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TAX COMPETITION AND GOVERNMENTAL EFFICIENCY

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Summary

International tax competition has been studied quite thoroughly throughout the past decade. However, the efficiency of governments involved in creating public goods has received little attention in the analysis of tax competition. This paper contributes to filling this gap. Namely, we claim that international investors consider the tax rates of a country, as well as its efficiency in providing public goods when making an investment decision. As a result, it becomes possible that a country with a higher tax rate can still attract some investment.

We outline a model where two countries are competing for foreign investments by strategically setting their income tax rates. One of the countries is relatively more efficient than the other. Formally, this means that the government of this country is able to produce more public goods out of the same revenue than the government of the other country. The existence of public goods reduces the production costs of the firms – public goods considered here are such as infrastructure or public education. As a result, it might be worthwhile to invest in countries with higher tax rates but with a higher level of public goods provision. The main conclusion is that, in equilibrium, the more efficient government always sets a higher tax-rate than the government of the less efficient country.

The model is tested empirically on a sample of 28 countries, for the years 1996 to 2005. With minor deviations, the predictions of the theoretical model are supported by the empirical analysis. In a "race to the bottom" framework, this implies that highly efficient countries that traditionally impose higher taxes should not be afraid of tax competition, since they can still attract investments by creating a high-quality business infrastructure. At the same time, less efficient countries should not "converge" to those of higher efficiency in taxation policy, since this will drive out all the foreign capital.

1 Introduction*

This paper examines the effect of a government's efficiency on the taxation policy of a state. Namely, we claim that countries are different in the way they tax capital as well as in the way they spend the collected revenue. Obviously, there are governments that spend the tax revenue more efficiently than other governments. Therefore, they can produce more public goods out of the same amount of money. We assume that firms, when choosing the location of investment, consider not only the tax rate set in the country, but also its provision of public goods. As a result, capital tax rates are different in equilibrium: the more efficient country attracts investments even with higher taxes, while the less efficient one is forced to use lower fiscal pressure as its only instrument of inducing firms to stay.

Due to its relevance for policymakers, the topic of international tax competition has been studied quite thoroughly through the past decades. The theoretical framework used here is a modification of the "work-horse" Zodrow-Mieszkowski (ZMW) model, conceptualized by Oates (13) and formalized by Zodrow and Mieszkowski (22). Some scholars adopt also a game theoretical approach.[1] The role of the government in these models varies from purely beneficent, like in Zodrow-Mieszkowski (22) and Devereux et al. (8), to completely mercenary, like in Leviathan-type framework of Wooders et al. (20).[2] At the same time, despite their diversity, none of these models account for the efficiency of governments involved in tax competition. Indeed, all of them assume that each state can produce the same amount of public good out of one unit of private good. At the same time, it is clear that the way bureaucrats spend the tax revenue in a country defines the quantity and quality of the public good produced. Therefore, not only the amount of revenue collected is important but also how efficiently it is spent. On the other hand, the investment decision of a multinational corporation may be based not only on the domestic tax rate, but also on the public infrastructure provided by the country. Indeed, for a company such infrastructure may reduce the cost of the good's production and its

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[1] See, for instance, Devereux et al. (8), Wooders et al. (20)

[2] We provide more detailed explanation of these in Section 2.2.

delivery to the market.

Our paper is an attempt to fill the above-mentioned gap, present in the existing literature. Namely, we propose a model of two countries engaged in competition for foreign investments. There is a continuum of multinational companies willing to invest in either of the two possible locations. They are assumed to be technologically "dependent" on the amount of public good produced in the country. Therefore, they make their investment choices comparing not only the tax rates in the competing countries, but also the reduction of their production costs due to the business infrastructure. At the same time, the government of one country is relatively more efficient than the government of the other, which allows it to produce relatively more public good out of the same tax revenue, and therefore attract more firms. We find that in equilibrium the more efficient country always sets a higher tax-rate than the less efficient one. Our results, though, do not contradict the "overall" conclusion of the contemporary literature that the reaction functions of both governments are increasing near the equilibrium. Here the reaction function is the tax rate of a country as a function of the "rest-of-the-world" tax rate. One more conclusion of the model is that the reaction function of a country becomes steeper with an increase in governmental efficiency.

Finally, we test the model empirically, using data of 28 countries, for the years 1996 to 2005. As a proxy for tax burden we use the effective average tax rate (EATR). EATR basically defines the share of the firm's future cash flow, which it will have to transfer to the country's government. Governmental efficiency is proxied by the Index of Economic Freedom (published annually by the Heritage Foundation), and by gross domestic product per capita. The methodology we use is standard for testing strategic interaction between several players. We find that, indeed, the "rest-of-the-world" tax rate and governmental efficiency affect significantly and positively the tax rate of a given country, as well as the slope of the reaction function. Therefore, the main conclusions of the model are confirmed by the empirics.

The structure of the paper is the following: we present some stylized facts from European history as well as a literature overview concerning the theory and the testing of tax competition in Section 2. In Section 3 we set up and solve the model. Next, Section 4 is devoted to the empirical testing of the results obtained in Section 3. Finally, Section 5 concludes.

2 Background

This section concerns the motives leading us to writing this paper. Namely, we discuss here the history of European tax competition and its connection with the efficiency of a country's government. Further, we proceed with the theory of tax competition as it is presented in the current literature, and highlight its possible gaps.

2.1 Historical Evidence from Europe

Europe represents a perfect training range for those who study tax competition. Indeed, especially after the Maastricht Treaty in 1992, the obstacles for capital movements in EU-15 are practically absent. Although there are a few discrepancies between the EU-15 and the new members in corporate legislation,[3] the capital is highly mobile in these countries as well. Perfect capital mobility is one of the main assumptions of tax competition modelling, therefore EU-25 becomes a flawless region for theory testing.

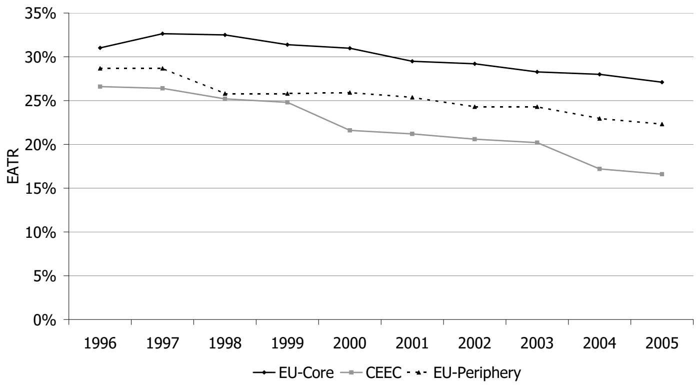
We are not going to get into details about the tax rate movements in Europe throughout the history. Those interested may refer to the extensive surveys of Devereux, Griffith and Klemm (7), Devereux and Sorensen(9) (for EU-15), and Devereux (5) (for the new members). On the contrary, to make our analysis more tractable, we divide Europe into three groups, consisting of countries that are homogeneous in certain properties. First is the EU-Core, to which we ascribe France, Germany, Belgium and the Netherlands. These are the long-held stable democracies, traditionally providing high level of public good. EU-periphery, the second group, consists of Spain, Greece and Portugal. These countries entered the EU relatively recently and are still trying to catch up with the EU-core standards. Finally, the last group is CEE countries, Poland, Hungary, Slovakia, Czech Republic and Slovenia: new EU members, lagging quite substantially behind the EU-Core. Figure 1 shows, how the effective average corporate tax rates were changing in these groups from 1996 to 2005.[4]

One can easily see from figure 1 that the average EATR was always higher in the EU-Core than in any other group, while EATRs of EU-periphery and CEEC were practically the same until recently. However, EATR's of CEEC

[3] First of all, the new member countries are still allowed to subsidize and create special allowances for certain industries and certain geographical areas.

[4] EATR's for EU-15 were calculated by Devereux and Griffith, who used them in (6). For CEE countries EATR's were calculated by Bellak et al. (2) and Jacobs et al. (11). We return to this measure in Section 4.2.

