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**IS INTERNATIONAL CAPITAL TAX COMPETITION FUELED BY THE QUEST FOR INCREASED PRODUCTIVITY?****Abstract:**

In this paper we examine the relationship between capital tax competition amongst countries and the productivity spillover effects from foreign capital movements. The traditional theoretical literature regarding tax competition examines the phenomenon through analysis of the competition over tax revenue, which is generated by incoming capital. However, as the theoretical literature on FDI points to improving levels of productivity from managerial and technological spillovers, we investigate the question of whether governments also take into account productivity changes when competing over tax rates. We construct a two country, two firm model incorporating production functions which include productivity spillovers from foreign direct investment. According to our theoretical model, the larger the productivity spillovers from foreign capital, the more intense tax competition will be. We then empirically test this prediction using a spatial dynamic panel data model utilizing a dataset consisting of 42 countries spanning the years of 1998-2012. The empirical model employs system-GMM in order to overcome the endogeneity problem associated with the variables involved in the estimation. We find evidence that productivity levels are having a significant negative impact on tax rates as predicted by the model. Empirical testing is also performed with 21 European Union countries with similar results.

**Keywords:**

Tax Competition Foreign Direct Investment Productivity Spillovers

**JEL Classification:** A10, H23

# 1 Tax Competition and Productivity

## 1.1 Introduction

Corporate income taxation (capital taxation) produces large income streams for governments, especially for industrialised countries. For most countries in the OECD the corporate income tax revenue is equal to about 2-5 percent of total GDP. To illustrate—in the United States, corporate income taxation in 2013 amounted to 274 billion dollars (Taxpolicycenter.org, 2014). Although not the lion's share of taxable funds, it is large enough to potentially fight for. The mobility which corporate income has means that governments must worry about the flight potential of this important revenue stream. Global FDI flows in 2013 amounted to approx. 1.2 trillion dollars. This investment means jobs and technology for host nations which are increasingly competing for this valuable resource. Thus, the question of tax competition is incredibly important for governments today. Having a better understanding of why tax competition is happening can give policy makers better tools with how to best deal with tax policy.

This paper begins by going over the main rationale for the existence of capital tax competition between countries by examining several strains of research. After identifying the main reasons, an apparent gap in the literature is identified, namely— do countries change tax rates as a reaction to productivity changes in other countries? Next, an econometric model is constructed to test for the relationship between tax and productivity. To the author's knowledge, there does not yet exist any work which investigate the impact that productivity shocks has on capital tax rate decisions.

### 1.1.1 Tax Competition

This first section will review the basic tax competition literature in order to identify the gap which is the subject of this paper. The reasoning behind much of the early tax competition literature concludes that countries compete between each other in order to gain revenues from the mobile tax bases which enter their jurisdictions (Wilson, 1999). Thus, tax competition was viewed as a form of perfect competition where countries would eventually compete their tax rates down to 0. The formal research of tax competition started with a seminal paper by Oates (1972), where he examined the potential for efficiency problems that arise when governments compete against each other for mobile tax bases. Oates fundamental conclusion, which ends up being the argument for tax harmonisation, is that competition between governments for mobile tax bases leads to an inefficiently low tax rate meaning that governments collect too little in taxes and, therefore, under-provide public goods. Thus, tax competition is modelled as a fight for tax revenue between competing governments.

The basic model assumed that there are an unlimited number of similar sized countries competing on tax rates. However, Wildasin (1988) stated that with a smaller number of countries competing against each other the negative effects of tax competition also decreased. This is due to the fact that as the number of competitors decreases the relative market power increases for the competitors, creating a form of monopolistic

competition where above normal rents can be extracted. Thus, the consequences of unrestricted tax competition could be worse than the Oates model predicted.

Bucovetsky (1991) and Bucovetsky and Wilson (1991) further modified the model to allow for asymmetry in the size of countries. In their two country model with a large and small country, when the large country raises its tax rate, capital will flow out, just like before. However, the large country will be able to affect the world return on capital because any. This means that any loss of capital will be proportionately smaller for a large country because as capital leaves it, the world supply of capital increases. Thus the return on capital in the world will go down, making it less attractive for locals to invest outside of the country. This model could help to explain why a country like Germany can have higher tax rates than its neighbours but still have a lot of capital investment. Bucovetsky (1991) also helped to explain how larger countries could have higher tax rates than smaller countries by showing that if a small country lowers its tax rates it can siphon off a relatively large amount of capital from a large neighbour and gain large benefits but if the large neighbour lowers its tax rates to steal capital investment from its smaller neighbour, the loss of corporate tax revenue will be more than the gain from capital coming in from the smaller neighbour. Therefore, tax competition helps smaller countries at the expense of the larger ones.

