Is International Tax Competition Only about Taxes? A Market-Based Perspective

Abstract

This paper revisits tax competition among governments for foreign direct investment (FDI) by considering the role played by the economic dynamism of competitors on the setting of corporate tax rates (CTRs). Using a database with worldwide coverage over the period 1995-2014, we find that strong growth performance of neighbouring countries is associated with a lower CTR, especially in developed countries. This spatial effect is particularly manifest if competing countries are large and open to capital flows. These results appear to hold in most regions of the world and suggest that governments perceive foreign economic dynamism as a threat, leading them to reduce their CTRs to maintain their FDI attractiveness.

Keywords: tax competition, country size, foreign direct investment, developing countries, free-trade zones, spatial lag.

JEL classification: E62; F23; H25.

1 Introduction

Corporate income tax rates (CTRs) have fallen substantially worldwide over the past decades. Between 1995 and 2015, the median (top marginal) statutory tax rate in both developed and developing countries declined by nearly one-third, from about 35% to 24%. Researchers on European and OECD economies attribute this shift towards lower taxes on profits to tax competition between countries eager to retain and attract capital, notably foreign direct investment (FDI), in an increasingly integrated world economy (Devereux et al., 2008; Davies and Voget, 2008; Overesch and Rincke, 2011; Redoano, 2014). This trend is likely to persist as special regimes (e.g. patent box, interest reductions, ruling arrangements) are discouraged by the OECD Base Erosion and Profit Shifting project adopted by over 130 collaborating countries, progressively leaving CTR cutting as the only tool to attract FDI.[1] The aim of this paper is to contribute to a better understanding of the drivers of international tax competition. The existing empirical research investigates this issue by testing whether a country's CTR is partly determined by the CTR of other countries. In doing so, this literature finds substantial evidence for the existence of strategic interactions between governments. For example, the seminal paper of Devereux et al. (2008), which focuses on 21 OECD countries for the period 1982-1999, shows that countries open to capital flows compete over their CTRs, but not over their effective marginal tax rates.[2] This strand of research has strongly improved our understanding of tax competition. However, it neglects a key insight from the recent theoretical tax competition literature: that relative market size should also matter.

Recent tax competition models acknowledge that countries are not symmetric. A country with a large market can afford to impose a higher CTR than a smaller country because it offers a more attractive environment due to its larger market (Haufler and Wooton, 1999, 2010) and agglomeration economies (Baldwin and Krugman, 2004; Ottaviano and Ypersele, 2005).[3] These models suggest, in a world where FDI tends to be market-seeking, that a government ought to perceive, all other things equal, faster growth in neighbouring countries as a threat, leading it to adjust downward its CTR to maintain its attractiveness for FDI. The first contribution of this paper is to investigate empirically the relevance of this theoretical proposition, by considering market-based (indirect) tax competition as another spatial determinant of CTRs. More precisely, we estimate a spatial dynamic fixed effects model with country-specific trends in which we take into account not only the weighted average of for-

[1] Among OECD countries, the United States, Hungary, Italy, Belgium, Luxembourg, Norway, France, Israel, Slovakia, Greece, United Kingdom, Sweden, and Japan have decreased their CTR between 2015 and 2019. See `https://home.kpmg/xx/en/home/services/tax/tax-tools-and-resources/tax-rates-online/corporate-tax-rates-table.html`

[2] A 1 percentage point fall in the weighted average CTR in other (open) countries reduces the tax rate in the home country by about 0.60-0.70 percentage point. Using a dynamic model, Overesch and Rincke (2011) find a similar long-run effect. Davies and Voget (2008) and Redoano (2014) highlight that this large effect mainly applies to tax competition for FDI involving European Union (EU) members, due to lower costs of cross-border FDI for and towards EU countries.

[3] Some empirical works, e.g. Bénassy-Quéré et al. (2005) and Azémar and Delios (2008), find evidence that small countries have to charge a lower CTR than a larger country to attract FDI. Brülhart and Schmidheiny (2015) also show that agglomeration economies reduce the impact of CTR differences across Swiss munipalities.

eign CTRs but also the weighted average of foreign GDPs. Given the nature of our econometric model, we investigate in practice whether CTRs are influenced by out-of-trend foreign growth performance.

While tax competition amongst developed countries has been investigated in a large number of papers, the same cannot be said in the case of developing countries.[4] This is a puzzling omission given that CTRs in these countries have also strongly fallen in the last decade. Our second contribution to the literature is to shed light on the extent of tax competition in the developing regions of the world. Using a variety of sources, we have created a database of statutory CTRs covering a large number of developed and developing countries for the period 1995-2014. Our largest sample includes 38 EU-OECD countries and 76 other countries. This is a significant improvement on databases used previously.[5] We look at tax competition within geographical regions as well as within free-trade zones, given that regional economic integration ought to be stronger in such sub-sets of countries. To the best of our knowledge, we are the first study to comprehensively look at strategic interactions between governments of developing countries.[6]

Our key result is that CTRs are lower when the growth performance of geographically close countries is particularly strong. This relationship is especially robust in EU and OECD countries and in several developing regions. Further investigations indicate that this market-based spatial effect is stronger if neighbouring countries are developed, large, and open to capital flows. In contrast to previous research, we have not found strong statistical evidence of direct competition over CTRs, although our econometric approach and period of investigation may prevent us from identifying this. All in all, and in agreement with asymmetry-based tax competition models (Haufler and Wooton, 1999, 2010), our results suggest that market-based considerations of relative international attractiveness is a driver of tax competition for FDI.

The paper is organised as follows. Section 2 discusses the tax competition literature, with an emphasis on models dealing with asymmetric market size. Section 3 describes our spatial econometric approach and the data. Section 4 presents our results and provides an overall interpretation. Finally, Section 5 concludes the paper.

[4]Increasing attention is being paid to the tax systems of developing countries. Keen and Simone (2004), Keen and Mansour (2010), Abbas and Klemm (2013), and Abramovsky et al. (2014) compare the corporate tax regimes of emerging and developing countries to those of developed economies. They show that both systems have tended to converge over time, with a decline in CTRs combined with a stable or larger tax base (except for Sub Saharan Africa, which has experienced a narrowing of the tax base).

[5]Devereux et al. (2008), Davies and Voget (2008), Overesch and Rincke (2011), and Redoano (2014) consider between 17 and 37 (mostly) OECD countries. The period of analysis goes up to 1999 for Devereux et al. (2008) and Redoano (2014), and up to 2005-2006 for Davies and Voget (2008) and Overesch and Rincke (2011).

[6]Crivelli et al. (2015) estimate government response to foreign CTRs within two groups of countries (between 29 OECD countries and between 102 non-OECD countries) over the period 1980-2013. Klemm and Parys (2012) estimate the fiscal reactions of 37 countries from Africa, Latin America and the Caribbean, over the period 1985-2004. Pulling together developing countries from different regions, both studies find evidence of regional tax competition using spatial weights based on GDP (Crivelli et al., 2015) or the inverse geographic distance (Klemm and Parys, 2012).

2 Corporate Tax Rates and Market-Based Relative Attractiveness

The existing literature on tax competition is vast and is not comprehensively surveyed in this section. Rather, our discussion focuses on one aspect of this literature: the role of *relative* market size, resulting from asymmetric country sizes, as a determinant of CTRs. We start with basic tax competition models, which emerged in the late 1980s, as they illustrate the outcome of tax competition with symmetry. Then, we turn to models relaxing this assumption and discuss their testable predictions.

2.1 Symmetric tax-competition models

The earliest formal models of capital tax competition are those of Zodrow and Mieszkowski (1986) and Wilson (1986), where a large number of identical, small, open countries choose their tax rates on capital. This decision is reached in a set-up where competitive firms produce a single output using two factors of production: capital, which is perfectly mobile between countries; and labour (or land), which is immobile. With small, open economies and perfectly mobile capital, any individual country has a negligible influence on the after-tax return to capital. Consequently, each country has an incentive to reduce its capital tax rate in order to induce an inflow of capital. This leads to a 'race to the bottom' whereby countries undercut each other's taxes in an attempt to attract capital, to the point where the gains from the investment are entirely captured by the owners of the capital. This theoretical framework is the starting point of a large strand of the empirical tax competition literature, such as Devereux et al. (2008).

2.2 Asymmetric tax-competition models

Market access

Haufler and Wooton (1999) relax the key assumption of identical competing countries. They analyse tax competition between two countries of unequal size trying to attract a foreign-owned monopolist in the presence of trade costs. The introduction of trade costs in the set-up together with differences in the sizes of countries gives rise to a location-specific rent that the firm can earn in the country with the larger market. If there is a sufficiently large difference in the sizes of the two markets, the larger country can attract the FDI despite charging a positive tax, since trade costs generate a location advantage due to better market access.[7] In addition, Haufler and Wooton (2010) show that while lower trade costs reduce the disadvantage that a firm has from locating in the smaller market, they also increase competitive pressures relatively more in the smaller country,

[7]When two countries have a large market-size asymmetry, a similar result is obtained by Ferrett and Wooton (2010) where both countries compete for a duopoly, and by Haufler and Wooton (2010) where both countries compete for an oligopoly. With the oligopoly model, the optimal tax rate is a U-shape function of trade costs, with the larger country imposing a higher tax rate than the smaller country at each level of trade costs. Even within the symmetric equilibrium, positive tax rates are possible in both the duopoly and oligopoly models.

as firms from neighbouring countries become closer competitors. Their analysis suggests that this second effect dominates and that economic integration increases the attractiveness of the larger country.

Overall, this market-access literature highlights that CTRs depend on the *relative* market size of a country, i.e. its size relative to that of neighbouring countries. Larger countries can set higher CTRs than smaller countries but differences in inter-country taxation will fall if the asymmetry in market size declines.

Agglomeration and market potential

In models combining tax competition and new economic geography (NEG), agglomeration externalities generate a location-specific rent.[8] In the presence of trade costs, when two countries differ in size, firms have an incentive to locate in the larger market. Using a core-periphery structure where population is the only asymmetry introduced in the model, Ludema and Wooton (2000), Kind and Schjelderup (2000), Andersson and Forslid (2003), Baldwin and Krugman (2004), and Ottaviano and Ypersele (2005) show that the rent generated by agglomeration can be taxed without inducing a relocation of economic activity.[9]

A key difference with the market-access literature is that NEG models using a core-periphery structure (e.g. Baldwin and Krugman (2004)) do not necessarily generate the prediction that a fall in relative market size is associated with a compensating CTR cut. A country which has initially been able to attract FDI may benefit from being surrounded by fast-growing economies, as firms can benefit from both agglomeration forces and a larger market potential (domestic consumption and exports). From a slightly different perspective, an initially small and unattractive country can start attracting FDI if its growing market potential, combined with a cost advantage, allows it to become an export-platform.

FDI motives

The market-access and NEG literatures can diverge in their theoretical predictions regarding the impact of relative market size on the level of corporate taxation. A discriminating factor is the objective of the multinational enterprise in undertaking FDI. So-called 'horizontal' FDI is motivated by sales to the local market whereas 'export-platform' FDI is motivated by sales to nearby countries. In a world dominated by horizontal FDI, the market-access literature is more relevant and, from a policymaker perspective, foreign economic dynamism is likely to be perceived as a threat. On the other hand, in a world where export-platform FDI prevails, the NEG literature becomes pertinent and a government may then perceive foreign economic dynamism as an

[8] Agglomeration externalities stem from the dynamics created by the demand and supply linkages (Forslid, 2005). The combination of better market access with expenditure shifting (demand for intermediate inputs and labour moving with firms) corresponds to the demand linkage of agglomeration forces. The supply linkage corresponds to lower costs of production generally associated with the fact that firms locate near each other (due for instance to knowledge spillovers and input-sharing).

