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WORKING PAPER

Do EU15 countries compete over labour taxes?

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October 2011

2011/750

D/2011/7012/55

Do EU15 countries compete over labour taxes?*

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October 25, 2011

Abstract

Empirical research on international tax competition has mainly considered corporate taxation. Because of the limited international mobility of labour, labour tax competition tends to be overlooked. This may be unjustified. The tax base in labour taxation is the wage mass that depends on employment. While labour is largely internationally immobile, jobs are certainly not because of the international mobility of goods. Given the higher share of labour tax in government revenues, labour tax competition could also have more important welfare consequences than corporate tax competition. We model the possibility of labour tax competition using a standard Dixit-Stiglitz two-country model with immobile firms and workers and transportation costs in exporting goods. The model is extended with the assumptions of non-clearing labour markets and income redistribution by the government, financed by a labour tax. The model results in an empirical specification of the labour tax reaction function in the form of a spatial lag panel. The tax reaction function is then estimated for the EU15 member states using an instrumental variable approach. Our results point to the presence of small, but significant labour tax competition within the EU15.

JEL Classification: H0, H25, H77

Keywords: tax competition, labour tax, spatial autocorrelation, strategic interactions.

*This research is part of the ANR project MONDES. Financial support by the ANR is gratefully acknowledged

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1 Introduction

In the past, the empirical research on tax competition almost exclusively considered the local or regional policy level (see Brueckner, 2003). In the last ten years, however, an increasing number of studies analyses tax competition between countries, in particular between EU-members. These studies consider the question whether market integration and the removal of barriers to factor mobility has induced EU-members to set tax rates strategically.

In line with the definition of Wilson and Wildasin (2004) of tax competition as "*...non-cooperative tax setting by independent governments under which each government's public choices influence the allocation of a mobile tax base among 'regions' represented by the governments...*" in short "*competition for mobile factors*", empirical research on international tax competition has almost exclusively considered corporate taxation because of the high international mobility of firms (capital) relative to workers. Competition in the taxation of immobile production factors is neglected in almost all theoretical and empirical studies, with Altshuler and Goodspeed(2003) at the empirical and Andersen (2003) at the theoretical level as notable exceptions. We see, however, at least three arguments why the analysis of labour tax competition is important, even if labour is a to a large extent immobile production factor[1].

- While labour may be immobile, because of goods or capital mobility jobs are not. To the extent that jobs' mobility depends on production costs, labour taxation will influence the allocation of jobs through wage costs.

- Corporate taxation represents only a limited share of government revenue in the industrialised countries. Hence, the effects on the level of provision of public goods or on the distortion of the tax structure of a suboptimal level of corporate taxation due to corporate tax competition could be rather small. The welfare consequences of labour tax competition, on the other hand, could be far more considerable given labour tax's weight in government finance.[2]

- Taxation of immobile production factors is seen as the possible synthesis of the "compensation" and the "efficiency" hypotheses concerning globalization and public spending (social security spending in particular). Since Rodrik (1997) the relation between globalization and social protection is considered in terms of two contradicting tendencies. On the one hand, globalization may increase the demand for social spending as

[1] See also Andersen (2003) for similar arguments

[2] In 2007, at the level of the EU15, taxes on labour represented about 45% of total taxation (based on European Commission, 2009)

> compensation for the increased risks of unemployment and income inequality. On the other hand, globalization may constrain the government in raising the necessary funds for social compensation because of increased capital mobility. The "synthesis" of the two hypotheses is therefore a higher taxation of immobile production factors (labour). This synthesis would be obstructed, however, if globalization induces governments to set labour tax rates strategically.

We notice two strands in the literature on the empirical relation between economic integration and tax policy at the national level. The first strand in the literature attempts to estimate tax reaction functions, while the second analyses the effect of globalization, proxied by an openness indicator, on tax receipts or public spending in a reduced form regression framework. This difference almost parallels the distinction in the literature between the analysis of corporate taxation using the reaction function approach (e.g. Bénassy-Quéré et al 2007, Casette and Paty 2008, Davies and Voget 2008, Devereux et al. 2008, Redoano 2007) and the analysis of social protection spending using the globalization impact approach (e.g. Bretscher and Hettich 2002, Dreher 2006, Garrett and Michell 2001, Haufler et al. 2009, Rodrik 1997).

We follow the first approach because of its better theoretical foundation through its link with a structural model of tax competition. Labour tax reaction functions of the EU15 countries are estimated in a spatial econometrics framework. We focus on the EU for three reasons. First, the EU is characterised by an unprecedented and far-reaching economic integration of both goods and capital markets in the last decades (e.g. the Single Market Program). Second, an EU-focus allows for comparison of our results with existing literature that has mainly used EU-data to estimate (corporate) tax reaction functions at the country level. Finally, tax competition and the threat of race-to-the-bottom tax dynamics are intensively debated and thus highly policy-relevant for the EU.

In the next section, we give a brief presentation of the theoretical model from which we derive the hypothesis to be tested. The definition of the elements of the spatial weight matrix in the estimations also follows from our theoretical model. Since Anselin (1988) the importance of a judicious choice of the weighting scheme, in particular its theoretical consistency, has been repeatedly stressed (see e.g. Davies and Voget, 2008). In the third section, we discuss the empirical model specification and the data used for estimation. In the fourth section, the estimation methodology and the estimation results are dealt with. Finally, the fifth section concludes.

2 Theoretical background

To our knowledge, the theoretical literature on (immobile) labour tax competition is quite limited, with Andersen (2003) a one of the exceptions. Because of the lack of a standard theoretical framework in the literature, we develop the analytical model on which our estimations are based in this section.