The field of economic geography contributed to the study of tax competition when Baldwin and Krugman (2004) noticed that the race to the bottom didn't seem to be happening as much as was earlier predicted. In their work they put forth a model from economic geography that agglomeration economies were one important reason why capital was not fleeing high tax economies. The theory suggests that agglomeration economies form as a consequence of external economies of scale. The economies of scale cause clusters to be built, which lower the costs for companies located in the cluster. Lower costs mean that the return on capital would be higher and it means that the local government could charge a high tax rate and still expect that the company would not relocate because if it did relocate it would not benefit from the economies of scale from the agglomeration. They even reasoned that tax harmonisation might set taxes too low for large countries because of this reason. In addition, they also observed that small countries with less clusters tend to have lower tax rates

Further work involving tax rates and FDI questions the existence of the race to the bottom through the theory that companies that are investing in countries are willing to pay higher taxes because there are benefits from social welfare that the companies experience in return (Goerg, Molana, & Montagna, 2009). It found that competition between nations is not as strong as suggested by earlier proponents of the tax competition hypothesis and that governmental spending was related to FDI flows. These results are useful in explaining why, for example, Scandinavian nations could still have so much investment despite having relatively high capital taxes.

Summing up, the seminal literature focuses on tax policy as the driver of capital flows while the later literature focuses on other drivers (i.e. agglomeration, asymmetric size, governmental spending), which in addition to tax policy, affect capital flows. This paper will seek to continue research in this area by focusing on one of these other drivers, namely productivity, which has not yet been studied. Therefore, it will also be necessary to review the literature regarding productivity and capital movements as well.

### 1.1.2 Capital and Productivity Spillovers

Thus far, all of the tax competition theory mentioned has been focused on the revenue aspects of tax competition but there are other reasons for why governments would want to lower their capital taxes. While it is certainly true that governments are hungry for tax revenue so that they can fund their budgets, they are also interested in attracting foreign direct investment (FDI) for many of the secondary benefits (spillover effects) which it can theoretically provide. FDI is often touted as a way to increase productivity through the spread of new technologies, capital formation, and human capital (Piteli, 2009). Thus, productivity should be a factor which governments are taking into account when determining their tax rates.

The literature concerning the relationship between FDI and its spillover effects has been reviewed extensively by several authors (i.e. (Goerg & Greenaway, 2004); (Gachino, 2010)), who lay out the basic channels of productivity transmission. The first channel where FDI leads to improved productivity is through human capital. When multinational enterprises (MNEs) enter a host nation they necessarily employ local labor. Over time, this newly trained labor may leave the MNE to find employment in local firms or start their own businesses, thus spreading the knowledge acquired at the MNE throughout the host economy (Fosfuri, Motta, & Rønde, 2001). Another channel of spillover occurs through increased competition between the MNE and local firms (Glass & Saggi, 2002). Even if the local firms do not have access to the technology of the MNE or its employees, they are still under pressure to reduce costs and increase productivity in order to compete. Thus countries compete for revenues but also for the productivity spillovers which FDI brings with it.

Empirically, the literature has produced mixed results with regard to productivity spillovers resulting from FDI. Rodrik (1999) asserts that it has been hard to find these supposed productivity spillovers of FDI in host countries. While some like Haskel, Pereira, and Slaughter (2007) and Keller and Yeaple (2003) were able to find some evidence of spillovers in the advanced countries, it did not appear to apply as well to developing countries. However, Javorcik (2004) finds spillovers in Lithuania from FDI but only across industries. Kugler (2006) also finds these inter-industry spillovers in Columbia. Nicolini and Resmini (2010) also finds evidence for spillovers both horizontally and vertically when looking at a panel data set of new EU members of Poland, Romania, and Bulgaria. If we accept that these spillovers are taking place (or that at least governments assume they exist) then it is a reason why countries would be induced to compete over taxes.

