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Tax competition among European countries. Does the EU matter?

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ABSTRACT

This paper provides a simple theoretical model of capital tax competition between countries that differ in spatial location, and where cross-border investment costs are proportional to distance (a gravity model). We model EU membership as a reduction in 'distance' between countries. Precise predictions about reaction functions' intercepts and slopes are derived. In particular we find that joining the Union lowers the intercept and that all countries react more to member countries than they do to non-members. These predictions are largely confirmed using a panel data set of statutory corporate tax rates on Western European countries.

1. Introduction

This paper explores the impact of EU membership on capital tax competition among European countries. The creation of a 'common market' for goods, capital and to some extent labor was the main focus of the Treaty of Rome in 1957, and also of the Single European Act, which came into force in July 1987. Its provisions included gradually establishing a single market over a period up to the end of 1992, by means of a vast legislative program involving the adoption of hundreds of directives and regulations. This program has been largely successful, and has reduced the costs of trade and investment between EU countries. To take only one example, European Union countries have to comply with a number of technical harmonization standards for goods and services, which means a firm located in one EU country faces a lower cost of exporting goods to, or indeed of investing in, another EU country than to a third country outside the EU, where different technical standards may apply.[1] Economic theory suggests that such market integration will impact positively on FDI flows both between member states and between member states and the rest of the world (Motta and Norman, 1996; Barrell and Pain, 1997; Raff, 2004).

There is supporting empirical evidence for this. Baltagi et al. (2008) show that the effects of preferential trade liberalization in Europe go beyond the involved countries and affect not only trade but also FDI. Brenton (1996) finds that the EU single market program led to a significant increase in investment by EU firms in other EU countries in the late 1980s. Barrell and Pain (1997, 1998, 1999) and Van Aarle (1996) show that the removal of internal barriers to trade and capital mobility during the single

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[1] An important example is the standards for the production of new motor vehicles. Here, EU emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states.

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market program have been accompanied by a rapid growth in multinational activity in the European Union both by European and non-European firms. Overall, several studies show a robust positive relationship between market size and the likelihood to attract FDI (e.g. Devereux and Griffith, 1998; Head and Mayer, 2002), and, in particular, that firms are more likely to invest in a country that is a member state of the EU. A similar effect cannot be observed for members of other regional trade agreements (Grubert and Mutti, 2000). Other research concentrates on the effect of the EMU on FDI; Petroulas (2007) shows that the introduction of the Euro raised inward FDI by 14 to 16% between Eurozone countries, by 11 to 13% from member countries to non-members, and by around 8% from non-member countries to member countries and Schiavo (2007) uses a gravity model on a sample of OECD countries to demonstrate that currency unions have a positive impact on FDI.

However, while the deepening of the single market in goods, capital and labor has progressed, there has been little progress on corporate and personal income tax harmonization, despite the fact that there is now almost unanimous consensus that the corporate tax rate of the host country has a significant, negative effect on inward FDI (Haufler and Wooton, 2006; Bénassy-Quéré et al., 2005). This is not a direct objective of the EU[2] and, in practice, harmonization has been minimal: member states are reasonably free to set their own direct and corporate tax rates and tax bases. For example, although a common consolidated tax base for the corporate tax is an objective of the European Commission, little progress on this has been made to date (Fuest, 2008), and harmonization of personal taxes on capital income is not even on the agenda. Rather, the EU has adopted a policy of exchange of information to minimize evasion of these taxes.[3]

Our hypothesis is that the combination of these two factors, i.e., the lower cost of cross-border FDI between EU member countries, on the one hand, and the lack of tax harmonization programs between members, on the other hand, should cause EU countries to compete more intensively for FDI amongst themselves than with countries outside the EU. This might in turn cause them to react more to each others' taxes than to taxes of countries outside the EU.

We develop a simple model of tax competition which verifies and refines this intuition. Motivated by the success of 'gravity models' in explaining FDI flows (e.g., Egger and Pfaffermayr, 2004), we assume that, conditional on taxes, the size of cross-border investment between two countries is inversely proportional to the marginal cost of cross-border investment (these marginal costs could be physical, legal, or regulatory). We model EU membership as a reduction in 'distance' to other EU countries. We derive precise predictions on reaction function slopes and intercepts. In particular we predict that (i) EU members react more to each other than they do to non-members; (ii) non-EU countries also react to EU countries more than non-EU countries; and (iii) EU membership lowers the intercept of the tax reaction function.

We then take the model to the data: we investigate competition in statutory corporate tax rates using a dataset on seventeen Western European countries for a period of thirty years. Tax reaction functions are estimated following a literature initiated by Case et al. (1993) and followed by several other researchers (e.g. Brueckner and Saavedra, 2001; Solè-Ollè, 2003; Devereux et al., 2008). Specifically, taxes in any given country are assumed to depend linearly on a weighted average of taxes in other countries, where the weights are not estimated, but chosen a priori.

We find evidence in support of our theory for statutory corporate tax rates. Specifically, in our preferred specification, with weights inversely related to the effective distance between countries, EU countries react to a one percentage point decrease in the statutory rate of corporate tax of EU members by cutting their own taxes by 0.71 percentage points, and to a one percentage point decrease in the statutory rate of corporate tax of other non-EU countries by cutting their own tax by only 0.01 percentage points, but the latter figure is not significantly different from zero. Moreover we find that non-EU countries react to a one percentage point cut in the statutory tax rate of corporate tax of EU members by decreasing their own tax rate by 0.56 percentage points, and to a one percentage point decrease in the statutory rate of corporate tax of non-EU countries by cutting its own tax by 0.12 percentage points, but, again this latter figure is not significant. Finally, we find that joining the EU has a negative effect on the level of taxes equal to 0.02 points. Other alternative weighting schemes work much worse. So, overall, our results are consistent with the pattern of tax competition that emerges endogenously from a model where cross-border investment costs are lower for and towards union members.

The related literature is as follows. Bretschger and Hettich (2002), Dreher (2006), Haufler et al. (2008), and Raff (2004) analyze the impact of market integration on corporate tax setting. Altshuler and Goodspeed (2002), Besley et al. (2001), Crabbe and Vandenbussche (2008), Devereux et al. (2008), and Overesch and Rincke (2011) all estimate corporate tax reaction functions for OECD countries. For Europe, in particular, Altshuler and Goodspeed (2002) find that European countries behaved as if the US were a leader in setting corporate taxes after the 1986 tax reform; Crabbe and Vandenbussche (2008) investigates the effect of the new members on EU 15 members, finding a positive correlation for countries close to the new countries. Overesch and Rincke (2011) estimate a dynamic panel data on European countries that relates current tax rates to lagged values of a country's own as well as other countries' tax rates. But none of these papers explicitly models the impact of EU membership on tax competition, either theoretically or empirically.

The most closely related paper is the independent[4] work of Davies and Voget (2009). They construct a theoretical model of firm location and corporate tax competition, where their derived tax reaction slopes (i.e., how the tax in country i reacts to the tax

[2] The legal basis for corporate tax harmonization is formed by art. 100, which deals with the harmonization of laws in general. This general harmonization is obligatory only in so far as the establishment or functioning of the internal market is at stake. Additionally article 94 of the EC Treaty provides for approximation of such laws, regulations or administrative provisions of the Member States as directly affect the establishment or functioning of the common market.

[3] "The Council on 21 April 2004 adopted an amending Directive that is designed to speed up the flow of information between the tax authorities of Member States. The Directive which relates to direct taxation (income tax, company tax and capital gains tax), together with Insurance Premium Tax, enables Member States to co-ordinate their investigative action against cross-border tax fraud and carry out more procedures on behalf of each other." Council Directive 2004/56/EC of 21 April 2004.

[4] The first version of this paper (Redoano, 2003) only studied fiscal interactions between EU members. A later version (Redoano, 2007) addressed the issue of different responses by EU members and non-members by running separate regressions for the two groups. The first version of the paper by Davies and Voget came out in 2008.

in country j relative to how it reacts to the tax in country k) depend on relative market potentials of countries j and k. The market potential of a country, according to their theoretical model, is the expected profit a firm can expect by locating in that country. Their argument is that market potential of a country increases when it joins the EU. So, Davies and Voget's theoretical predictions do not make a distinction between the behavior of EU and non-EU countries per se, but derive a general prediction that countries respond more to countries that have greater market potential. We, instead, predict directly from the theoretical model what effect EU membership will have on the slope of the tax reaction functions. A second difference is that we also predict that EU members will react differently to the taxes of both EU and non-EU countries than non-members will, and this is verified in our empirical results. Finally, our paper covers a different time period (for reasons that we will explain later), and focuses only on Western European countries. So in practice, Davies and Voget (2009) paper is somehow complementary to ours, and provides a sort of robustness check for the idea that EU membership has indeed increased tax competition in Europe.

This paper also contributes to the literature on the effect economic integration on the level of taxes. The results are mixed so far. On one hand, in line with theoretical models predicting that integration of capital market intensifies tax competition with negative effects on tax rate (Hillman, 2009; Lai, 2010), there is evidence that the process of European integration had a negative effect on corporate taxes (Bénassy-Quéré et al., 2005). On the other hand, using a political economy framework, Haufler et al. (2008), Lai (2010), and Garrett and Mitchell (2001) have shown that economic integration may raise or lower the equilibrium tax rate, and it is more likely to raise the tax rate of a low-tax country. Our results are consistent with both views, that the process economic integration in Europe has intensified tax competition within countries, driving countries' tax rates closer to each others.

The remainder of the paper is organized as follows. Section 2 introduces the theoretical framework. Section 3 presents the dataset and the empirical methodology. Empirical results are discussed in Section 4. The last section concludes the paper.

2. The theoretical framework

In this section, we set up a simple theoretical model of tax competition between both EU and non-EU countries, which is designed to capture the effect that EU membership has on lowering the costs of cross-border FDI. The main purpose of the model is to explicitly calculate tax reaction functions and to derive precise predictions on how EU membership affects the slope of these reaction functions.

We use an n-country version of Persson and Tabellini (2002). There are $i = 1, \ldots, n$ countries, n even. The distance between countries i and j is d_{ij}; 'distance' can be interpreted geographically, or by similarity of characteristics, institutions, etc.[5] The role of distance is that it determines the cost of cross-border investment between i and j. A subset U of these countries is members of an international union. The key feature of union membership is that if i and j are members, the effective distance between them is reduced, making cross-border investment more profitable.

In each country i, there is a single household, with a capital endowment, $\widetilde{k}_i$, that can be allocated across all countries. Let k_{ij} be the amount allocated by the household in country i to country j. The production function is linear: output in country i is $y_i = k_i$, where k_i is capital employed in country i, also output is the numeraire good in the model and tax revenues are collected in units of the numeraire. So, the pre-tax return on capital is fixed at 1. Capital is taxed at source, i.e. tax revenue is $R_i = \tau_i k_i$.