[9] In order to simplify the dynamics and avoid circular causality, the supply linkages and expenditures shifting are absent from those models. See Forslid (2005) for a very good discussion of tax competition and agglomeration.

asset. In practice, the vast empirical literature on FDI suggests that domestic market size is the most important determinant (Blonigen and Piger, 2014). The importance of horizontal FDI is corroborated by the summary statistics of Bilir et al. (2019). They report that the typical U.S. foreign affiliate primarily sells to the local market rather than to the home or third-countries (74% of total sales vs. 7% and 20%, respectively).[10] Hence, the predictions of the market-access literature are more likely to hold.

On the basis of this selective review of the theoretical literature, we expect a **negative net impact of relative market size on CTRs**, although this relationship may change depending on the region and countries in the sample being considered.

3 Econometric approach and data

3.1 Spatial econometric models

The tax competition literature, including the extension that we propose, fundamentally rests upon the concept of spatial dependence.[11] The standard econometric model that is used is a spatial autoregressive (SAR) model in which the CTR is assumed to be influenced by its spatial lag (i.e. the CTR of other countries):

$$\tau_{it} = \alpha_i + \rho \sum_{j=1}^{n} w_{ij}\tau_{jt} + X_{it}\beta + \Gamma_{it} + \epsilon_{it}, \tag{1}$$

where τ_{it} denotes the corporate income tax rate of country i at period t, $\sum_{j=1}^{n} w_{ij}\tau_{jt}$ is a measure of 'average' CTRs in other countries, X_{it} represents a vector of control variables, α_i corresponds to country fixed effects, Γ_{it} are country-specific time trends, and $\epsilon_{i,t}$ is the error term. A positive and statistically significant ρ is usually interpreted as evidence of tax competition. However, this model may be misspecified because it lacks dynamics and does not account for other potentially relevant spatial effects.

Overesch and Rincke (2011) have addressed the issue of dynamics. Hence, our major contribution to the empirical literature on tax competition is how we take into account relative market size (RMS). This concept can be understood as the ratio between the GDP (taken as proxy of market size) of country i and the GDP of country j: $RMS_{ijt} = \frac{GDP_{it}}{GDP_{jt}}$. As previously discussed, we need to impose a constraining structure to avoid overparametrisation. The average RMS is the market size of country i relative to the geometric mean of other countries' market size such that $\overline{RMS_{it}} = \frac{GDP_{it}}{\prod_{j=1}^{n} GDP_{jt}^{z}{}_{ij}}$, with z_{ij} being pair-specific weights. This can be rewritten in log form as: $ln(\overline{RMS_{it}}) = ln(GDP_{it}) - \sum_{j=1}^{n} z_{ij} ln(GDP_{jt})$. If we assume that the weights used are the same as those to construct the spatial lag of CTR, we obtain $ln(\overline{RMS_{it}}) = ln(GDP_{it}) - \sum_{j=1}^{n} w_{ij} ln(GDP_{jt})$. In

[10]This is an average across 163215 foreign affiliates, in 95 countries and 115 industries, for the period 1989-2009.

[11]We provide an introduction to the estimation of panel data dynamic spatial econometric models in the Appendix.

other words, if our hypothesis is correct, the correct econometric model of tax competition ought to include, not only the spatial lag of CTR, but also the spatial lag of (the log of) GDP.

A spatial econometric model including a lagged dependent variable (LDV) and spatial lags of the explanatory variables as well as the dependent variable is known as a time-space Durbin Model (SDM).[12] Our baseline model is then:

$$\tau_{it} = \alpha_i + \lambda \tau_{it-1} + \rho \sum_{j=1}^{n} w_{ij} \tau_{jt} + \delta ln(GDP_{it}) + X_{it}\beta + \theta \sum_{j=1}^{n} w_{ij} ln(GDP_{jt}) + \Gamma_{it} + D_{00,07} + \epsilon_{it} \quad (2)$$

where the tax competition model now includes a LDV and the log of GDP and its spatial lag, with spatial weights identical to those used to define the spatial lag of CTR. We also partly take into account the presence of common time effects through the presence of a dummy variable D which takesi the value of one for the period 2000-2007. Standard errors are clustered at the country level.[13] As explained in the Appendix, we estimate this model by maximum likelihood.

We do not impose $\delta = -\theta$.[14] In that way, it is possible to test whether policymakers truly engage in inter-country comparisons ($\delta > 0, \theta < 0$), only pay attention to what is happening in other countries ($\delta = 0, \theta < 0$), only take into account their own country's performance ($\delta > 0, \theta = 0$), or are not concerned with their own or foreign performance ($\delta = 0, \theta = 0$). It must also be acknowledged that δ may also capture effects of market size on the CTR beyond the mechanism addressed in this paper.[15]

The presence of country fixed effects and country-specific trends have implications for the interpretation of our results.

[12]While estimation of a more general SDM allowing for a spatially autocorrelated error term may seem attractive, Elhorst (2010) warns that parameters cannot be meaningfully identified and advises to consider the SDM only. LeSage (2014) also writes that "*For the case where a global spillover specification is implied by theoretical or substantive aspects of the problem, one need only estimate an SDM specification*" (p.20).

[13]Angrist and Pischke (2009) and Cameron and Miller (2015) caution that clustered standard errors may require at least between 20 and 40 balanced clusters to perform well. In several of our regressions, we do not exceed these numbers. The risk is that confidence intervals are too narrow. In these cases, our results ought to be interpreted as the most favourable to the rejection of the null effect of a given explanatory variable. To deal with the issue of few clusters, Cameron et al. (2008) suggest using a wild cluster resampling method. However, as highlighted by Belotti et al. (2017), in the context of spatial panels, panel-data bootstrapping would violate a crucial cross-sectional independence assumption because resampling on the basis of panel units (countries) does not account for the fact that the observations for different countries are correlated across space at any given period. In the Appendix, we show that our results are robust when we use another covariance-matrix estimator developed by Driscoll and Kraay (1998), which allows the errors to be autocorrelated, heteroscedastic, and cross-sectionally dependent. Note that the presence of a LDV and spatial lag terms may partly eliminate serial and spatial correlation of the error terms (LeSage and Pace, 2009; Elhorst, 2010; Beck and Katz, 2011). The SDM nests the spatial error model (SEM) as a special case and therefore the former does not ignore spatial dependence in the errors.

[14]The spatial lag of GDP could in fact purely capture spatial dependence in the error process (Anselin, 1988; LeSage and Pace, 2009; Elhorst, 2010). This would be the case if the following common factor restriction holds: $\theta = -\rho\delta$. However, we have never found this to be true in our empirical application.

[15]As highlighted by a referee, $\theta < 0$ would not mean that foreign economic dynamism cannot have both positive (e.g. fast-growing economies investing more in their neighbours) and negative effects but only that the net effect is negative.

The results of the theoretical models of tax competition involving asymmetric country sizes rely on an inter-country comparison of absolute market sizes. However, once we introduce country fixed effects, this 'between' dimension disappears and the estimation of the model parameters are solely based on time-series variation. Although our dynamic modelling allows for convergence towards a long-run 'cross-sectional' equilibrium, assuming a permanent shock, the presence of fixed effects implies that our estimates reflect, in practice, the possibility that policymakers adjust their CTRs on the basis of the 'average' growth (strictly, mean-deviation) performance of neighbouring countries and, possibly, their own growth performance. Economic growth is a clearly identified performance metric and the economic voting literature emphasises that it is a strong determinant of public support for the an incumbent government (Stegmaier et al., 2017). Nevertheless, a small country and a large country growing at the same rate are implicitly weighted similarly. Such an assumption may be too strong and will be further examined in Section 4.3.2.

Time fixed effects are not usually included in spatial tax competition models (Devereux et al., 2008; Davies and Voget, 2008; Klemm and Parys, 2012). The reason is that they can be seen as crude proxies of unobserved spatial effects. Time fixed effects eliminate a common time-specific factor by implicitly controlling for time-specific averages: $\overline{x_t} = \frac{1}{N}\sum_{i=1}^{N} x_{it}$. In the absence of weights (or uniform weights normalised so that their sum is equal to one), $\overline{x_t}$ is nearly equivalent to the spatial lag of variable x, $\sum_{j=1}^{n} w_{ij}x_{jt} = \sum_{j=1}^{n} \frac{1}{N}x_{jt}$. This means that it is nearly impossible, in tax competition applications, to identify a spatial effect when time fixed effects are included. Our compromise is to include a dummy variable for one period 2000-2007.[16]

As in previous research, we also control for country-specific time trends Γ_{it}. Time trends can be interpreted as capturing the 'usual' (average) change over time of a given variable. Hence, the presence of time trends implies that we associate the setting of the CTR to 'remarkable' (i.e. out-of-trend) growth rate performances. This seems to be a plausible assumption to make since policymakers are likely to pay more attention to the performance of foreign economic countries when these countries grow at remarkable rates.

One potential worry is that reverse causality exists between the CTR and the log of GDP. For example, Djankov et al. (2010) find that a high statutory CTR is associated with less FDI and entrepreneurial activity (but not less aggregate investment) in a cross-section of countries in 2005. Hence, the coefficient of the log of GDP could suffer from a negative simultaneity bias. However, in their up-to-date survey of the literature, Ten Kate and Milionis (2019) highlight that the effect of capital taxation is ambiguous, both in theory and in practice, because engaging in higher capital taxation can be neutral or growth enhancing once this policy is not considered in isolation. A higher CTR can be offset by lower taxes on other forms of income (e.g. labour taxation) leaving the overall level of taxation unchanged. The additional tax revenues generated may also fund productive government spending. Hence, the relationship between the CTR and the log of GDP is not clear-

[16]Our results are robust its omission. Note that Overesch and Rincke (2011) is a rare exception as their econometric model includes a full set of time fixed effects.

cut.[17] Unfortunately, finding an external instrument for the latter is difficult.[18] Acemoglu et al. (2008) and Boix (2015) use, respectively, the spatial lag of GDP and the interaction of a time trend with a time-invariant index of genetic distance. We cannot adopt these instrumental variables because our model includes the spatial lag of GDP and country-specific time trends. We prefer therefore to acknowledge that the estimated coefficient on the log of GDP could be biased (possibly but not certainly) downward, i.e. smaller than it ought to be.

3.2 Spatial Weights

We have not yet defined the spatial-weight matrix W. The spatial weights reflect the fact that some foreign countries matter more than others. The weights are unknown but their empirical counterparts ought to be based on theoretical grounds (Neumayer and Plümper, 2016). Our weights are the inverse bilateral geographical distances d_{ij}:

$$w_{ij} = \frac{1/d_{ij}}{\sum_{j=1}^{n} 1/d_{i,j}}$$

where the weights have been row-normalised so that their sum is equal to one. This implies that the spatial lags are weighted averages of values taken by observations in all foreign countries in the sample used, with more weight given to proximate countries.[19] In concrete terms, when we have n countries in the sample of countries considered, the spatial lags for country i at time t are based on the $n - i$ values.

