but not before. Once we allow for a different effect of the U.S. rate before and after the U.S. tax reform, the coefficient on the neighbors' tax rate falls and becomes insignificant. The coefficient on the U.S. rate after 1986 (since the interaction dummy takes on a value of zero after 1986) is highly significant. At the sample means, a 10 percent decrease in the U.S. tax rate leads to a 6.1 percent decrease in the own tax rate. The coefficient on the lagged U.S. tax rate prior to TRA'86 is not statistically different from zero.[19] The negative and statistically significant coefficient on the interaction term indicates that the difference between the coefficient on the U.S. rate before and after 1986 is statistically different from zero. It also suggests that the finding is not due to cyclical spillovers from the U.S.

In the final column we explore whether our results are sensitive to the inclusion of "tax havens". It is possible that the tax havens in our sample (Ireland, Luxembourg, and Switzerland) are playing a different game, possibly responding to each other's tax changes but not to the rates chosen by their neighbors that are not tax havens.[20] In addition, they may react in a different way to changes in the U.S.

[19] We estimate the coefficient and obtain the t-statistic on the neighbor tax rate prior to 1986 by running the same regression but replacing the pre-1986 dummy with a variable that equals one if the observation is for the later period (1987-1996).

[20] Our classification of European tax havens follows Hines and Rice (1994).

rate. The fifth column presents results of a regression that drops these countries from the sample. Although the coefficient on the U.S. rate is similar, the coefficient on the neighbor's rate is now larger in magnitude and is statistically significant at a greater than 1 percent confidence level. These results suggest that non-havens compete with each other and react to U.S. tax reforms.

Table 2 presents regressions that consider the possibility that other large countries have played the role of Stackelberg leader after 1986. We start by examining the case of Germany. The first two columns of table 2 present estimates of reaction functions using a sample that excludes Germany.[21] The results in column two show that Germany is not perceived as a Stackelberg leader by European countries. The coefficient on the lagged German rate is negative and not statistically different from zero. The same result holds if we allow the effect of the German tax rate to be constant over time by dropping the dummy variable for 1986 and the interaction between the lagged German corporate tax rate and the dummy variable.[22] The remaining columns consider the case of the United Kingdom. Column 4 contains results of tests of whether the U.K. was a leader after 1986. As was the case with Germany, the coefficient on the U.K. rate is not statistically significant. It may be important, however, to take into account that the U.K. had a major corporate tax reform in 1984. The final column tests whether this reform resulted in the U.K. being a "tax leader". Again, the coefficient on the U.K. rate is not statistically different from zero. This result shows that a simple comparison of statutory rate changes would be misleading since the UK statutory rate decreased prior to the US rate.

Our results suggest that in the post-TRA86 period, U.S. tax changes precede European tax changes of the same direction. However, it may also be the case that changes in European tax rates influence U.S. tax changes. To explore this, we present results of Granger causality tests in table 3. We test whether, controlling for past changes of country tax rates, past changes in U.S. tax rates help forecast

[21] Germany is excluded as a country (observation) in the sample and as a neighbor.
[22] The results of this regression are not shown in the table to conserve on space.

current changes in country tax rates. The null hypothesis is that U.S. corporate tax changes do not Granger cause European changes. In addition, controlling for past changes in U.S. rates, we test whether past changes in European rates contain any information that is useful for predicting changes in U.S. rates. Similarly, the null hypothesis is that European tax changes do not Granger cause U.S. ones. We use three lags of the tax variables in each test. The results are consistent with the story that emerges in table 1. The first and last two rows of table 3 show that for the whole sample period and the pre-TRA86 period we cannot reject either null hypothesis. However, for the post-TRA86 period we reject the null hypothesis and accept the alternative that the U.S. tax changes Granger cause the European tax changes.