The literature presented on productivity spillovers investigates how foreign companies investing in a home country disperse their higher productivity levels to these home country firms. In the same vein of research a related idea has also emerged, that high home country productivity can attract foreign firms looking to benefit from productivity spillovers.

While there has been a glut of studies investigating how increased FDI leads to higher productivity, there seems to be less research looking at the question of whether FDI is attracted to areas with increasing productivity. The few works dealing with the question of FDI being attracted to productivity shocks will be addressed and then a hypothesis will be formed relating this idea to tax competition. Razin and Sadka (2007) construct a model where productivity shocks in one country may lead to a change in FDI

flows. If productivity increases it raises the marginal return on capital and would induce more FDI (in the form of mergers and acquisitions) to flow into the country.

Razin, Sadka, and Tong (2008) show that productivity shocks will have different effects for different types of FDI. In their model, they look at the case of greenfield FDI between a rich and a poor country. Initially, a productivity increase in the poor country will cause an increase in marginal returns for foreign investors. However, over time, increasing productivity leads to increased wages, thus lowering profitability for foreign companies operating the host country. This theory is, in effect, assuming that spillovers will work in the reverse way, benefiting the FDI owners and inducing the FDI source countries to potentially send even more investments. The source country would then need to take action to prevent an outflow of its capital and it is logical to presume that it would use its tax rate to accomplish this.

A possible reason why so much of the literature focuses on FDI causing productivity is because the authors are interested in studying FDI from developed to developing countries. However, as a large portion of FDI flows between developed countries, understanding this flow should also be an important part of the literature. Piteli (2009) conducted a study about FDI in developed countries to address this point. She found that total factor productivity (TFP) was the most important determinant for FDI from other developed countries. Finally, Calderon, Loayza, and Servén (2004) when doing an extensive study into FDI flows found that FDI is attracted to countries with economic growth. While this does not relate directly to productivity, productivity growth is a factor contributing to economic growth.

The tax competition literature focuses on how countries compete on tax rates to attract FDI, while Razin et al. (2008) and Piteli (2009) argue that FDI is attracted to productivity in the economy. Logically, combining these two ideas provides the hole in the literature which has yet to be investigated. Thus, the main hypotheses are presented:

H1: An increase in productivity in an FDI host country will cause the FDI source country to lower its tax rate.

H2: An increase in productivity in an FDI source country will cause the FDI source country to raise its tax rate.

## **2 Empirical Modelling**

### **2.1 Methodology**

As the present study deals with tax competition, a brief review of the methodologies of past studies is in order. According to Leibrecht and Hochgatterer (2012), past studies which investigate tax competition can be classified in two ways – direct and indirect studies. Indirect studies are those which do not look directly for the existence of tax competition but instead look at proxies or indicators. One way of doing this is to directly measure tax capital elasticities, thus finding the negative impact that raising taxes has on the level of foreign capital. Then there are the direct studies which Leibrecht and Hochgatterer (2012) break up into first generation and second generation studies. These direct studies aim to tackle the problem head on and try to explain the movements in the tax rate. The first generation studies do this by using a measure of a country's openness

as the independent variable of study. The logic being that if a country is sufficiently open to globalisation and foreign investment then it should engage in tax competition and strategically lower its tax rate.

Testing tax competition empirically poses a series of problems for researchers. Going back to the philosophical underpinnings of economics, many of the same problems which are experienced in the social sciences can be seen again here. The theory of tax competition predicts a reduction in tax rates but does a reduction in tax rates necessarily imply that the reduction was due to competition? There are many possible reasons for lowering tax rates. There is the possibility that a common intellectual trend is making its way between countries which accounts for the drop in tax rates (M. Devereux & Loretz, 2012). Yardstick competition, whereby governments simply set tax rates by comparing what their neighbours have set for tax rates is another possibility. In addition, government might lower capital taxes but instead shift to another form of taxation because they think it is more efficient (M. P. Devereux, Lockwood, & Redoano, 2008). The challenge of investigating why taxes seem to be dropping is what led to the first generation studies. These studies indirectly measure tax competition through the proxy of openness. These proxies are problematic due to the difficulty in measuring them. For example, Quinn (1997) used the proxy of capital mobility to measure the openness of countries. However, the index provided in the study is a subjective assessment of capital mobility and can not be perfectly calculated for different countries.