Figure 1: Effective average corporate tax rates



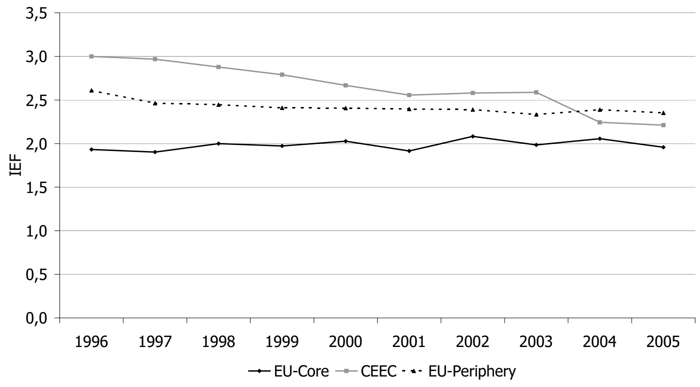
Note: Unweighted average in 3 country groups: EU-Core – France, Germany, Belgium, Netherlands; CEEC – Poland, Czech Republic, Slovakia, Slovenia, Hungary; EU-Periphery – Spain, Portugal, Greece
Source: Devereux, Griffith (6), Bellak et al. (2), Jacobs et al. (11), Kotans (12)

decreased significantly (almost by 6 percentage points) in the last two years. Note that 2004 is the year, when these countries became EU members.

Figure 2 depicts the development of the governmental efficiency in these groups. As a proxy here we use the Index of Economic Freedom, issued yearly by the Heritage Foundation (10).[5] It varies from 1 for a perfectly free country to 5 for a deeply repressed one. As we can see from the graph, the EU-Core countries always attained the highest degree of economic freedom, while CEEC lagged behind the other two groups. The indices seem to converge with the time. However, until 2005, the pattern stays the same: EU-core has the lowest index, then comes EU-periphery, followed by CEEC. The picture shown in this section clearly testifies the positive correlation between the tax rate set by the country and the efficiency of its government. Indeed, EU-core countries charge high taxes, but at the same time they are the most efficient, while CEE countries charge low taxes in exchange for the lowest level of efficiency.

[5]Refer to Section 4.2 for more details.

Figure 2: Index of economic freedom, Heritage Formation (higher numbers mean less economic freedom)



Note: Unweighted average in 3 country groups: EU-Core – France, Germany, Belgium, Netherlands; CEEC – Poland, Czech Republic, Slovakia, Slovenia, Hungary; EU-Periphery – Spain, Portugal, Greece

2.2 Literature Review

The contemporary economic literature on the issue of international capital tax competition is more than crowded by different theories and directions.[6] The first one, who has driven the attention to this topic was Tiebout (17). He claims that the competition between jurisdictions leads to more efficient provision of public goods, accounting for the heterogeneous preferences of their inhabitants. However, Oates (13), Zodrow and Mieszkowski (22) and Wilson (18) (ZMW) assert that the interjurisdictional competition for the capital results in welfare-reducing tax undercutting, which they call "race-to-the-bottom". This framework was adopted by OECD and EU officials when arguing about the ban of tax competition.[7] At the same time, there were few responses to the ZMW-type models. In some of them, such as Brennan and Buchanan (3), competition among jurisdictions is considered as the way to "tame" ever-growing Leviathan state. In addition, Wooders et

[6]See Wilson (19), Brueckner (4), Stewart and Webb (16) for detailed surveys.
[7]See OECD (14) for more details.

al.(21) use the ZMW-framework to show that the tax competition may even lead to "race-to-the-top" if the public good affects positively the production function of the firm.

The models described above use different computation techniques, as well as adopt various assumptions about the firms and the governments. However, we did not find any theoretical paper dealing with the efficiency of the government. Indeed, all the models assume that the government produces one unit of public good out of one unit of private good, collected as a tax revenue, i.e. the production function is $g = x$. What we do in our model is that we assign different production functions to the governments of two competing countries, and then study the effect of this modification on the equilibrium outcome.

There are a few papers, which resemble to a certain degree our considerations. Tiebout (17), Qian and Weingast (15) deal with the increase of governmental efficiency whenever the countries are engaged in international competition. However, these articles are rather narratives about the functioning of institutions. In our paper we use formal modelling approach, and in the end empirically test the model.

Leviathan-state models, mentioned above, may be claimed to accounting for governmental efficiency. But our setup is much wider than studying the behavior of the selfregarding government. While we can include such factors as corruption level, or unwillingness to work in the production function, efficiency of the government also depends on the experience, traditions, technologies, etc., regardless of bureaucrats' malevolence or benevolence. The same argument works when comparing our model to the agglomeration economy literature.[8]

The framework of the model was borrowed from Wooders and Zissimos (20). They also use two competing countries and continuum of technologically different firms. However, in their model governments are assumed to be identical, which gives completely different results in the outcome.

3 The Model

Here we shortly present a theoretical grounding for the fact that the tax rates in countries should not necessarily converge to a common value. Namely, we build a model in which two countries are in competition for foreign investments. One of the countries is relatively more efficient than

[8] See Baldwin and Krugman (1), for instance.

the other, meaning that the government of the former country is able to produce relatively more public good out of the same revenue. The countries play a classical game, in which they choose optimal taxation policy. The result is that in Nash equilibrium the more efficient country always charges higher tax than the "inefficient" one. Moreover, the reaction functions of both countries are upward sloping and become steeper with the increase of difference between them.

Section 3.1 sets up the model: we describe the behavior of the firms and governments, and give the rules of the game. In section 3.2 we describe the reaction functions of the governments and find corresponding Nash equilibria. Section 3.3 concludes.

3.1 Setup of the Model

The model consists of two countries, A and B, and multinational firms, willing to invest in these countries. Governments of both countries levy tax on every firm entering the market, and produce public goods out of the collected revenue. Firms make their investment choices taking into account the tax rates observed. First, we concentrate on the behavior of the firms, then go back to the governments, and finally set up the rules of the tax setting game.

3.1.1 Firms

We assume that there are infinitely many firms in the model. Each of them, in the absence of taxation and public good provision, incurs cost c of producing one unit of some good. Later it delivers this good to the market and sells for a price p.[9] Public goods, provided by the government, are assumed to affect positively the production technology of each firm. Indeed, public good provision in a country includes such productivity enhancing activities as road construction, investments in education (hence fostering qualified labor), work of the contract-enforcing institutions, such as courts, police, labor unions, antitrust bodies, and production of the business-related laws. Therefore, when investing in one of the countries, each firm has to pay a tax, imposed by the government, and at the same time it can use the business infrastructure of the country to reduce the cost of the good's production and it's delivery to the market.

[9] Therefore, $p - c$ is assumed to be constant for every firm. Even if we allow for different costs and profits it will not change the results of the model, since neither p nor c influence the firm's choice about the investment place.

Each firm is characterized by the parameter s of its technological attachment to the level of public good provision in the country: the higher is s the more advantages can the firm extract from present business infrastructure. For simplicity, s is uniformly distributed on the interval $[0,1]$. One can interpret this parameter as the degree to which the firm is tied to the public goods in the country, or as a share of resources, which it needs to produce and deliver the good to the market, and which are provided by the state for free. Naturally, different firms in different industries have different needs for such resources. For example, an original software developer will be willing to open its subsidiary in the country with highly educated labor, developed Internet network, etc. Probably, the most important thing for this firm will be the effective system of intellectual property rights protection. At the same time, retailers of cracked software need none of above mentioned services, except maybe Internet network availability.[10]

The firm with parameter s, f_s, invests in country i, $i \in \{A,B\}$, in which it makes more profits. The profit function looks the following way:

$$\Pi_i = p - c - \tau_i + s \cdot \ln(\frac{g_i}{\hat{s}_i}), \quad (1)$$

where p is the price of the good, c is the cost of producing it when there is no public good provision, and $-\tau_i + s \cdot \ln(\frac{g_i}{\hat{s}_i})$ is the "technology" function, showing the eventual cost for firm f_s with "technological attachment" parameter s, defined above, of producing one unit of good after paying tax τ_i and using the level of the public good provision $\frac{g_i}{\hat{s}_i}$. g_i is country i's overall amount of public good produced, and $\hat{s}_i$ is the share of all firms investing in that country. This way we assume that the public input is a rival good for the firm, and the more firms invest in the country the harder will it be for f_s to use business infrastructure provided by the government. For example, regardless of how good the public education is in the country, the competition for talented graduates on the labour market gets tougher with the increasing number of investors. The same applies to the usage of roads and transport networks. However, this assumption certainly has some implausible features. Clearly, some public goods proposed by the government, such as business legislation, are non-rival, while others are partly non-rival. For instance, if the market is not too saturated, one road can be used by many firms, and no firm is completely excluded. However, our assumption about public input rivalry helps to simplify the model

[10] In this example public good provision, such as protection of intellectual property rights, may even harm the firm.

significantly, while bringing no significant changes in results compared to the case when public good is defined in a usual way.[11]

The "technology" function fits quite well the real life. Indeed, the firm firstly pays a tax ($-\tau_i$ in the model) and then estimates additional to c the extra profit that follows from the existence of public goods. This extra profit ($+\ln(\frac{g_i}{\hat{s}_i})$ in the model) has decreasing returns to scale property, which is a plausible assumption.