Finally, we test whether strategic interaction between European countries has intensified in recent years. To do this, we simply break the sample into two periods encompassing the first and last ten years of data and estimate reaction functions. Thus, the "early" period contains the years 1971-1980 and the "late" period runs from 1987-1996. Table 4 contains our results. Column one reports results for the early period for the Nash model. The estimated coefficient on the neighbor's tax rate is much larger in magnitude than our results for the full sample and is statistically different from zero at conventional levels. Although we expected to find that tax competition has become fiercer in recent times, our estimates for the "late" sample suggest that this is not the case for the European Nash model. The estimated coefficient on the neighbor tax rate reported in column two falls almost in half and is statistically different from the column one coefficient.[23] The last two columns of the table show results of our "Stackelberg" econometric model. As we found in our table 1 regressions, changes in the lagged U.S. tax rate are not significant determinants of changes in European corporate tax rates in the "early" period. However, as in table 1, during the post-TRA86 period (our "late" sample) countries respond to changes in

[23] Desai, Foley, and Hines (2003) report a similar finding. One focus of their work is identifying the factors that contribute to the tax sensitivity of U.S. multinational investment abroad. They find that U.S. affiliate investment in Europe is more sensitive to differences in local tax rates than U.S. affiliate investment generally. However, their results do not indicate that this sensitivity has increased over their sample period (1983-1997). The interpretation is that tax competition within Europe has not intensified over time.

the lagged U.S. tax rate. Further, once the lagged U.S. tax rate is included as an explanatory variable, the coefficient on the neighbor tax rate decreases in magnitude and loses significance. European countries thus seem to have become more competitive in taxes vis-à-vis lagged U.S. changes, but not more competitive amongst themselves.

5. Conclusions

Global tax competition is a potentially important force shaping national tax systems around the world and influencing countries' tax revenue, progressivity, tax mix and overall efficiency. In spite of a large theoretical literature, very little empirical evidence concerning national tax systems has been offered. The purpose of our paper has been to provide some evidence on the period between 1968 and 1996. Our focus is on tax competition among European countries and between those countries and the United States. A common observation among policy makers is that the Tax Reform Act of 1986 in the United States led to reforms in other nations, particularly those in Europe.

The background for our empirical work is a simple model of tax competition in which one large country acts as a Stackelberg leader while the other countries follow the leader and compete among themselves in a Nash way. The slope of the reaction function of a follower with respect to the leader is ambiguous in sign. It tends to be positive because the leader's tax change increases the elasticity of capital but negative because of a desire to maintain public spending. Our empirical work provides estimates of European reaction functions for the standard tax competition model in which each country plays a Nash game as well as the European reaction function in a game in which the U.S. is a Stackelberg leader.

Our empirical tests add to the evidence of a positively sloped Nash reaction function in corporate tax as found in recent papers on OECD countries by Devereux, Lockwood, and Redoano (2002) and Besley,

Griffith, and Klemm (2001). We also find no competition in labor tax between European countries. In contrast to previous research, we also estimate reaction functions that include the tax rate of a Stackelberg leader. Our main finding is that the European countries behave as if the U.S. is a Stackelberg leader in setting corporate taxes after TRA'86 but not before. We test whether Germany or the United Kingdom played a leadership role and find that they did not. Our Stackelberg findings for the U.S., Germany, and the U.K. are reinforced by our Granger causality tests, and our results on the responsiveness of European countries to changes in neighbors' tax rates and the U.S. rate are somewhat stronger when we exclude certain tax havens. Over time we find that European countries have become more intensely competitive with the U.S. in corporate taxes, but less intensely competitive among themselves. It would seem that European countries moved from being Nash competitors among themselves to being Stackelberg followers to the U.S. after TRA'86.

Table 1
Estimates for Tax Setting Games (1971-1996)