The portfolio design problem of the household in country i is, then, to choose k_{ij}, $j = 1, \ldots, n$ to maximize the net return to capital

$$V_i = \sum_j k_{ij}\left(1-\tau_j\right) - \sum_{j \neq i} c_{ij} \frac{\left(k_{ij}\right)^2}{2} \tag{2.1}$$

where V_i is national income net of investment costs, subject to the resource constraint

$$\sum_j k_{ij} = \widetilde{k}_i, \quad k_{ij} \geq 0. \tag{2.2}$$

Here, c_{ij} is the cost of cross-border investment between i and j and is

$$c_{ij} = \begin{cases} \lambda d_{ij} & \text{if } i, j \in U \\ \theta d_{ij} & i \notin U, \ j \in U, \quad \lambda < \theta < 1 \\ d_{ij} & \text{otherwise} \end{cases}. \tag{2.3}$$

This captures the idea that, other things being equal, the cost of cross-border investment is proportional to the distance (with the constant of proportionality being set at 1), but that union membership by one or both countries lowers the cost of cross-border investment. The rationale for $\lambda < 1$ is straightforward: cross-border investment from one member country to another is governed by similar tax and regulatory rules, and the firm locating in one country can sell into the entire internal market, i.e. bilateral union membership. For an investment from a non-member to a member (unilateral union membership),

[5] This is consistent with some recent findings; for example, a study by the European Commission (2006) has found that proximity to the home region is an important factor in explaining the pattern of FDI across regions in Europe.

again the advantage of being able to sell to the internal market reduces the effective cost. So, we also expect $\theta < 1$, but possibly $\lambda < \theta$.[6]

Substituting the resource constraint (2.2) in Eq. (2.1), the maximand becomes

$$\sum_j k_{ij}\left(\tau_i - \tau_j\right) - \sum_{j \neq i} c_{ij} \frac{\left(k_{ij}\right)^2}{2}.$$

The solution to this problem is that the household in country i will invest abroad only if the tax is lower than that in the home country, i.e.,

$$k_{ij} = \max\left\{\frac{\tau_i - \tau_j}{c_{ij}}, 0\right\}. \tag{2.4}$$

Hence the capital employed in country i, and thus the tax base of country i, is

$$k_i = \widetilde{k}_i - \sum_{j \neq i} k_{ij} + \sum_{j \neq i} k_{ji} = \widetilde{k}_i - \sum_{j \neq i} \max\left\{\frac{\tau_i - \tau_j}{c_{ij}}, 0\right\} + \sum_{j \neq i} \max\left\{\frac{\tau_j - \tau_i}{c_{ji}}, 0\right\} = \widetilde{k}_i + \sum_{j \neq i} \frac{\tau_j - \tau_i}{c_{ij}}$$

using $c_{ij} = c_{ij}$. Following Kanbur and Keen (1993), we assume that governments are revenue-maximizers. This assumption will be relaxed in Section A.2 in the Appendix A.[7] Then, the government of country i chooses τ_i to maximize

$$TR_i = \tau_i\left(\widetilde{k}_i + \sum_{j \neq i} \frac{\tau_j - \tau_i}{c_{ij}}\right). \tag{2.5}$$

The first-order condition for a maximum of Eq. (2.5) with respect to τ_i is

$$\widetilde{k}_i + \sum_{j \neq i} \frac{\tau_j}{c_{ij}} - 2\sum_{j \neq i} \frac{\tau_i}{c_{ij}} = 0.$$

These first-order conditions give reaction functions

$$\tau_i = \frac{\widetilde{k}_i + \sum_{j \neq i} \frac{\tau_j}{c_{ij}}}{2\left(\sum_{j \neq i} \frac{1}{c_{ij}}\right)}, \quad i = 1, \ \ldots, \ n.$$

Writing out reaction functions for union members and non-members separately and using Eq. (2.3):

$$\tau_i = \frac{\widetilde{k}_i + \sum_{j \neq i, j \in U} \frac{\tau_j}{\lambda d_{ij}} + \sum_{j \neq i, j \notin U} \frac{\tau_j}{\theta d_{ij}}}{2\left(\sum_{j \neq i, j \in U} \frac{1}{\lambda d_{ij}} + \sum_{j \neq i, j \notin U} \frac{1}{\theta d_{ij}}\right)}, \quad i \in U, \tag{2.6}$$

and

$$\tau_i = \frac{\widetilde{k}_i + \sum_{j \neq i, j \in U} \frac{\tau_j}{\theta d_{ij}} + \sum_{j \neq i, j \notin U} \frac{\tau_j}{d_{ij}}}{2\left(\sum_{j \neq i, j \in U} \frac{1}{\theta d_{ij}} + \sum_{j \neq i, j \notin U} \frac{1}{d_{ij}}\right)}, \quad i \notin U. \tag{2.7}$$

Next, we reformulate Eqs. (2.6) and (2.7), following standard practice in the empirical tax competition literature, so that the taxes of other countries enter as weighted sums with exogenously specified weights, w_{ij}. We define $\tau_{-i,U}$ and $\tau_{-i,NU}$ to be the two distance-weighted averages of other countries' taxes for, respectively, the sets of countries in the union or not in the union

$$\tau_{-i,U} = \sum_{j \neq i, j \in U} w_{ij}^{U} \tau_j, \quad \tau_{-i,NU} = \sum_{j \neq i, j \notin U} w_{ij}^{NU} \tau_j, \tag{2.8}$$

[6] This is consistent with models of export-platform FDI, where multinational firms re-locate their subsidiaries in countries from which consumers in a larger area can be served at lower trade costs (Raff, 2004; Ekholm et al., 2007).

[7] In particular, the welfare of the representative household is $V_i + H(\tau_i k_i)$ where $H(\tau_i k_i)$ is utility from public good provision.

where the weights w_{ij}^{U}, w_{ij}^{NU} are inversely proportional to the normalized distance between i and j i.e.

$$w_{ij}^{U}=\frac{\frac{1}{d_{ij}}}{A_i},\quad A_i=\sum_{j\neq i,j\in U}\frac{1}{d_{ij}},w_{ij}^{NU}=\frac{\frac{1}{d_{ij}}}{B_i},\quad B_i=\sum_{j\neq i,j\notin U}\frac{1}{d_{ij}}. \tag{2.9}$$

Note that by construction, the weights sum to 1, i.e., $\sum_{j\neq i}w_{ij}^{U}=1$ and $\sum_{j\neq i}w_{ij}^{NU}=1$. Then, the reaction functions (2.6) and (2.7) can be equivalently written:

$$\tau_i=\frac{\widetilde{k}_i+\frac{A_i}{\lambda}\tau_{-i,U}+\frac{B_i}{\theta}\tau_{-i,NU}}{2\left(\frac{1}{\lambda}A_i+\frac{1}{\theta}B_i\right)},\quad i\in U,\tau_i=\frac{\widetilde{k}_i+\frac{A_i}{\theta}\tau_{-i,U}+B_i\tau_{-i,NU}}{2\left(\frac{1}{\theta}A_i+B_i\right)},\quad i\notin U. \tag{2.10}$$

Now let $R_i = A_i / B_i$; this is the distance-weighted average number of countries in the EU, other than i, relative to the distance-weighted average number of countries out of the EU, other than i, or the relative size of the union, for short. Using this definition, and further rearranging, we get a formulation where τ_i responds to a weighted average of $\tau_{-i,U}$, $\tau_{-i,NU}$:

$$\tau_i=\alpha_{i,U}+\frac{1}{2}\left[\omega_{i,U}\tau_{-i,U}+\left(1-\omega_{i,U}\right)\tau_{i,NU}\right],\quad \omega_{i,U}=\frac{\theta R_i}{\theta R_i+\lambda},\quad i\in U, \tag{2.11}$$

$$\tau_i=\alpha_{i,NU}+\frac{1}{2}\left[\omega_{i,NU}\tau_{-i,U}+\left(1-\omega_{i,NU}\right)\tau_{i,NU}\right],\quad \omega_{i,NU}=\frac{R_i}{R_i+\theta},\quad i\notin U. \tag{2.12}$$

Also, the intercept terms for a country in and out of the union are:

$$\alpha_{i,U}=\frac{\lambda\theta\widetilde{k}_i}{2B_i(\theta R_i+\lambda)},\quad \alpha_{i,NU}=\frac{\theta\widetilde{k}_i}{2B_i(R_i+\theta)}. \tag{2.13}$$

Finally, let

$$\tau_{-i}=\sum_{j\neq i}w_{ij}\tau_j,\quad w_{ij}=\frac{\frac{1}{d_{ij}}}{\sum_{j\neq i}\frac{1}{d_{ij}}} \tag{2.14}$$

be the ordinary distance-weighted average of taxes other than country i's. We can now state our first Proposition:

Proposition 1.

(i) *If $\lambda=\theta=1$ (a) then $\alpha_{i,U}=\alpha_{i,NU}$, i.e. for any country, joining the union does not affect the intercept of the tax reaction function; and (b) then any country i responds in the same way to country j irrespective of whether i, j are in the union or not i.e.*

$$\omega_{i,U}\tau_{-i,U}+\left(1-\omega_{i,U}\right)\tau_{-i,NU}=\omega_{i,NU}\tau_{-i,U}+\left(1-\omega_{i,NU}\right)\tau_{-i,NU}=\tau_{-i}.$$

(ii) *If $\lambda<\theta=1$ then (a) $\alpha_{i,U}<\alpha_{i,NU}$, i.e. for any country, joining the union reduces the intercept of the tax reaction function; (b) $\omega_{i,U}>\omega_{i,NU}$ i.e. conditional on the size of the union (measured by R), any country in the union will react more to other union members, and less to countries outside the union, than a non-member; and (c) non-members respond the same way to members and non-members i.e.*

$$\omega_{i,NU}\tau_{-i,U}+\left(1-\omega_{i,NU}\right)\tau_{-i,NU}=\tau_{-i}.$$

(iii) *If $\lambda<\theta<1$, then (a) $\alpha_{i,U}<\alpha_{i,NU}$,* i.e. *for any country, joining the union reduces the intercept of the tax reaction function; and (b) if $\theta^2>(<)\lambda\Rightarrow\omega_{i,U}>(<)\omega_{i,NU}$ i.e. conditional on the size of the union, any country in the union will react more (less) to other union members, and less (more) to countries outside the union, than a non-member does.*

So, in the benchmark case ($\lambda=\theta=1$) where union membership has no effect on cross-border investment costs, the coefficients of the tax reactions function do not depend on union membership, and we get a tax reaction function as is standard in the literature. (The reaction function slope of $\frac{1}{2}$ is just an artifact of the simplicity of the theoretical model, and we make no attempt to impose this in the empirical estimation.)