We consider the possibility of labour tax competition using a standard Dixit-Stiglitz two-country framework with transportation costs in exporting goods and immobile workers and firms, to which we add the assumption of non-clearing labour markets and the possibility of equilibrium unemployment. In this framework, tax competition is intuitively conceivable as follows. Because of unemployment, the government may want to redistribute income by providing unemployment allowances that are financed by a tax on labour. The labour tax affects the wage cost and hence the output prices and the market shares of firms. Firms' market shares determine production and employment. Assuming that the government considers the foreign tax rate as independent from its decisions, it will set a tax rate below the pareto optimum because it does not take into account the implications of its tax decisions for foreign social welfare. This results in strategic complementarity of the tax rates.

More formally, based on Rayp and Vanbergen (2009), we use a modified version of the footloose capital (FC) model of Martin and Rogers (1995) to which we add unemployment via efficiency wages and an optimizing government that provides unemployment benefits. There are two regions, north (N) and south (S), that are symmetric in terms of consumers' tastes, technology, openness to trade and factor supplies. Each region is endowed with a fixed number of immobile consumers L. As is custom in a FC-setting, we assume that each region has half of the worldwide capital endowment (K_W): $s_K = \frac{K}{K_W} = \frac{1}{2}$. The north (south) produces n_N (n_S) units of differentiated goods under increasing returns to scale using a linear technology. Because we consider symmetric regions $n_N = n_S = n$ and hence $s_N = \dfrac{n_N}{n_W} = \dfrac{n_N}{(n_N + n_S)} = \frac{1}{2}$. More specifically, we assume that the production of each variety i requires a fixed amount k $(= 1)$ of capital and a variable unit input requirement involving $\dfrac{1}{a(w_i)}$ units of labour l_i. $a(w_i)$ indicates the worker's effort as function of the wage received. The total output of a firm x_i equals $a(w_i)l_i$ and the total cost function for a variety i is equal to $\pi_i + l_i w_i$, with π_i and w_i respectively are equal to the reward to capital and to labour. The export of goods is inhibited by iceberg type of trade costs which imply that τ (> 1) units have to be shipped to get one unit at destination. Market clearing implies that the total production of a (northern) firm x_N is equal to the sum of the total consumption of its good in the north C_{NN} and total consumption in the south C_{NS} multiplied by the trade costs: $x_N = C_{NN} + \tau C_{NS}$.

2.1 Consumers' choice

The optimization problem for a northern consumer with an expenditure level e who consumes an amount c_i (at the price p_{iN}) of a good i is given by:

$$\max(U) = (\int_0^{n_N+n_S} c_i^{\frac{\sigma-1}{\sigma}} di) \tag{1}$$

$$\text{s.t.} \int_0^{n_N+n_S} p_{iN} c_i di = e.$$

Standard utility maximization and aggregating the j consumers' demand lead to the following result for the northern market demand of a variety i

$$C_{iN} = (\frac{p_{iN}}{P_N})^{-\sigma}(\frac{E_N}{P_N}). \tag{2}$$

where E_N stands for the total northern expenditures and $P_N = (\int_0^{n_N+n_S} p_{iN}^{1-\sigma} di)^{\frac{1}{1-\sigma}}$ is the northern price index.

2.2 Producers' choice

Under the Chamberlinian large group assumption, profit maximization by a northern firm leads to the well-known determination of the price the firm applies in the north (south) p_{NN} (p_{NS}) as a fixed mark-up over marginal labour costs in the north and transportation costs:

$$p_{NN} = \frac{\sigma}{\sigma-1}\frac{w_N}{a(w_N)}, \quad p_{NS} = \frac{\sigma}{\sigma-1}\frac{w_N}{a(w_N)}\tau = \tau p_{NN}. \tag{3}$$

Similar mill pricing applies for the prices charged by southern firms. Based on these expressions, we can work out the (northern) price index:

$$P_N = \alpha\frac{w_S}{a(w_S)}(\frac{\epsilon+\phi}{2})^{\frac{1}{1-\sigma}} = \alpha\frac{w_S}{a(w_S)}\Delta_N^{\frac{1}{1-\sigma}}. \tag{4}$$

with $\alpha = \frac{\sigma}{\sigma-1}n_W^{\frac{1}{1-\sigma}}$. $\phi = \tau^{1-\sigma}$ represents the well-known freeness of trade and $\epsilon = (\frac{w_N/a(w_N)}{w_S/a(w_S)})^{1-\sigma}$ is a function of the relative unit production cost $\frac{w_N/a(w_N)}{w_S/a(w_S)}$. When the north has lower (higher) production costs than the south, ϵ is larger (smaller) than 1. So ϵ can serve as a measure of the competitiveness of the northern region relative to the southern region. We also introduced the short-hand notation[3] Δ_N.

[3]Similarly to Δ_N, we also define $\Delta_S = (\frac{1+\epsilon\phi}{2})$

Next, we determine the sales of a firm in function of the share of expenditures s_E. The total sales of a northern firm S_N equals the sum of its sales in the north ($p_{NN}C_{NN}$) and the south ($p_{NS}C_{NS}$). Using (3) and (2) it is easily derived that the northern sales equals:

$$S_N = \frac{E_W}{n_W}\epsilon\left[\frac{s_E}{\Delta_N} + \frac{\phi(1-s_E)}{\Delta_S}\right] = \frac{E_W}{n_W}B_N, \tag{5}$$

This result and our technology assumption lead to a very simple expression for the northern operating profit $OP_N = S_N - w_N l_N = \frac{E_W}{\sigma n_W}B_N$. Since physical capital is only used in the fixed cost component of industrial production (and $k = 1$), the operating profit of a typical variety is also equal to the reward to capital[4].

$$\pi_N = \frac{E_W}{\sigma n_W}B_N = \frac{E_W}{\sigma n_W}\epsilon\left[\frac{s_E}{\Delta_N} + \frac{\phi(1-s_E)}{\Delta_S}\right]. \tag{6}$$

2.3 Labour market and share of expenditures

We introduce unemployment via an efficiency wage mechanism. In its fair wage form, this hypothesis has been used in recent work to analyse the impact of labour market imperfections on the wage and unemployment effects of international trade (e.g. Kreickemeier and Nelson 2006, Helpman and Grossman 2007) or on economic agglomeration (Egger and Seidel, 2008). Given that worker heterogeneity is not crucial to our analysis, we simplify the analysis by assuming that the delivered effort by a worker is positively related to the difference between the net wage $w_N(1-z_N)$ and some reference wage w_R (Stiglitz, 1976; Summers, 1988):

$$a(w_N) = (w_N(1-z_N) - w_R)^\beta, \tag{7}$$

in which z_N represents the tax rate set by the northern government on gross wages w_N. The strength of the productivity enhancing effect of higher wages is characterized by β and lies between 0 and 1. The reference wage w_R represents the outside option for the worker.