Distance is likely to be an appropriate weight because it is a sensible proxy for trade and mobility costs or economics dissimilarity (Overesch and Rincke, 2011; Redoano, 2014).[20] Geographically close countries become competing locations for MNEs wishing to serve a fast-growing local market as well as satisfying regional demand (horizontal FDI (Markusen, 1984) or export-platform FDI (Ekholm et al., 2007)). A similar argument can be provided regarding *outward* FDI. Domestic firms could decide to substitute FDI for domestic investment, and even relocate existing domestic activities, if tax and market size conditions significantly improve in a nearby country.[21] Geographically close countries also tend to share similar climatic and economic factors, as suggested by the existence of space-related convergence clubs (Abreu et al., 2005). They may therefore provide

[17] In the Appendix, using the Cross-Section Augmented Distributed Lag estimator proposed by Chudik et al. (2016) which allows for heterogeneous slopes, we show that the country-specific estimates of the long-run 'naive' effect of CTR on economic growth are extremely dispersed, with an average (median) value of 0.08 (0).

[18] The use of a spatial econometric model estimated by maximum likelihood prevents us from exploiting 'GMM-style' internal instruments (Blundell and Bond, 1998). Their validity is also controversial (Roodman, 2009; Bazzi and Clemens, 2013).

[19] Geographic distances are great-circle distance, i.e. the shortest distance between two points on the surface of Earth (which is nearly spherical).

[20] Distance is also perceived as a key identifying feature in sub-national studies investigating spatial interactions and exploiting natural experiments such as Baskaran (2014), Isen (2014), and Eugster and Parchet (2019).

[21] Of course, it is entirely possible that domestic investors decide to locate their new activities in a distant country. For example, the tax reform of the United States, a large and fast-growing country, has resulted in a major (top marginal) statutory CTR cut from about 40% to 27%. Spengel et al. (2018) argue that this will lead over time to a major increase in the U.S. activities of European firms. However, the FDI literature (e.g. Blonigen and Piger (2014)) also points out that bilateral FDI flows follow a 'gravity' pattern, with distance acting as a proxy for a wide range of transaction and information costs, which reduce bilateral FDI flows.

alternative locations for firms wishing to take advantage of international differences in factor costs (both in terms of vertical FDI (Helpman, 1984) and resource-seeking FDI).[22]

Distance could also be relevant when countries compete for 'paper profits' rather than real investment. Shifting profits can be easier and less costly between affiliates in nearby countries because, if low trade costs are associated with large trade volumes, only a small change in transfer prices is required to shift a large amount of profit (Overesch and Rincke, 2011; Beer et al., 2018). Governments may then react more strongly to CTR cuts in proximate countries.

3.3 Data and stylised facts

Our dependent variable is the *(top marginal) statutory corporate tax rate*. This CTR measure presents a number of advantages. As emphasised by Overesch and Rincke (2011), it is the simplest indicator of expected tax payments for firms and it is available for a large number of countries and years. In addition, meta-analyses (De Mooij and Ederveen, 2003, 2008; Feld and Heckemeyer, 2011) find substantial tax semi-elasticities of financial (balance of payments) and real (e.g. capital expenditures) FDI of between -2.5% and -3%. More complex CTR measures exist, which account for the tax base, but these effective CTRs rely on a large number of relatively arbitrary assumptions (Slemrod, 2004). In addition, findings of Devereux et al. (2008) and Overesch and Rincke (2011) suggest that governments compete only over the statutory CTRs. While the data were readily available for most OECD countries (OECD database), we have had to gather data from various other sources (Worldwide Tax Database, Price-WaterhouseCoopers, Ernst and Young, and KPMG) and verify their consistency to obtain the statutory tax rates of transition and developing countries. Our largest sample includes 38 EU-OECD countries and 76 other countries over the period 1995-2014.

Beside GDP (expressed in constant 2010 U.S. dollars), we control for various determinants of the CTR, commonly used in the literature (Devereux et al., 2008). The age and the geographical distribution of the population could influence national tax policies. We therefore include the proportion of the population below 14 years old (*proportion of young*), the proportion of the population above 65 years old (*proportion of old*), and the proportion of the population living in urban areas (*proportion urban*). Data for all the preceding variables come from the World Development Indicators.[23] We also control for the revenue needs of a government by including government expenditure as a percentage of GDP (*government expenditure*). Data come from the IMF Government Finance Statistics and Public Finances in Modern History Database.[24] Gordon and Slemrod (2000) and Slemrod (2004) argue that the corporate income tax serves as a 'backstop' for the personal income

[22] As previously discussed, we expect market seeking to be the dominant form of FDI in both developed and developing countries. In addition to the evidence provided by Bilir et al. (2019), Azémar and Desbordes (2010) calculate that 'market oriented' U.S. FDI (local sales plus sales to other foreign countries) correspond to 93% of total U.S. FDI in developed countries and 86% of total FDI in developing countries.

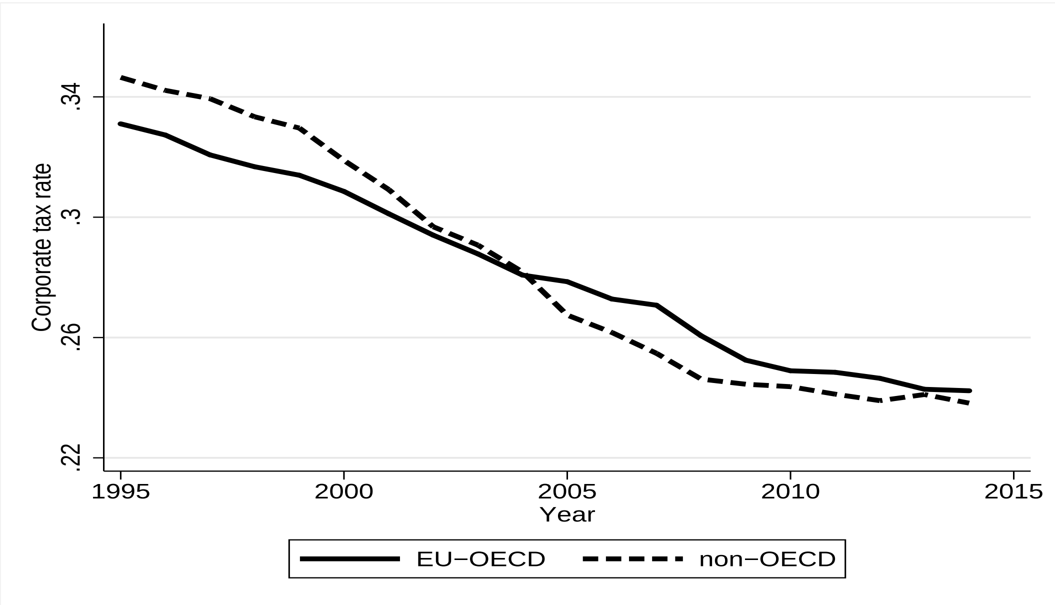
[23] `http://datatopics.worldbank.org/world-development-indicators/`

[24] `https://data.imf.org/GFS` and `https://www.imf.org/external/np/fad/histdb/`.

tax, since it ensures that individuals do not have an incentive to escape personal income taxes by reclassifying their income as corporate income. We take this into account by including the *top personal income tax rate*. Data come from Sabirianova Peter et al. (2009) and KPMG. The sensitivity of a government to the pressures of financial globalisation should naturally vary according to the country's openness to capital flows (*financial openness*). We take this into account by including the Chinn-Ito index (Chinn and Ito, 2008) which is a *de jure* measure of financial openness, ranging from 0 (closed) to 1 (open). Finally, we include a dummy variable *centre-right orientation* given that the political orientation of a government with respect to economic policy may influence its view on the appropriate level of the CTR. Data come from the Database of Political Institutions.[25] Table 1 provides some summary statistics for three broad regions (EU, EU-OECD, non EU-OECD).[26]

Figures 1 and 2 provide stylised facts. Figure 1 shows that CTRs have been declining in both EU-OECD and non-OECD countries. Figure 2 depicts the relationship between de-trended changes in CTRs and de-trended changes in the spatial lag of market size in these two broad income groups. It is clearly negative in EU-OECD countries whereas there is no obvious pattern in non-OECD countries, suggesting considerable heterogeneity in this group of countries.

Figure 1: CTRs over time and across income groups



[25]https://publications.iadb.org/en/database-political-institutions-2017-dpi2017

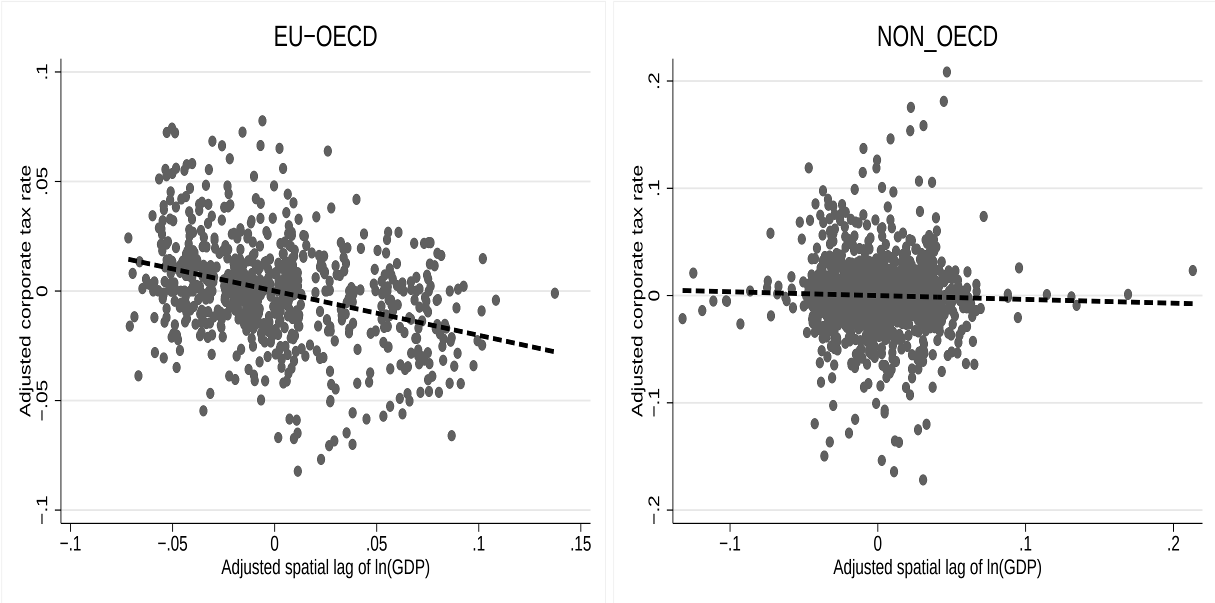
[26]In addition to the EU countries, membership of the OECD is comprised of Australia, Canada, Chile, Iceland, Israel, Japan, South Korea, Mexico, New Zealand, Turkey, and the United States.

Table 1: Summary Statistics

	EU				EU-OECD				non EU-OECD			
	Mean	Std. Dev.	Min	Max	**Mean**	Std. Dev.	Min	Max	**Mean**	Std. Dev.	Min	Max
Corporate tax rate (CTR)	0.27	0.09	0.10	0.59	0.28	0.09	0.10	0.59	0.27	0.1	0	0.55
Market size (ln GDP)	25.97	1.64	22.48	28.93	26.3	1.77	22.48	30.42	24.47	1.69	19.93	29.75
Population proportion young	16.86	2.2	13.25	24.22	18.52	4.28	13.08	36.14	31.37	9.18	11.05	49.77
Population proportion old	15.66	2.44	10.11	21.64	14.37	3.57	4.8	25.35	5.94	3.55	0.69	18.91
Population proportion urban	72.12	11.99	50.65	97.83	75.24	11.84	50.65	97.83	56.5	23.12	12.98	100
Personal income tax rate	0.41	0.12	0.10	0.66	0.41	0.11	0.1	0.66	0.27	0.14	0	0.65
Government expenditure	44.17	6.8	29.45	65.05	41.28	8.71	14.19	65.05	25.7	8.73	0.88	62.04
Financial openness	0.86	0.26	0.17	1	0.83	0.28	0	1	0.49	0.35	0	1
Centre-Right orientation	0.50	0.50	0	1	0.54	0.5	0	1	0.26	0.44	0	1
	EU				EU-OECD				non EU-OECD			
Observations	513				722				1444			
Countries	27				38				76			

Note: The number of observations/countries correspond to the following regressions: column [10] in Table 2, column [4] in Table 3, column [7] in Table 3.