In the case where union membership has an effect on cross-border investment costs, the coefficients of the tax reaction functions will be affected by union membership but its intensity will depend on the parameters λ and θ. A direct test would be to estimate λ and θ directly. However, a complication comes from the fact (2.11) and (2.12) are non-linear functions of both underlying parameters λ, θ and of observed regressors $\tau_{-i,U}$, $\tau_{-i,NU}$, R_i apart from the special case where $\theta = 1$, where τ_i, $i \notin U$, is a linear function of τ_{-i} only.

So, we proceed as follows. First, we take a linear approximation of Eqs. (2.11) and (2.12) of around $\tau_{-i,U}$, $\tau_{-i,NU}$, R_i sample means $(\overline{\tau}_U, \overline{\tau}_{NU}, \overline{R})$ and, after explicit calculation of the first derivatives, we get the system of reaction functions in linear form;

$$\begin{aligned}\tau_i &= \alpha_{i,U} + \frac{a_U}{2}\tau_{-i,U} + \frac{(1-a_U)}{2}\tau_{i,NU} + \frac{b_U \Delta\overline{\tau}}{2}R_i, \quad i \in U,\\ a_U &= \frac{\theta\overline{R}}{(\theta\overline{R}+\lambda)}, \quad b_U = \frac{\theta\lambda}{(\theta\overline{R}+\lambda)^2}, \quad \Delta\overline{\tau} = (\overline{\tau}_U - \overline{\tau}_{NU})\end{aligned} \tag{2.15}$$

$$\begin{aligned}\tau_i &= \alpha_{i,NU} + \frac{a_{NU}}{2}\tau_{-i,U} + \left(\frac{(1-a_{NU})}{2}\right)\tau_{i,NU} + \frac{b_{NU}\Delta\overline{\tau}}{2}R_i, \quad i \notin U,\\ a_{NU} &= \frac{\overline{R}}{(\overline{R}+\theta)}, \quad b_{NU} = \frac{\theta}{(\overline{R}+\theta)^2}.\end{aligned} \tag{2.16}$$

Also, from now on we will distinguish between *large unions*, $(\overline{R} \geq 1)$, and *small unions* $(\overline{R} < 1)$. Given that our empirical analysis refers to large unions (i.e. $\overline{R} = 2.6$) we will restrict our next Proposition to this case, but it is easy to derive results for small unions. We will only consider the case where $\lambda < \theta \leq 1$, since in the benchmark case $\lambda = \theta = 1$, the reaction function is linear in τ_{-i} and independent of R_i. We can now state:

Proposition 2. *Assume a large union* $(\overline{R} > 1)$. *Then*:

(i) *if* $\lambda < 1$, $\theta = 1$, *then* $a_U > \frac{1}{2}$ *i.e. union countries react more to* $\tau_{-i,U}$ *than to* $\tau_{-i,NU}$, *and* $bU > 0$ *i.e. a positive union size effect.*
(ii) *if* $\lambda < \theta < 1$, *then* a_U, $a_{NU} > \frac{1}{2}$, *i.e., all countries react more to* $\tau_{-i,U}$ than to $\tau_{-i,NU}$ *and* b_{NU}, $b_U > 0$, *i.e. the union size effect is positive for all countries.*
(iii) *if* $\theta^2 > (<)\lambda$, *then* $a_U > (<)$ a_{NU}, *i.e. countries in the union react more (less) to* $\tau_{-i,U}$ *but less (more) to* $\tau_{-i,NU}$ than countries outside the union, and also $b_{NU} > (<)$ b_U, *i.e. the union size effect is larger (smaller) for countries outside the union.*

In the most plausible case, i.e., that union membership lowers costs, but that this effect is bigger if both countries are members, we have a clear-cut theoretical predictions, viz., all countries react more to members than to non-members.

Proposition 2 indicates that R must be included as a regressor when λ and θ are different from one. This is because R controls for the relative size of the union on the slope of the reaction function, and thus addresses the issue that the weight assigned to each country is dependent on the number of countries in and out the union. Finally, the interpretation of the positive union size effect is as follows: if $\Delta\overline{\tau}$ is positive, which is the case in our sample, since $\overline{\tau}_U = 0.40, \overline{\tau}_{NU} = 0.30$, then, as b_U, $b_{NU} > 0$, we should expect an additional increase in the country i taxes, proportional to the size of the union measured by R_i.

3. Empirical specification

The reaction functions (2.15) and (2.16) can be equivalently written:

$$\tau_i = \alpha_{iU} + \beta_U \tau_{-i,U} + \gamma_U \tau_{-i,NU} + \mu_U R_i, \quad i \in U \tag{3.1}$$

$$\tau_i = \alpha_{iNU} + \beta_{NU} \tau_{-i,U} + \gamma_{NU} \tau_{-i,NU} + \mu_{NU} R_i, \quad i \in N/U. \tag{3.2}$$

This will be the basis of our regression analysis. Note that Eqs. (2.15) and (2.16) additionally imply that $\beta_U + \gamma_U = \beta_{NU} + \gamma_{NU} = \frac{1}{2}$. We do not impose the equal to half but we test for $\beta_U + \gamma_U = \beta_{NU} + \gamma_{NU}$; which is generally accepted.

To obtain an estimable equation, we add country fixed effects, α_{iNU}, year dummies YD_t, a vector of controls, X_{it} and an i.i.d. error term u_{it} and we write Eqs. (3.1) and (3.2) more compactly as:

$$\begin{aligned}\tau_{it} = {} & \alpha_{iNU} + \sigma_i U_{it} + \beta_U\left(U_{it} \times \tau_{-it,U}\right) + \beta_{NU}\left((1-U_{it}) \times \tau_{-it,U}\right)\\ & + \gamma_U\left(U_{it} \times \tau_{-it,NU}\right) + \gamma_{NU}\left((1-U_{it}) \times \tau_{-it,NU}\right) + \mu_U(U_{it} \times R_{it})\\ & + \mu_{NU}((1-U_{it}) \times R_{it}) + \delta' X_{it} + YD_t + u_{it}\end{aligned} \tag{3.3}$$

where U_{it} is a dummy for EU membership i.e. $U_{it} = 1$ if i is a member at time t and $\sigma_i = \alpha_{iU} - \alpha_{iNU}$. We now face a problem; σ_i cannot be estimated independently of α_i. Initially, we deal with this by assuming that $\sigma_i = \sigma$ i.e. that the effect of joining the EU on the intercept is uniform across countries. This coefficient σ is identified because some countries (Denmark, Ireland, United Kingdom, Greece, Spain, Portugal, Austria, Finland and Sweden) joined during the sample period. Later on, we relax this. Note that to retain degrees of freedom, we impose the restriction that union and non-union countries respond in the same way to changes in country-specific controls. Relaxing this assumption would imply that the regressions for the union and non-EU countries would be completely separate.

Eq. (3.3) is our *unrestricted* model. Note from Proposition 1 that there are two special cases. The first one, part (i) in Proposition 1, is where EU membership has no effect on cross-border FDI costs, i.e., $\lambda = \theta = 1$. Then, Eq. (3.3) implies a *restricted* model:

$$\tau_{it} = \alpha_i + \zeta\tau_{-it} + \delta' X_{it} + YD_t + u_{it} \tag{3.4}$$

where $\sigma = 0$, $\beta_U = \gamma_U = \beta_{NU} = \gamma_{NU} = \zeta$, and τ_{-it} is defined in Eq. (2.14) above. This is a standard tax reaction function, as estimated in many contexts by other researchers.

The second one, from part (ii) in Proposition 1, is where EU membership lowers cross border costs only for members (*bilateral union membership effect*), i.e., $\lambda < \theta = 1$, in which case we get $\beta_U > \gamma_U$, $\mu_U > 0$, $\sigma < 0$ and $\beta_{NU} = \gamma_{NU} = \zeta_U$. Under these restrictions we obtain our *intermediate* model:

$$\begin{aligned}\tau_{it} = {} & \alpha_i + \sigma U_{it} + \beta_U\left(U_{it} \times \tau_{-it,U}\right) + \gamma_U\left(U_{it} \times \tau_{-it,NU}\right) \\ & + \mu_U(U_{it} \times R_{it}) + \zeta_{NU}(1-U_{it})\tau_{-it} + \delta' X_{it} + YD_t + u_{it}.\end{aligned} \tag{3.5}$$

Our approach is to run all these regressions, Eqs. (3.3), (3.5) and (3.4), and examine whether the restrictions implied by Eq. (3.4) or (3.5) can be accepted.

The estimation of Eq. (3.3), (3.5) or (3.4) requires the construction of the w_{ij} and R_{it} and thus, from Eq. (2.9), an empirical proxy for d_{ij}. There are many ways in which this distance can be computed, for example geographical distance, or cultural distance, or distance in institutions. However geographical distance is the one that fits the purposes of this paper best and it is motivated by the existing literature pointing out the importance of geographical distance for the location of FDI; see for example Carr et al. (2001), Blonigen et al. (2003), Markusen (2002), and Overesch and Rincke (2011).

The simplest way to do so is to measure the linear distance in kilometers or miles between the capital cities of i and j[8]; another way is to assign a positive weights only to those countries sharing a common border and zero to the others.[9] However these two approaches fail to account for the location of human and economic activities within and between countries which might well affect FDI. To allow for this, we construct our weighting matrix using the well known measure of *effective bilateral distance*[10] developed by Head and Mayer (2002). This measure uses city-level data to assess the geographic distribution of population inside each nation. The idea is to calculate distance between two countries based on bilateral distances between the largest cities of those two countries, those inter-city distances being weighted by the share of the city in the country's population; we use this effective bilateral distance to construct our weights d_{ij}, and thus $\tau_{-it,U}$, $\tau_{-it,NU}$, τ_{-it} and R_{it}.[11]

It remains to discuss econometric issues. The system of Eq. (3.3) is known as a spatial autoregressive model (SAR). This model is the standard model that has been employed to estimate tax reaction functions (just to cite some contributions based on the estimation of tax reaction functions in an international setting: Davies and Voget, 2009; Besley et al., 2001; Altshuler and Goodspeed, 2002; Devereux et al., 2002, 2008; Cassette and Paty, 2008; Overesch and Rincke, 2011; Crabbe and Vandenbussche, 2008; Lockwood and Migali, 2009). Estimation of a SAR model by OLS is inappropriate because the right-hand side variables τ_{-it} are endogenous. Existing empirical works rely their estimation either on Maximum Likelihood or IV (OLS or GMM). If one relies the estimation on IV method the standard procedure is to instrument the endogenous variables, defined in Eq. (2.8), i.e., τ_{-it}, $\tau_{-it,U}$, and $\tau_{-it,NU}$, with the corresponding weighted averages of the control variables, using the same set of weights. That is, for example, $\tau_{-it,U} = \sum_{j \neq i, j \in U} w_{ij}\tau_{jt}$ is instrumented by $x^k_{-it,U} = \sum_{j \neq i, j \in U} w_{ij} x^k_{jt}$, $k = 1, \ldots, K$, where x^k_{jt} is the value of the control variable k in country j at time t. The advantage of this method, besides computational techniques, is that that even in the presence of spatial error dependence,[12] the IV method yields a consistent estimation of ζ, β and γ,[13] as demonstrated by Kelejian and Prucha (1998).