Firm f_s faces the tax rates in counties A and B - τ_A and τ_B respectively, and the levels of public good provision - g_A and g_B. If $-\tau_A + s \cdot \ln(\frac{g_A}{\hat{s}_A}) > -\tau_B + s \cdot \ln(\frac{g_B}{\hat{s}_B})$ then f_s goes to country A, if $-\tau_A + s \cdot \ln(\frac{g_A}{\hat{s}_A}) < -\tau_B + s \cdot \ln(\frac{g_B}{\hat{s}_B})$ then it goes to country B. Otherwise, f_s is indifferent.

3.1.2 Governments

Governments are assumed to be benevolent. Their objective is to gather as much revenue as possible and transform it to the public good. From the first point of view such a setup may seem strange: no governments devote all their revenue on production of business enhancing public goods. Apparently, more reasonable would be to assume that the governments split the revenue into two parts: one of them goes to the production of economy-enhancing public goods, another one goes to different social payments and other expenditures. The government would then make decisions depending on some weighted sum of those two parts. However, as it can be seen later, such assumption makes the model much less tractable. At the same time, the model presented in the paper has quite substantial explanatory power. Indeed, transforming the whole revenue into "useful" public goods undoubtedly brings some positive externality on all spheres of life in the country. For example, investments in higher education or road construction give benefits to both firms and individuals living in the country. Therefore our assumption does not sound completely irrational.

The transformation from private good into public good is not one-to-one as it is assumed in most of the similar models.[12] The government of country A is assumed to be more efficient in producing the public good then the government of country B, i.e. it is able to produce more units of

[11] I.e. when the public good is non-rival. Such assumption makes the model intractable even when the simplest "technology" function is used. Please contact the author if interested in this case.

[12] These models assume that the amount of the public good produced is equal to the amount of private good collected by imposing tax. See Wilson (19), Brueckner (4), Stewart and Webb (16) for detailed surveys of theory and empirical evidence of tax competition.

public good out of the same amount of private good than government B.[13] In our model we assume that the governmental production functions have the following form:

$$g_A = \hat{s}_A a + bx,\ g_B = \hat{s}_B + x,\ a > 1,\ b \geq 1,\ a > b, \tag{2}$$

where x is the amount of the private good collected, g_A and g_B are the amounts of the public good produced out of the private good by the governments A and B, and $\hat{s}_A$ and $\hat{s}_B$ are the shares of firms investing in countries A and B. The relative efficiency of government A is expressed by the fact that both a and b are greater than 1. Note that the amount of private good collected in country i is equal to the tax rate τ_i imposed by the government multiplied by the share $\hat{s}_i$ of the firms investing in that country. As a result, the governmental production functions can be rewritten in the following way:

$$g_A = \hat{s}_A(a + b\tau_A),\ g_B = \hat{s}_B(1 + \tau_B),\ a > 1,\ b \geq 1,\ a > b, \tag{3}$$

What the difference in the public good production functions means in real life is that one country simply handles the revenue from taxes in a better way than the other country does. It involves different aspects. Apparently, one of the main features of the efficient government is a low level of corruption, i.e. how much money is really spent on a production of public good, and not put in the pockets of government officials through preferring their own businesses or receiving bribes for inefficient solutions. Undoubtedly, efficiency as well as corruption is deeply correlated with the state of political and civil rights in the society, freedom of mass-media, and stability of economic and political situation in the country. Not less important is the expenditure side of the government. Obviously, the lump-sum payments to the population would be less useful for economic development than the investments in higher education, roads and digital networks building, or in the fight against corruption. We will come back to this issue in section 4.

3.1.3 Game

As it was said in the previous subsection, the objective of a government is to collect as much revenue as possible. At the same time, firms are looking for a jurisdiction, where they can earn more after-tax profits. After observing the tax rates τ_A and τ_B in countries A and B, and the levels of public good provision g_A and g_B as well, $\hat{s}_B$ share of the firms will go

[13] We call the government of country I just government I, $I \in \{A, B\}$

to country B, the others $\hat{s}_A = 1 - \hat{s}_B$ will go to A.[14] Obviously, both $\hat{s}_A$ and $\hat{s}_B$ are between 0 and 1, and both depend on the strategic interaction between the governments: given a and b, $\hat{s}_A$ and $\hat{s}_B$ depend on τ_A and τ_B: $\hat{s}_A = \hat{s}_A(\tau_A, \tau_B)$, $\hat{s}_B = \hat{s}_B(\tau_A, \tau_B)$.

Facing completely mobile firms, which look for bigger profits, governments are engaged in a tax competition game. The sequence of the game is the following:

1. Governments choose the tax rates τ_A and τ_B;

2. Firms compare their profits in country A and country B, $\hat{s}_B$ and consequently $\hat{s}_A$ are defined;

3. The revenues of the governments are $\tau_A(1 - \hat{s}_B)$ and $\tau_B \hat{s}_B$, i.e. tax rates imposed by the governments multiplied by the respective tax bases.

$\hat{s}_B$ is defined here as a share of firms investing in country B, and it is basically a technology attachment parameter $\hat{s}$ of a firm $f_{\hat{s}}$, which is indifferent between investing into country A and investing into country B. Indeed, firms which are more technologically attached than $f_{\hat{s}}$ (such f_s's that $s > \hat{s}$) will invest in a country with more efficient government.[15] This is country A in our case. On the contrary, those less attached will invest in country B. Therefore, it is the case that $\hat{s}_B = \hat{s}$ and $\hat{s}_A = 1 - \hat{s}$, where $\hat{s}$ is the technological attachment of the indifferent firm.

Considering the statement of the previous paragraph, we can calculate the tax base for both governments (i.e. the shares of firms investing in either of the countries) by simply finding the technological attachment index of an indifferent firm. For such a firm $f_{\hat{s}}$ the following equality is true:

$$-\tau_A + \hat{s} \cdot \ln\left(\frac{\hat{s}(a + b\tau_A)}{\hat{s}}\right) = -\tau_B + \hat{s} \cdot \ln\left(\frac{\hat{s}(1 + \tau_B)}{\hat{s}}\right) \tag{4}$$

As a result, $\hat{s}$, which is equal to the tax base of the government B (and $1 - \hat{s}$

[14] In some cases there will be a firm, which will be indifferent between two countries, but since we have continuum of firms, finite amount of them brings no revenue to the governments. Therefore the signs ">" and "≥" are identical in the model.

[15] One should consider different cases. However, it is true in equilibrium, so for the sake of simplicity we leave detailed analysis out of this paper. For detailed analysis please refer to the theoretical appendix (**Proposition 1**).

is the tax base of the government A), will be the following:[16]

$$\hat{s} = \frac{\tau_A - \tau_B}{\ln(a + b\tau_A) - \ln(1 + \tau_B)} \qquad (5)$$

Further, we proceed with sketching the analytical solution to the model.

3.2 Reaction Functions

In this section we solve the model. First, reaction functions of the governments are described. After that the Nash equilibrium is found, depending on the parameters a and b.