The second generation direct studies use game theory as the underpinning for their work. Much of the theoretical work dealing with the interaction between countries and their setting of taxes takes the form of Cournot and Stackelberg games like in Borck and Pflueger (2006). Cournot games involve two countries, possibly symmetric, which have to choose their tax rates at the same time. In a Stackelberg game, there is a leader who gets to choose their tax rate first and then the other players react to that choice. The first mover in the Stackelberg game is often times assumed to be the biggest or most powerful country economically, i.e., the United States. Once the authors have modeled a tax reaction function they then try to test it out on actual data. Finally, studies from the school of economic geography attempt to test the effects of agglomeration forces on tax competition and can be considered as being within the second generation studies because of their inclusion of strategic behavior in their models. Since these models explicitly define the home country tax as being a function of foreign countries, the foreign country tax rate needs to be included in the empirical model. In real life there is more than one country involved in the competition, thus the researcher is forced to come up with a way to model all of the foreign tax rates as one variable. From the field of economic geography, a spatial weighting can be performed, whereby a weighted average of all foreign countries can be calculated as the foreign country tax rate. One of the most logical ways is to set up a geographical weighted matrix where countries which are closer geographically are given higher weights (Brueckner, 2003). However, as Redoano (2007) suggests if equal weights are used then it shows that perhaps an intellectual trend is the reason why taxes are changing. She suggests that the best way to test for tax competition is to use weights based on country size or on the degree of economic ties. The methodology of this paper will incorporate this idea.

A primary challenge of dealing with tax rates is that the statutory rate is often times not representative of the actual tax burden incurred by firms in a country. Thus, when testing tax competition, it becomes necessary to transform the tax rates into more

realistic forms. There are several methods of doing this provided within the literature. The first method is to use average tax rates. This means calculating the average tax that was paid on the capital base in a country, which, because of tax planning and aggressive use of accounting rules, may end up being substantially lower than the statutory rate. These tax rates in the literature are known as backward looking and can be problematic because of the endogeneity problem. This is because the average tax rate could also change by very recent capital investments (M. P. Devereux, 2007). A question which illustrates this endogeneity problem is as follows: is the tax rate changing because the government wants more FDI or is the rate changing because more FDI has recently come in? And if we try to look only at average tax rates, there maybe a situation where a corporation locates in country with high average taxes but with laxly enforced transfer payment laws, so that profits can be easily shifted to other countries (Leibrecht & Hochgatterer, 2012). Thus, backward looking tax rates are clearly not desirable.

Forward looking tax rates incorporate all of the possible deductions from the statutory rate that corporations could make going forward using present value calculations. These rates are a more realistic measure of tax because they represent what the firm expects to pay, which will influence their investment decisions for the future (Egger, Loretz, Pfaffermayr, & Winner, 2009). Forward looking tax rates can be broken down into average effective tax rates (AETR)—which take all of the deductions into account and calculate the average tax to be paid for an investment—and also marginal effective tax rates (METR). The METR is the tax incurred by every additional capital addition, thus, the AETR is more suitable when a company is looking at making a new investment and METR when the company already has an investment and is looking to increase or decrease that investment. However, problems with these forward looking tax rates are that they do not take into account all of the tax regulations and rules (that would be too complicated), and they also can't capture profit shifting that goes on within businesses (Sørensen, 2004). Finally, statutory tax rates come into play especially when looking at highly mobile tax bases. Firms use these rates when calculating the incentives of shifting deductions and income between countries (De Mooij & Ederveen, 2008).

## 2.2 The Study

The goal of this study is show a relationship between tax competition and productivity. Thus, an econometric model is constructed which can successfully measure the relationships involved despite the econometric issues mentioned before. To begin, the AETR is chosen as the measure of tax ( $\tau_{it}$ ) for country  $i$  at time  $t$  to be used as the dependent variable and also to represent the tax of other countries, as is also done by many other tax competition studies (e.g. (M. P. Devereux et al., 2008); (Klemm & Van Parys, 2012);(Liu, 2013)). A further reason for using AETR is that M. P. Devereux, Griffith, and Klemm (2002) explain that governments tend to reduce AETR more for profitable projects, which seems to be driving tax competition.