Figure 2: Correlation between CTRs and spatial lag of market size



Note: values have been adjusted for country-specific fixed effects and time trends.

4 Results

4.1 Relative Attractiveness and CTR in the European Union (EU)

We initially present our results for the EU in Table 2. These countries have traditionally been the focus of previous research on tax competition, e.g. Overesch and Rincke (2011). We use various samples of EU countries. In columns [1]-[9], our 'EU 25' sample includes all countries which have been members of the EU for most of the period 1995-2014 and for which we have no missing observations.[27] In column [10], we can include Latvia and Malta in our 'EU 27' sample by adopting a more parsimonious econometric model. In columns [11]-[14] our 'EU extended' sample expands to 44 countries through the inclusion of non-EU countries located less than 2000km from at least one EU country. Before turning to a discussion of the variables of interest, we briefly note that most of the control variables have the expected sign but are not statistically significant. This is not an unusual outcome in studies accounting for country-specific fixed effects and time trends, such as Devereux et al. (2008). Many of these variables do not vary much over time and/or grow at a constant rate, leaving little variation for identification.

Column [1] replicates a common finding in the tax competition literature. The coefficient on the spatial lag of CTR is positive, large, and statistically significant, suggesting that countries compete over CTRs. A 1 percentage point fall in the weighted average CTR of other countries is expected to reduce a country's CTR by about 0.50 percentage point. This effect is very close to that found, for example, in Devereux et al. (2008).

[27] We exclude Croatia from this sample as this country became a member of the EU in late 2013.

In Column [2], we include a time dummy variable for the period 2000-2007, during which CTRs in the EU substantially declined. While there is a risk that this variable absorbs a fraction of the spatial effect, it also ensures that our results are not driven by a common shock unrelated to spatial interactions. The coefficient on the spatial lag of CTR remains nearly unchanged. In Column [3], we allow for dynamic effects by including the lagged dependent variable. The coefficient on this variable justifies this choice as it is large, positive, and statistically significant. The coefficient on the spatial lag of the CTRs remains positive and the short-run effect (0.14) and long-run effect (0.60) are nearly identical to those of Overesch and Rincke (2011). However, both are only statistically significant at the 11% level.

In Columns [4]-[6], we carry out the same empirical exercise but we replace the spatial lag of CTR with the spatial lag of the log of GDP. The coefficient on this variable is always negative, large, and statistically significant. Interestingly, the coefficient on the log of GDP is much larger than in previous columns but it is still not statistically significant once we control for dynamics. In agreement with the hypothesis motivating this paper, we find thus evidence that relative market size matter, although policymakers seem to pay more attention to the (remarkable) economic performance of neighbouring countries. Columns [7]-[9] show that these results hold when we include the spatial lag of CTR. The estimated coefficients on the log of GDP and its spatial effects are nearly the same as before. On the other hand, in contrast to Columns [1]-[3], the coefficient on the spatial lag of CTR is much smaller and becomes statistically insignificant once we include dynamics.[28]

In the remaining columns of Table 2, we carry out several robustness checks. The spatial ML estimators require the use of balanced panel data because, conceptually, values of the dependent variable for one country may be a function of the values of the dependent and independent variables of all other countries in the sample. The risk is that the influence of some important 'absent neighbours' is wrongly not taken into account due to a lack of data availability. We will notably be confronted by this issue when dealing with samples of non-OECD countries. To maximise sample size, we adopt a more parsimonious model in Column [10] by excluding the following (irrelevant) control variables: government expenditure, financial openness, and centre-right orientation. We now have Latvia and Malta in our sample. Following the same logic, in Columns [11]-[14] we include non-EU countries located no more than 2000 km from at least one EU country. This increases the number of countries in the sample to a maximum of 44. Neumayer and Plümper (2016) point out that the 'relativeness' induced by row standardisation of the matrix is not inconsequential. Imposing the restriction that the weights must add to one implies that countries being exposed to heterogenous levels of spatial exposure still end up

[28]One may be worried that our results are due to multicollinearity. When we account for country-specific fixed effects and time trends, the coefficient of correlation between the two spatial lags is -0.80. However, by progressively augmenting our econometric model in Table 2, we make clear that potential collinearity between the two terms is not driving our results. The coefficient on the spatial lag of CTR is positive and statistically significant on its own (Columns [1]-[2]) or when the spatial lag of GDP is also included (Columns [7]-[8]). What makes the coefficient on the spatial lag of CTR statistically insignificant is the inclusion of a lagged dependent variable (Columns [3] and [9]). In Section 4.4, we explain why our results do not imply that direct tax competition has not taken place in EU-OECD countries.

Table 2: Market-based tax competition in the EU

	SAR	SAR	SAR	SLX	SLX	SLX	SDM	SDM	SDM	SDM	SDM	SDM	SDM	SDM
	Static	Static	Dynamic	Static	Static	Dynamic	Static	Static	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic
	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Row norm.	Spectral norm.	Spectral norm.
	EU 25	EU 25	EU 25	EU 25	EU 25	EU 25	EU 25	EU 25	EU 25	EU 27	EU extended	EU extended	EU extended	EU extended
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
Lagged own tax rate			0.767***			0.717***			0.718***	0.738***	0.725***	0.726***	0.722***	0.722***
			(0.049)			(0.054)			(0.053)	(0.046)	(0.027)	(0.023)	(0.026)	(0.022)
Market size (ln GDP)	0.058	0.067	0.017	0.159***	0.158***	0.059	0.163***	0.162***	0.058	0.049	0.024	0.022	0.026	0.026
	(0.048)	(0.049)	(0.030)	(0.053)	(0.053)	(0.037)	(0.052)	(0.052)	(0.036)	(0.032)	(0.032)	(0.029)	(0.034)	(0.031)
Proportion young	0.008	0.006	0.001	0.003	0.003	-0.000	0.003	0.003	-0.000	0.001	0.002	0.004	0.002	0.004
	(0.008)	(0.007)	(0.004)	(0.006)	(0.006)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Proportion old	-0.007	-0.008	-0.003	-0.012*	-0.012*	-0.006*	-0.013**	-0.013**	-0.006*	-0.006**	0.004	0.002	0.004	0.002
	(0.008)	(0.007)	(0.003)	(0.006)	(0.006)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.004)
Proportion urban	-0.014*	-0.016**	-0.007*	-0.015*	-0.015*	-0.007*	-0.015**	-0.015**	-0.007*	-0.006	-0.010	-0.009	-0.010	-0.010
	(0.008)	(0.008)	(0.004)	(0.008)	(0.008)	(0.004)	(0.007)	(0.007)	(0.004)	(0.004)	(0.007)	(0.008)	(0.007)	(0.007)
PIT	0.116	0.122	0.091*	0.110	0.112	0.090*	0.104	0.105	0.090*	0.089**	0.047	0.043	0.051	0.047
	(0.091)	(0.090)	(0.050)	(0.083)	(0.083)	(0.047)	(0.082)	(0.082)	(0.048)	(0.045)	(0.035)	(0.031)	(0.035)	(0.031)
Gov. expenditure	0.000	-0.000	-0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001		-0.000		-0.000	
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)		(0.001)		(0.001)	
Financial openness	-0.040	-0.043	-0.002	-0.049	-0.050	-0.007	-0.044	-0.045	-0.007		-0.021		-0.021	
	(0.039)	(0.039)	(0.019)	(0.034)	(0.034)	(0.018)	(0.035)	(0.035)	(0.018)		(0.017)		(0.018)	
Centre-Right	0.004	0.004	-0.000	0.004	0.004	0.000	0.004	0.004	-0.000		0.001		0.001	
	(0.005)	(0.005)	(0.002)	(0.005)	(0.005)	(0.002)	(0.005)	(0.005)	(0.002)		(0.003)		(0.003)	
Dummy 2000-2007		-0.007	-0.008***		-0.002	-0.006**		-0.001	-0.006**	-0.005**	-0.003	-0.003	-0.003	-0.003
		(0.004)	(0.003)		(0.004)	(0.003)		(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Spatial lag CTR	0.492***	0.442***	0.141				0.224**	0.219**	0.028	0.030	0.130	0.049	0.158*	0.058
	(0.086)	(0.087)	(0.086)				(0.111)	(0.108)	(0.105)	(0.105)	(0.084)	(0.075)	(0.087)	(0.075)
Spatial lag GDP				-0.378***	-0.367***	-0.147***	-0.336***	-0.331***	-0.151***	-0.110***	-0.096***	-0.065**	-0.116***	-0.082**
				(0.056)	(0.061)	(0.035)	(0.057)	(0.062)	(0.041)	(0.039)	(0.036)	(0.033)	(0.043)	(0.036)
Observations	500	500	475	500	500	475	500	500	475	513	722	836	722	836
Countries	25	25	25	25	25	25	25	25	25	27	38	44	38	44

Notes: $^{***}p<0.01$ $^{**}p<0.05$ $^{*}p<0.10$. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in all regressions. SAR: Spatial autoregressive model. SLX: Spatial lag of X model. SDM: Spatial Durbin Model. PIT rate: Personal Income Tax rate. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

with the same row-standardised spatial stimulus. They suggest using another normalisation, such as spectral normalisation, which does not impose the assumption of homogenous total exposure by using only one single scaling value. In Columns [13] and [14], we replicate Columns [11] and [12] using this new spatial weight matrix.

Across these columns, our results are roughly unchanged. In addition, the coefficient on the spatial lag of the log of GDP tends to decrease when non-EU countries are included in the analysis. This can be interpreted as suggesting that European countries are more responsive to the attractiveness of neighbouring countries belonging to the same single market, where competition is expected to be stronger, than to non-EU neighbouring countries.

All in all, governments in the EU appear to perceive the economic dynamism of other countries as a threat, leading them to adjust downward their CTRs in order to maintain their FDI attractiveness.

4.2 The Scope of Tax Competition

The bulk of empirical research on tax competition has focused on European or OECD countries. Very little is known about the extent of tax competition among countries in other regions of the world, despite the fact that we also observe a fall in CTRs. For this reason, we extend the coverage of our analysis to 114 countries. We work first at a global and broad income group level and then we group countries by geographic region and membership of free-trade zones.

4.2.1 Broad income groups

In Table 3, we extend our sample to all countries of the world, before splitting it in two broad income groups: EU-OECD and non-OECD countries. For each group of countries, we provide results based on different and progressively larger samples (all control variables, parsimonious model, extra-regional neighbouring countries). In the world samples (Columns [1]-[2]), we replicate our previous results. The coefficient on log of GDP is small and statistically insignificant whereas the spatial lag of GDP is large, negative, and statistically significant. This latter result appears to be driven by the presence of OECD countries in the sample (Columns [3]-[5]). Indeed, in Columns [6] and [7], when considering non-OECD countries, neither spatial lag is statistically significant. As previously discussed, this spatial distinction based on income levels may be too strict as it does not allow for inter-group competition. Indeed, in Column [8], when we allow for extra-regional countries, which include OECD countries, the coefficient on the spatial lag of GDP is very similar to that obtained in Column [5].[29] Indirect tax competition is possibly stronger when there are spatial interactions between developing and developed countries. Governments of the latter countries may feel threatened by fast-growing developing

[29] In unreported regressions, we investigated the robustness of the results presented in Table 3 to spectral normalisation. Our results were unaffected.

countries which offer benefits to foreign investors in terms of both high regional market potential and low factor costs (Davies and Voget, 2008).