(Northern) Firms determine the wage w_N employees receive by maximizing their profit. The first-order condition resulting from this optimization is the well-known Solow condition (Akerlof and Yellen, 1986) that states that the elasticity of the efficiency function with respect to the wage equals one:

$$\frac{w_N \frac{\partial a(w_N)}{\partial w_N}}{a(w_N)} = 1. \tag{8}$$

The firm keeps hiring additional people as long as the wage per unit of effort is falling.

[4]Southern capital reward equals $\pi_S = \frac{E_W}{\sigma n_W}B_S = \frac{E_W}{\sigma n_W}\left[\frac{\phi s_E}{\Delta_N} + \frac{(1-s_E)}{\Delta_S}\right]$

Substituting (7) in (8) leads to the wage paid to northern employees w_N:

$$w_N = \frac{w_R}{(1-\beta)(1-z_N)}. \tag{9}$$

A similar expression holds for the southern region. Net wages are invariant to tax rates and only depend on the efficiency enhancing effect and the reference wage. Hence, for given reference wages and productivity parameter(s), the competitiveness variable ϵ and the relative product prices will only depend on the tax decisions of the governments and the trade freeness ϕ.

The amount of labour each firm employs is easily derived from the zero pure-profit condition as $l_N = \frac{(\sigma-1)\pi_N}{w_N}$. Assuming that all inhabitants of a region (inelastically) supply labour and confining our analysis to situations where labour supply exceeds demand, we can write the unemployment rate as $u_N = 1 - \frac{nl_N}{L}$, which equals, using the definition of the amount of labour each firm employs l_N and the wage w_N:

$$u_N = 1 - \frac{(\sigma-1)(1-\beta)\frac{n_W}{2}}{Lw_R}(1-z_N)\pi_N. \tag{10}$$

Next, we determine the share of expenditures s_E. There are no savings, which implies that the total expenditures of a region are equal to its total income. We distinguish two components of the regional income: the income of the employed and unemployed, and the total capital reward. The combined (northern) income of labourers and unemployed is equal to $TLR_N = nl_Nw_N(1-z_N)+(L-nl_N)b_N$, in which b_N stands for the northern unemployment benefit. Applying the balanced budget restriction of the government and the expression for the employment level in a northern firm, $l_N = \frac{(\sigma-1)\pi_N}{w_N}$, allows us to rewrite TLR_N in terms of the northern capital reward:

$$TLR_N = nl_Nw_N = (\sigma-1)\frac{n_W}{2}\pi_N. \tag{11}$$

The second component of total regional income is the capital reward that accrues to the residents of a region. Assuming that half of the capital used in each region belongs to the northern capital owners regardless of s_N (this follows Martin and Rogers, 1995), each unit of capital earns the world average reward to capital $ACR_N = \frac{TCR_N+TCR_S}{K_W}$, with $TCR_N = n\pi_N$ ($TCR_S = n\pi_S$) the total northern (southern) capital reward. Substituting the expressions for the capital reward in ACR_N and multiplying this with the total number of units of capital owned by the north, K gives us the following result for total (northern) capital reward:

$$TCR_N = \frac{E_W}{2\sigma}. \tag{12}$$

Given both components of income (or expenditures) in a region and using (6), the share of expenditure is easily derived as:

$$s_E = \frac{TCR + TLR}{E_W} = \frac{1}{2\sigma}(1 + (\sigma - 1)\, B_N). \tag{13}$$

Substituting B_N in (5) and solving for s_E gives a closed-form expression for the northern share of expenditures:

$$s_E = \frac{(\epsilon + \phi)\left((2\sigma - 1)\,\epsilon\phi + 1\right)}{2\left[\sigma\,(\epsilon + \phi)\,(1 + \epsilon\phi) - \epsilon(\sigma - 1)(1 - \phi^2)\right]}. \tag{14}$$

(14) implies that (for given demand elasticity and efficiency wage parameters) the expenditure share will only depend on the tax rates and the trade freeness. Hence, in particular from (6) and (10), it follows that all the variables in the model are determined by the taxation decisions in the two countries and the trade freeness

2.4 Redistribution and tax competition

For simplicity, the amount of taxes is determined by maximizing an ad hoc social welfare function in which the indirect utility of the unemployed is given a relative weight γ. In our model there are two individual sources of (real) income: labour income or unemployment benefits and capital rewards. To simplify the model, we assume that the capital rewards are evenly distributed between each individual whether he or she is employed or unemployed. The (northern) social welfare function becomes:

$$SW_N = (1 - u_N)\left(\frac{w_N(1 - z_N) + ACR_N}{P_N}\right) + \gamma u_N\left(\frac{b_N + ACR_N}{P_N}\right) \tag{15}$$

After substituting the expressions for the northern profit (6), the northern share of expenditures (14), the budget constraint of the government ($u_N b_N = z_N(1 - u_N)w_N$) and ignoring the capital reward part of the indirect utility (since it is a constant), the social welfare function is just a function of the northern and southern tax rate:

$$SW_N = \frac{(1 - u_N)w_N(1 + (\gamma - 1)z_N)}{P_N} \tag{16}$$

After some straightforward transformations, the optimal northern tax rate follows from the first order condition:

$$\frac{\partial SW}{\partial z_N}\Big|_{z_S = cte} = 0 \Leftrightarrow (\gamma - 1) + (1 + (\gamma - 1)z_N)\left(\frac{1}{\pi_N}\frac{\partial \pi_N}{\partial z_N} - \frac{1}{P_N}\frac{\partial P_N}{\partial z_N}\right) = 0, \tag{17}$$

which represents the northern tax reaction function (in implicit form).