3.2.1 Optimal Responses of the Governments

The usual way to find Nash equilibria in a game is to look at the intersection of the reaction functions of the players. To find the reaction function of one player we have to fix the strategy of the other player and come out with the optimal response to it. We start with government A in our model.

Assume government B sets the tax rate on a level τ_B. The optimal response of government A would then be a tax rate τ_A, which maximizes the function:

$$\tau_A \cdot (1 - \hat{s}(\tau_A, \tau_B)) \;\rightarrow \max_{0 \le \tau_A \le \infty}, \qquad (6)$$

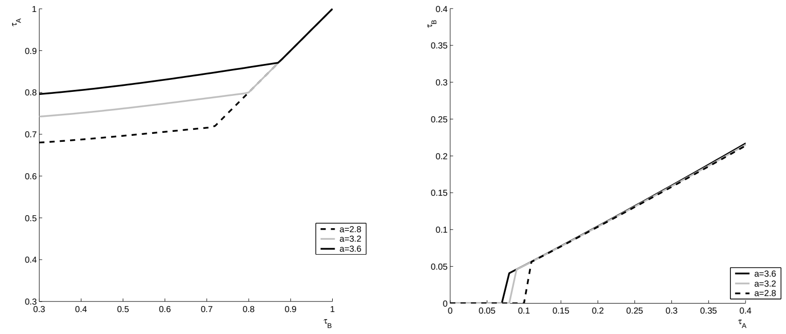
where $\hat{s}$ is given by equation (5).

It is not optimal for government A to charge a tax lower than τ_B, since even by setting the same tax, country A attracts all firms. At the same time, if τ_B is low enough, government A will charge higher tax than τ_B in the optimum. The intuition of this action is the following. Naturally, after the increase the least "attached" firms will move to country B, since they care mostly about the tax they pay, and not about the public good they receive in exchange. Therefore, $1 - \hat{s}$ will decrease. However, if the tax is increased not too much, some firms will stay in A. Those firms will pay more to the government, hence the revenue may increase. If τ_B is too high, then the revenue gains fail to overweight the shrinkage of a tax base, and government A charges τ_B.[17] Besides the fact that the optimal response of

[16]Again, $\hat{s}$ in general may be different, but for our purposes it is enough to use one specific case. For more detailed analysis please refer to the theoretical appendix (**Proposition 1**).

[17]This feature of the reaction function is the outcome of the specific "technology" function chosen. However, it does not influence the results in equilibrium. Refer to the appendix for the detailed proof (**Proposition 2**).

Figure 3: Optimal response of government A (left) and B (right)



government A, $r_A(\tau_B)$, is always at least as high as τ_B, it is also the case that $r_A(\tau_B)$ is increasing in τ_B around the equilibrium.[18] The left part of figure 3 shows the graph of r_A, as a function of τ_B, calibrated with different parameter values.

Now let us turn to government B. Facing the tax rate τ_A, its optimal response would be the value τ_B, which maximizes the following function:

$$\tau_B \cdot \hat{s}(\tau_A, \tau_B) \;\rightarrow \max_{0 \le \tau_B \le \infty}, \qquad (7)$$

where $\hat{s}$ is given by equation (5).

First of all, it is worth to note that government B will never set higher tax rate than τ_A if it follows optimal strategy. Indeed, it is obvious that no firm will go to B if $\tau_A \le \tau_B$, since otherwise for any nonzero s f_s would pay higher tax and receive less public good.[19]

As a result, having no incentive to set high tax rate, government B definitely would want to deviate from the "τ_A-strategy", i.e. setting always τ_A. Applying similar techniques as we did for government A's optimal response to the maximization problem, we can show that government B's response function, $r_B(\tau_A)$ is always lower than τ_A, and is increasing in τ_A. This means that government B looks for a "compromise" between the tax rate it imposes and the share of firms it wants to attract to the country. The right part of figure 4 shows the graph of government B's optimal response, calibrated with different parameter values.

[18]The proof of this fact is omitted from the paper. Contact author for details.

[19]For details, see the appendix(**Proposition 4**).

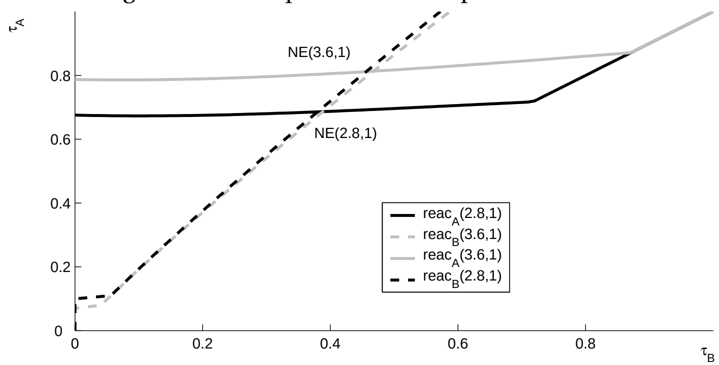
3.2.2 Equilibrium

The Nash equilibrium of the game will be the intersection of our reaction functions, $r_A(\tau_B)$ and $r_B(\tau_A)$. Obviously, the Nash equilibrium will depend only on a and b. To find it analytically we have to solve the equation:

$$\tau_A = r_A(r_B(\tau_A)) \,. \tag{8}$$

We can easily show that under our assumptions about the parameters the solution always exists, and is unique. Indeed, as we found in the previous sections, the reaction function of government A is always increasing in τ_B. Moreover, when τ_B is smaller than a certain τ_B^* value determined by a and b, the optimal τ_A is always above the 45-degree line (for $\tau_B \geq \tau_B^*$ τ_A is equal to τ_B). At the same time, government B, following its optimal taxation strategy, never sets its tax rate higher than or equal to τ_A. Therefore, its whole reaction function lies above the 45-degree line. Since τ_B is increasing in τ_A, both response functions intercept once in the area above the 45-degree line (when τ_A's are depicted on the y-axis, and τ_B's on the x-axis). $\tau_B^{NE} < \tau_B^*$, and therefore $\tau_A^{NE} > \tau_B^{NE}$. Figure 4 shows the Nash equilibria of the game, calibrated with different parameter values. It is left to add that both τ_A^{NE} and τ_B^{NE} are increasing with a, as well as the reaction function of the more efficient country becomes relatively steeper, as it can be seen from the figure and can be shown formally.

Figure 4: Nash equilibria for two parameter values



3.3 Conclusions

The main result of this section is that in equilibrium the more efficient country charges higher tax rate than the one with less productive government. It happens because on the one hand, government A extracts rents from its efficiency by giving up some part of the least demanding firms, but collecting higher revenue from those who stay. On the other hand, government B is forced to set lower tax rate, since it is the only way it can compete with the more developed country for foreign investments.

The reaction functions of both governments are monotonically increasing, which together with the main result, is a testable prediction of the model. Indeed, it is optimal for both countries to increase the tax rate in response to the same action of the neighboring government. The key idea here is that policymakers weight the potential profits of having the maximal share of firms in the country and actual profits of having smaller share, but with higher tax. The model predicts that under certain conditions[20], the governments prefer the latter.

One more insight of the model, which can also be tested, is that with the increase of the difference in efficiency between countries, the reaction function of the relatively more efficient country becomes steeper. At the same time the reaction function of the less efficient gets flatter.[21] This means that being more efficient, country A adopts more aggressive taxation policy, while country B has to defend its investments even more.

4 Testing the Theory

We now turn to the empirical testing of the model. In doing so we follow Devereux et al. (8) and Brueckner (4) in their methodology. Specifically, we run instrumental variable (IV) estimation on a panel of 28 countries, years from 1996 to 2005. Accounting for a few control variables, we find the coefficients of the "rest-of-the-world" average tax rate and of the proxy for governmental efficiency to be highly significant and positive, as it was predicted by the theory. Moreover, having added the interaction term to the econometric model we are able to estimate the effect of governmental efficiency on the slope of the reaction function. We find it positive, as it was predicted by the theory.

[20] Such as τ_B is not too high.

[21] The formal proof of this fact is out of the scope of this paper. However, this is easily seen on the calibrated variants of the model, figure 3.