Table 3: Market-based tax competition in broad income groups

	World	World	EU-OECD	EU-OECD	EU-OECD extended	Non-OECD	Non-OECD	Non-OECD extended
	ML	ML	ML	ML	ML	ML	ML	ML
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Lagged own tax rate	0.693***	0.696***	0.706***	0.704***	0.677***	0.681***	0.687***	0.693***
	(0.030)	(0.028)	(0.068)	(0.068)	(0.036)	(0.033)	(0.030)	(0.031)
Market size (ln GDP)	0.015	0.008	0.012	0.017	0.017	0.024	0.011	0.016
	(0.020)	(0.015)	(0.031)	(0.031)	(0.027)	(0.032)	(0.019)	(0.021)
Proportion young	0.001	0.002	0.002	0.002	0.003	0.002	0.003	0.001
	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Proportion old	0.000	0.000	-0.005	-0.005	0.004	0.000	0.001	0.001
	(0.004)	(0.003)	(0.003)	(0.003)	(0.005)	(0.007)	(0.005)	(0.004)
Proportion urban	0.002	0.002	0.003	0.003	-0.001	0.003	0.002	0.002
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)	(0.003)	(0.003)
PIT	0.066**	0.052**	0.084*	0.086*	0.040	0.042	0.036	0.055*
	(0.029)	(0.024)	(0.049)	(0.046)	(0.030)	(0.033)	(0.025)	(0.028)
Gov. expenditure	-0.000		-0.000		-0.000	-0.000		-0.000
	(0.000)		(0.001)		(0.001)	(0.000)		(0.000)
Financial openness	0.001		0.010		-0.007	-0.004		0.000
	(0.008)		(0.012)		(0.012)	(0.011)		(0.008)
Centre-Right	-0.001		-0.001		-0.001	-0.001		-0.001
	(0.002)		(0.002)		(0.002)	(0.004)		(0.002)
Dummy 2000-2007	-0.002	-0.002	-0.003	-0.003	-0.000	-0.001	0.000	-0.002
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Spatial lag CTR	0.021	0.076	0.041	0.059	0.112	0.146	0.080	0.046
	(0.076)	(0.062)	(0.104)	(0.102)	(0.072)	(0.092)	(0.077)	(0.075)
Spatial lag GDP	-0.088***	-0.043*	-0.091***	-0.072**	-0.102***	-0.035	0.004	-0.096***
	(0.033)	(0.025)	(0.035)	(0.033)	(0.035)	(0.048)	(0.030)	(0.034)
Observations	1,805	2,166	684	722	1,045	1,121	1,444	1,691
Countries	95	114	36	38	55	59	76	89

Notes: $^{***}p<0.01$ $^{**}p<0.05$ $^{*}p<0.10$. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in all regressions. ML: Maximum-likelihood. PIT: Personal Income Tax rate. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

4.2.2 Geographic regions and free trade zones

We explore the possibility of regional heterogeneity in the estimated effects by decomposing the non-EU world into the following regions, according the World Bank classification: North America & Latin America & Caribbean; Central Europe & Central Asia; Middle East & North Africa; South Asia & East Asia & Pacific; and Sub-Saharan Africa. To avoid any spatial arbitrariness, we also include extra-regional neighbours.[30] Nevertheless, spatial dependence relations remain dominated by the presence of geographically close countries belonging to the same regions. The region-specific coefficients on the spatial lags, which reflect the average level of spatial dependence, maintain their 'local' nature.

Our results are presented in Table 4.[31] Across regions, the coefficient on the log of GDP tends not be statistically significant and, among the spatial lags, only the coefficient on the spatial lag of GDP is statistically significant. In the first three regions, we find again a robust, negative effect. More striking is that there is some

[30]From this point, we always include in the sample extra-regional neighbours.

[31]From this point, control variables are included but not reported.

weak evidence that faster growth in neighbouring countries has a positive impact on CTRs in South & East Asia & Pacific and Sub Saharan-Africa. This could be cautiously interpreted as the positive market-potential effect put forward by the NEG literature. For example, it is easy to argue that Asian developing countries have benefited from the creation by foreign MNEs of regional supply chains articulated first around Japan and, later, China (Degain, 2011). For African countries, there may be a 'halo effect', whereby being surrounded by fast-growing neighbours makes foreign investors more confident in a country's business environment, allowing it to charge a higher CTR (Ramos and Ashby, 2017).

The geographical distance between countries is a sensible proxy for trade costs, as distance increases transport costs, but it does not account for tariffs and other trade barriers. Some countries form free-trade zones (FTZ) in order to facilitate regional trade. Tax competition between governments might then be relatively more intense in these zones because countries become spatially 'closer'. We investigate this possibility in Table 5, by looking at tax competition in eight different FTZ: CIS (Commonwealth of Independent States, 9 countries), GAFTA (Greater Arab Free Trade Area, 18 countries), MercosurACN (Mercosur and the Andean Community of Nations, 10 countries), CAFTA-DR (Dominican Republic - Central America - United States Free Trade Agreement, 7 countries), APTA (Asia Pacific Trade Agreement, 7 countries), ASEAN (Association of Southeast Asian Nations, 10 countries), ESC (East African Community, Southern African Development Community, and Common Market for Eastern and Southern Africa, tripartite Free Trade Area, 27 countries),[32] and COMESA (Common Market for Eastern and Southern Africa, 19 countries).[33] Once again, we allow extra-regional countries to be part of the sample. Broadly speaking, the results for each FTZ mirror those associated with their regional location, without evidence of stronger spatial dependence relations. Such an outcome may not be surprising given that the international trade literature has shown that only 20-60% of trade agreements (generally those not purely involving developing nations) are found to stimulate trade in practice (Kohl, 2014; Baier et al., 2019).

4.3 Extensions

4.3.1 Alternative explanations

Our paper is grounded in the literature on tax competition to attract FDI. We interpret our results as suggesting that the effect of the spatial lag of GDP is indirect tax competition, whereby policymakers consider that CTRs need to be adjusted to offset the perceived threat of the increasing attractiveness of fast-growing neighbours. However, our findings are also compatible with models of 'political yardstick' competition, formally introduced by Salmon (1987). In this framework, voters partly evaluate the policies and performance of their government

[32]This tripartite agreement is not yet in force but a number of COMESA countries are also EAC or SADC countries or vice-versa. The countries of this zone benefit already from multilateral free-trade with some other countries of the zone.

[33]The full list of national membership of free-trade zones is available in Appendix.

Table 4: Market-based tax competition by geographic regions

	North & Latin America & Caribbean		Central Europe & Central Asia		Middle East & North Africa		South & East Asia & Pacific		Sub Saharan Africa	
	Extended regions									
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Lagged own tax rate	0.440***	0.433***	0.731***	0.733***	0.725***	0.738***	0.710***	0.726***	0.605***	0.674***
	(0.087)	(0.084)	(0.029)	(0.022)	(0.039)	(0.021)	(0.047)	(0.042)	(0.058)	(0.054)
Market size (ln GDP)	0.014	0.014	0.027	0.027	0.021	0.027	-0.086	-0.040	0.071***	0.009
	(0.031)	(0.025)	(0.033)	(0.029)	(0.038)	(0.036)	(0.053)	(0.034)	(0.019)	(0.023)
Spatial lag CTR	0.060	0.103	0.073	0.050	0.164**	0.123**	0.049	0.004	0.172*	0.132
	(0.070)	(0.079)	(0.070)	(0.070)	(0.066)	(0.062)	(0.045)	(0.054)	(0.102)	(0.090)
Spatial lag GDP	-0.095*	-0.096*	-0.072**	-0.062*	-0.150***	-0.109**	0.169***	0.078*	-0.035	0.083*
	(0.054)	(0.050)	(0.034)	(0.032)	(0.053)	(0.042)	(0.066)	(0.041)	(0.042)	(0.043)
Without the controls GE, FO, CR		X		X		X		X		X
Observations	475	494	684	855	646	722	380	475	247	361
Countries	25	26	36	45	34	38	20	25	13	19

Notes: $^{***}p<0.01$ $^{**}p<0.05$ $^{*}p<0.10$. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in all regressions. All the control variables are included in each regression unless specified. GE: Government expenditure. FO: Financial openness. CR: Centre-right orientation. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-‘regional’ neighbouring countries are included.

Table 5: Market-based tax competition by free-trade zones

	CIS	CIS	GAFTA	GAFTA	MercosurACN	MercosurACN	CAFTA-DR	CAFTA-DR	APTA	APTA	ASEAN	ASEAN	ESC	ESC	COMESA
								Extended groups							
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
Lagged own tax rate	0.695***	0.724***	0.726***	0.741***	0.435***	0.430***	0.457***	0.443***	0.458***	0.535***	0.716***	0.764***	0.546***	0.737***	0.737***
	(0.040)	(0.024)	(0.085)	(0.020)	(0.088)	(0.086)	(0.075)	(0.070)	(0.142)	(0.129)	(0.055)	(0.075)	(0.087)	(0.028)	(0.028)
Market size (ln GDP)	0.001	0.024	-0.003	0.015	0.023	0.021	-0.007	-0.004	-0.073	-0.023	-0.007	-0.002	0.067***	0.005	0.005
	(0.025)	(0.030)	(0.031)	(0.039)	(0.034)	(0.027)	(0.026)	(0.022)	(0.070)	(0.026)	(0.027)	(0.014)	(0.025)	(0.032)	(0.032)
Spatial lag CTR	0.010	0.046	0.159**	0.119*	0.053	0.088	0.056	0.114	0.206**	0.184***	0.155***	0.087	0.049	0.008	0.008
	(0.076)	(0.065)	(0.073)	(0.063)	(0.063)	(0.076)	(0.076)	(0.091)	(0.092)	(0.070)	(0.046)	(0.120)	(0.128)	(0.088)	(0.088)
Spatial lag GDP	-0.040	-0.055*	-0.147***	-0.105**	-0.089*	-0.088*	-0.076	-0.066	0.081	0.014	0.086*	0.035*	-0.002	-0.027	-0.027
	(0.036)	(0.032)	(0.042)	(0.046)	(0.051)	(0.047)	(0.048)	(0.050)	(0.097)	(0.021)	(0.050)	(0.020)	(0.047)	(0.045)	(0.045)
Without the controls GE, FO, CR		x		x		x		x		x		x		x	x
Observations	589	779	608	684	380	399	323	342	152	190	114	190	152	513	513
Countries	31	41	32	36	20	21	17	18	8	10	6	10	8	27	27

Notes: '***', '**', and '*' indicate respectively a significance level of 1%, 5% and 10%. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in all regressions. All the control variables are included in each regression unless specified. GE: Government expenditure. FO: Financial openness. CR: Centre-right orientation. For COMESA, the sample was too small for a spatial estimation when including all control variables. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

on the basis of those of neighbouring countries. Higher growth in a foreign country associated with a decrease in its CTR could then lead neighbouring countries to mimic this tax policy in the hope of achieving a similar positive outcome. Alternatively, CTR cuts could be part of a common policy-making trend. The discriminating factor between these two theories and our conceptual framework is financial openness. Tax competition for FDI cannot logically happen between financially closed countries, whereas yardstick competition and policy diffusion are indifferent to financial openness. Following Devereux et al. (2008), we distinguish between two groups of countries, based on average financial openness.[34] Using the Chinn-Ito index, a country is said to be open if this index, ranging from 0 (closed) to 1 (open), is at least 0.50 in every year of the sample. This strict definition prevents having together purely and sometimes financially open countries.