[8] Devereux et al. (2007) for example follow this approach.

[9] This is quite common way to proceed when the researcher aim to estimate tax reaction functions under the assumptions of cross-border shopping, see for example Devereux et al. (2008).

[10] This measure is available on line at http://www.cepii.fr/anglaisgraph/bdd/distances.htm, for more information see Mayer and Zignago (2011).

[11] An alternative approach to the reaction function estimation could be to investigate the precise features of EU membership that give rise to easier FDI flows and how they could be captured by specific variables. This is potentially a very intersting exercise, albeit a very challenging one, because the act of joining the EU is accepting a package of measures, regulations and institutional features known as the "aquis", which covers 35 different policy areas (http://ec.europa.eu/enlargement/policy/conditions-membership/). These measures are common to all members. This makes it very difficult to identify the effect of single policies on tax competition. A possibility, in terms of asymmetries of policies within the EU, could be to identify the effect of a common currency on tax competition, since not every country in the EU also adopted the Euro. However, the use of the Euro to identify the effect of EU membership on tax competition would shift the focus of the paper to the effect of a monetary union on tax setting, which is per se an interesting question, although a different one from the question addressed in this paper. An interesting analysis in this direction is proposed by Bénassy-Quéré et al. (2007) where, using a dataset on developing countries, the authors investigate whether similarity of institutions between the host and the origin country raises bilateral FDI.

[12] Spatial error dependence occurs, if neighbors are subject to correlated random shocks, which determines a correlation between states' fiscal choices, which could be erroneously interpreted as causal influence.

[13] If we do not take into account spatial error dependence in Eq. (3.3), this would not bias the estimation of β but it would reduce the efficiency of the estimation and produced biased standard errors. There are two more ways in addition to IV method to deal with this. One approach is to use maximum likelihood to estimate Eq. (3.3) taking into account of the error structure, this methodology has been explored by Case et al. (1993). The other way is to estimate Eq. (3.3) by ML under the hypothesis of error independence and rely on hypothesis tests to verify the absence of spatial correlation. Examples of this approach can be found in Brueckner (1998), Saavedra (2001), and Brueckner and Saavedra (2001). Anselin et al. (1996) suggest a robust test that can be employed to detect the presence of spatial error dependence, which is based on the analysis of the residual generated by regressing the dependent variables on the exogenous variables using OLS.

However, recently, Gibbons and Overman (2012) argued that the spatial coefficients (ζs, βs, and γs in our setting) in SAR models cannot be identify unless very strong assumptions are imposed; and, in particular, the assumption relative to the exclusion of the weighted controls, $wX = \sum_{k=1}^{K} x^k_{-it}$, from the regressors in the estimation of the reaction functions. Their suggestion is to estimate (at least initially) a more general model, known as the Spatial Durbin (SDM) instead. The difference between SAR and SDM models is that the latter includes, in addition, wX (or a subset of them) as regressors. SDM models, like SAR ones, cannot be estimated by OLS, because of the endogeneity of the spatial lag regressors, but they can be estimated by ML or IV. However in the latter case, there is a further complication because, obviously, the full set of wX cannot be used as instruments.

We take Gibbons and Overman (2012) concerns seriously and in Section A.3 in the Appendix A we address the issue of model selection by estimating our baseline reaction functions both as SAR as well as SDM, by ML and IV (OLS and GMM). We then test the validity of the restrictions on wX and its subsets. The tests carried out clearly suggest that, in this particular context, the best model is SAR and therefore Eq. (3.3), (3.5) or (3.4) is correctly specified and can be estimated as SAR. We decide to estimate them by instrumental variables, using the weighted controls as instruments.

A final issue is that in practice, our tax rates are serially correlated, perhaps because abrupt changes in the tax system are likely to be costly to governments, either because such changes impose costs of adjustment on the private sector, or because such changes may be blocked at the political level by interest groups who stand to lose from the change. We present t-statistics based on standard errors clustered by country which are robust to serial correlation.

4. The data

We use annual data on the Western European states over the period 1970–1999.[14] Our sample includes countries: (i) that were members of the European Union at the beginning of the period, (ii) that became subsequently members, and (iii) that never joined. Details on countries included and accession year to the EU are given in Table 1a.

Starting from the main variable of interest, the tax in the theoretical model is a capital income tax. Following Devereux et al. (2002) the correct tax measure for analyzing discrete capital choices is the effective average tax rate or, alternatively, the statutory tax rate.[15] In this paper we use the latter measure since average tax rates are available only for a shorter period. Precisely, our data refer to the top marginal tax rate on corporations.[16] The main sources are the Price Waterhouse — Corporate Taxes and Individual Taxes (A Worldwide Summary), and the on-line database at the Office of Tax Policy Research at Michigan State University.

There has been a remarkable change in statutory rates in European countries since the early 1970s. Table 1b shows for each country in the dataset, the variation of tax rates from 1970 to 1999 and their distance between European and EU averages at the beginning and at the end of the period. Overall the average statutory tax in the 17 European countries in our dataset went from 40% in 1970 to 32% in 1999. In some cases there has been a substantial fall of the tax rate, for example both Germany and UK registered a drop of 21 percentage points. However, in other cases there has been a considerable increase in the tax rate, like in Switzerland (29% points), Portugal (26% points) and Italy (22% points). A striking fact is that, in every European country, but two — Belgium and Greece, there has been a substantial convergence of corporate tax rates towards those of geographical neighbors, and this trend is even stronger considering the average of the EU neighbors.

More light is shown on individual countries in Fig. 1, where we report for the statutory tax, the time series by country, and also the corresponding weighted averages of the other countries in the sample, (i) across all samples,(ii) across EU members, and (iii) across non-EU states. Two points stand out. First that there is an overall fall in the tax rates, second a clear convergence towards neighbors' average (in particular EU neighbors).

Table 1c gives some basic summary statistics of both taxes and covariates.

Following our theoretical prediction we include R_{it} as regressor, which is a measure of the relative size of the EU compared to the rest of Europe using our effective distance measure.

Moreover we use a set of time varying variables X_{it} which are conventionally assumed to affect the determination of statutory taxes These variables include: total population (POPUL), proportion of population less than 14 years old and over 65 (POPDEP), GDP per capita expressed in dollars at 1995 prices (GDPPC), the public expenditures as a proportion of GDP (PUBEXP) (this variable is lagged one year to avoid endogeneity) and EU membership dummy, U, equal to 1 if the country is a member of the *EU* and 0 otherwise; an election year dummy, ELECTION, equal to 1 if there is an election in that year (either executive or legislative).[17]

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[14] Our sample stops in 1999 because we want to abstract from additional complications to our analysis deriving from the accession to the EU of Eastern European countries, which had very different characteristics from the existing EU members at that time.

[15] Unless otherwise mentioned, this is the tax rate applicable at the national level on domestic companies. An alternative approach to measure capital taxes is proposed by Mendoza et al. (1994), and is based on the ratio of tax payments to a measure of the operating surplus of the economy. This approach is not ideal for analyzing the competition between jurisdictions over taxes on corporate income because, it does not necessarily reflect the impact of taxes on the incentive to invest in a particular location, for reasons discussed in Devereux et al. (2008).

[16] In the working paper versions of the paper (Redoano (2003, 2007, 2012) we also present the results where the top marginal rate of personal income tax is used as a proxy for the capital income tax. However, since the results are not sufficient supported by the data, we do not include it in this version of the paper. For the full set of results see Redoano (2012).

[17] Political variables in this dataset come from two sources: *Comparative Political Dataset* available at http://www.ipw.unibe.ch/mitarbeiter/ru_armingeon/CPD_Set_en.asp and *Database of Political Institution* available at http://www.worldbank.org/research/bios/pkeefer.htm.

Table 1a
Country list and year of EU accession.

Year of accession to the EU	Countries
Original members	Belgium, France, Germany, Italy, Luxemburg, The Netherlands.
Joined in 1973	Denmark, Ireland, United Kingdom.
Joined in 1981	Greece.
Joined in 1986	Spain, Portugal.
Joined in 1995	Austria, Finland, Sweden.
Never joined	Switzerland, Norway

5. Regression results

5.1. The main results

Our main regression results are described in Table 2. The table is divided into 3 panels. The top panel gives regression coefficients. The results for the restricted model are in the first two columns; columns three to five are for the intermediate model; while the last three columns report the results for the unrestricted model. In columns one, three and six the respective models are run without controls; while in the remaining columns the control variables are added. Under the restricted model the underlining assumption is that union membership does not have any effect on the slopes of the reaction functions either for members or for non-members (i.e., $\beta_U = \beta_{NU} = \gamma_U = \gamma_{NU} = \zeta$),which is what it is stated in part (i) of Proposition 1. In the intermediate model, Eq. (3.5), the assumption is that union membership affects only the behavior of its members (i.e., $\beta_U > \gamma_U$ and $\beta_{NU} = \gamma_{NU}$); i.e. part (ii) of Proposition 1. Finally in the unrestricted model, Eq. (3.3), we estimate four coefficients, allowing two types of asymmetric response both 'by' and 'towards' EU and non-EU countries, which cover the full set of possibilities as illustrated in parts (ii) and (iii) of Proposition 2. Also, this will enable us to compare the intensity of bilateral and unilateral union membership effects. Given our theoretical predictions, we should expect that at least $\beta_U > \gamma_U$, but possibly also that $\beta_{NU} > \gamma_{NU}$: union membership has an effect also on non-members, but possibly the effect on members is stronger than on non-members, $\beta_U > \beta_{NU}$.

The middle panel gives the number of observations, an F-test for joint significance of the controls. We also report the following diagnostic. The Klebergen–Paap underidentification test is an LM test of whether the equation is identified, i.e., that the excluded instruments are correlated with the endogenous regressors, the null hypothesis that the equation is underidentified, a rejection of the null indicates that the model is identified. The Hansen-J test is a test of overidentifying restrictions. The null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term. Under the null, the test statistic is distributed as chi-squared in the number of overidentifying restrictions. A rejection casts doubt on the validity of the instruments.

In the last part of the panel we first report some tests on the equality of the coefficients of the tax interaction terms and the results for the test on the linear restriction that $\beta_U + \gamma_U = \beta_{NU} + \gamma_{NU}$.

Table 1b
Trend in tax rates.