The structure of the chapter is the following. Section 4.1 describes the empirical model and some econometric issues concerning its estimation. Definition of variables, used in the regression, are given in section 4.2, the results are presented in section 4.3. In the last part, 4.3.1, we present the specification of the model with the interaction term.

4.1 Econometric Model

Extending our theoretical model to n countries we obtain a system of equations:

$$\tau_{i,t} = R_i(\tau_{-i,t}, X_{i,t}),\ i = 1,\dots,n,\ t_1 \le t \le t_k \tag{9}$$

where $\tau_{i,t}$ denotes the tax rate in country i in year t, $\tau_{-i,t}$ denotes the tax rates in the same year in the rest of the countries in the sample, $X_{i,t}$ is a vector of other variables influencing the tax rate in the country, and $R_i(.,.)$ denotes the country-specific reaction function. In principle, governments can react differently to the tax rate of each country. However, the estimation of separate coefficients is hardly possible due to a large number of countries and short time series of the sample. To overcome the above-mentioned difficulty, we take the standard approach for testing the presence of strategic interactions between jurisdictions.[22] Instead of including separate countries in the equation, we assume that the average "world tax rate" influences the tax rate in country i. The following model is estimated:

$$\tau_{i,t} = \alpha + \beta \sum_{j \ne i} \omega_{ij}\tau_{j,t} + \theta_1 X_{i,t,1} + \theta X_{i,t,-1} + \epsilon_{i,t},\ i = 1,\dots,n,\ t_1 \le t \le t_k\,. \tag{10}$$

Similar to above, here t is the time index, ranging from some initial year t_1 to t_k, and n is the number of countries (jurisdictions) in the sample. Then $\tau_{i,t}$ is the tax rate in country i at time t. $X_{i,t}$ is the set of control variables for country i at time t. Note that we divided the vector X into two parts: X_1 and the rest, X_{-1}. This is because we want to stress the importance of one of the control variables - government efficiency. Finally, $\omega_{ij},\ i = 1,\dots,n,\ j = 1,\dots,n$ are country-to-country specific weights, used to calculate the average "rest-of-the-world" tax for a country i. They are assumed to be exogenously given. Note that the ω_{ij}'s do not change with time. α, β, θ are to be estimated by the regression. We are particularly interested in β and θ_1. Our model predicts them to be positive.

[22] See Brueckner (4), Devereux et al. (8), for example.

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The choice of ω_{ij}'s in our model is not straightforward. The usual approach in the literature is to take either uniform weights or those based on the distance between the jurisdictions. While we estimate our model with uniform weights, our opinion is that the distance is not the main factor influencing investment decisions and setting tax rates. Therefore, in addition to uniform ω_{ij}'s, we also report results with four other kinds of weights. The first one is based on the size of the country: the bigger its GDP, the bigger is its role in the "rest-of-the-world" tax rate. The rest three weights are based on FDI flows between the countries. Namely, we assign bigger weights to the more open counties, i.e. those with higher ratio of FDI flows to GDP. In the first case we take FDI flows for the last 3 years, in the second the average FDI flows for the period studied. Finally, the last weights matrix is formed using the data on FDI inflows split by geographical area. Having divided the world into seven regions, we assume the role of country j in forming the tax rate in country i is bigger, the bigger is the share of investments coming from i's region to country j (compared to investments towards the rest of the world), and the bigger is the share of investments from j's region to country i, compared to other regions. We find this weight system most relevant to our estimation framework. At the same time, we report the results with all the five weights.

Two main econometric issues must be considered when estimating (10). First, as all τ_i's at time t are jointly determined, their weighted sum will clearly be endogenous and correlated with the error term. Indeed, it is easy to see if we rewrite equation (10) in matrix form:

$$\tau = \beta W\tau + X\theta + \epsilon, \tag{11}$$

where W is the matrix of weights and α is included in vector θ. It is possible now to derive the equilibrium τ's:

$$\tau = (I - \beta W)^{-1} X\theta + (I - \beta W)^{-1}\epsilon, \tag{12}$$

where I is the identity matrix. As it can be seen from equation (12), every element of τ depends on all ϵ's, which leads to endogeneity in (10), and hence to inconsistent OLS estimates.

The second issue, which hinders us in estimating (10) directly, is that the error terms in (10) may be spatially correlated, i.e. ϵ satisfies the relationship:

$$\epsilon = \gamma M\epsilon + \xi, \tag{13}$$

where γ is a certain vector and M is a certain matrix, depending on the relationships between the error terms. Such correlation may occur when the empirical model does not control for certain jurisdiction-specific characteristics, which may in turn be spatially dependent. As a result, some of ϵ_i's and ϵ_j's may be correlated, which will drive us to a wrong conclusion about the presence of strategic interaction, when there is no such. (Refer to Brueckner (4) for detailed description of these issues.)

We follow Devereux et al. (8) in their method of solving these problems. Namely, we use the instrumental variables approach. At the first stage we regress $\tau_{i,t}$ on $X_{i,t}$, then use fitted values from the first-stage regression, $\hat{\tau}_{i,t}$, to calculate weighted averages for each country: $\sum_{j\neq i}\omega_{ij}\hat{\tau}_{i,t}$. These fitted values are asymptotically uncorrelated with the error term in (10), therefore OLS will produce consistent estimates. So, at the second stage of our estimation we run the regression (10), but with $\hat{\tau}_{j,t}$ instead of $\tau_{j,t}$ in the right-hand side. In addition, the very same method also helps to resolve our second problem.

Another option is to use WX as instrument for $W\tau$ in the same manner as in the paragraph above. Substituting $\sum_{j\neq i}\omega_{ij}\tau_{j,t}$ with the fitted values from the first-stage regression will also lead to asymptotically consistent OLS estimates. With slight adjustments in specification, we use both methods in the paper. Although the directions of the estimates do not change, the second method proved to produce more robust results than the first one.

4.2 Data

We use a sample of 28 countries, years from 1996 to 2005. Countries include EU-15 (except Denmark and Luxembourg), Switzerland, Norway, USA, Canada, Japan, Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Bulgaria and Romania. As a result, 280 observations are included in the sample.

As a dependent variable we take the nowadays widely used effective average tax rate (EATR). It is defined as a proportion of the pre-tax profit from assets previously invested in the country, taken by the state as a tax levy. EATR is calculated for a firm, which invests one unit, financed by equity, debt or retained earnings, into plants or machinery with predefined rate of profitability (usually 20% per period is considered). Then the profits under no-taxation and existing taxation system in the country are compared. EATR, generally, depends heavily on the statutory tax rate, and on the definition of the taxable profit in each country, which is usually affected by depreciation allowances. The EATR indicator is claimed to be the main

measure of the tax burden for multinationals choosing the country to invest in. This is definitely what we consider in our model, when firms invest in the country with higher after-tax profit. Therefore we have chosen this measure of the tax rate. At the same time, we also check the results when statutory tax rates are used as a dependent variable. EATR's for "old" OECD (i.e. all except CEE) countries were calculated by Devereux and Griffith and used in their paper (6). For the rest of the countries EATR's were calculated by Bellak et al. (2), Jacobs et al. (11), and Kotans (12). We use the ones adjusted for country-specific inflation and interest rate. Statutory tax rates are also adjusted for local income taxation.

While the choice of the tax burden measure is more or less obvious, it is much more challenging to come up with an appropriate proxy of governmental efficiency. The theoretical model solves this issue in a simple way: the more efficient government produces more public goods out of the same revenue. However, real life is more complicated and there are several problems with implementing this measure in our estimation. First is that governments produce more than one public good. Moreover, many of them are hardly measurable in quantity (such as defense or law-making) and, especially, quality. Secondly, even if we succeed in measuring these it will be hard to come up with a unified indicator combining all factors and sorting all countries in terms of their efficiency. Therefore, governmental efficiency may be more easily proxied by less direct indicators, both on the production side (such as the level of corruption, which eventually influences the level of public good production) and on the side of final outcomes (for instance, some macroeconomic indicators of the country - the better they are the more efficient is, apparently, the government). At the same time, using such proxies makes the results of an estimation less robust.