The econometric model is specified as the following:

Figure 1

$$\tau_{it} = \alpha + \beta_1 \tau_{i,t-1} + \beta_2 \sum_{j \neq i}^n \omega_{ij} \tau_{j,t-1} + \beta_3 \text{Prod}_{i,t-1} + \beta_4 \sum_{j \neq i}^n \omega_{ij} \text{Prod}_{j,t-1} + \beta_5 X_{i,t-1} + \eta_i + \varepsilon_{it}$$

$\tau$ = Tax rate (AETR)

$\omega$ =Weight

Prod=Productivity

X=Control Variables

$\eta$ =State Fixed Effects

$\varepsilon$ =Error

In this estimation, countries set their tax rates by observing foreign tax rates, as predicted by the tax competition similar to a Stackelberg model mentioned earlier. The foreign tax rate is modeled as the weighted average of the AETR of the other nations in the study. Next, the domestic and weighted foreign productivity rates (*Prod*) are included as the main regressors of interest. As the measure of productivity, log GDP per person employed was chosen as a proxy for productivity. As mentioned by Schreyer and Pilat (2001), GDP per employee is only one way of measuring productivity and is far from perfect, but the data for this variable is widely available for all of the countries in the present study. *X* represents country specific control variables, which are included due to previously mentioned theory of tax competition and sourced from previous empirical works on tax competition (Mileva, 2007). The first variable included is country openness, which is proxied by exports per GDP as a percentage. Openness to exports should mean that a country is also experiencing FDI and should be responding to the tax rate changes of neighbor nations. Next gross fixed capital formation (*gfc*) as a percentage of GDP is added. This variable encompasses fixed assets including factories, equipment, offices, etc. and is used as a proxy for industrialisation of an economy. This control variable takes into account the theoretical impact that agglomeration should have on tax competition (Charlot & Paty, 2010). Next, government expenditure is included as a percentage of GDP as the tax rate should be affected by how much the government is spending. This variable can also be affecting tax competition through the channel of competition between governments for foreign investment through public spending as spelled out by (Goerg et al., 2009). Then, a population variable is added that shows the proportion of the population which is 15-65, which can be considered to be working age. More working age population suggests that a government could have a greater revenue effect by taxing labor more and also, might favour capital more as a way to increase employment. All of these control variables are included  $t - 1$  to deal with any endogeneity issues associated with reverse or dual causality. The model also includes a time dummy with values of 1 before the financial crisis of 2007 and values of 0 afterwards in order to catch any



disturbance from this time period. Finally  $\eta_i$  is used to account for state fixed effects and  $\varepsilon$  is the error term.

As the model in question is a spatial lag model, an important decision involves the choice of the weights to be included in the econometric specification. When dealing with spatial models distance is almost certainly one of the most important factors to take into account. There are several ways of incorporating this geographic weight. The first method is to give weights for countries which are direct neighbours (touching) a country and 0 weight for all others. The problem with this approach is that certain countries in this study's sample, for example the UK, have no neighbours. In addition, it is important to note that capital is fairly mobile and is not easily confined to neighbouring countries (Klemm & Van Parys, 2012). This leaves open the second method which is to construct the weighting matrix by measuring the distances between countries (several methodologies are possible). In addition to distance, other factors can also be included in the weighting matrix. As it has been shown previously that governments do take into account the actions of states which are more economically similar to themselves (Case, Rosen, & Hines Jr, 1993), and that FDI flows between developed countries are linked to productivity (Piteli, 2009), this study will include a weight which also rewards countries which are more similar to each other economically as is done in (Liu, 2013). Thus the weight will be calculated as follows in figure 2:

Figure 2

$$\omega = \frac{s_{ij} * d_{ij}}{\sum_{j=1}^n s_{ij} * d_{ij}}$$

$$s_{ij} = \frac{1}{|gdp\ capita_i - gdp\ capita_j|}$$

$$d_{ij} = \frac{1}{distance\ between\ county\ i\ and\ j}$$

Here  $s_{ij}$  represents the absolute value of the inverse of the difference of GDP per capita between country  $i$  and  $j$ . Smaller differences in GDP per capita will thus increase the weights for foreign countries. In addition,  $d_{ij}$  represents the inverse of the distance between countries, so that the larger the distance, the smaller the weight. Then this number is divided by the sum of all the values obtained from other countries so that the weights will sum up to 1.