In the case of a symmetricum, i.e. two identical regions such that $z_N = z_S$ and hence $\epsilon = 1$, (17) can be solved explicitly:

$$z^* = 1 - \frac{\gamma\left(1-\phi+2\sigma^2\phi\right)}{\left(\gamma-1\right)\left(2+\phi\left(\left(2\sigma-1\right)\left(1+\phi\right)+2\sigma\phi\right)\right)} \tag{18}$$

It can easily be checked that $\frac{\partial z^*}{\partial\gamma} > 0$ (i.e. the optimal tax rate is monotonically increasing in the weight of the unemployed in the social welfare function), but that z^* remains bounded from above: $z^* < 1, 1 < \gamma < \infty$. For a low enough value of γ, z^* is equal to its lower bound: $z^* = 0$.

The slope of the reaction function follows from the total differentiation of (17):

$$\frac{d\left(\frac{\partial SW_N}{\partial z_N}\right)}{dz_S} = \frac{\partial^2 SW_N}{\partial z_N^2}\frac{\partial z_N}{\partial z_S} + \frac{\partial^2 SW_N}{\partial z_N \partial z_S} = 0 \iff \frac{\partial z_N}{\partial z_S} = -\frac{\frac{\partial^2 SW_N}{\partial z_N \partial z_S}}{\frac{\partial^2 SW_N}{\partial z_N^2}} \tag{19}$$

Whether the tax rates are strategic complements or substitutes will depend on the sign of $\frac{\partial z_N}{\partial z_S}$. For the optimal tax rate, z^*, $\frac{\partial^2 SW_N}{\partial z_N^2} < 0$, therefore $sign(\frac{\partial z_N}{\partial z_S}) = sign(\frac{\partial^2 SW_N}{\partial z_N \partial z_S})|_{z=z^*}$. Working out this last cross derivative, it can be shown that[5]:

$$sign(\frac{\partial^2 SW_N}{\partial z_N \partial z_S})|_{z=z^*} = sign\left\{\phi\left[2-\phi-4\sigma\left(1+\sigma\left(1-\sigma\right)+\phi\left(\sigma-1\right)\right)\right]-1\right\} \tag{20}$$

We use (20) to define the function:

$\sigma_T\left(\phi\right), \{\sigma|\ \phi \in [0,1]$ and $\phi\left[2-\phi-4\sigma\left(1+\sigma\left(1-\sigma\right)+\phi\left(\sigma-1\right)\right)\right]-1 = 0\}$.

$\sigma_T\left(\phi\right)$determines a threshold value of the substitution elasticity σ in terms of ϕ, such that:

$$\begin{aligned} \sigma &< \sigma_T \iff sign\left\{\phi\left[2-\phi-4\sigma\left(1+\sigma\left(1-\sigma\right)+\phi\left(\sigma-1\right)\right)\right]-1\right\} < 0 \\ \sigma &> \sigma_T \iff sign\left\{\phi\left[2-\phi-4\sigma\left(1+\sigma\left(1-\sigma\right)+\phi\left(\sigma-1\right)\right)\right]-1\right\} > 0 \end{aligned} \tag{21}$$

$\sigma_T\left(\phi\right)$ defines σ as a non-linear function of ϕ. However, it is possible to show that $\sigma_T\left(\phi\right)$ has only one real root, such that σ_T is uniquely determined. Figure 1 shows the plot of $\sigma_T\left(\phi\right)$ for the interval on which ϕ is defined. Given $\sigma > 1$, we notice that, in general, σ can be below as well as above the threshold value σ_T for each value of ϕ. However, from very

[5]Detailed calculations are available upon request

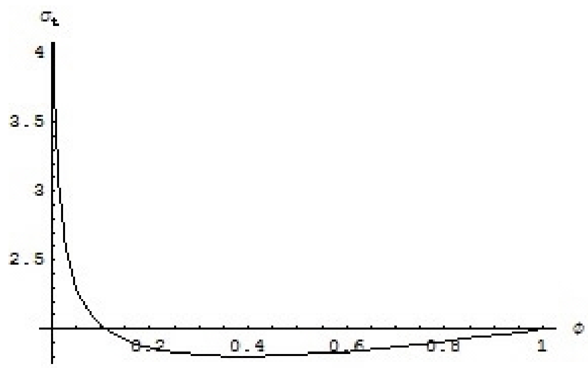

Figure 1: The function $\sigma_T(\phi)$

small values of ϕ (e.g. $\phi = 0.05$), in other words, near-autarky situations, $\sigma_T \approx 2$. This is a value substantially below the commonly assumed (or obtained) values of the substitution elasticity in simulation or empirical studies in the literature. Therefore, in function of the hypothesis to be tested in our analysis, we may expect from this model that, even with very high barriers to trade, $\sigma > \sigma_T$ and hence $\frac{\partial z_N}{\partial z_S} > 0$, i.e. tax competition. We summarize this conclusion in the following proposition.

Proposition 1 *Labour tax rates are strategic complements in a symmetric equilibrium for commonly assumed values of the product elasticity of substitution, with the exception of near-autarky situations.*

3 Empirical methodology and data

3.1 Econometric specification

We obtain an empirical specification from the theoretical model as a first order Taylor expansion at the Nash equilibrium (see Devereux et al., 2008). While the model is defined for the two-country case, the model's prediction will be tested by estimating a tax reaction function for the EU15 countries. Our basic specification (22) further includes control variables that -in addition to strategic interaction among EU15 countries- may affect the equilibrium labour tax rate .

$$z_{i,t} = \beta \sum_{j \neq i} \omega_{ij} z_{j,t} + \theta X_{i,t} + \alpha_i + \epsilon_{i,t} \tag{22}$$

where i and j are a country index and t a time index. ω_{ij} represent the elements of a weight matrix ω and $X_{i,t}$ is a vector of control variables. α_i is a fixed effect that captures country specific time-invariant unobservable determinants such as the Nash equilibrium tax rates or cross-country differences in the relative preference parameter γ. $\epsilon_{i,t}$ is the error term. β and θ are the parameters to be estimated, together with α_i. From the theoretical model, the hypothesis to be tested is $H_0 : \beta \leq 0$, which, in fact, requires a one-sided test.