Country	Difference tax rates[a] (1970–1999)	Distance from average[b] 1970	Distance from average[b] 1999	Distance from EU average[c] 1970	Distance from EU average[c] 1999
Austria	0.100	0.109	0.017	0.042	0.013
Belgium	−0.090	−0.019	0.067	−0.036	0.063
Denmark	0.040	0.049	−0.013	−0.004	−0.016
Finland	0.150	0.110	−0.055	0.046	−0.057
France	0.167	0.160	0.014	0.137	0.010
Germany	0.210	0.196	−0.027	0.169	−0.031
Greece	0.000	0.002	0.029	−0.062	0.025
Ireland	0.030	0.018	−0.006	−0.019	−0.010
Italy	−0.220	−0.206	0.052	−0.291	0.048
Luxemburg	0.150	0.126	−0.022	0.112	−0.026
Netherland	0.110	0.147	0.025	0.130	0.021
Norway	−0.015	−0.053	−0.055	−0.108	−0.056
Portugal	−0.260	−0.287	0.020	−0.312	0.017
Spain	−0.050	−0.064	0.032	−0.095	0.028
Sweden	0.120	0.086	−0.056	0.024	−0.058
Switzerland	−0.290	−0.315	0.000	−0.356	−0.004
United Kingdom	0.210	0.199	−0.016	0.162	−0.019
Average deviation	0.126	0.123	0.030	0.126	0.029

The calculation of the averages is based on the effective distance weights. In the last row the average of the absolute deviation of tax rates from their mean is reported.
[a] For each country the difference in the tax rates in 1970 and 1999 is reported.
[b] For each country the difference between own tax rate and the average of the neighbors is reported for 1970 and 1999.
[c] For each country the difference between own tax rate and the average of EU neighbors is reported for 1970 and 1999.

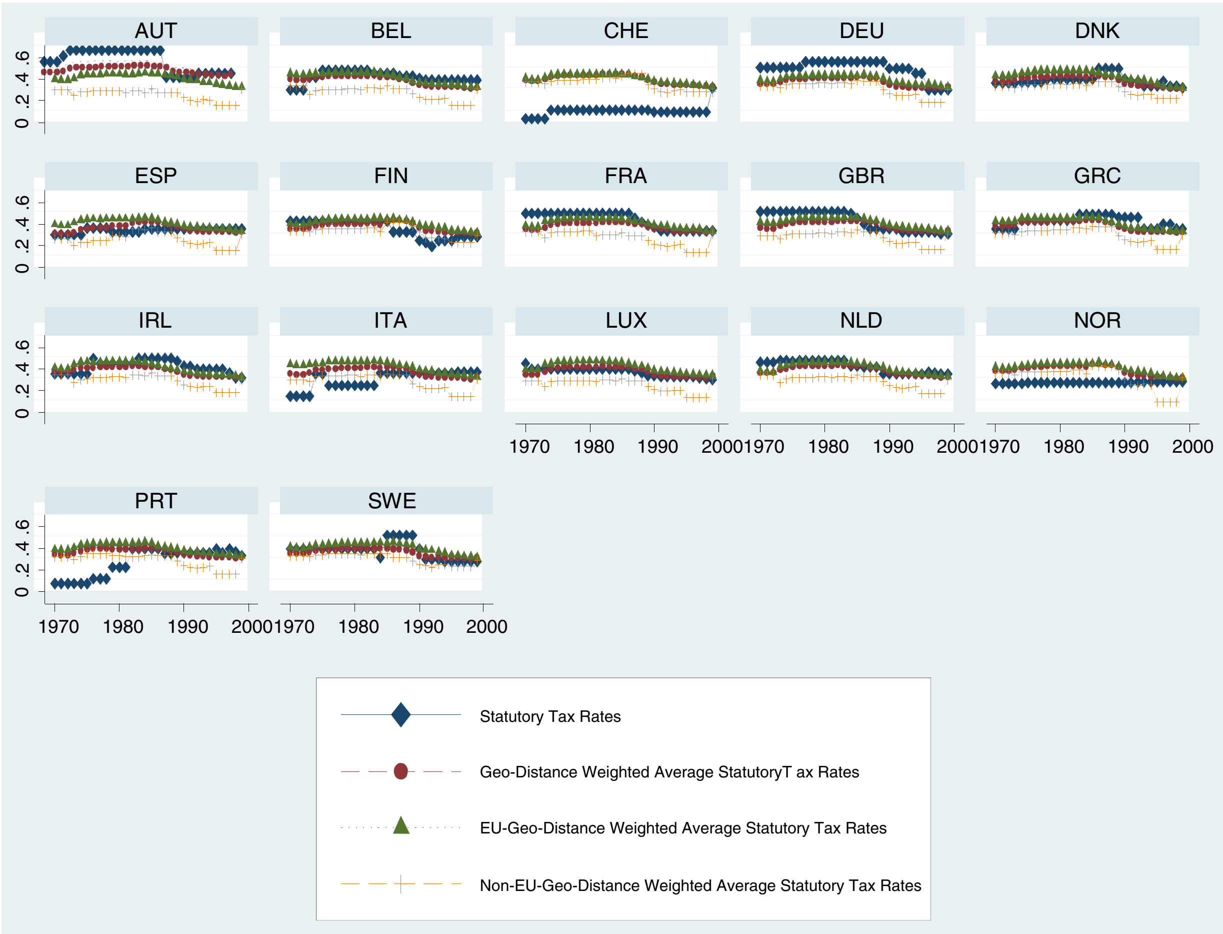

Fig. 1. Statutory tax rates: trend by countries.

The interpretation of these figures, and all the ones that follow, is that a coefficient of (say) ζ means that a one percentage point in a tax rate of the right-hand side of the regression leads to an increase of ζ percentage points in the dependent tax variable.

Looking now at columns one and two, we estimate our restricted model, Eq. (3.4), which is a standard tax reaction function, as estimated in many contexts by other researchers. Column 1 includes only $\tau_{-i,t}$ and no country controls Xs_{it} as regressors. In column 2, we add country controls. The coefficients on τ_{-i} have always the expected positive sign, with a value between 0.61 and 0.57, and are significant, at 1%, in both specifications.

In columns three, four and five we estimate Eq. (3.5). Recall in that case, we allow countries in the EU to respond differently to EU ($\tau_{-i,U}$) and non-EU countries ($\tau_{-i,NU}$), but we restrict the response of non-EU countries to be the same towards EU countries

Table 1c
Summary statistics.

Variable	Source	Observations	Mean	Standard deviation	Min	Max
Statutory tax rates	Office of Tax Policy Research[a]	510	0.37	0.11	0.10	0.56
EU	EU[b]	510	0.63	0.48	0.00	1.00
R	Our calculations	510	2.60	2.97	0.17	14.33
Election	Comparative Political Database[c]	510	0.28	0.45	0.00	1.00
GDPpc	WDI[d]	510	2.17	0.92	0.50	5.30
PopDep	WDI[d]	510	20.82	3.56	14.38	31.33
Population	WDI[d]	510	21.75	24.12	0.34	82.09
PubExp	WDI[d]	510	0.36	.084	0.13	0.55

[a] Available at otpr.org.
[b] Available http://europa.eu/abc/history/indexen.ht.
[c] Available at nsd.uib.no.
[d] World Bank, World Development Indicators.

Table 2
Dependent variable: statutory tax rates.

	Restricted model		Intermediate model			Unrestricted model		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
ζ	0.6148***	0.5704***						
	[0.229]	[0.162]						
ζ_{NU}			0.7986**	0.4812**	0.5175**			
			[0.328]	[0.219]	[0.224]			
β_U			0.8511***	0.7504***	0.7811***	0.9375***	0.6890***	0.7139***
			[0.323]	[0.204]	[0.204]	[0.295]	[0.180]	[0.188]
γ_U			−0.0953	−0.1896	−0.1588	−0.0189	0.0293	0.0148
			[0.217]	[0.171]	[0.173]	[0.206]	[0.169]	[0.173]
γ_{NU}						0.0258	−0.0333	0.1263
						[0.198]	[0.192]	[0.240]
β_{NU}						0.6154***	0.5247**	0.5619**
						[0.238]	[0.222]	[0.228]
μ_U				−0.0017	−0.0008			0.0022
				[0.003]	[0.003]			[0.003]
μ_{NU}								0.0057*
								[0.003]
σ			−0.0128	−0.0698	−0.0824	−0.1156	−0.0935	−0.0255
			[0.149]	[0.077]	[0.078]	[0.073]	[0.084]	[0.087]
$\delta_{Election}$		0.0009		0.0010	0.0010		0.0010	0.0009
		[0.004]		[0.004]	[0.004]		[0.004]	[0.004]
δ_{GDPpc}		0.0441***		0.0487***	0.0487***		0.0541***	0.0516***
		[0.016]		[0.018]	[0.018]		[0.018]	[0.017]
δ_{PopDep}		0.0119***		0.0114***	0.0115***		0.0118***	0.0103***
		[0.003]		[0.003]	[0.003]		[0.003]	[0.003]
$\delta_{Population}$		−0.0331***		−0.0356***	−0.0357***		−0.0340***	−0.0347***
		[0.007]		[0.007]	[0.007]		[0.007]	[0.007]
$\delta_{PubExp.\text{lag}}$		0.3046***		0.3278***	0.3244***		0.2938***	0.3215***
		[0.060]		[0.070]	[0.070]		[0.077]	[0.077]
N of observations	493	493	493	493	493	493	493	493
N of cluster	17	17	17	17	17	17	17	17
F-test on significance of controls (p-value)		50.50		47.22	47.27		46.62	48.97
		0.00		0.00	0.00		0.00	0.00
Hansen J (p-value)	0.23	0.2	0.10	0.23	0.58	0.15	0.18	0.18
K–P-under (p-value)	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
K–P-weak Id F	47.77	123.4				15.77	20.76	7.88
Ho: $\beta_U = \gamma_U$ (p-value)			0.00	0.00	0.00	0.00	0.00	0.01
Ho: $\beta_U = \beta_{NU}$ (p-value)						0.02	0.00	0.00
Ho: $\beta_{NU} = \gamma_{NU}$ (p-value)						0.01	0.06	0.00
Ho: $\gamma_U = \gamma_{NU}$ (p-value)						0.62	0.91	0.24
Ho: $\gamma_U + \beta_U = \gamma_{NU} + \beta_{NU}$ (p-value)						0.07	0.27	0.22

Significance levels: * 10%, ** 5%, and *** 1%.
T-statistics based on standard errors clustered by country which are robust to heteroskedasticity and serial correlation. Country dummies and time dummies included in all regressions F-test on significance of controls: the null hypothesis is that all $\delta = 0$.

and non-EU countries, which is the case if $\lambda < \theta = 1$. Moreover we include an EU dummy membership, U_{it} and we also include the variable $U \times R_{it}$, which is directly derived from the theory. In column five we address a possible concern that EU membership is endogenously determined along with taxes: this would cause the U dummy as well as $U \times R$ and $(1 - U) \times R$ to be endogenous. The instruments used are lagged trade over GDP, as well as lagged values of R.[18]

We see that these responses, measured by β_U (i.e., the response of EU countries towards other EU countries) and ζ_{NU} (the response of non-EU countries toward other European countries) are positive and significant. The response of EU countries towards non-EU ones (γ_U) instead is not significant. This is the case both without and with controls. So the first departure from standard results is that EU countries respond significantly more to EU countries than to non-EU countries, the response relative to the weighted average of EU countries goes between 0.75 and 0.85 in the three columns and it is always highly significant, while is not significantly different form zero with respect to the weighted average of non-EU countries. Moreover γ_U is significantly smaller than β_U, as emerged from our tests reported in the last part of the panel. Turning to non-EU countries, their response to other countries is between 0.48 and 0.79 (with and without controls respectively). Moreover the effect of EU membership on the level of taxes measured by the coefficient σ is always negative, as expected, and around -0.8 in column four and five but not significant. Finally μ_U, the coefficient of $U \times R$, is negative but not significant.