Table 6 reports our results. They unquestionably support a tax competition explanation. Indeed, in Columns [1]-[2] for open EU-OECD countries and [5]-[6] for open non-OECD countries, the coefficient estimated on the spatial lag of GDP is large, negative and statistically significant. By contrast, in Columns [3]-[4] for closed EU-OECD countries and [7]-[8] for closed non-OECD countries, the coefficient estimated on the same variable is not statistically significant. The positive and statistically significant coefficient estimated on the spatial lag of CTR in Column [3] could be interpreted as yardstick competition over CTRs. However, we do not find the same result in Column [2] and the coefficient loses size and significance when one additional country is considered thanks to a more parsimonious econometric model in Column [4].

4.3.2 Large and small countries

The theoretical tax competition literature emphasises the importance of absolute differences in country size. As previously discussed, we lose this 'absolute size' dimension in our identification by estimating a fixed effects model. Nevertheless, we can re-introduce it by including the spatial lag of the interaction between GDP and a dummy variable LARGE which takes the value of one if the country's GDP is greater than the world median in 1995. In that way, we allow heterogeneity in responsiveness (Neumayer and Plümper, 2016) to the spatial effect, which is now mediated by the absolute country size of neighbouring countries. Columns [9]-[12] of Table 6 show that distinguishing between 'large' and 'small' competitors matters. Whereas, across columns, the coefficients on the spatial lag of GDP are positive and statistically insignificant, the sum of this coefficient and the coefficient on the spatial lag of the interaction term is large, negative, and statistically significant. Furthermore, in three out of the four columns, the difference is statistically significant. It appears, in line with 'cross-sectional' tax competition literature, that governments feel more threatened by fast-growing neighbours when those countries have large markets, meaning that a given proportionate growth change translates into a substantial absolute change in market size.

[34]Given this sample split, we omit the financial openness variable from the econometric model.

Table 6: Capital controls and country size

	EU-OECD	EU-OECD	EU-OECD	EU-OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD	EU-OECD	EU-OECD	Non-OECD	Non-OECD
							Extended groups					
	Open	Open	Closed	Closed	Open	Open	Closed	Closed	Country size			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
Lagged own tax rate	0.685***	0.703***	0.681***	0.656***	0.704***	0.710***	0.662***	0.671***	0.673***	0.673***	0.689***	0.691***
	(0.039)	(0.035)	(0.079)	(0.066)	(0.036)	(0.032)	(0.057)	(0.049)	(0.036)	(0.033)	(0.032)	(0.029)
Market size (ln GDP)	0.012	0.029	-0.024	-0.035	-0.001	0.008	0.024	0.006	0.007	0.005	0.026	0.018
	(0.035)	(0.036)	(0.060)	(0.055)	(0.027)	(0.027)	(0.029)	(0.022)	(0.033)	(0.023)	(0.033)	(0.021)
Spatial lag CTR	0.064	0.005	0.201***	0.046	0.081	0.022	0.035	0.069	0.135*	0.082	0.092	0.015
	(0.066)	(0.061)	(0.078)	(0.079)	(0.065)	(0.062)	(0.056)	(0.057)	(0.073)	(0.065)	(0.076)	(0.060)
Spatial lag GDP	-0.133***	-0.087**	-0.037	0.009	-0.099**	-0.077**	-0.049	0.003	0.136	0.134	0.059	0.070
	(0.043)	(0.038)	(0.078)	(0.069)	(0.039)	(0.035)	(0.045)	(0.040)	(0.100)	(0.103)	(0.102)	(0.060)
GDP*LARGE									0.012	0.019	-0.015	-0.013
									(0.039)	(0.033)	(0.037)	(0.026)
Spatial lag (GDP*LARGE)									-0.279**	-0.287*	-0.193	-0.183**
									(0.125)	(0.149)	(0.128)	(0.091)
*Overall spatial lag (GDP*LARGE) effect*									-0.143***	-0.134*	-0.153***	-0.113**
									(0.045)	(.046)	(0.058)	(0.049)
Without the controls												
FO	x		x		x		x					
GE, FO, CR		x		x		x		x		x		x
Observations	817	893	171	190	931	1,083	741	874	1,045	1,159	1,691	2,052
Countries	43	47	9	10	49	57	39	46	55	61	89	108

Notes: '***', '**', and '*' indicate respectively a significance level of 1%, 5% and 10%. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in all regressions. All the control variables are included in each regression unless specified. GE: Government expenditure. FO: Financial openness. CR: Centre-right orientation. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

4.3.3 Other measures of the corporate tax burden

The statutory CTR is a common measure for the tax burden, despite its neglect of the tax base. As previously discussed, three reasons motivate its use: empirical relevance, data availability, and lack of evidence on spatial competition over effective CTRs. Nevertheless, the existing literature has focused on developed countries and its findings might therefore not be valid for developing countries. More than 80% of these countries offer tax holidays, as compared to about 25% of high income countries (OECD, 2015).[35] Governments might thus compete over tax concessions which are ignored by the CTRs.

To address this issue, we replace the statutory CTR by an effective average tax rate (EATR) computed by Bösenberg and Egger (2017) for a large number of countries over the period 1996-2014. This EATR takes into account the various tax incentives offered in a given country and corresponds to the difference between the pre-tax and after-tax net present values of a hypothetical investment in one period, divided by the net present value of the total income stream net of depreciation. As argued by Devereux and Griffith (1998, 2003), the EATR is the appropriate measure for discrete or lumpy investment decisions. This makes it a more relevant variable for our purposes than a measure of effective *marginal* tax rate, which would be more suitable for the special case of a marginal investment. Governments generally try to influence the location decisions of discrete FDI projects. Given that developed countries often offer R&D tax incentives, we also include an EATR measure taking into account R&D tax incentives (EATR R&D). The results are presented in Columns [1]-[2] and [4]-[5] of Table 7 and mirror our previous findings. In both groups of countries and whatever EATR measure is used, the coefficient on the spatial lag of GDP is negative but is much larger and statistically significant in the EU-OECD group. We also do not find statistical evidence for an influence of the log of GDP or for direct tax competition over EATR or EATR R&D.

Another concern related to the use of the statutory tax rate as a measure of the tax burden is that it can capture tax base reforms taking place at the same time. Kawano and Slemrod (2016) show that for OECD countries, 53% of country-year tax rate changes are accompanied by tax base changes. In addition, there is a tendency of governments to broaden the corporate tax base when they decrease the CTR. It might therefore be appropriate to also account for changes to the corporate tax base. These changes are related to any reform affecting R&D promotion (such as tax credits), investment promotion (such as depreciation rules), loss-carry rules, thin capitalisation, and capital gains. Using data from the IMF Tax Policy Reform Database (Amaglobeli et al., 2018), we include in our econometric model two variables and their spatial lags, 'tax base increase' and 'tax base decrease', corresponding to the number of policy changes in a given year leading to an increase or a decrease in the CTR base. Unfortunately, data are not available for most non-OECD countries. We restrict

[35] The most popular tax concession offered by high income countries corresponds to R&D tax incentives. Two-thirds of developed countries offer these incentives whereas only 10% of developing countries do so.

therefore the analysis to the EU-OECD sample. Column [3] shows that our key results are unchanged and it seems that both an increase and a decrease in the tax base can be associated with a lower CTR, as coefficients on the two tax base variables are negative and statistically significant. We consequently do not find evidence of tax competition over the corporate income tax base.

Table 7: Alternative measures of the tax burden

	EU-OECD	EU-OECD	EU-OECD	Non-OECD	Non-OECD
				Extended groups	
	[1]	[2]	[3]	[4]	[5]
Lagged own tax rate			0.759***		
			(0.038)		
Lagged own EATR (normal)	0.768***			0.712***	
	(0.034)			(0.037)	
Lagged own EATR (R&D)		0.725***			0.682***
		(0.039)			(0.038)
Market size (ln GDP)	-0.011	0.017	-0.037	-0.032	-0.017
	(0.025)	(0.030)	(0.027)	(0.022)	(0.025))
Spatial lag CTR			0.111		
			(0.087)		
Spatial lag EATR (normal)	0.008			0.051	
	(0.082)			(0.090)	
Spatial lag EATR (R&D)		0.057			0.038
		(0.069)			(0.077)
Decrease CIT base			-0.003***		
			(0.001)		
Increase CIT base			-0.010***		
			(0.003)		
Spatial lag increase CIT base			0.007		
			(0.005)		
Spatial lag decrease CIT base			0.003		
			(0.003)		
Spatial lag GDP	-0.069*	-0.118***	-0.110***	-0.038	-0.076*
	(0.037)	(0.039)	(0.041)	(0.036)	(0.042)
Observations	756	756	399	1,062	1,062
Countries	42	42	21	59	59

Notes: '***', '**', and '*' indicate respectively a significance level of 1%, 5% and 10%. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in the regressions. All the control variables are included in all regressions. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

4.3.4 Other spatial lags

As previously argued, economic growth is an obvious and intuitive measure for governments and the public to compare a country's performance over time and across space (Stegmaier et al., 2017). Nevertheless, other factors can influence relative FDI attractiveness and conceivably CTR levels, such as international price competitiveness or quality of public governance. To account for this possibility, we include in our econometric model the unit labour costs in the manufacturing sector and a measure of governance as well as their spatial lags.[36] Table 8 presents our results. Coefficients on these additional terms are not statistically significant, while the coefficient on the spatial lag of GDP remains large, negative, and statistically significant in all Columns. Economic growth is possibly the key benchmark measure for policymakers.

4.4 Interpretation

Overall, our results indicate that a government wishing to attract inward FDI and limit outward FDI is likely to take into account the spatial economic environment when setting its CTR. More specifically, policymakers, especially in developed countries, appear to perceive the growth performance of their neighbouring countries as a threat to their attractiveness when these countries are open to capital flows and have a large market size.

As pointed out by LeSage and Pace (2009) and Mummolo and Peterson (2018), the counterfactuals ought to be based on the information set used for identification to avoid extreme and unfounded statements. Following the rest of the literature, we have controlled for country fixed effects, country-specific time trends, and a common time effect for the period 2000-2007. This means that our estimates mostly reflect the impact of remarkable (out of trend) proportionate changes in the market sizes (log of GDP) of proximate competitors. These regional performance shocks can be temporary and, obviously, can fluctuate from positive to negative, depending on the regional business cycle. Nevertheless, they are expected to have lasting effects because we estimate a dynamic model which accounts for the persistence of CTRs through the inclusion of the lagged dependent variable. We therefore interpret our results as suggesting that governments are more likely to envisage a CTR cut when their neighbours experience growth rates which are unusually high and which may be considered durably sustainable at the time of observation. These CTR cuts then lock governments into lower CTRs.