Based on our reading of the related literature (*cf.* introduction), we choose the following variables as elements of $X_{i,t}$:

- civil employment;

- the young age dependency ratio;

- the old age dependency ratio;

- the size of the public sector (share of government expenditure in GDP or share of public in total employment);

- the country share in the OECD GDP (as an indicator of size);

- the country's GDP per capita;

- the real growth rate of GDP (in purchasing power parities);

- the public debt to GDP ratio;

- the openness rate with respect to the rest of the world (i.e. non-EU15), in terms of GDP

The public debt to GDP ratio controls for the balanced budget assumption in the model. The openness rate with respect to non-EU15 countries controls for possible spurious cross-country correlation between labour tax rates due to common trends in tax policy as a consequence of world economic integration.

Anselin (1988) stresses the crucial importance of a judicious choice of the weighting scheme for spatially correlated variables because misspecified weight matrices may yield biased results. Therefore, like Davies and Voget (2008), our weighting scheme of foreign tax rates builds on the theory that supports the empirical specification. Following the theoretical model in the previous section the weights are determined by trade freeness, i.e. the distance between the countries and barriers to trade. As a proxy for the first, we take distances between major cities. As a simple and exogenous way to account for barriers to trade (or economic integration) we opt for the number of year of common membership of the EU, rather than e.g. for trade intensity, which is more subject to endogeneity. With these two components, we construct four (row normalised) weight matrices with typical elements:

$$\omega_{ij,1} = \frac{\frac{1}{d_{ij}}}{\sum_j \frac{1}{d_{ij}}}; \qquad \omega_{ij,2} = \frac{\left(\frac{1}{d_{ij}}\right)^2}{\sum_j \left(\frac{1}{d_{ij}}\right)^2};$$

$$\omega_{ij,3} = \frac{\frac{\min_{ij}(\#EU_i,\#EU_j)}{d_{ij}}}{\sum_j \frac{\min_{ij}(\#EU_i,\#EU_j)}{d_{ij}}}; \qquad \omega_{ij,4} = \frac{\left(\frac{\min_{ij}(\#EU_i,\#EU_j)}{d_{ij}}\right)^2}{\sum_j \left(\frac{\min_{ij}(\#EU_i,\#EU_j)}{d_{ij}}\right)^2} \tag{23}$$

where d_{ij} denotes the bilateral distance between country i and j, and $\#EU_i$ the number of years country i has been member of the EU.

3.2 Data

3.2.1 Tax rate data

To identify the data sources for labour taxation, we draw a comparison with the sources used in corporate tax analysis. Obviously statutory tax rates cannot be used because of the progressivity of most labour tax schemes. With respect to corporate tax rates an implicit tax rate is often used as a proxy (e.g. total amount of taxes related to a macroeconomic aggregate that resembles the tax base as closely as possible). This can be straightforwardly extended to labour taxation as well. Implicit tax rates have the advantage that they take into account the full set of characteristics of the tax system and include information on the tax rate as well as on the tax base. However, the macroeconomic aggregate to which the tax receipts are related may deviate substantially from the actual tax base. Moreover, all economic influences that do not affect tax receipts and the tax base proportionally, e.g. business cycle effects or changes in the income structure, will translate into changes in the implicit tax rate without changes in taxation rules. Therefore the underlying true tax scheme and its dynamics is likely to be measured with a considerable error. Mendoza et al. (1994) is a frequently used source for implicit tax rates. For the EU countries, however, more recent data according to the same methodology are available from European Commission (2009) for the period 1995-2007.

An alternative to the use of implicit tax rates is the calculation of effective tax wedge rates. This is done by applying the taxation rules of the different countries to a given income in a specific situation. Since the tax rates are determined from the tax amount one is due from a given income and personal situation, they better reflect the microeconomic characteristics of the tax systems across countries. Their variation is also more likely to be determined by changes in taxation rules. However, effective tax wedges require that specific

	1995	2000	2005	2007
Austria	38.5	40.1	40.8	41.0
Belgium	43.8	43.9	43.8	42.3
Germany	39.4	40.7	38.8	39.0
Denmark	40.2	41.0	37.1	37.0
Spain	29.0	28.7	30.3	31.6
Finland	44.3	44.1	41.5	41.4
France	41.2	42.1	41.9	41.3
United Kingdom	25.7	25.3	25.5	26.1
Greece	38.6	37.8	34.1	33.8
Ireland	29.7	28.5	25.4	25.7
Italy	38.0	43.7	42.9	44.0
the Netherlands	34.6	34.5	31.6	34.3
Portugal	26.5	27.0	28.1	30.0
Sweden	46.8	47.2	45.0	43.1
Average	**36.9**	**37.5**	**36.2**	**36.5**

Source: European Commission (2009)

Table 1: Implicit tax rates, averages14 EU countries 1995-2007

assumptions are made regarding a set of parameters that is needed to compute the tax amount. Therefore, they are only calculated for a limited number of standard situations and do not take all possible information into account. In this sense their representativeness is not warranted. For corporate taxation, it is sometimes argued that considering a common set of parameters across countries is misleading because profit maximising firms will optimise the financial characteristics of their investment projects to the tax rules in each country. The finance structure of an investment project will then be endogenous to the tax scheme. In case of labour taxation, however, this is less of an issue given the limited scope to adjust the revenue structure to the tax scheme.