As a main proxy for governmental efficiency we use the Index of Economic Freedom (IEF), issued yearly by the Heritage Foundation (10). IEF provides a thorough examination of the factors, which contribute to the economic freedom and prosperity. All of them are related to the activity of the government. The index is the average of ten indicators: trade policy, fiscal burden of the government, government intervention in the economy, monetary policy, capital flows and foreign investment, banking and finance, wages and prices, property rights, regulation, and informal market activity. All these fields, apparently, are influenced by the governmental efficiency. At the same time, economic freedom and efficiency are not necessarily positively correlated. Such factors as government ownership in manufacturing and banking or trade liberalization can have an ambiguous effect on the country, and in particular on its attractiveness for investors. Therefore, we slightly adjust the index for our needs. Namely, we exclude the fiscal burden, since it is already accounted for in the model, and in fact is a main object for estimation. We experiment as well with the exclusion of other factors from the final index, but these changes do not seem to affect the results significantly. As a result, we obtain the series varying from 1 – perfectly free country to 5 – completely suppressed state. We also calculate relative efficiency index (rel_IEF): for a certain year we divide every country's index by the average "rest-of-the-world" index, calculated for each year using the same weights as for the tax rate.

In addition to IEF, we also test our model using other proxies for governmental efficiency. In particular, we report the results when GDP per capita (GDP_capita) is used instead. Indeed, the welfare of the population, characterized quite closely by this indicator, should be a direct consequence of governmental actions, including its policy towards attraction of investments. In addition to GDP per capita, we also control for Leviathan state indicators, in particular the share of public employees compensation in the country's GDP (govt_compens). It can also be viewed as a proxy for governmental efficiency.

In order to satisfy the assumptions of our theoretical model, as well as in order to avoid endogeneity in our estimation we control for several other factors. As a measure of the economy's openness we use the amount of foreign direct investments relative to GDP of the country (FDI/GDP). In addition, we control for the size of the economy (GDP) and average investment project's profitability. As a proxy for this indicator we take annual GDP growth (GDP_growth). As it was mentioned above, we also include measure of Leviathan state (govt_compens) in each regression. Finally, we add country dummies[23] to the model's specification in order to capture country-specific effects.

Definitions, sources and certain statistical characteristics of the data used in the estimation are presented in table 1.

4.3 Results

The results are presented in tables 2 and 3. Taking into account our "hard" choice of proxies we report the received values for the five weights in two different specifications: the first is when the proxy for governmental efficiency is the Index of Economics Freedom, and the second is when we use

[23] Series x_i such that $x_i(i) = 1$ in each year, and $x_i(j) = 0$ for all other countries.

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Table 1: Data

Variable	**Definition**	**Mean**	**Std. dev.**	**Min-Max**	**Source**
EATR	effective average tax rate (tax burden)	0.22	0.08	0.00 - 0.55	Devereux, Griffith (6), Bellak et al. (2), Jacobs et al. (11), Kotans (12)
stat_tr	statutory tax rate (tax burden)	0.32	0.09	0.10-0.57	Devereux, Griffith (6), Kotans (12)
IEF	index of economic freedom (governmental efficiency)	2.25	0.54	1.28 - 3.78	Heritage Foundation (10)
rel_IEF	relative index of economic freedom (governmental efficiency)	1.04	0.25	0.61 - 1.87	calculated from IEF
GDP_capita	GDP per capita (governmental efficiency), thousand PPP units	20.9	9.0	5.2 - 42.4	IMF World Statistics
GDP	GDP, 10^9 PPP units	886	1912	10 - 12278	IMF World Statistics
GDP_growth	annual growth of GDP (expected profitability), %	3.4	2.7	-9.4 - 11.70	EUROSTAT
FDI/GDP	FDI to GDP ratio (openness), $\$/10^3$ PPP units	606	665	11 - 3039	UNCTAD
govt_compens	compensation of employees, general government, share of GDP (Leviathan state)	0.11	0.03	0.01 - 0.24	EUROSTAT

Table 2: Estimation results: IEF as proxy*

Weights	FDI_3y	FDI_av	GDP	FDI_ geogr	uniform
av_tax_ fitted	2.85	2.82	0.74	1.01	1.09
	(2.33)	(2.28)	(2.04)	(1.65)	(2.18)
IEF	-0.05	-0.05	-0.05	-0.05	-0.05
	(3.21)	(3.28)	(3.31)	(3.13)	(3.15)
$GDP \cdot 10^{-7}$	5.7	1.3	23	5.5	-1.2
	(0.05)	(0.11)	(0.19)	(0.05)	(0.01)
GDP_ growth	0.002	0.002	0.002	0.002	0.002
	(1.29)	(1.37)	(1.47)	(1.45)	(1.30)
$FDI/GDP \cdot 10^{-5}$	1.9	2.0	1.8	1.7	1.8
	(1.49)	(1.54)	(1.40)	(1.26)	(1.40)
govt_ compens	-0.64	-0.63	-0.63	-0.65	-0.69
	(3.46)	(3.33)	(3.34)	(3.37)	(3.88)
R^2	0.65	0.65	0.64	0.64	0.64
N			280		

*: t-statistics (absolute values) are reported in the brackets. Values more than 1.9 indicate strong significance. Dependent Variable: EATR, proxy for governmental efficiency: IEF, estimation method: least squares.

GDP per capita instead. We include country dummies in both cases, even though the estimation without them brings relatively analogous results (at least, signs of the coefficients studied do not change).

The estimation method used in both specifications is 2SLS with instrumenting weighted average tax directly.[24] At the same time, using IVs for each country's individual tax rate and then calculating weighted average brings analogous results in most cases. The dependent variable used is EATR adjusted for country-specific inflation and interest rates. Again, the signs of the coefficients studied do not change in most cases when statutory tax rate is used instead.[25]

The results reported in the tables fit quite well our theoretical predic-

[24] Refer to section 4.1 for more details.

[25] The exact magnitudes and t-statistics with these specifications are not reported in the paper. However, it is possible to obtain them directly from the author.

Table 3: Estimation results: GDP per capita as proxy*

Weights	FDI_3y	FDI_av	GDP	FDI_ geogr	uniform
av_tax_ fitted	4.86	5.34	1.14	2.42	1.98
	(3.11)	(3.16)	(2.36)	(2.45)	(3.04)
GDP_	6.5	7.4	6.28	8.0	6.6
$capita \cdot 10^{-6}$	(2.95)	(3.12)	(2.55)	(2.71)	(2.93)
$GDP \cdot 10^{-5}$	-1.4	-1.5	-1.2	-1.3	-1.5
	(1.21)	(1.23)	(1.04)	(1.08)	(1.25)
GDP_ growth	0.002	0.002	0.002	0.002	0.002
	(1.15)	(1.28)	(1.43)	(1.51)	(1.17)
$FDI/GDP \cdot 10^{-6}$	-1.4	-1.3	-2.9	3.5	-2.6
	(0.10)	(0.09)	(0.20)	(0.24)	(0.18)
govt_ compens	-0.65	-0.61	-0.65	-0.60	-0.73
	(3.49)	(3.26)	(3.39)	(3.05)	(4.06)
R-squared	0.64	0.64	0.64	0.64	0.64
N			280		

*: t-statistics (absolute values) are reported in the brackets. Values more than 1.9 indicate strong significance. Dependent Variable: EATR, proxy for governmental efficiency: GDP_capita, estimation method: least squares.

tions. Indeed, the main prediction of our theoretical model was about the influence of governmental efficiency on the tax rate setting. Using both proxies (IEF and GDP per capita) produced results in line with the theory. Namely, countries with higher predicted governmental efficiency, proxied by the Index of Economic Freedom adjusted and GDP per capita, tend to tax capital income heavier. The coefficient of IEF is negative in all 5 cases and significantly different from zero. The p-value of it does not exceed 3% level regardless of weights, which is a very strong evidence in favour of our predictions. The magnitude of the coefficient, -0.05, means that 0.1 decrease in the Index of Economic Freedom in some country (without accounting a fiscal burden) – which is quite a reasonable improvement for a 1-year period [26] – should lead to 0.5 percentage point increase of the effective average tax rate (so that EATR rises from, say, 22% to 22.5%). This is exactly what we predicted since IEF is by definition greater for the governments which are less efficient, i.e. their average grade for different policies is high.[27]

At the same time, the coefficient of GDP_capita (see table 3) is positive with high significance. The p-values are somewhat larger than in the case with IEF proxy, but still do not exceed the 3% level. This is also in line with our expectations, since higher income of the population, as it was argued in section 4.1, is usually the outcome of efficient actions of the government. The magnitude of the coefficient is small in levels but quite significant economically, since GDP_capita is measured in purchasing power parity units in the sample, and the mean of it is a 5-digit number (20920 PPP units). According to our estimations, an increase in annual population income of 1000 PPP (purchasing power parity) units, which is in line with observed GDP and population growths, will lead the EATR to increase by about 0.7 percentage points. Therefore, the usage of both proxies support our theoretical predictions.