	Dependent variable:				
	Country corporate tax (t-[t-2]) (1)	Country personal tax (t-[t-2]) (2)	Country corporate tax (t-[t-2]) (3)	Country corporate tax (t-[t-2]) (4)	Country corporate tax (t-[t-2]) (5)
Neighbors' corporate tax (t-[t-2])	0.451**		0.410**	0.284	0.537**
	(0.195)		(0.193)	(0.221)	(0.220)
Neighbors' personal tax (t-[t-2])		-0.158			
		(0.109)			
Country GDP per capita/100 (t-[t-2])	0.014	-0.014	0.003	0.006	0.014
	(0.019)	(0.018)	(0.021)	(0.020)	(0.027)
Country spending (t-[t-2])	0.166***	0.401***	0.172***	0.171***	0.157***
	(0.041)	(0.035)	(0.042)	(0.040)	(0.045)
Country personal tax rate (t-[t-2])	-0.193**		-0.203***	-0.199***	-0.188**
	(0.078)		(0.078)	(0.074)	(0.081)
Country corporate tax rate (t-[t-2])		-0.331***			
		(0.068)			
Lagged U.S. corporate tax ([t-1]-[t-3])			0.148**	0.451**	0.428**
			(0.073)	(0.183)	(0.188)
Lagged U.S. rate * dummy for pre-86				-0.335*	-0.413**
				(0.180)	(0.184)
Dummy for pre-1986				0.002	0.001
				(0.001)	(0.001)
Time trend (year/1000)	0.145	-2.40**	-0.088	0.695	0.477
	(0.468)	(0.693)	(0.485)	(0.667)	(0.736)
Constant	-0.000	0.476***	0.017	-0.139	-0.096
	(0.002)	(0.137)	(0.096)	(0.133)	(0.147)
Include tax havens?	Yes	Yes	Yes	Yes	No
Number of observations	442	442	442	442	364
Adjusted R-squared	.11	.52	.12	.14	.11

Notes: Corporate tax equals corporate tax revenues divided by GDP. Personal tax equals personal tax revenues divided by GDP. Spending equals total tax revenue divided by GDP. Numbers in parentheses are Newey-West standard errors. The dummy for pre-1986 equals one for observations prior to 1986. Instrumental variables estimation (see text for details). Tax havens include Ireland, Luxembourg and Switzerland. * denotes statistical significance at a 10 percent confidence level, ** at a 5 percent level and *** at a 1 percent level.

Table 2
Estimates for Tax Setting Games: Germany and U.K. as Stackelberg leaders
(1971-1996)

	Dependent variable: Country corporate tax (t-[t-2])				
	(1) Exclude Germany from sample	(2) Germany leader	(3) Exclude U.K. from sample	(4) U.K. leader	(5) U.K. leader
Neighbors' corporate tax (t-[t-2])	0.288	0.345*	0.397*	0.416	0.344
	(0.183)	(0.199)	(0.209)	(0.264)	(0.248)
Country GDP per capita/100 (t-[t-2])	0.012	0.011	0.012	0.011	0.009
	(0.020)	(0.020)	(0.019)	(0.022)	(0.022)
Country spending (t-[t-2])	0.168***	0.169***	0.156***	0.155***	0.156***
	(0.041)	(0.041)	(0.044)	(0.044)	(0.043)
Country personal tax rate (t-[t-2])	-0.201***	-0.199***	-0.180**	-0.174**	-0.175**
	(0.078)	(0.076)	(0.083)	(0.080)	(0.079)
Lagged German corporate tax ([t-1]-[t-3])		-.095			
		(0.268)			
Lagged U.K. corporate tax ([t-1]-[t-3])				0.093	0.105
				(0.090)	(0.080)
Lagged German rate * dummy for pre-1986		0.276			
		(0.301)			
Lagged U.K. rate * dummy for pre-1986				-0.081	
				(0.119)	
Lagged U.K. rate * dummy for pre-1984					-0.096
					(0.116)
Dummy for pre-1986		0.000		0.000	
		(0.001)		(0.001)	
Dummy for pre-1984					0.001
					(0.001)
Time trend (year/1000)	0.180	0.130	0.202	0.598	0.715
	(0.481)	(0.839)	(0.481)	(.843)	(.804)
Constant	-0.036	-0.027	-0.041	-0.119	-0.143
	(0.095)	(0.167)	(0.095)	(0.168)	(0.160)
Adjusted R-squared	.12	.11	.09	.09	.10

Notes: Corporate tax equals corporate tax revenues divided by GDP. Personal tax equals personal tax revenues divided by GDP. Spending equals total tax revenue divided by GDP. The dummy for pre-1986 equals one for observations prior to 1986. Similarly, the dummy for pre-1984 equals one for observations prior to 1984. Numbers in parentheses are Newey-West standard errors. Instrumental variables estimation (see text for details). Number of observations = 416. * denotes statistical significance at a 10 percent confidence level, ** at a 5 percent level and *** at a 1 percent level.