For our empirical work we prefer effective tax wedge rates over implicit rates as indicator of labour tax rates because their main source of variation is more certain to be exogenous to the tax scheme (changes). In collaboration with national tax administrations the OECD calculates effective tax wedges of labour income since 1979. These data are available in the OECDs Taxing Wages database. Because of a recent change of the reference income, there is a series of effective tax wedges according to the 'old' definition that are available for 14 of the EU15 countries from 1979 to 2004. In the old definition, the average income of a blue collar worker is taken as reference income. Two effective tax wedges are computed based on this reference income: i) for a single person without children and ii) for a married wedges

	1979	1989	1995	2000	2004
Austria	28.5	30.7	34.2	37.2	36.8
Belgium	40.3	44.7	48.3	48.4	44.9
Germany	35.7	39.7	43.8	42.6	41.5
Denmark	35.8	39.5	38.1	37.7	35.7
Spain	34.2	33.7	35.9	34.1	34.8
Finland	37.0	40.5	46.7	43.6	40.3
France			44.3	44.0	43.2
United Kingdom	30.6	29.6	29.8	25.8	24.6
Greece	17.4	32.9	35.3	36.0	34.9
Ireland	27.1	35.3	31.9	22.2	14.9
Italy	43.1	47.5	47.6	41.6	41.0
the Netherlands	43.7	42.9	39.9	40.3	38.9
Portugal	26.2	30.2	30.2	29.9	27.5
Sweden	46.6	49.1	45.8	46.0	44.6
Average	**34.3**	**38.2**	**39.4**	**37.8**	**36.0**

3.pdf **Source:** OECD, Taxing Wages

Table 2: Effective tax wedges (old definition), averages14 EU countries 1979-2004

couple with two children having the reference earnings. There is also a series of effective tax wedges according to a new definition that is available for all the EU15 countries. These data are, however, only available for a limited period, i.e. 2000-2008. The new definition of the reference income is the average earnings of an employee in the private business sector, based on which eight tax wedges are determined depending on family and income situation. For our econometric analysis we take the data for which the longest time series is available, i.e. 'old' definition effective tax wedges. As a proxy for the average national effective tax wedge, we use the simple arithmetic mean of the effective tax wedges by family type.

Tables(1) and (2) provide an overview of the values of the implicit labour tax rates and the effective labour tax wedges for the EU15 countries (except Luxemburg). For most countries the levels of both variables match to a reasonable extent. Presumably in part because of the relatively short time span (only 13 years), the implicit tax rates seem rather stable. The effective labour tax wedges, on the other hand, follow an inverse U-shaped pattern for the majority of countries. They increase from 1979 to the mid 1990s, after which a more moderate fall to levels still superior to those of the early 1980s sets in. The United Kingdom is an exception to this pattern and is characterised by a steady fall in the labour tax wedge since 1979. The average correlation between the implicit tax rates and the effective tax wedges by country is, as could be expected, positive yet rather low (0.30). This correlation could obviously be biased by the limited number of common years (only 10) for which the variables are available. Nevertheless the fact that the correlation pattern by country varies from strongly positive over near zero to strongly negative induces one to question whether these indicators measure the same underlying variable. Given the possible drawbacks of the implicit rates discussed above, this strengthens our preference of effective tax wedge rates over implicit rates as indicator of labour tax rates.

3.2.2 Data of the control variables

Empirical data for most control variables are taken from the following OECD databases: the National Accounts database (share in the OECD GDP, the GDP per capita and the share of public expenditure in GDP), the Labour Force Survey database (the activity ratio, the young and old age dependency ration and the share of public employment) and the Economic Outlook database (public debt, proxied by the general government gross financial liabilities). Openness with respect to the rest of the world was determined from the International Trade by Commodities Statistics database, also from the OECD. The real GDP growth rate was retrieved from the Penn World Tables.

In the appendix we include the correlation matrix of the independent variables. Overall, collinearity between the variables is fairly small, except for the old and young age dependency ratio of which the correlation is -0.78. Given their status as control variables in the empirical specification, we do not try to correct for this multicollinearity.

3.3 Estimation issues

Spatial interaction effects are typically included in an empirical model at the level of the explanatory variables (by extending the set of determinants with the spatially lagged dependent variable), at the level of the residual error term, or even at both the level of the explanatory variables and the error term (the general spatial model). Since the estimation of the general spatial model in a panel data framework is still in its first stages[6], an assumption has to be made at which level spatial autocorrelation may occur. Given that we derived our empirical specification in (22) from a theoretical model as a tax reaction function that includes a spatially lagged dependent variable, we opt for the estimation of a spatial lag model.

In a panel data framework, the spatial effects are combined with another component of cross-sectional or spatial heterogeneity, which is typically modelled as a fixed or random component of the error term, specific for each observation unit. From the theoretical model,

[6] See Lee and Yu (2010) and Mutl and Pfaffermayer (2008) for recent contributions

unobserved country heterogeneity can be linked to differences in inequality aversion (γ) or the Nash equilibrium tax rate, which are intuitively likely to be fixed components, correlated with the explanatory variables included in the model. In addition, Elhorst (2009) questions the appropriateness of the random effects specification in a framework with spatial interaction. In the commonly considered spatial sample design the population units (i.e. regions, states, countries,...) are more or less sampled exhaustively and they are not straightforwardly representative for a larger population. Almost by definition, spatial units are fixed and inference is conditional on the observed units.

There are two main approaches to estimate a model with spatial correlation: an approach based on the principle of maximum likelihood (ML) or an instrumental variable (IV) approach. It is difficult to determine the approach that is to be preferred over the other. Elhorst (2009) mentions that there are indications that the ML-approach of the spatial lag model (weakly) outperforms the IV-approach, be it in a panel framework without other sources of cross sectional heterogeneity (random or fixed effects). However, the ML-estimates may be less consistent than the IV-estimates when the spatial interaction effects are rather small. In addition, the ML-estimation assumes normality and homoscedasticity of the error term. Given that we can expect the presence of heteroscedasticity in the error term and anticipating an at most fairly weak spatial interaction effect, we estimate the model by IV. Estimating a panel spatial lag model by an instrumental variable approach is a straightforward extension of the cross-section panel IV-model, using the spatially lagged explanatory variables as instruments (Anselin et al., 2006). In this approach a heteroscedasticity and autocorrelation consistent estimate of the error variance-covariance matrix can be obtained in the lines of White (1980) and Newey and West (1987). This allows to take account of spatial dependence in the error term in a non-parametric way and can as such constitute an alternative for a spatial error modellisation (see Anselin, 2006), which, in addition, moderates the consequences of the a priori assignment of the spatial interaction effect to the level of the explanatory variable, indicated above.