[18] In our simple model union membership is treated as exogenous; we do believe that this the correct way to proceed given that EU formation is a very complex phenomenon which is driven by several forces, and it is a combination of both a political vision, based on European common history, as well as economic considerations.

So the predictions of part (ii) in Proposition 1 seem to hold, and this is the first step in support of, at least, the unilateral union membership effect versus no effect.

In columns six to eight we estimate the complete unrestricted model, this will allow us to explore the hypothesis of a bilateral union membership effect. Recall that, from Proposition 2, if this is the correct hypothesis we should expect that EU members react more to other members and less to non-members than non-members do. Moreover, if the effect of unilateral union membership is stronger than that of bilateral union membership, we should expect that all countries react more to members than to non-members.

Again we propose three variations of the same model: in column six the model is run without controls, in column eight with controls; in column nine with controls and with $U \times R$ and $(1 - U) \times R$. There, we see that our parameter estimates are in the case with all controls: $\beta_U = 0.71$, $\gamma_U = 0.01$, $\beta_{NU} = 0.56$, $\gamma_{NU} = 0.12$, however the γs are not significant. This is quite consistent with our theoretical model. Specifically, an EU country reacts to a one percentage point decrease in the statutory rate of corporate tax of EU members by cutting its own tax by $\beta_U = 0.71$ percentage points, and to a one percentage point decrease in the statutory rate of corporate tax by other non-members by cutting its tax by only $\gamma_U = 0.01$ percentage points, although this second effect is insignificant. Similarly, a non-EU country reacts to a one percentage point decrease in the statutory rate of corporate tax of other EU members by cutting its own tax by $\beta_{NU} = 0.56$ percentage points, and to a one percentage point decrease in the statutory rate of corporate tax of non-members by cutting its tax by $\gamma_{NU} = 0.12$ percentage points, although this latter effect is insignificant. The effect of EU membership on the new members' statutory taxes is a negative one, as predicted by the theory, and but not significant. Finally in column nine we find that the coefficients of $U \times R$ and $(1 - U) \times R$, μ_U and μ_{NU}, are not significant.

We can now compare the fit of the restricted, intermediate, and unrestricted models. An F-test reported in the bottom panel of columns three to five of Table 2, where the null hypothesis is that $\beta_U = \gamma_U$, comparing the intermediate and restricted models, can be clearly rejected in favor of the intermediate. Proceeding further, the last panel in the last two columns provides a test for equality of coefficients; in particular the null hypotheses that $\beta_U = \beta_{NU}$, γ_U and that $\beta_{NU} = \gamma_{NU}$ can be rejected but not that $\gamma_U = \gamma_{NU}$. In conclusion our evidences seem to support the claim that the EU has caused an increase in tax interdependence not only for its members, but also towards the other European countries; however the latter effect is less strong, consistently with the hypothesis of "strong" bilateral union membership. Moreover the linear restrictions that $\beta_U + \gamma_U = \beta_{NU} + \gamma_{NU}$ implied by Proposition 2 can be accepted in all three specifications.

Finally for all specifications the control variables are jointly significant as the F-test in the second panel of the table shows. The coefficient of the population dependency ratio variable is always positive and significant in all our specifications and equal to 0.01, consistent with the hypothesis that it is a proxy for demand for public goods that must be funded via taxation. The coefficient on size of a country measured by its population is always negative, significant and always around −0.03. At first glance the fact that larger countries have, ceteris paribus, smaller taxes is somehow counter-intuitive, but it becomes more understandable since we control for per capita income. Moreover richer countries, measured by the variable GDP per capita (*GDPpc*), not surprisingly, have higher taxes, the coefficient being significantly different from zero and equal to 0.05 in column eight. This is because, for a given size of the economy, poorer countries have to cut their corporate taxes more because they rely more on international investments. Unsurprisingly, the previous year's public expenditure is good predictor for taxation, one point increase in public spending in the previous year is associated with around 0.3 increase in tax rates. Finally, electoral goals do not seem to have an impact on corporate taxes, the election dummy is never significant.

To summarize, evidence on corporate taxes fits the predictions of the theory quite well, specifically, in all our regressions we find consistency with the theory that, when we allow asymmetric response between EU and non-EU countries, all the countries in our dataset mainly respond to EU members tax setting, and in particular they do so more if they are themselves part of the EU, which is supportive of the strong bilateral union membership hypothesis in Proposition 2 part (iii).

5.2. Robustness checks

So far, we have assumed that the effect of joining the EU on both the level of taxes,[19] and the degree of interaction, is uniform across all countries in the sample. We cannot completely relax this, and allow these coefficients to vary by country, due to lack of degrees of freedom. But, we can use the fact that Denmark, Ireland, United Kingdom, Greece, Spain, Portugal, Austria, Finland and Sweden joined the EU during the sample period. In this section, we relax the uniformity assumption by allowing the "joiners" to react differently to other countries, possibly those already in the EU, after they join than before — our theory suggests that actually, they should react more, given that the effect of union membership is to reduce effective distance costs and therefore to increase tax competition. We will consider two different variants of this exercise, first by considering all the countries who joined, and then by considering just Greece, Spain, Portugal, who joined in the middle of the sample period. So, each variant is defined by a list of "joiners". Define $J_i = 1$ if country i is on the list of joiners, and $J_i = 0$ otherwise. Let $O_i = 1 - J_i$, where "O" stands for others. Then the first and fourth regressions in Table 4 are of the form

$$\begin{aligned}\tau_{it} = {} & \alpha_i + \sigma U_{it} + \beta_{J,NU}\left(J_i \times (1-U_{it}) \times \tau_{-i,t}\right) + \beta_{J,U}\left(J_i \times U_{it} \times \tau_{-i,t}\right) \\ & + \beta_{O,NU}\left(O_i \times (1-U_{it}) \times \tau_{-i,t}\right) + \beta_{O,U}\left(O_i \times U_{it} \times \tau_{-i,t}\right) + \delta' X_{it} + YD_{it} + u_{it}.\end{aligned} \tag{5.1}$$

[19] This is the assumption that $\sigma_i = \sigma$.

This regression allows the "joiners" to respond differently to the taxes of all other countries, τ_{-it} after they join ($\beta_{J,U}$) and before they join ($\beta_{J,NU}$). They are also allowed to respond differently to τ_{-it} than the other countries, who may be members or not.

The results are reported in Table 3. In the case where $J_i = 1$ for i being all joining countries, before joining the EU the joiners would have responded to an increase of one percentage point of other countries' taxes by increasing their own by 0.31 percentage points; this coefficient is statistically significant only at 10%. After joining the union, their reaction to their European partners would increase to 0.85 and also would become significant at 1%. Moreover, these two figures are statistically different from each other as the *t*-test in the bottom panel suggests. The other countries in the sample, by definition, are either non-members or members throughout the sample period. Call the latter group initial members; they comprise Belgium, the Netherlands, Luxembourg, France, Germany and Italy. Consistent with previous results and with the theory, initial members respond to a one-point tax increase of others of others by 0.63 points ($\beta_{O,U} = 0.68$), whereas non-members do respond positively ($\beta_{O,NU} = 0.58$), both coefficients are significant at 1%.

Similar results are obtained if we restrict the set of joiners to be just Greece, Spain and Portugal. The results in column four indicate that before joining the EU, these three countries would have followed an increase of one percentage point of other countries taxes by increasing their own by 0.37 percentage points; however this coefficient is not statistically significant from zero. After joining the union, their reaction to their European partners would increase to 0.78 and also would become significant at 1%. Again, these two figures are statistically different from each other as the *t*-test in the bottom panel suggests.

Table 3
Statutory tax rates: countries who joined during 1970–99.

	All joiners			Greece, Spain, Portugal (GSP)		
	[1]	[2]	[3]	[4]	[5]	[6]
	All	All EU members	Original EU members	All	All EU members	Original EU members
$J \times (1 - EU) \times \tau_{-i}$	0.3109*			0.3702		
	[0.161]			[0.448]		
$J \times EU \times \tau_{-i}$	0.8513***			0.7870***		
	[0.192]			[0.249]		
$J \times (1 - EU) \times \tau_{-i,U}$		0.2357			0.1697	
		[0.357]			[0.372]	
$J \times EU \times \tau_{-i,U}$		0.8432*			0.7489**	
		[0.471]			[0.306]	
$J \times (1 - EU) \times \tau_{-i,IN}$			0.3678**			0.4356
			[0.183]			[0.347]
$J \times EU \times \tau_{-i,IN}$			0.8499***			0.8088*
			[0.219]			[0.419]
$O \times EU \times \tau_{-i}$	0.6812***			0.9513***		
	[0.109]			[0.268]		
$O \times (1 - EU) \times \tau_{-i}$	0.5874***			0.5703**		
	[0.154]			[0.254]		
$O \times (EU) \times \tau_{-i,U}$		0.4788**			0.8620**	
		[0.225]			[0.361]	
$O \times (1 - EU) \times \tau_{-i,U}$		0.3138			0.3395	
		[0.269]			[0.397]	
$O \times (EU) \times \tau_{-i,IN}$			0.3867***			0.9328**
			[0.137]			[0.461]
$O \times (1 - EU) \times \tau_{-i,IN}$			0.2659			0.7169**
			[0.174]			[0.329]
$\tau_{-i,NU}$		0.2519			0.1966	
		[0.183]			[0.250]	
$\tau_{-i,NIN}$			0.3032*			0.7039**
			[0.159]			[0.276]
EU	−0.1964**	−0.2718*	−0.2140**	−0.1457	−0.2218	−0.1203
	[0.077]	[0.160]	[0.090]	[0.159]	[0.165]	[0.179]
N of observations	493	493	493	493	493	493
N of clusters	17	17	17	17	17	17
Ho: $\beta_{before} = \beta_{after}$ (p-value)	11.21	3.88	7.77	9.80	2.54	9.89
	0.00	0.04	0.01	0.03	0.11	0.09
Hansen J (p-value)	0.14	0.32	0.18	0.15	0.35	0.60
K–P-under (p-value)	0.00	0.00	0.00	0.01	0.05	0.06
K–P-weak Id F	27.11	3.43	7.25	40.23	9.48	9.41

Significance levels: * 10%, ** 5%, and *** 1%.
T-statistics based on standard errors clustered by country which are robust to heteroskedasticity and serial correlation.
Country dummies and time dummies included in all regressions.
All regressions include the full set of controls: population, population dependency, election dummy, GDP per capita, lagged values of the ratio of public spending over GDP.