Table 3
Results of Granger Causality Tests

	F-value
Full sample	
U.S. corporate change Granger causes Europe's change	1.44
Europe's corporate change Granger causes U.S. change	1.05
Post-TRA86	
U.S. corporate change Granger causes Europe's change	2.71**
Europe's corporate change Granger causes U.S. change	0.28
Pre-TRA86	
U.S. corporate change Granger causes Europe's change	0.94
Europe's corporate change Granger causes U.S. change	1.50

*denotes statistical significance at a 5 percent confidence level.

Table 4
Tests of Whether Tax Competition has Intensified

	Dependent variable: Country corporate tax (t-[t-2])			
	(1) "Early" sample (1971-1980)	(2) "Late" sample (1987-1996)	(3) "Early" sample (1971-1980)	(4) "Late" sample (1987-1996)
Neighbors' corporate tax (t-[t-2])	1.08**	0.560**	1.00*	0.307
	(0.532)	(0.259)	(0.562)	(0.266)
Country GDP per capita/100 (t-[t-2])	0.074	0.010	0.067	0.001
	(0.064)	(0.023)	(0.068)	(0.024)
Country spending (t-[t-2])	0.104**	0.205***	0.107**	0.223***
	(0.051)	(0.069)	(.050)	(0.070)
Country personal tax rate (t-[t-2])	-0.074	-0.223	-0.082	-0.240
	(0.064)	(0.149)	(0.062)	(0.146)
Lagged U.S. corporate tax ([t-1]-[t-3])			0.105	0.467**
			(0.121)	(0.204)
Time trend (year/1000)	-1.98	-1.89	-2.60	2.27
	(1.91)	(2.43)	(2.10)	(2.32)
Constant	0.389	-0.377	0.511	-0.454
	(0.377)	(0.483)	(0.414)	(0.462)
Number of observations	170	170	170	170

Notes: Corporate tax equals corporate tax revenues divided by GDP. Personal tax equals personal tax revenues divided by GDP. Spending equals total tax revenue divided by GDP. Numbers in parentheses are Newey-West standard errors. Instrumental variables estimation (see text for details). * denotes statistical significance at a 10 percent confidence level, ** at a 5 percent level and *** at a 1 percent level.

Appendix Table 1
Geographic Neighbors

Country	**Neighbors**
Austria	Germany, Italy, Switzerland
Belgium	France, Germany, Luxembourg, Netherlands, United Kingdom, Ireland
Denmark	Germany, Norway, Sweden
Finland	Norway Sweden
France	Belgium, Italy, Luxembourg, Spain, Switzerland, Germany, United Kingdom, Ireland
Germany	Austria, Belgium, Denmark, France, Luxembourg, Netherlands, Sweden, Switzerland
Greece	Italy, Turkey
Ireland	United Kingdom, Belgium, Netherlands, France
Italy	Austria, France, Greece, Switzerland
Luxembourg	Austria, France, Greece, Switzerland
Netherlands	Belgium, Germany, United Kingdom, Ireland
Norway	Denmark, Finland, Sweden
Spain	France
Sweden	Denmark, Finland, Germany, Norway
Switzerland	Austria, France, Germany, Italy
Turkey	Greece
United Kingdom	Belgium, France, Netherlands, Ireland

Appendix Table 2
Summary Statistics

	Mean	Standard deviation
Country tax variables (t-[t-2])		
Corporate tax	0.000739	0.00658
Personal tax	0.00218	0.0108
Neighbor's tax	.000584	.00362
U.S. corporate tax	-0.00103	0.00476
U.S. corporate tax rate*dummy for pre-1986	-0.00149	0.00421
Country variables (t-[t-2])		
GDP per capita/100	0.0174	0.0239
Spending /GDP	0.00811	0.0190

Notes: Corporate tax and personal tax equal corporate and personal tax receipts, respectively, divided by GDP. Spending equals total tax receipts divided by GDP.