3.4 Results

We estimated equation (22) using effective tax wedges, based on the old reference wage (the average earnings of a blue collar worker in the manufacturing sector), for the EU15 countries, with the exception of France and Luxemburg, in the period 1979-2004. Because initially the effective tax wedges were computed only every two years, we used biennial data for the whole period. In this way, we obtained a balanced panel of 13 observations in time for 13 countries.

The empirical model was estimated using two sets of instruments for the spatially lagged

	Spatial Weights							
	ωij,1		ωij,2		ωij,3		ωij,4	
Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
W*Y	0.34 **	0.15	0.16 **	0.07	0.27 **	0.13	0.15 **	0.07
Civil employment	0.06	0.11	0.06	0.11	0.06	0.11	0.05	0.11
Old age dep.ratio	-0.71 **	0.30	-0.73 **	0.31	-0.72 **	0.30	-0.74 **	0.31
Young age dep. ratio	-0.02	0.17	-0.03	0.18	-0.03	0.18	-0.04	0.18
Share public employment	33.84 ***	10.21	34.07 ***	10.15	33.65 ***	10.3	33.75 ***	10.2
GDP per capita	-0.49 ***	0.09	-0.48 ***	0.09	-0.46 ***	0.09	-0.47 ***	0.09
Share GDP OECD	76.83	52.14	82.1	52.79	75.68	51.85	80.78	51.89
Growth rate GDP	-4.61	12.89	-3.58	13.29	-5.14	12.86	-3.96	13.26
Public debt ratio	0.14 ***	0.02	0.14 ***	0.02	0.14 ***	0.02	0.14 ***	0.02
Openness ROW	23.84 ***	4.87	22.63 ***	4.82	22.6 ***	4.87	22.02 ***	4.84
Number of obs	169		169		169		169	
Number of countries	13		13		13		13	
F(10,146)	19.38 ***		19.18 ***		18.95 ***		18.85 ***	
R^2	0.66		0.66		0.66		0.65	
Underidentification test (Kleinbergen-Paap rk LM)	71.35 ***		72.84 ***		70.60 ***		74.21 ***	
Weak identification test (Kleinbergen-Paap rk Wald F)	104.59 ***		113.42 ***		129.25 ***		97.9 ***	
Hansen J statistic	9.67		11.5		11.60		12.53	

*, **, and *** indicate significance at the 10%, 5%, and 1% level

Table 3: Estimation Results for Effective Tax Wedges, 13 Countries, 1979-2004

dependent variable WY: i) a set consisting of the one time spatially lagged explanatory variables, WX, and ii) a more extended set of instruments composed of the one and two times spatially lagged explanatory variables, WX and W^2X. Since the estimation results for the two sets of instrumental variables differ only marginally, we only report the estimation results for the most parsimonious set of instruments. The empirical model is estimated for the four different definitions of the spatial weight matrix in (23), i.e. $\omega_{ij,1}$, $\omega_{ij,2}$, $\omega_{ij,3}$ and $\omega_{ij,4}$. Table 3 reports the results of these estimations, column headings indicate the definition of the spatial weight matrix used for the estimation. All estimations include country specific effects that are not reported.

For all estimations the instruments seem appropriate in the sense that underidentification and weak identification is rejected (the test statistics being significant), whereas the Hansen test for the validity of overidentifying restrictions is not. The spatial interaction term is positive and significant, in particular given that for the null hypothesis regarding the tax competition effect the one-sided test values are relevant. To the extent that unambiguous theoretical expectations can be formulated, most explanatory variables have the expected sign (i.e. the size of the public sector, the country's share in the OECD GDP and the size of public debt). The coefficient of the old age dependency ratio, which is significantly

Variable	Coefficient		SE
W*Y	0.27		0.40
Civil employment	0.04		0.12
Old age dep.ratio	-0.67	**	0.30
Young age dep. ratio	-0.03		0.17
Share public employment	30.57	***	10.53
GDP per capita	-0.46	***	0.09
Share GDP OECD	74.4		47.96
Growth rate GDP	-9.63		12.97
Public debt ratio	0.14	***	0.17
Openness ROW	23.60	***	4.92
Number of obs	169		
Number of countries	13		
F(10,146)	19.76	***	
R^2	0.65		
Underidentification test (Kleinbergen-Paap rk LM)	61.47	***	
Weak identification test (Kleinbergen-Paap rk Wald F)	53.58	***	
Hansen J statistic	21.66	***	

*, **, and *** indicate significance at the 10%, 5%, and 1% level

Table 4: Estimation Results for Effective Tax Wedges, Homogenous Weights, 13 Countries, 1979-2004

negative, is the most important exception. A similar result is found is some recent estimations of corporate tax competition (see Devereux et al., 2008, and Davis and Voget, 2010). It could indicate that countries react to population ageing by lowering the labour tax rate to encourage people to work.

The positive and significant effect of the spatial interaction term indicates that the labour tax rates of the considered EU15 countries are strategic complements and suggests the presence of labour tax competition. From our estimations, the expected direct effect varies between 0.15 and 0.34, i.e. an average labour tax rate increase of 1 percentage point in the EU15, induces a single country (directly) to increase its tax rate with 0.2 to 0.3 percentage points. Hence, though significant and positive, the tax interaction effect does not seem very strong (which also motivated our choice for IV-estimation rather than ML).