### 2.2.1 Econometric Choice

The most important econometric challenge within the study of tax competition has been the endogeneity problem. The problem with running regressions on the tax rate of a country is that both the dependent and independent variable are being chosen simultaneously. This leads to correlations within the error terms of the regression which then leads to biased estimates. This endogeneity leaves standard ordinary least square (OLS) useless as the estimates would be biased. This endogeneity problem has been

addressed in several ways, mostly employing the general method of moments (Arellano & Bond, 1991).

The first way of overcoming the endogeneity problem is through the use of instrumental variables. With regards to tax competition, M. P. Devereux et al. (2008) create instrumental variables by using weighted averages of control variables which are used in other countries in the study. Simply put, for a vector of control variables  $X_{it}$  it is possible to construct instruments for each element by taking the weighted averages of the other countries. Well-constructed instruments should be correlated with the endogenous variable and not be correlated with the error term in order to eliminate the bias of the estimated coefficients.

Regarding the present study there are multiple endogenous variable involved with the specification which need to be dealt with. While including the first lag of the dependent variable (AETR) catches the autoregressive aspects of the tax rate, it is clearly an endogenous variable and it will correlate with the fixed effects, thus making any kind of OLS approximation biased and unusable. Secondly, the inclusion of the spatial lag (foreign AETR and foreign productivity) create endogeneity because of simultaneity. Using spatial lags assumes that countries are affecting each other, and while using OLS one would have to assume that one country is dependent while the others are independent. However, the influence should be going in both directions as countries affect each other simultaneously. Therefore, this study turns to an alternative method which can combat the multiple layers of endogeneity.

The Generalised Method of Moments (GMM) developed by (Hansen, 1982) is an econometric method which utilises the moment conditions to get consistent unbiased estimators when OLS would normally fail. Thus, studies dealing with endogeneity are forced to use GMM to get consistent unbiased results. The present study utilises a panel data set from the World Bank and the OECD, encompassing 41 countries listed in table 1, and ranging from the years 1998-2012.

Table 1

Argentina	Australia	Austria
Belgium	Canada	Chile
Czech Republic	Denmark	Estonia
Finland	France	Germany
Greece	Hungary	Iceland
Ireland	Israel	Italy
Japan	Korea	Luxembourg
Mexico	Netherlands	New Zealand
Norway	Poland	Portugal
Slovak Republic	Slovenia	Spain
Sweden	Switzerland	Turkey
United Kingdom	United States	Brazil
China	India	Indonesia
Russian Federation	South Africa	

Due to the data type and restrictions, the so called Arellano-Bond estimator is employed (Arellano & Bond, 1991). This type of model is specifically designed for panel

data with a large number of “N” (countries) and small “T” (Years) and which has a dynamic element, which is the lagged value of the dependant variable used as an independent variable. In addition, these models also contain fixed effects, which are also present in the current study. To deal with the Arellano-Bond estimator, econometricians generally employ difference GMM, which is outlined by Arellano and Bond (1991). Difference GMM deals with the endogeneity problem by using the lagged endogenous variables as instruments of themselves. In addition, it uses differences of the variables to eliminate the fixed effects which might otherwise bias the estimates. However, the problem with difference GMM is that the lagged values of the regressors do not always make the best instruments, which led to the creation of system GMM, which was formulated by Blundell and Bond (1998). System GMM can be thought of as difference GMM with the addition that it adds additional instruments by taking levels equations and instrumenting them with the first differences. System GMM is thus able to use more moment conditions and produce more efficient results (Bond, 2002). The present study will use system GMM for the reasons previously presented.