An additional prediction of our model was that the tax rate in a country should react in the same direction to the changes of taxation levels in other countries. The results presented in tables 2 and 3, support this finding, too. Indeed, the coefficient of the "rest-of-the-world" tax, which basically estimates the slope of the governmental reaction function, is significantly positive in all ten cases.[28] The p-value ranges here from 10% to less than 3%, which is comparable with other empirical estimations of interjurisdictional

[26] Refer to the Table 2 for maximal, minimal and average magnitudes of IEF.
[27] See the discussion about our choice of proxies in section 4.1.
[28] 5 kinds of weights over two proxies for governmental efficiency.

competition in the literature.[29] The magnitude of the coefficient is quite big compared to the results from other studies. However, it is comparable with the results of similar estimation in tax competition.[30] In addition, in the most interesting cases of GDP and FDI_geogr weights the change in the "rest-of-the-world" tax rate is forecasted to produce a change in the country's tax rate of almost the same magnitude (the coefficient varies from 0.74 to 2.42 in different specifications). It means that if the world's average capital income tax rate (with different weights) increases by 1 percentage point, the response of a government of a given country would also be to increase EATR by about 1 percentage point, given there are no changes in other controls.

It is worth noting again that the results presented are quite robust. First, they are consistent through all 5 kinds of wages. Secondly, when another specification is used the results do not change significantly. Namely, the choice of dependent variable, choice of proxy for governmental efficiency, method of IV estimation, and inclusion of country dummies are all considered. Therefore, we can conclude that a strong support of our theory is found.

4.3.1 Testing the slope coefficient

One more prediction of our theoretical model concerns the slope of the reaction function. We predict that the reaction function of a country becomes steeper with higher governmental efficiency. In this section we are presenting our trials to estimate this theoretical finding on the same sample of countries.

To be able to estimate the above mentioned property we have to modify our model. The regression equation now looks the following way:

$$\tau_{i,t} = \alpha + \beta \sum_{j\neq i} \omega_{ij}\tau_{j,t} + \theta_1 rel\_GE_{i,t} + \gamma(rel\_GE_{i,t} - 1)\cdot \sum_{j\neq i}\omega_{ij}\tau_{j,t} + \quad (14)$$
$$+\theta X_{i,t,-1} + \epsilon_{i,t},\ i = 1,\dots,n,\ t_1 \le t \le t_k\ .$$

Here the notations of equation (10) are kept. In addition, $rel\_GE_{i,t}$ denotes the series of relative government efficiencies, i.e. normalized to the weighted average of governmental efficiency for a certain year.

As it can be easily seen, we modified equation (10) by adding the interaction term between relative governmental efficiency and "rest-of-the-world"

[29] See Brueckner (4) for a survey.
[30] See, for example, Devereux (8).

tax. With such specification the coefficient γ will be nothing more than the magnitude of the governmental efficiency effect on the slope of the reaction function. Note that it is important to compare each governmental efficiency with the average one in the interaction term. That is why we subtract one from $rel\_GE_{i,t}$.

To be fully in line with our theoretical predictions we would demand β, θ and γ to be positive, with γ sufficiently small in order not to overwhelm the strategic interaction effect, expressed in the model by β.[31] However, these requirements may be substituted with weaker ones. Namely, the following three properties should hold:

$$\frac{\partial \tau_{i,t}}{\partial (av.tax)_{i,t}} = \beta + \gamma (rel\_GE_{i,t} - 1) > 0, \quad \forall rel\_GE_{i,t},\ i = 1,\dots,n,\ t_1 \le t \le t_k, \tag{15}$$

$$\frac{\partial \tau_{i,t}}{\partial rel\_GE_{i,t}} = \theta_1 + \gamma * (av.tax)_{i,t} > 0, \quad \forall (av.tax)_{i,t},\ i = 1,\dots,n,\ t_1 \le t \le t_k, \tag{16}$$

$$\frac{\partial^2 \tau_{i,t}}{\partial rel\_GE_{i,t} \partial (av.tax)_{i,t}} = \gamma > 0,\ i = 1,\dots,n,\ t_1 \le t \le t_k. \tag{17}$$

Properties 15-17 hold if β, θ_1 and γ are positive, and $\gamma < \beta$, but it is not necessary condition.

Except for the interaction term the estimation procedure is similar to the one described above in section 4.1. Again, we use WX, where X are country-specific controls, as instrumental variables for $W\tau$. The dependent variable is again EATR adjusted for country-specific inflation and interest rates, and IEF is used as a proxy for governmental efficiency. Additionally, we control for the size of the economy (GDP), its openness (FDI/GDP), expected profitability of an average project (GDP_growth), and Leviathan state (govt_compens).

The results of the estimation are presented in table 4. As usual, we report them using five kinds of weights.

It is easy to notice that the results presented in Table 4 are less robust, with coefficients being less significant. Moreover, adding country dummies to the regression makes the t-statistics even smaller. In addition, the coefficient of rel_IEF does not have the desirable sign. As IEF and governmental

[31] In fact, for extreme case, when $rel\_GE = 0$, we would demand that $\gamma < \beta$. However, the sample minimum in our case is 0.61, and we can somewhat relax this restriction. Refer to the next paragraph.

Table 4: Estimation results: slope coefficient*

Weights	FDI_3y	FDI_av	GDP	FDI_ ge-ogr	uniform
av_tax_ fitted	2.45	2.26	1.00	1.28	0.89
	(1.66)	(1.64)	(2.71)	(2.07)	(1.69)
rel_IEF	0.86	1.07	0.93	1.28	0.57
	(0.85)	(1.15)	(3.20)	(2.77)	(1.28)
interaction	-3.98	-4.84	-3.54	-5.07	-2.83
	(0.90)	(1.20)	(3.36)	(2.87)	(1.39)
GDP·10^{-6}	7.7	7.7	7.7	7.9	7.8
	(3.13)	(3.10)	(3.08)	(3.13)	(3.20)
GDP_ growth	-0.01	-0.01	-0.009	-0.009	-0.009
	(6.10)	(6.09)	(6.42)	(6.37)	(6.27)
FDI/GDP·10^{-6}	-2.9	-2.8	0.1	-1.8	-1.7
	(0.37)	(0.36)	(0.01)	(0.23)	(0.22)
govt_ compens	-0.33	-0.35	-0.48	-0.49	-0.37
	(1.87)	(1.98)	(2.89)	(2.85)	(2.24)
R^2	0.24	0.24	0.24	0.25	0.25
N			280		

*: t-statistics (absolute values) are reported in the brackets. Values more than 1.9 indicate strong significance. Dependent Variable: EATR, proxy for governmental efficiency: rel_IEF, estimation method: least squares.

efficiency are negatively correlated we would expect its coefficient to be negative. However, these results are in line with our predictions at least partly. Indeed, if we rewrite properties 15-17 for our concrete model we obtain the conditions for the sample values:

$$rel\_IEF_{i,t} < \frac{\beta-\gamma}{-\gamma}, \tag{18}$$

$$(av.tax)_{i,t} > \frac{-\theta_1}{\gamma}, \tag{19}$$

$$\gamma < 0. \tag{20}$$

Note that γ in this case is smaller than zero. This fact is in line with our predictions, since governmental efficiency and the Index of Economic Freedom are negatively correlated by our assumption.