Appendix Table 3
First-stage Results for Corporate Tax Regressions

	Dependent variable: Change in neighbors' corporate tax	
	(1)	(2)
Neighbors' change in GDP	-0.017	-0.025
	(0.016)	(0.016)
Neighbors' change in spending	0.091***	0.103***
	(0.018)	(0.018)
Neighbors' change in personal tax rate	-0.253***	-0.273***
	(0.036)	(0.036)
Neighbors' change in population density/1000	-0.172**	-0.108
	(0.069)	(0.069)
Neighbors' change in proportion young	-0.151**	-0.153**
	(0.073)	(0.072)
Neighbors' change in proportion old	0.014	-0.044
	(0.096)	(0.096)
Neighbors' change in unemployment	-0.0004***	-0.0003
	(0.0001)	(0.0001)
Constant	0.028	0.098*
	(0.055)	(0.057)
Includes own state covariates?	Yes	Yes
Includes lagged U.S. corporate rate?	No	Yes
Number of observations	442	442
Adjusted R-squared	.16	.20

Notes: The neighbor variables are defined in the text (see the discussion of equation 12). Corporate tax equals corporate tax revenues divided by GDP. Personal tax equals personal tax revenues divided by GDP. Spending equals total tax revenue divided by GDP. All regressions include own state covariates (those that appear in the second-stage regression and those that appear in the table above). Robust-to-heteroskedasticity standard errors are reported in parentheses. *denotes statistical significance at a 10 percent confidence level, ** at a 5 percent level and *** at a 1 percent level.

References

Altshuler, Rosanne and Harry Grubert, 2002, Repatriation Taxes, Repatriation Strategies and Multinational Financial Policy,", *Journal of Public Economics*, Volume 87(1), 73-107.

Altshuler, Rosanne and Harry Grubert, 2005, "The Three Parties in the Race to the Bottom: Host Governments, Home Governments and Multinational Corporations," *Florida Tax Review*, Volume 7 (3), 137-209.

Altshuler, Rosanne, Harry Grubert, and T. Scott Newlon, 2001, "Has U.S. Investment Become More Sensitive to Tax Rates?" in: James R. Hines, Jr. (editor), *International Taxation and Multinational Activity*, University of Chicago Press, 9-32.

Baldwin, Richard and Paul Krugman, 2004, "Agglomeration, Integration and Tax Harmonization," *European Economic Review* 48, 1-23.

Bond, Eric and Larry Samuelson, 1989, "Strategic Behavior and the Rules for International Taxation of Capital," *Economic Journal* 99, 1099-1111.

Besley, Timothy and Anne Case, 1995, "Incumbent Behavior: Vote-Seeking, Tax-Setting and Yardstick Competition," *American Economic Review* 85(1), 25-45.

Besley, Timothy and Harvey Rosen, 1998, "Vertical Externalities in Tax Settting: Evidence from Gasoline and Cigarettes," *Journal of Public Economics* 70(3), 383-398.

Besley, Timothy, Rachel Griffith and Alexander Klemm, 2001, "Fiscal Reaction Functions," mimeo, April.

Brueckner, Jan, 2003, "Strategic Interaction Among Governments: An Overview of Empirical Studies," *International Regional Science Review* 26, April, 175-188.

Desai, Mihir, 1999, "Are We Racing to the Bottom? Evidence on the Dynamics of International Tax Competition," *Proceedings of the 91st Annual Conference on Taxation* (Washington D.C.: National Tax Association), 176-187.

Desai, Mihir, 2002, "The Substitutability of Foreign and Domestic Capital: Evidence from TRA," mimeo, February.

Desai, Mihir, C. Fritz Foley and James R. Hines Jr., 2003, "Chains of Ownership, Regional Tax Competition and Foreign Direct Investment," in Heinz Herrmann and Robert Lipsey (editors), *Foreign Direct Investment in the Real and Financial Sector of Industrial Countries* (Heidelberg: Springer Verlag), 61-98.

Devereux, Michael, Ben Lockwood, and Michela Redoano, 2002, "Do Countries Compete over Corporate Tax Rates?," CEPR Discussion Paper No. 3400.

Devereux, Michael and Rachel Griffith, 2003, "Evaluating Tax Policy for Location Decisions," *International Tax and Public Finance* 10(2), 107-126.