In contrast to our *ex ante* expectations, we have failed to find that countries characterised by remarkable economic growth set a higher CTR, all other things equal. An intuitive explanation is that policymakers see the international economic environment as a zero-sum world, in which the number of FDI projects that countries can attract is fixed. As highlighted by Schmidheiny and Brülhart (2011), such an assumption would be consistent with standard location-choice models (conditional logit) in which one location's FDI gain is another location's loss.[37] It is therefore possible that a government believes that its country would have done better,

[36] Data on unit labour costs come from UNIDO Industrial Statistics Database (INDSTAT2): `https://www.unido.org/researchers/statistical-databases`. They are defined as total labour costs divided by total value added. Unit labour costs take into account the average level of nominal wages and the average productivity of workers. For this reason, it is considered to be a good measure to compare price competitiveness across time and space. Our governance variable comes from the Worldwide Governance Indicators, and is the first principal components of five different dimensions of governance; `https://info.worldbank.org/governance/wgi/`. The five dimensions are Voice and Accountability, Political Stability, Government Effectiveness, Rule of Law, Control of Corruption. We do not use 'Regulatory Quality' because it contains items related to the level of taxation. For the years 1997 and 1999, values are not available. They have been linearly interpolated.

[37] Brülhart and Schmidheiny (2015) construct a rivalness factor to discriminate between zero-sum and positive-sum environments and find that the former is a better fit when explaining the distribution of FDI across U.S. States.

Table 8: Indirect tax competition: alternative spatial lags

	EU-OECD	EU-OECD	EU-OECD	EU-OECD	EU-OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD	Non-OECD
	Extended groups									
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Lagged own tax rate	0.743***	0.754***	0.749***	0.753***	0.747***	0.722***	0.742***	0.725***	0.739***	0.721***
	(0.040)	(0.040)	(0.040)	(0.039)	(0.038)	(0.033)	(0.033)	(0.033)	(0.031)	(0.032)
Market size (ln GDP)	-0.002	-0.009	0.010	-0.024	-0.004	0.005	-0.019	0.008	-0.023	0.006
	(0.031)	(0.030)	(0.033)	(0.028)	(0.031)	(0.030)	(0.025)	(0.031)	(0.024)	(0.030)
Spatial lag CTR	0.046	0.010	0.076	0.023	0.087	0.090	0.011	0.115	0.034	0.112
	(0.072)	(0.097)	(0.083)	(0.083)	(0.077)	(0.076)	(0.096)	(0.089)	(0.081)	(0.078)
Spatial lag GDP	-0.081***		-0.089***		-0.110***	-0.121***		-0.126***		-0.153***
	(0.028)		(0.030)		(0.037)	(0.044)		(0.045)		(0.052)
Governance		-0.014	-0.015				-0.006	-0.007		
		(0.010)	(0.010)				(0.008)	(0.007)		
Spatial lag governance		0.036	0.037				0.023	0.025		
		(0.041)	(0.041)				(0.027)	(0.026)		
Unit wage cost (UWC)				-0.018	-0.016				0.001	-0.002
				(0.036)	(0.035)				(0.029)	(0.027)
Spatial lag UWC				-0.060	-0.131				-0.030	-0.144
				(0.077)	(0.091)				(0.077)	(0.092)
Observations	665	665	665	665	665	893	893	893	893	893
Countries	35	35	35	35	35	47	47	47	47	47

Notes: '***', '**', and '*' indicate respectively a significance level of 1%, 5% and 10%. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in the regressions. All the control variables are included in all regressions. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

whatever the growth performance achieved, if other countries had not also expanded and captured a fraction of worldwide FDI.[38]

The coefficient on the spatial lag of CTR is positive *but* small and statistically insignificant in most of our regressions. In the case of EU-OECD countries, this does not signify that direct tax competition has not taken place. First, previous research used samples mostly covering the time period 1980-2000. This particular period is marked by a structural break in CTR levels, which were stable until the late eighties and then declined over time at a regular pace. This discontinuity is a crucial source of variation to identify spatial competition over CTRs. On the other hand, our period of analysis is 1995-2014. Figure 1 indicates that the fall in CTRs has continued unabated throughout this period, suggesting a smooth, dynamic, self-reinforcing tax competition process without structural break. Given that we estimate a dynamic model with country-specific time trends, it seems unlikely that we can precisely identify the coefficient on the spatial lag of CTR (Angrist and Pischke, 2009). Second, the initial tax competition process has taken place in the wider context of the broad acceptance of neoliberalism (Furceri et al., 2016), roughly based on the idea that governments should not hinder private sector initiative through excessive regulations and taxation. The recent fall in CTRs, initially triggered by international tax competition, may now also reflect domestic policies grounded in a global intellectual trend. Both explanations seem also relevant in the case of non-OECD countries, given that Figure 1 also shows a persistent decline of CTRs in these countries over the period 1995-2014.

5 Conclusion

The study of tax competition for foreign direct investment (FDI) has been limited to direct competition over corporate tax rates (CTRs) in developed countries. Our results show that market-based tax competition also takes place. In developed countries and several developing regions, we find that governments pay attention to the economic dynamism of neighbouring countries. Remarkable foreign performance appears to be considered as a threat, leading policymakers to cut their CTRsi to maintain their FDI attractiveness. In further work, it would be interesting to analyse political statements and economic news reported by the media to obtain a more qualitative assessment of how policymakers assess relative FDI attractiveness and react to a perceived loss in the latter.

[38]Of course, we cannot rule out the possibility that changes in market size influence the CTR for reasons beyond the conceptual framework of this paper. It is also possible, as pointed out in Section 3.1, that the estimated effect is downward biased due to reverse causality.

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A.1 Appendix

A.1.1 Spatial econometrics

Description and estimation

LeSage and Pace (2009) provide an illuminating introduction to spatial econometric modelling. Consider the following data generating process (DGP):

$$\begin{aligned} y_i &= \alpha_{i,j} y_j + \alpha_{i,k} y_k + X_i \beta + \epsilon_i \\ y_j &= \alpha_{j,i} y_i + \alpha_{j,k} y_k + X_j \beta + \epsilon_j \\ y_k &= \alpha_{k,i} y_i + \alpha_{k,j} y_j + X_k \beta + \epsilon_k \end{aligned}$$

The value taken by the observation for country i depends on the value taken by the observations for countries j and k, with all countries being spatially close. Likewise, the value taken by the observation for country j (k) depends on the value taken by the observations for countries i and k (i and j). X_i is a vector of control variable with associated (homogeneous) parameters β. This is a simultaneous DGP which immediately raises two key issues. First, there is an over-parametrisation problem. We have three observations but six spatial parameters (with n countries, we would have $n^2 - n$ spatial parameters).[39] Second, simultaneity implies that an OLS estimator cannot be used because a key assumption for its consistency is violated. The observations y_i, y_j, and y_k are partly determined by the shocks to the variables they are expected to explain, introducing a correlation between the explanatory variables and the error terms (Franzese and Hays, 2007).

The first issue is solved by imposing constraints on spatial dependence effects. Spatial dependence relations are allowed to happen but they are forced to follow a specific pattern, defined by spatial weight matrix W, and only one parameter is estimated:

$$y_i = \rho \sum_{j=1}^{n} w_{ij} y_j + X_i \beta + \epsilon_i$$

The term $\sum_i^n w_{ij} y_j$ is called a spatial lag and is a linear combination of the values of the variable y in other countries. $W = \sum_{j=1}^{N} w_{ij}$ is the spatial matrix. ρ is now the only 'spatial' parameter to be estimated and reflects an average level of spatial dependence.

The second issue is the need to account for the simultaneity bias generated by spatial dependence. As it is well known, the log-likelihood function for a non-spatial normal linear regression model is

$$logL = -\frac{N}{2} log(2\pi\sigma^2) - \frac{1}{2\sigma^2} \sum_{i=1}^{N} (y_i - x_i \beta)^2$$

with σ, the standard deviation of the error term. The maximum likelihood (ML) estimators for β are the values that maximise this log-likelihood function. As shown by Anselin (1988), this log-likelihood function can be modified to account for the endogenous nature of the spatial lag term

$$logL = -\frac{N}{2} log(2\pi\sigma^2) + log|I_n - \rho W| - \frac{1}{2\sigma^2} \sum_{i=1}^{N} (y_i - \rho \sum_{j=1}^{N} w_{ij} y_j - x_i \beta)^2$$

[39] With the presence of control variables, the number of parameters is obviously larger than the number of spatial parameters.

The key and crucial difference is the introduction of the Jacobian term $log|I_n - \rho W|$. It is a correction to deal with the endogeneity issue created by spatial simultaneity.[40] This ML approach to estimate cross-sectional spatial models can be easily extended to the estimation of fixed effects panel data models (Elhorst, 2014). Prior to estimation, a within transformation (e.g. $y^*_{it} = y_{it} - \frac{1}{T}\sum_{t=1}^{T} y_{it}$) is applied to eliminate the fixed effects from the regression equation. The log-likelihood function is then:

$$logL \quad = \quad -\frac{NT}{2}log(2\pi\sigma^2) + Tlog|I_n - \rho W| - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{it} - \rho\sum_{j=1}^{n} w_{ij}y_{jt} - x_{it}\beta)^2$$

Endogeneity of the spatial lag term could also be addressed through an instrumental variables (IVs) approach. This has been frequently done in the tax competition literature (Devereux et al., 2008; Cassette and Paty, 2008; Crabbe and Vanderbussche, 2008; Davies and Voget, 2008; Lockhood and Migali, 2009; Overesch and Rincke, 2011; Redoano, 2014; Altshuler and Goodspeed, 2015). The IV variables are traditionally the spatial lags of the exogenous variables, $\rho\sum_{j=1}^{n} w_{ij}x^k_{jt}$, where x^k_{jt} is the value of control variable k in country j at period t. These IVs must obviously satisfy two conditions for consistency of the IV estimator, relevance and exogeneity. Relevance depends on the ability of the explanatory variables not directly related to CTRs (i.e. not the spatial and temporal autoregressive CTRs terms) to explain changes in taxes over time in various samples. If these instruments are weak, the IV estimators are severely biased and hypothesis tests strongly distorted (Stock et al., 2002). Even if the IV variables are relevant, the variance of the IV estimator may be high given that only a fraction of the variation in the troublesome variable is exploited. Furthermore the use of a more complex spatial econometric model, in which the spatial lags of explanatory variables are believed to belong in the econometric model, reduces the number of IV variables available. This last point ties in with the concerns raised by Gibbons and Overman (2012) regarding the exogeneity of the spatial lags of some explanatory variables used as IV variables. For these reasons, we prefer to adopt the more conventional ML approach.[41]

Including dynamics

A ‘typical’ dynamic spatial autoregressive tax competition model is:

$$\tau_{it} = \alpha_i + \lambda\tau_{it-1} + \rho\sum_{j=1}^{n} w_{ij}\tau_{jt} + X_{it}\beta + \Gamma_{it} + \epsilon_{it},$$

where τ_{it} denotes the corporate income tax rate of country i at period t, $\sum_{j=1}^{n} w_{ij}\tau_{jt}$ is a measure of ‘average’ CTRs in other countries, X_{it} represents a vector of control variables, α_i corresponds to country fixed effects, Γ_{it} are country-specific time trends, and $\epsilon_{i,t}$ is the error term.

Dynamics are traditionally modelled through the inclusion of a lagged dependent variable (LDV) in the model (Beck and Katz, 2011). Several justifications can be provided for its presence. Conceptually, it seems naive to assume that the impact of a change in the value of a given explanatory variable is contemporaneous and limited to one period only. We cannot directly estimate a model with an infinite number of lags without restrictions. In a similar fashion to the modelling of spatial dependence relations, we need to impose constraints.

[40] Note that the spatial ML estimators require the use of a balanced panel.