We further explore to what extent we are able to identify the spatial lag mechanism as an economic integration interaction effect. To this aim we verify if the data are consistent with an alternative explanation of the spatial lag effect, namely yardstick competition or common intellectual trends. In line with the literature (see e.g. Devereux et al., 2008), this is done by re-estimating the model with a spatial weight matrix with uniform elements ($\omega_{ij} = \dfrac{1}{(N-1)}$). Table 4 reports the results of the IV-estimation of this model with the effective tax wedges as

	Spatial Weights							
	ωij,1		ωij,2		ωij,3		ωij,4	
Variable	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**	**Coefficient**	**SE**
W*Y	-0.04	0.11	-0.02	0.04	-0.10	0.1	-0.03	0.04
Civil employment	0.37 ***	0.06	0.37 ***	0.05	0.37 ***	0.06	0.37 ***	0.06
Old age dep.ratio	-0.90 ***	0.23	-0.90 **	0.23	-0.90 ***	0.23	-0.90 ***	0.22
Young age dep. ratio	-0.47 **	0.21	-0.47 **	0.21	-0.48 **	0.22	-0.48 **	0.21
Share public expenditure	0.01 ***	0.00	0.01 ***	0.00	-0.01 ***	0.00	0.01 ***	0.00
GDP per capita	-0.52 ***	0.09	-0.52 ***	0.09	-0.51 ***	0.09	-0.51 ***	0.09
Share GDP OECD	-62.63 ***	19.15	-61.75 ***	19.58	-59.15 ***	20.36	-60.53 ***	20.02
Growth rate GDP	-0.01	0.07	-0.01	0.06	-0.004	0.07	-0.01	0.07
Public debt ratio	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
Openness ROW	11.18 ***	2.54	11.18 ***	2.53	11.22 ***	2.56	11.19 ***	2.53
Number of obs	182		182		182		182	
Number of countries	14		14		14		14	
F(10,158)	19.76 ***		19.95 ***		18.95 ***		20.16 ***	
R^2	0.44		0.44		0.43		0.44	
Underidentification test (Kleinbergen-Paap rk LM)	50.72 ***		56.25 ***		48.20 ***		53.41 ***	
Weak identification test (Kleinbergen-Paap rk Wald F)	26.95 ***		66.75 ***		31.71 ***		56.58 ***	
Hansen J statistic	5.32		6.04		5.21		7.11	

*, **, and *** indicate significance at the 10%, 5%, and 1% level

Table 5: Estimation Results for Implicit Tax Rates, 14 Countries, 1995-2007

dependent variable. Estimation results are very similar to those with bilateral distance (and number of years of common EU membership) as elements of the weight matrix, except for the coefficient of the spatial lag which is not significantly different from zero. This suggests that it is unlikely that the observed spatial interaction in labour tax rates can be explained by common trends or yardstick competition.

In addition to the estimation of (22) using effective tax wedges as data for the labour tax rates, we estimated the model using implicit tax rates as data for the dependent variable. With these data a balanced panel was constructed for 14 countries (EU15 less Luxemburg) and 13 years (the period 1995 to 2007). We report in Table 5 the results of the estimations, again for the four possible definitions of the weight matrix that we distinguished and using the same sets of instruments (either WX or the combination of WX and W^2X).

The tests of underidentification and weak identifcation, as well as the test using the overidentifying restriction (Hansen J-test) indicate that the instruments used in these estimations can be considered as adequate. The coefficient estimates vary substantially, however, compared to estimates using effective tax wedges as dependent variable. The spatial interaction effect turns insignificant, whereas almost all the control variables included are significant, the public debt to GDP ratio being the surprising exception. Furthermore, except for the public sector size (proxied by the share of public expenditures in GDP), the sign of the coefficients of the significant control variables runs counter to theoretical expectations and common findings in the literature. All in all, it seems likely that these results for the implicit tax rate definition suffer from its endogeneity to economic determinants which are unrelated to the taxation system, economic business cycle effects in particular.

4 Conclusion

In recent years an increasing number of studies has analysed corporate tax competition between countries, in particular between EU-countries. In this paper we investigate to what extent tax competition at the national level may also occur for an immobile production factor, labour in particular.

We derive a tax rate reaction function from a two-country model with transportation costs in which unemployment is allowed for due to an efficiency wage mechanism. In our model a national welfare maximising government is able to redistribute income between the employed and the unemployed. This is financed by a tax on labour. Bringing the model to the data, we estimate the labour tax reaction function of EU15-countries and test for the significance of a positive spatial lag effect. The estimation of a tax reaction function implies a judicious choice of both the tax rate variable and the weighting scheme for the construction of the spatially lagged tax rate. As regards the former, our preferred data source is the taxing wages data of the OECD. As regards the latter, we choose weight matrices with elements that -in line with the theoretical model- are based on bilateral distance and a simple, but fairly exogenous indication of economic integration: the number of common years of EU membership. Our analysis reveals a significant and positive strategic interaction in labour tax rates. By varying the weighting scheme of the spatial lag matrix, we find no indications for alternative causal mechanisms, like yardstick competition or common trends. Though the value of the estimated coefficient suggests that the spatial interaction effect is rather small, we conclude that there are indications that EU-countries take strategic considerations into account when setting their labour taxes.

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Appendix

	Civil employment	Youg age depency ratio	Old age depency ratio	Share ublic employme	GDP per capita	Share GDP OECD	Growth rate GDP	Public debt ratio
Young age dep ratio	0.375							
Old age dep ratio	-0.196	-0.779						
Share public employment	0.568	0.423	-0.274					
GDP per capita	-0.066	0.296	-0.358	-0.053				
Share GDP OECD	0.387	0.496	-0.553	0.612	0.128			
Growth rate GDP	-0.081	-0.212	0.131	-0.011	-0.162	-0.022		
Public debt ratio	-0.353	0.182	-0.145	0.208	-0.150	0.156	0.159	
Openess ROW	0.008	-0.312	0.253	0.341	-0.147	0.348	0.276	0.214

Table 6: Correlation matrix