Esteller-Moré, Á., and A. Solé-Ollé. 2001, "Vertical Income Tax Externalities and Fiscal Interdependence: Evidence from the U.S.," *Regional Science and Urban Economics* 31, 247-272.

Fredriksson, Per G., and Daniel L. Millimet, 2002, “Is there a ‘California effect’ in US Environmental Policymaking?”, *Regional Science and Urban Economics* 32, 737-764.

Fuest, Clemens, Huber, Bernd and Jack Mintz, 2003, “Capital Mobility and Tax Competition: A Survey,” CESifo Working Paper No. 956.

Fundenberg, Drew and Jean Tirole. 1991. Game Theory. Cambridge: MIT Press.

Goodspeed, Timothy, 1998, “Tax Competition, Benefit Taxes and Fiscal Federalism,” *National Tax Journal* 51(3), 579-586.

Goodspeed, Timothy, 2000, “Tax Structure in a Federation,” *Journal of Public Economics* 75, 493-506.

Goodspeed, Timothy, 2002, “Tax Competition and Tax Structure in Open Federal Economies: Evidence from OECD Countries with Implications for the European Union,” *European Economic Review* 46(2), 357-374.

Gordon, Roger, 1992, “Can Capital Income Taxes Survive in Open Economics?,” *Journal of Finance* 47, 1159-1180.

Gordon, Roger, 1986, “Taxation of Investment and Savings in a World Economy,” *American Economic Review* 76, 1086-1102.

Grubert, Harry, William C. Randolph, and Donald J. Rousslang, 1996, “Country and Multinational Responses to the Tax Reform Act of 1986,” *National Tax Journal* 49 (3), 341-58.

Hartman, D., 1985, “Tax Policy and Foreign Direct Investment,” *Journal of Public Economics* 26 (1), 107-21.

Hayashi, M., and Robin Boadway, 2001, “An Empirical Analysis of Intergovernmental Tax Interaction: The Case of Business Income Taxes in Canada,” *Canadian Journal of Economics* 34 (May),481-503.

Hines, James Jr., 1994, "Credit and Deferral as International Investment Incentives," *Journal of Public Economics*, volume 55, 323-347.

Hines, James Jr. and Eric Rice, 1994, “Fiscal Paradise: Foreign Tax Havens and American Business,” *Quarterly Journal of Economics* 109, 149-182.

Kanbur, Ravi and Keen, Michael J., 1993, "Jeux Sans Frontieres: Tax Competition and Tax Coordination When Countries Differ in Size," *American Economic Review,* September, 877-892.

Kelejian, H.H, and I.R. Prucha, 1988, “A Generalized Spatial Two-stage Least Squares Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances,” *Journal of Real Estate Finance and Economics* 17, 99-121.

Newey, Whitney and K.D. West, 1987, “A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix,” *Econometrica*, 55: 703-708.

Sinn, Hans Werner, 1993, "Taxation and the Birth of Foreign Subsidiaries," in *Trade, Welfare, and Economic Policies: Essays in Honor of Murray C. Kemp*, edited by H. Herberg and N.V. Long. Ann Arbor: University of Michigan Press, 325-352.

Slemrod, Joel, 2004, "Are Corporate Tax Rates, or Countries, Converging?", *Journal of Public Economics* 88(6), 1169-1186.

Weichenrieder, Alfons., 1996, "Anti Tax-avoidance Provisions and the Size of Foreign Direct Investment," *International Tax and Public Finance*, volume 3, 67-81.

Wildasin, David E., 1988, "Nash Equilibria in Models of Fiscal Competition, *Journal of Public Economics* 35, 229-240.

Wilson, John D., 1986, "A Theory of Interregional Tax Competition," *Journal of Urban Economics* 19(3), 296-315.

Wilson, John D., 1991, "Tax Competition with Interregional Differences in Factor Endowments," *Regional Science and Urban Economics* 21, 423-51.

Wilson, John D., 1999, "Theories of Tax Competition," *National Tax Journal* 52, 269-304.

Zodrow, George R. and Peter Mieszkowski,1986, "Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods," *Journal of Urban Economics* 19, 356-370.