[41] A few recent studies have used natural experiments to identify spatial interactions. Lyytikäinen (2012) generates on IV on the basis of the Finnish property tax reform of 2000 to investigate property tax competition among local governments. Baskaran (2014) exploits an exogenous reform of the local fiscal equalization scheme in the German State of North Rhine-Westphalia in 2003 within a difference-in-differences framework to identify tax mimicking by municipalities in the neighboring state of Lower Saxony. Isen (2014) makes use of the close results of local referenda in the U.S. state of Ohio in a regression discontinuity design to examine local government fiscal spillovers. Eugster and Parchet (2019) propose a difference-in-differences strategy exploiting cultural differences between the different Swiss municipalities to identify local tax competition. Some of these studies question the validity of standard spatial econometrics estimators, which rely on assumptions perceived as restrictive for identification. Unfortunately, the use of natural experiments seems incompatible with a worldwide cross-country time-series analysis such as ours.

Through the inclusion of the LDV, we obtain a model in which an infinite number of lags is possible but their effects are solely determined by two parameters, β and λ where λ is the parameter associated with the LDV. In this geometric distributed lag model, the impact of a change in a given explanatory variable takes place in contemporaneous and future periods, with a period-specific impact decaying geometrically, and converges over time towards the long-run impact $LRP = \frac{\beta}{1-\lambda}$, which is the sum of all the lag coefficients. A similar specification can be obtained by simply assuming a partial adjustment model where the exogenous explanatory variables define the equilibrium (desired) value of the dependent variable (Verbeek, 2017). In that case, λ measures the speed of the adjustment process, with high λ implying slow adjustment over time. The short-run and long-run interpretations of the coefficients remain unchanged. Econometrically, the inclusion of a LDV may reduce an omitted variable bias and, by extension, may eliminate serial correlation of the errors, because it is a function of the variables omitted in the model (Beck and Katz, 2011). Empirically, CTRs are strongly persistent over time and this feature of the DGP should be taken into account.

Including a LDV in the empirical model adds a new challenge because the within transformation introduced above to eliminate the fixed effects induces a correlation between the transformed LDV, $y^*_{it-1} = y_{it-1} - \frac{1}{T}\sum_{t=1}^{T} y_{it-1}$ and the transformed error term $\epsilon^*_{it} = \epsilon_{it} - \frac{1}{T}\sum_{t=1}^{T} \epsilon_{it}$ since y_{it-1} is correlated with $\sum_{t=1}^{T} \epsilon_{it}$ (Nickell, 1981). However, this dynamic bias decreases as T increases and becomes small with $T \geq 20$. Furthermore, we apply the bias-corrected quasi-ML approach for dynamic spatial models suggested by Yu et al. (2008).[42]

A.1.2 Heterogeneous impact of CTR on economic growth

Using a sample of 110 countries over the period 1995-2014, we estimate the long-run effect of CTR on economic growth in a dynamic heterogeneous panel data models (with potentially cross-sectionally dependent errors) using the Cross-Section Augmented Distributed Lag estimator developed by Chudik et al. (2016). Long-run growth of real income per capita is assumed to depend on the CTR and the quality of governance (see Section 4.3.4 for a definition of the governance variable). Slope heterogeneity and the presence of unobserved common factors are allowed. Figure 3 shows that there is tremendous cross-country heterogeneity in the relationship between the CTR and economic growth, with an average (median) effect of 0.08 (0).[43] Very similar results are found when including country-specific time trends or removing the governance variable.

A.1.3 Serial and spatial error correlation: Driscoll-Kraay covariance matrix estimator

Table 9 replicates the key estimations of Tables 2 and 3 using the covariance-matrix estimator developed by Driscoll and Kraay (1998), which allows the errors to be autocorrelated, heteroscedastic, and cross-sectionally dependent.

A.1.4 Membership of free trade zones

Table 10 provides a list of the countries belonging to the various free trade zones.

[42] We use the command for spatial analysis coded by Belotti et al. (2017) in Stata.

[43] We omit from this Figure extreme estimates, i.e. estimates with an absolute value above 1.

Figure 3: Long-run estimates of CTR on economic growth

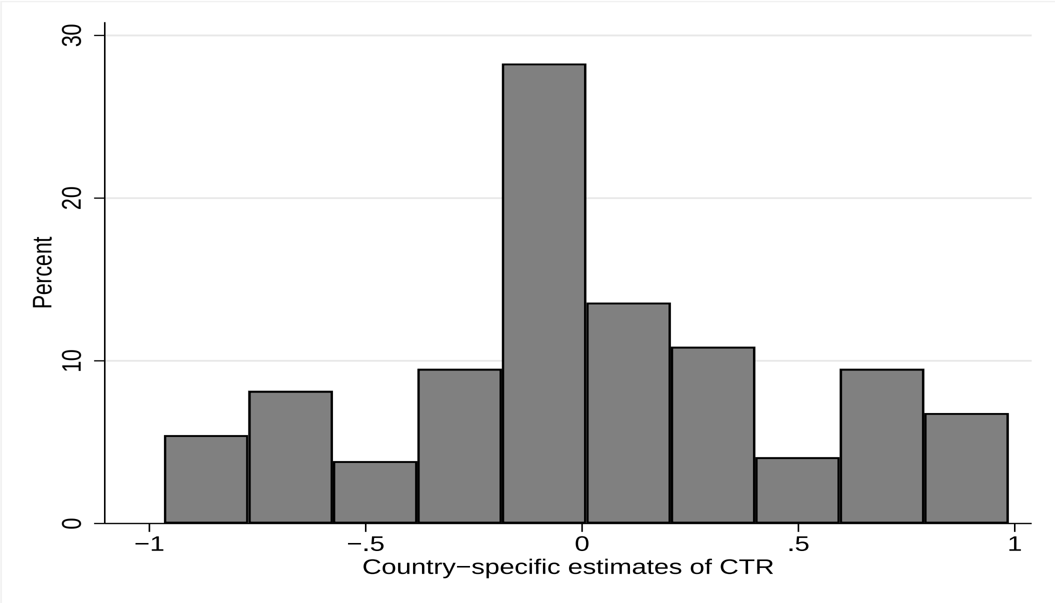

Table 9: Key estimations of Tables 2 and 3 using the Driscoll-Kraay covariance matrix estimator

	EU 25	EU 27	EU extended	World	EU-OECD	EU-OECD extended	Non-OECD	Non-OECD extended
	ML	ML	ML	ML	ML	ML	ML	ML
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Lagged own tax rate	0.718***	0.738***	0.725***	0.693***	0.706***	0.677***	0.681***	0.693***
	(0.062)	(0.062)	(0.085)	(0.056)	(0.040)	(0.065)	(0.068)	(0.057)
Market size (ln GDP)	0.058*	0.049	0.024	0.015	0.012	0.017	0.024	0.016
	(0.031)	(0.032)	(0.015)	(0.011)	(0.021)	(0.019)	(0.020)	(0.011)
Proportion young	-0.000	0.001	0.002	0.001	0.002	0.003*	0.002	0.001
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Proportion old	-0.006***	-0.006***	0.004	0.000	-0.005***	0.004	0.000	0.001
	(0.002)	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Proportion urban	-0.007***	-0.006***	-0.010***	0.002	0.003	-0.001	0.003	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
PIT	0.090***	0.089***	0.047*	0.066***	0.084***	0.040**	0.042*	0.055***
	(0.032)	(0.030)	(0.025)	(0.019)	(0.022)	(0.016)	(0.024)	(0.020)
Gov. expenditure	-0.001		-0.000*	-0.000**	-0.000	-0.000	-0.000*	-0.000*
	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Financial openness	-0.007		-0.021**	0.001	0.010	-0.007	-0.004	0.000
	(0.006)		(0.009)	(0.006)	(0.006)	(0.008)	(0.008)	(0.006)
Centre-Right	-0.000		0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.001)		(0.003)	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)
Dummy 2000-2007	-0.006***	-0.005***	-0.003**	-0.002*	-0.003***	-0.000		
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Spatial lag CTR	0.028	0.030	0.130	0.021	0.041	0.112	0.146**	0.046
	(0.128)	(0.109)	(0.080)	(0.070)	(0.097)	(0.075)	(0.073)	(0.073)
Spatial lag (SL) GDP	-0.151**	-0.110*	-0.096***	-0.088***	-0.091**	-0.102***	-0.035*	-0.096***
	(0.065)	(0.059)	(0.024)	(0.025)	(0.039)	(0.015)	(0.021)	(0.022)
Observations	475	513	722	1,805	684	1,045	1,121	1,691
Countries	25	27	38	95	36	55	59	89

Notes: ***$p<0.01$ **$p<0.05$ *$p<0.10$. Cluster-robust standard errors are in parentheses. Country fixed effects and country-specific time trends are included in all regressions. ML: Maximum-likelihood. PIT: Personal Income Tax rate. The spatial weights correspond to the inverse bilateral geographic distance. Extended: extra-'regional' neighbouring countries are included.

Table 10: Appendix: Membership of free trade zones

	European Union	APTA	ASEAN	CIS	GAFTA	EAC-SADC COMESA	EAC	SADC	COMESA	Mercosur-ACN	CAFTA-DR
1	Austria	Bangladesh	Brunei Darussalam	Armenia	Algeria	Angola	Burundi	Angola	Burundi	Argentina	Costa Rica
2	Belgium	China	Cambodia	Belarus	Bahrain	Botswana	Kenya	Botswana	Comoros	Bolivia	Dominican Rep.
3	Bulgaria	India	Indonesia	Kazakhstan	Egypt, Arab Rep.	Burundi	Rwanda	Congo, Dem. Rep.	Congo, Dem. Rep.	Brazil	El Salvador
4	Cyprus	Korea, Rep.	Lao PDR	Kyrgyz Republic	Iraq	Comoros	Sudan	Lesotho	Djibouti	Chile	Guatemala
5	Czech Republic	Lao PDR	Malaysia	Moldova	Jordan	Congo, Dem. Rep.	Tanzania	Madagascar	Egypt, Arab Rep.	Colombia	Honduras
6	Denmark	Mongolia	Myanmar	Russian Federation	Kuwait	Djibouti	Uganda	Malawi	Eritrea	Ecuador	Nicaragua
7	Estonia	Sri Lanka	Philippines	Tajikistan	Lebanon	Egypt, Arab Rep.		Mauritius	Ethiopia	Paraguay	United States
8	Finland		Singapore	Ukraine	Libya	Eritrea		Mozambique	Kenya	Peru	
9	France		Thailand	Uzbekistan	Morocco	Ethiopia		Namibia	Libya	Uruguay	
10	Germany		Vietnam		Oman	Kenya		Seychelles	Madagascar	Venezuela, RB	
11	Greece				Qatar	Lesotho		South Africa	Malawi		
12	Hungary				Saudi Arabia	Libya		Swaziland	Mauritius		
13	Ireland				Sudan	Madagascar		Tanzania	Rwanda		
14	Italy				Syrian Arab Rep.	Malawi		Zambia	Seychelles		
15	Latvia				Tunisia	Mauritius		Zimbabwe	Sudan		
16	Lithuania				United Arab Emirates	Mozambique			Swaziland		
17	Luxembourg				West Bank and Gaza	Namibia			Uganda		
18	Malta				Yemen, Rep.	Rwanda			Zambia		
19	Netherlands					Seychelles			Zimbabwe		
20	Poland					South Africa					
21	Portugal					South Sudan					
22	Romania					Sudan					
23	Slovak Republic					Swaziland					
24	Slovenia					Tanzania					
25	Spain					Uganda					
26	Sweden					Zambia					
27	United Kingdom					Zimbabwe					