The system GMM was calculated using STATA and the `xtabond2` program. As suggested by (Roodman, 2009a) the specification using `xtabond2` should be described in detail because it is possible to achieve seemingly valid results from invalid inputs if the model is misspecified. The first model, which is presented in column 1 of table 2, is set up by including all of the dependent variables with one year lags as an extra precaution to protect against endogeneity. Next, several variables from the specification should be chosen to have their lags instrumented: (EATR, foreign EATR, foreign GDP per employed person, GDP per employee, gross fixed capital formation, government expenditures). As recommended by (Roodman, 2009a) variables which are endogenous or are considered to be pre-determined should have their lags used as instruments. Then the exogenous variables (working age population, exports, and the time dummy) are entered into the instrument matrix separately. Thus every variable is included in the instrument set at least once. In order to limit the instrument set, lags of 1 or 2 were used and principal component analysis was additionally administered. It is recommended by STATA that the instrument count not exceed the number of groups, which in this case is 41, as too many instruments can overfit the endogenous variables.

The second column of table 2 displays the results for a static model where the first lag of the dependent variable is dropped from the regression. The inclusion of this lagged variable is necessary in small “T” samples because shocks to the fixed effects can correlate with the error term and cause bias. However, the time span that is used in this study (16 years) is not very small, thus testing the static model may also be legitimately considered.

For the third regression the instrument set was restricted as much as possible by fixing the lags used for instruments and by collapsing the instrument set. This specification is included because according to Roodman (2009b) the inclusion of too many instruments may give valid results to invalid estimates, thus specifications should be checked with as few instruments as possible to ensure model validity. In this specification all of the variables are left unchanged, but the instrument set is reduced to 22 instruments. For all of the above estimations, twostep estimation is employed as it makes the panel robust to heteroskedasticity. In addition, the Windmeijer correction was used because two-step system GMM tends to bias the standard errors downward when not corrected for.

Table 2

Dependent Variable:	Column 1	Column2	Column 3
AETR		Static Model	With collapsed instruments
AETR t-1 (z-score)	0.8596*** (15.20)		0.9077*** (16.04)
Foreign Tax (z-score)	0.9322** (2.14)	0.1125 (1.38)	0.0736* (1.91)
Pop 15-65 (z-score)	-0.0008 (-1.03)	-0.0063*** (-2.05)	-0.0004 (-0.07)
Gross Fixed Capital (z-score)	-0.0316 (-0.38)	0.1111 (0.98)	-0.0945*** (-2.81)
Gov. Expenditure (z-score)	0.0131 (0.09)	0.1432 (0.75)	0.0015 (0.02)
Exports (z-score)	-0.0001 (-0.90)	-0.0001*** (-3,47)	-8.33e-06 (-0.21)
Log GDP per Employed (z-score)	-0.0009 (.18)	0.0058 (0.37)	-0.0043 (-0.80)
Log Foreign GDP per Employed (z-score)	-0.0032** (-1.82)	-0.0094*** (-2.91)	-0.0029** (-2.05)
Time Dummy (z-score)	-0.0012 (-0.56)	0.0251*** (4.31)	-0.0010 (-0.51)
Constant (z-score)	0.1007** (1.52)	0.5961*** (3.97)	0.1003* (1.73)
Observations	549	560	549
Instruments	48	48	22
AR(1) (p-value)	0.031	0.438	0.032
AR(2) (p-value)	0.268	0.339	0.267
Hansen Test (p-value)	0.470	0.617	0.871
Difference in Hansen Test of GMM instruments			0.968
Difference in Hansen Test of IV instruments			0.921

## 2.3 Results

The results are presented in table 2 showing that the productivity shocks of home country had no significant effects on home country tax rates (H2 rejected), while

productivity shocks in foreign countries showed a small yet strongly significant effect (H1 accepted), thus confirming the idea that a positive productivity shock in an economically and geographically close country will induce a home country to lower its tax rate. In addition, tax competition is clearly confirmed from the regressions in columns 1 and 3 of table 2.

The main results can be interpreted as follows: a 10 percent fall in foreign tax rate would lead to a 0.9 percent decrease in the home tax rate. These results suggest that while tax competition exists, it is fairly weak in reality, as the reported coefficient is significant yet not large. Relating this to the literature of Goerg et al. (2009), tax competition may be weak because countries also compete on other factors like foreign government spending. However, the current study only tested if home government spending affected tax competition, which it does not, as can be seen in table 2.