Next, we re-run regression (5.1), allowing a differential response of joiners before and after joining to the weighted average of just the current EU members i.e. we replace τ_{-i} in Eq. (2.9) with $\tau_{-i,U}$ where the latter is defined in Eq. (5.1). We also add $\tau_{-i,NU}$ to allow all countries also to respond to non-EU countries. The results are reported in columns two and five of Table 3, and are qualitatively quite similar.

Finally, we re-run regression (5.1), allowing a differential response of joiners before and after joining to the weighted average of just the initial EU members i.e. we replace τ_{-i} in Eq. (5.1) with $\tau_{-i,IN}$ where the latter is defined as the weighted average of the taxes of countries that were initially in the union at the beginning of the sample, using the same weighting scheme. The results are reported in columns three and six of Table 3, and are again qualitatively quite similar.

To further assess the robustness of our results we also carry out some additional checks. So far, we have weighted other countries' taxes using effective geographical distance weights, which are the weights suggested by the theory. However, we conduct several robustness checks to see if there are other alternative weighting schemes that can work better. First, the main predictions of the theory are unchanged if we hypothesize that physical distance does not matter i.e. d_{ij} does not affect the costs of cross-border investment c_{ij}. This can be captured in the model by setting $d_{ij} = d$, for all i and j; this is the case of so-called *uniform weights*.

A possible source of criticism of distance weights could be that the fiscal interaction process may not depend on the EU as a whole but, instead, countries with smaller GDP simply follow larger countries. This would not be picked up by our weights since three of the largest four countries in Europe were members of the then European Community from the beginning of the sample period. In order to check if this is indeed the case, we replace the distance weights by *GDP weights*, where each country weights are calculated as the ratio between its own GDP and the sum all countries GDP.

Table 4 replicates the regressions in columns 2, 4 and 8 of Table 2 using uniform weights in the first panel, and GDP weights in the second. All the regressions are run using the full set of controls as in the previous tables as well as country fixed effects and time dummies.

Table 4
Robustness checks. Alternative weighting schemes.

	Restricted	Intermediate	Unrestricted
	−1	−2	−3
Uniform weights			
τ_{-i}	0.6453***		
	[0.114]		
$NU \times \tau_{-i}$		0.6570**	
		[0.298]	
$EU \times \tau_{-i,U}$		0.8692***	0.8624***
		[0.294]	[0.267]
$EU \times \tau_{-i,NU}$		0.1085	−0.0066
		[0.228]	[0.200]
$NU \times \tau_{-i,U}$			−0.1592
			[0.212]
$NU \times \tau_{-i,NU}$			0.8196***
			[0.251]
EU		−0.1465	−0.0645
		[0.096]	[0.112]
GDP weights			
τ_{-i}	0.9330		
	[4.88]***		
$NU \times \tau_{-i}$		1.8670	
		[1.14]	
$EU \times \tau_{-i,U}$		2.2050	1.6900
		[0.31]	[0.21]
$EU \times \tau_{-i,NU}$		−1.1720	−0.5910
		[0.17]	[0.07]
$NU \times \tau_{-i,U}$			−0.4450
			[0.13]
$NU \times \tau_{-i,NU}$			0.6080
			[0.23]
EU	0.0050	0.3280	−0.4380
	[0.30]	[0.56]	[2.01]**
N	493	493	493
Controls	Yes	Yes	Yes
Fixed effect	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes

Significance levels: * 10%, ** 5%, and *** 1%.
T-statistics based on standard errors clustered by country which are robust to heteroskedasticity and serial correlation.

We see that using uniform weights the coefficient estimates, and their significance levels, do not differ much across the two tables. In our preferred specification, column 3, we see that (i) an EU country reacts to a one percentage point decrease in taxes in other EU countries by cutting its own taxes by the 0.86 points, while (ii) a non-EU country reacts by cutting 0.81 points. Moreover a one percentage point cut undertaken by non-EU countries does not have any effect both on EU and non-EU countries.

If GDP weights are better, we should expect the coefficients of the weighted average tax rate to be positive and significant, in particular the one relative to the weighted average of the EU members' tax rates, since the largest European economies are also EU members. The results for this second exercise are reported in the second panel. The general picture is that this weighting scheme performs less well than effective distance or even uniform weights.

6. Conclusions

This paper has explored the impact of EU membership on fiscal interactions among countries. The starting point is the observation that the principal achievement of the European Union since its inception in 1957 has been the creation of a single market for goods, capital and labor, and this should have contributed to lower the cost of investing abroad, i.e. by facilitating capital mobility. This might in turn have caused countries to react more to each others' taxes.

We have developed a simple model of tax competition which verifies this intuition. In the model, conditional on taxes, the size (in absolute terms) of cross-border investment between two countries is inversely proportional to the (marginal) cost of cross-border investment (these marginal costs could be physical, legal, or regulatory). EU membership is modeled as a reduction in 'distance' to other EU countries. We have derived precise predictions of the slopes of the reaction function: that the EU countries react more to each other than they do to non-EU countries, and non-EU countries react to all countries less than EU countries react to each other, but more than EU countries react to non-EU countries. These predictions are confirmed using a panel data set of statutory corporate tax rates.

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Appendix A

A.1. Proofs of propositions

Proof of Proposition 1. To prove (i), if $\lambda = \theta = 1$, it is easy to check from Eq. (2.13) that $\alpha_{i,U} = \alpha_{i,NU}$. Also, Eq. (2.10) becomes

$$\tau_i = \frac{\widetilde{k}_i + A_i \tau_{-i,U} + B_i \tau_{-i,NU}}{2(A_i + B_i)} = \frac{\widetilde{k}_i}{2(A_i + B_i)} + \frac{\sum_{j \neq i, j \in U} \frac{\tau_j}{d_{ij}} + \sum_{j \neq i, j \notin U} \frac{\tau_j}{d_{ij}}}{2(A_i + B_i)} = \alpha_i + \frac{\sum_{j \neq i} \frac{1}{d_{ij}} \tau_j}{2 \sum_{j \neq i} \frac{1}{d_{ij}}} = \alpha_i + \frac{\tau_{-i}}{2} \tag{7.1}$$

for both countries in the union and not in the union.

To prove (ii.a) and (iii.a), note that

$$\sigma_i = \alpha_{i,U} - \alpha_{i,NU} = -\frac{\theta \widetilde{k}_i [(R_i(\theta - \lambda) + \lambda(1 - \theta)]}{2B_i(R_i + \theta)(\theta R_i + \lambda)} < 0.$$

To prove (ii.b), note that $\omega_{i,U} = \frac{R_i}{R_i + \lambda} > \frac{R_i}{R_i + 1} = \omega_{i,NU}$. To prove (ii.c), note that Eq. (7.1) continues to hold for $i \notin U$ when $\theta = 1$. To prove (iii.b), note that $\omega_{i,U} = \frac{\theta R_i}{\theta R_i + \lambda} > \frac{R_i}{R_i + \theta} = \omega_{i,NU}$ iff $\theta^2 > \lambda$. QED.

Proof of Proposition 2. (i) If $\overline{R} > 1$, the coefficients in Eq. (2.11) are $a_U = \frac{\overline{R}}{2(\overline{R} + \lambda)} > (1 - a_U) = \frac{\lambda}{2(\overline{R} + \lambda)}$. (ii) From the inspection of Eqs. (2.11) and (2.12) $a_U = \frac{\theta \overline{R}}{2(\theta \overline{R} + \lambda)} > (1 - a_U) = \frac{\lambda}{2(\theta \overline{R} + \lambda)}$ and $a_{NU} = \frac{\overline{R}}{2(\overline{R} + \theta)} > (1 - a_{NU}) = \frac{\theta}{2(\overline{R} + \theta)}$ also b_{NU} and b_U are unambiguously positive. (iii) $a_U > a_{NU}$ iff $\frac{\theta \overline{R}}{(\theta \overline{R} + \lambda)} > \frac{\overline{R}}{(\overline{R} + \theta)}$, and $b_U = \frac{\theta \lambda}{(\theta \overline{R} + \lambda)^2} < b_U = \frac{\theta}{(\overline{R} + \theta)^2}$ which is the case iff $\theta^2 > \lambda$. QED.

A.2. Testing theoretical assumptions: benevolent vs Leviathan governments

In the theoretical part of this paper we have assumed that governments maximize tax revenues; this is a standard assumption in the literature on tax competition (see for example Kanbur and Keen, 1993; Edwards and Keen, 1996; Brülhart and Jametti, 2007, and many others). This choice is also supported by an empirical literature addressing the choice between the Leviathan and the benevolent hypotheses.[20] So we believe that this is a reasonable assumption, especially in the context of capital taxes.

However, as a robustness check, we solve the model developed in the theoretical part of the paper under the new assumption that governments are instead benevolent. So, here, governments maximize representative household welfare, $V_i + H(g_i)$, where V_i is national disposable income net of investment costs, and $H(g_i)$ is the utility that representative household in i derives from the consumption of a public good g_i provided by the government and funded by tax revenue. Moreover, we assume without loss of generality that the cost of provision of the public good is unity and that $H(g_i) = \alpha g_i$, where α is a positive parameter greater than one. Everything else in the model stays the same. Then, given the optimal allocation of capital by households in Eq. (2.4), government i chooses τ_i that maximizes:

$$V_i + \alpha g_i = \sum_{j \neq i, j \in L_i} \frac{\left(\tau_i - \tau_j\right)^2}{2c_{ij}} + \widetilde{k}_i(1-(1-\alpha)\tau_i) + \alpha\tau_i \sum_{j \neq i} \frac{\tau_j - \tau_i}{c_{ij}}$$

where L_i is the set of countries j for which $\tau_i \geq \tau_j$.

These first-order conditions give reaction functions:

$$\tau_i = \alpha \frac{\sum_{j \neq i} \frac{\tau_j}{c_{ji}} + \sum_{j \neq i, j \in L_i} \frac{\tau_j}{c_{ij}} + \widetilde{k}_i(1-\alpha)}{\sum_{j \neq i, j \in L_i} \frac{1}{c_{ij}} + 2\alpha \sum_{j \neq i} \frac{1}{c_{ji}}.} \tag{7.2}$$

From the inspection of Eq. (7.2), tax reaction functions show now a kink at $\tau_i = \tau_j$ and, in particular, as before, country i responds positively to country j, but its response is stronger if country j has lower tax rates than i's. So, writing our reaction functions for union members and non-members separately, and using Eq. (2.3), we get, if $i \in U$:

$$\tau_i = \alpha \frac{\sum_{j \neq i, j \in U} \frac{\tau_j}{\lambda d_{ij}} + \sum_{j \neq i, j \in U, j \in L_i} \frac{\tau_j}{\lambda d_{ij}} + \alpha \sum_{j \neq i, j \notin U} \frac{\tau_j}{\theta d_{ij}} + \sum_{j \neq i, j \notin U, j \in L_i} \frac{\tau_j}{\theta d_{ij}} + \widetilde{k}_i(1-\alpha)}{\sum_{j \neq i, j \in L_i, j \in U} \frac{1}{\lambda d_{ij}} + 2\alpha \sum_{j \neq i, j \in U} \frac{1}{\lambda d_{ij}} + \sum_{j \neq i, j \in L_i, j \notin U} \frac{1}{\theta d_{ij}} + 2\alpha \sum_{j \neq i, j \notin U} \frac{1}{\theta d_{ij}}}$$

and if $i \notin U$:

$$\tau_i = \alpha \frac{\sum_{j \neq i, j \in U} \frac{\tau_j}{\theta d_{ij}} + \sum_{j \neq i, j \in U, j \in L_i} \frac{\tau_j}{\theta d_{ij}} + \alpha \sum_{j \neq i, j \notin U} \frac{\tau_j}{d_{ij}} + \sum_{j \neq i, j \notin U, j \in L_i} \frac{\tau_j}{d_{ij}} + \widetilde{k}_i(1-\alpha)}{\sum_{j \neq i, j \in L_i, j \in U} \frac{1}{\theta d_{ij}} + 2\alpha \sum_{j \neq i, j \in U} \frac{1}{\theta d_{ij}} + \sum_{j \neq i, j \in L_i, j \notin U} \frac{1}{d_{ij}} + 2\alpha \sum_{j \neq i, j \notin U} \frac{1}{d_{ij}}.}$$

We do not attempt to estimate directly these reaction functions because of the large number of coefficients to estimate (four relative to union membership, four relative to the level of taxes and two for the size of the union and the size of L_i). However we take the suggestion that reaction functions are not linear and we test whether or not countries exhibit a different response to other countries' tax setting depending on whether or not their tax rate is above or below other countries' weighted average taxes. We employ the same sets of weights used in the previous regressions and we propose variations to the restricted and intermediate models in Eqs. (3.4) and (3.5) to accommodate the asymmetric response. The modified restricted model becomes:

$$\tau_{it} = \alpha_i + \varsigma_L(\Lambda_{it} \times \tau_{-it}) + \varsigma_H((1-\Lambda_{it}) \times \tau_{-it}) + YD_t + u_{it}$$

where Λ_{it} is a dummy variable that takes value equal to one if $\tau_{it} \quad \tau_{-it}$, and ς_L and ς_H are the coefficients of interest to estimate. In particular, if the hypothesis of benevolent governments is the correct one in this context, than ς_L should be bigger than ς_H, if the hypothesis of Leviathan governments instead explains better governments' behavior in tax setting, than there should not be any statistical difference between ς_L and ς_H.

Finally, the modified version of the intermediate model to estimate is:

$$\tau_{it} = \alpha_i + \sigma U_{it} + \beta_{LU}\left(\Lambda_{it} \times U_{it} \times \tau_{-it,U}\right) + \beta_{HU}\left((1-\Lambda_{it}) \times U_{it} \times \tau_{-it,U}\right) + \gamma_U\left(U_{it} \times \tau_{-it,NU}\right) + \varsigma_{NU}\tau_{-it} + YD_t + u_{it}$$

where β_{LU} and β_{HU} are the coefficients of interest. As before, tests on the difference between β_{LU} and β_{HU} will give an indication on whether or not the initial modeling choice of Leviathan government can be accepted.

The results are displayed in Table A1. The table reports estimation results for both the restricted and the intermediate models, run both without controls and with the full set of controls employed in the other regressions. From the inspection of the table, and

[20] The empirical testing of the Leviathan model has begun in the 1980s. Early studies concentrate on data sets drawn from American and Canadian states. Nelson (1986) finds that in those states tax personal income has significantly larger government sectors as implied by the Leviathan model. Marlow (1988) and Zax (1989) find that total government size varies inversely with the relative importance of a local government, consistently with the Leviathan hypothesis.

Table A1
Asymmetric responses.

	−1	−2	−3	−4	−5
ζ_L	1.048	0.964			
	[6.65]***	[5.10]***			
ζ_H	1.011	1.026			
	[5.03]***	[4.59]***			
$\delta_{Election}$		0.002		0.002	0.003
		[0.55]		[0.90]	[0.75]
δ_{GDPpc}		0		0	0
		[2.02]**		[2.09]**	[1.73]*
δ_{PopDep}		0.016		0.013	0.016
		[1.95]*		[1.12]	[1.17]
$\delta_{Population}$		−0.049		−0.041	−0.051
		[2.32]**		[2.59]***	[2.02]**
δ_{PubExp}		0.277		0.209	0.289
		[2.70]***		[2.16]**	[1.88]*
ζ_{NU}			0.626	0.545	0.546
			[1.86]*	[1.43]	[1.83]*
β_{LU}			1.042	1.021	0.994
			[4.62]***	[3.85]***	[2.97]***
β_{HU}			0.914	1.013	1.073
			[4.33]***	[3.50]***	[3.06]***
γ_U			−0.063	−0.048	0.113
			[0.26]	[0.17]	[0.33]
σ			−0.125	−0.201	−0.288
			[0.73]	[0.82]	[1.24]
μ_U					0.006
					[1.09]
N	493	493	493	493	493
FE and time dummies	Yes	Yes	Yes	Yes	Yes
Ho: $\zeta_L = \zeta_H$ (p-value)	0.07	0.11			
	[0.79]	[0.74]			
Ho: $\beta_{LU} = \gamma_{HU}$ (p-value)			1.21	0	14
			[0.27]	[0.96]	[0.71]

Significance levels: * 10%, ** 5%, and *** 1%.
T-statistics based on standard errors clustered by country which are robust to heteroskedasticity and serial correlation.

guided by the *t* tests reported at the bottom of the table, we can accept the hypothesis that there is no significant difference between ς_L and ς_H and β_{LU} and β_{HU}, and therefore the assumption of Leviathan government appears to be the correct one.

A.3. Testing spatial modeling choices: SAR vs SDM models

Gibbons and Overman (2012) argue that the spatial coefficients (ζ, βs, and γs in our setting) in SAR models cannot be identify unless very strong assumptions are imposed; and, in particular, the assumption relative to the exclusion of wX from the regressors in the estimation of the reaction functions. Their suggestion is that researchers should estimate a SDM model instead of a SAR and then test for the restrictions that the coefficients on are equal to zero.

The estimation of spatial panel data model is discussed in details in Elhorst (2003, 2010), Elhorst and Fréret (2009), and Elhorst and Fréret (2003). The spatial parameter for the fixed effects model can be estimated by demeaning the fixed and year effect first and then using ML, following the estimation procedure developed by Anselin (1988) for the SAR model. Elhorst (2010) provides a Matlab routine in his website for estimating SAR and SDM models. A similar routine has been developed for Stata users by Belotti and Piano Mortari (2013).[21] Alternatively SAR and SDM models can be estimated by IV. Generally in SAR models wX are used as instruments, while the estimation of SDM is more complicated because it not possible to use the full set of wX as instruments.

In this section we employ our baseline specification in Eq. (3.4) to estimate tax reaction functions as SDM and SAR both using ML and IV to investigate whether or not we can accept the restrictions on wX. For computational reasons we use model (3.4) to test our restrictions, but we assume that the same results can be applied to Eqs. (3.3) and (3.5). Table A2 presents the results for this exercise, at the bottom of the panel we present tests for the inclusion of weighted average of the covariates. From the inspection of the table we can clearly see that the coefficients on wX are never significant and therefore we can conclude that the model that fit the data best is a SAR.

[21] The command, xsmle, is freely available to download for Stata users at http://ideas.repec.org/c/boc/bocode/s457610.html.

Table A2
SAR vs Spatial Durbin models.

Dependent variable: statutory tax rates	[1] SDM ML	[2] SDM ML	[3] SDM ML	[4] SDM ML	[5] SDM ML	[6] SDM ML	[7] SDM ML	[9] SAR ML	[10] SAR (IV) OLS	[11] SAR (IV) GMM
W_τ	0.4641***	0.5052***	0.5069***	0.4514***	0.5042***	0.5011***	0.4697***	0.4544***	0.5704***	0.5236***
	[0.062]	[0.089]	[0.087]	[0.089]	[0.085]	[0.089]	[0.077]	[0.091]	[0.162]	[0.161]
Dependency ratio	0.0320**	0.0314**	0.0252**	0.0193*	0.0251**	0.0315*	0.0320**	0.0193*	0.0009	0.0120***
	[0.014]	[0.015]	[0.011]	[0.012]	[0.011]	[0.017]	[0.014]	[0.011]	[0.004]	[0.003]
Population	−0.0022	−0.0044	−0.0005	−0.0008	−0.0005	−0.0045	−0.0021	−0.0008	0.0441***	−0.0342***
	[0.003]	[0.004]	[0.001]	[0.001]	[0.001]	[0.008]	[0.003]	[0.001]	[0.016]	[0.006]
GDP per capita	−0.0328	−0.0325	−0.0501**	−0.0717***	−0.0501**	−0.0322	−0.0327	−0.0717***	0.0119***	0.0497***
	[0.027]	[0.030]	[0.024]	[0.022]	[0.024]	[0.032]	[0.026]	[0.022]	[0.003]	[0.016]
Election dummy	0.0050*	0.0049	0.0048*	0.0047*	0.0048*	0.0048	0.0051*	0.0048*	−0.0331***	0.0012
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.007]	[0.004]
W (dependency ratio)	−0.0008		0.0120		0.0120	−0.0003				
	[0.012]		[0.010]		[0.010]	[0.019]				
W (population)	−0.0281	−0.0483				−0.0493	−0.0270			
	[0.032]	[0.039]				[0.069]	[0.026]			
W (GDP per capita)	−0.0444						−0.0435			
	[0.064]						[0.063]			
W (election dummy)	0.0085			0.0084	0.0079	0.0107				
	[0.009]			[0.010]	[0.010]	[0.010]				
Observations	493	493	493	493	493	493	493	493	493	493
Tests on $wX = 0$	3.92	1.5	1.31	0.71	1.87	2.31	2.47			
p-values	[0.41]	[0.22]	[0.25]	[0.40]	[0.39]	[0.31]	[0.48]			

Significance levels: *** 1%, ** 5%, * 10%.

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