Of main interest to this study are the coefficients for productivity—both home and foreign. Changes in home country productivity are statistically insignificant but changes in foreign productivity were found to have a significant impact on home country tax rate such that a 10 percent rise in foreign country productivity would be associated with a lowering of the domestic tax rate by .032 percent. While this does confirm the idea that productivity is affecting tax competition the effect appears to be quite small. It may be that countries are only competing for a few specific FDI projects, thus the aggregate results appear smaller through averaging. It is also important to note that the results found were contingent on the spatial weighting scheme employed, which may not have been optimal. It is possible that future studies, employing more advanced weighting schemes may find larger effects.

Many of the theoretically derived control variables proved to be statistically insignificant. One development of notice was when the gross fixed capital formation variable became significant after the reduction in instruments. This variable, was meant to proxy industrialization or agglomeration, and lends support to the Economic Geography literature mentioned in first section of this paper. According to Roodman (2009b) using less instruments increases efficiency of the model, so these results may hold more weight than the initial regression.

Concerning the validity of the results, STATA conducts several tests. First displayed are the Arellano-Bond tests for auto regression in first differences. These tests are necessary because if the instruments are autocorrelated then they would be endogenous with the error term. As specified in Arellano & Bond (1991) the test for AR(1) are not important when the lags have been restricted to t-2 as has been done in with the present regressions. The AR(2) test should show no autocorrelation in order for the instruments to be valid and this holds true for all of the results presented. The next tests reported are the Hansen test for overidentifying restrictions. This test tests the exogeneity of the instruments used. Since we fail to reject the nulls we can assume the model has valid exogenous instruments. For the third specification in column 3, Difference in Hansen tests are also reported as additional tests of exogeneity of the GMM instruments, (endogenous and predetermined variables) and the IV instruments (exogenous variables). As the p-values are quite high we fail to reject the null hypothesis of instrument exogeneity. These difference in Hansen tests are not included in the previous specifications because STATA does not report these tests when principal component analysis is performed.

Another check, which is suggested by (Roodman, 2009a) is to see if the deviations away from the steady state are not related to the fixed effects. This can be quite simply done by checking that the coefficient of the first lag of the dependent variable is less than 1, which in the case of this research, is true for all of the results. In addition, (Bond, 2002) suggests checking that the above mentioned coefficient is between the OLS and fixed effects (FE) estimates as an additional test of model validity. In the case of the first regression presented in table 2: OLS=.92, System GMM=.86, and FE=.73, thus validity is confirmed.

### 3 Conclusions

While confirming the existence of tax competition between countries, this study makes the important contribution of relating productivity shocks to changes in tax rates. Despite finding a relatively small connection between tax rates and productivity, this study confirmed that foreign productivity shocks cause a negative reaction in home tax rates. Their yet remains debate about whether tax competition should be allowed to continue unfettered or whether some form of tax harmonisation should be instituted. For instance, a Franco-German proposal titled the "Pact for Competitiveness" from February 4th, 2011 names a wide list of policies which should converge in order to foster a common market in the EU. Importantly, they include tax harmonisation as a possible solution. The results of the present paper, however, suggest that there could be some negative side effects of tax harmonisation. If countries were unable to change their tax rate in response to a positive productivity shock in a foreign country, they would lose this powerful tool to protect their capital from flowing out to exploit the higher returns in the foreign country. Being so limited, the country in question would have to resort to other, possibly less efficient ways, to retain its capital, thus lowering social welfare. As the spatial weighting used was one that put larger weights for countries of similar economic status, it can be concluded that tax competition and productivity are related between these types of countries.

Relating this study to the tax competition literature, the resulting coefficients relating to tax competition were relatively small. This result weakens the argument for tax harmonisation because if there was truly a race to the bottom, one might expect the tax rates to be more closely linked. Thus, policy makers need only be mildly concerned with the competitive reactions to their changes in domestic capital tax policy. These results lend credence to a foreign affairs paper by Krugman (1994) where he argues that the obsession with competitiveness in economics is being overblown. In politics it can be quite convenient to blame economic problems on a lack of competitiveness with other nations, when in fact, domestic policy failures may be more to blame.

Further studies will be able to look deeper into how productivity and tax competition are related. The present study was limited to broad measures of aggregate data. The use of other measurements of productivity and focusing on specific regions could provide more reliable results. In addition, different types of spatial weighting matrices may also reveal improved results.

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