Looking at the distributions of rel_IEF and the weighted average of tax rates we can calculate that in case of FDI_3y, not less than 97% records in the sample satisfy all three properties. In case of the other weights the figures are smaller, but still significant: 93% – FDI_av, 79% – GDP, 55% – FDI_geogr, and 78% – uniform weights. Considering the fact that our proxy for governmental efficiency is far from perfect, such figures provide quite strong evidence in favor of our theoretical predictions.

5 Conclusions

This paper examines the effect of relative governmental efficiency on the outcome of international tax competition game between countries. By relative efficiency here we mean the fact that more efficient governments can produce more units of public good out of one unit of private good. We build a model with two countries, engaged in competition for foreign investments. Multinationals are assumed to be technologically dependent on public good provision in the country, i.e. the more public good is provided by the country the less it costs to produce there. Therefore, they make their decision regarding the location of the investment based not only on the tax rate they face, but also on the potential reduction in production costs due to the availability of public goods.

We find that in equilibrium the more efficient country always sets higher tax rate than the less efficient one. Moreover, the reaction functions of the governments (i.e. the tax rate of a given country as a function of "rest-of-the-world" tax rate) are found to be increasing, which is in line with the

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existing literature. Another finding is that the reaction function becomes steeper with the increase in governmental efficiency.

The model is empirically tested on 28 countries, for the years 1996 to 2005. We find the "rest-of-the-world" average tax rate and the governmental efficiency to affect significantly positively the tax rate in a certain country, which supports the conclusions of the model. We also find quite a strong evidence in favor of our predictions regarding the slope of the reaction function.

What this means in practice is that the policy of tax harmonization persistently targeted by OECD and EU, is not necessarily optimal for all the countries in the region. On the one hand, highly efficient countries should not be afraid of tax competition, since they have other instruments to attract foreign firms. On the other hand, less efficient countries should keep their taxes lower in order to induce investments.

Appendix

Proposition 1 *Let $\hat{s}_i$ be the share of firms investing in the country i, $i \in \{A, B\}$, and $\hat{s}$ be the technological attachment parameter of the firm, which is indifferent between investing in either of countries. The following statements are true:*

1. *If $a + b\tau_A \geq 1 + \tau_B$ then $\forall s > \hat{s}$ f_s will invest in country A, and $\forall s < \hat{s}$ f_s will invest in country B. Therefore, $\hat{s}_B = \hat{s}$ and $\hat{s}_A = 1 - \hat{s}$.*

2. *If, on the contrary, $1 + \tau_B \geq a + b\tau_A$ then $\forall s > \hat{s}$ f_s will invest in country B, and $\forall s < \hat{s}$ f_s will invest in country A. Therefore, $\hat{s}_B = 1 - \hat{s}$ and $\hat{s}_A = \hat{s}$*

Proof. Let us see, how $\hat{s}(\tau_A, \tau_B)$ will look like. Firm s facing the tax rates compares two following numbers: $-\tau_A + s \cdot \ln(a + b\tau)$ and $-\tau_B + s \cdot \ln(1 + \tau_B)$. As earlier, we denote the share of firms going to B by $\hat{s}$. Define:

$$\tilde{s} = \frac{\tau_A - \tau_B}{\ln(a + b\tau_A) - \ln(1 + \tau_B)}. \tag{21}$$

Now let us consider the cases:

1. $a + b\tau_A \geq 1 + \tau_B$
   In this case all f_s, for which $s \leq \tilde{s}$, invest in country B. To see this we just have to solve the corresponding inequality:

   $$-\tau_A + s \cdot \ln(a + b\tau) \leq -\tau_B + s \cdot \ln(1 + \tau_B);$$
   $$s \leq \frac{\tau_A - \tau_B}{\ln(a + b\tau_A) - \ln(1 + \tau_B)} = \tilde{s}, \tag{22}$$

   since we divide by a positive number. By definition of $\hat{s}_i$, $\hat{s}_B = \hat{s}$, $\hat{s}_A = 1 - \hat{s}$.

   The problem with $\tilde{s}$ is that it is not always between 0 and 1. Therefore we have to consider three subcases:

   (a) $\tau_A \leq \tau_B \leq a - 1 + b\tau_A \Rightarrow \tilde{s} \leq 0$. In this case all firms go to A and $\hat{s} = 0$;

   (b) $\tilde{s} \geq 1$ whenever (τ_A, τ_B) lies in the intersection of $\{(\tau_A, \tau_B) : a + b\tau_A \geq 1 + \tau_B\}$ and the set of solutions to the inequality:

   $$\tau_A - \tau_B - \ln(a + b\tau_A) + \ln(1 + \tau_B) \geq 0. \tag{23}$$

   In this case all firms go to B and $\hat{s} = 1$.

   (c) Otherwise $0 < \tilde{s} < 1$ and $\hat{s} = \tilde{s}$.

2. $a + b\tau_A \leq 1 + \tau_B$
   This case is opposite to the previous one. Analogously, we have to solve inequality (22). However, now the denominator is negative, so the signs will change. Now f_s will invest in country B whenever $s \geq \tilde{s}$, so by definition of $\hat{s}_i$, $\hat{s}_B = \hat{s}$, $\hat{s}_A = 1 - \hat{s}$. But again, we have to consider a few subcases:

   (a) Both the nominator and the denominator in this case are negative, so $\tilde{s}$ can never be less than 0, hence $\hat{s}$ is never 1;

   (b) $\tilde{s} \geq 1$ when the solutions of the reverse of inequality (23):

   $$-\tau_A + \tau_B + \ln(a + b\tau_A) - \ln(1 + \tau_B) \geq 0 \tag{24}$$

   satisfy the condition $a + b\tau_A \leq 1 + \tau_B$. In this case $\hat{s} = 0$.

   (c) Otherwise $0 < \tilde{s} < 1$ and $\hat{s} = 1 - \tilde{s}$.

Proposition 2 *The response function of government A has the following structure:*

$$r_A(\tau_B) = \begin{cases} \tau_B + \epsilon & \text{if } \tau_B < \tau_B^*, \\ \tau_B & \text{otherwise.} \end{cases} \tag{25}$$

Proof. In the paper it was shown that government A will never set τ_A lower than τ_B. Now we find the conditions, when the deviation from "τ_B-strategy"[32] is optimal. Suppose, government A increases the tax from τ_B to $\tau_B + \epsilon$, $\epsilon > 0$. Firm s in this situation compares its potential profits in both countries. If

$$-\tau_B - \epsilon + s \cdot \ln(a + b(\tau_B + \epsilon)) \geq -\tau_B + s \cdot \ln(1 + \tau_B) \tag{26}$$

then it stays in A. Otherwise f_s moves to country B. Solving the inequality further we obtain:

$$s > \frac{\epsilon}{\ln(a + b(\tau_B + \epsilon)) - \ln(1 + \tau_B))}. \tag{27}$$

Under the "τ_B-strategy" the revenue is τ_B. We have to check when the new strategy gives more than τ_B. For that we solve the inequality:

$$(\tau_B + \epsilon)(1 - \frac{\epsilon}{\ln(a + b(\tau_B + \epsilon)) - \ln(1 + \tau_B))}) > \tau_B. \tag{28}$$

[32] The strategy, when it is optimal to set τ_B

Solving further we obtain:

$$\epsilon - \frac{(\tau_B+\epsilon)\epsilon}{\ln(a+b(\tau_B+\epsilon)) - \ln(1+\tau_B))} > 0 \,. \tag{29}$$

Since $\epsilon > 0$ by assumption, and $\ln(a+b(\tau_B+\epsilon)) > \ln(1+\tau_B)$, as the $\ln(x)$ is increasing function, we can simplify the inequality. Namely, we divide it by ϵ and find the common denominator. We get:

$$\tau_B + \epsilon - \ln(a+b(\tau_B+\epsilon)) + \ln(1+\tau_B) < 0. \tag{30}$$

Given that τ_B is sufficiently small, and a and b satisfy certain conditions, inequality (30) always has solutions. We prove this fact in Proposition 3.

Proposition 3 *Whenever $a > b$,*[33] *there exists some threshold taxation level $\tau_B^* > 0$ such that for any $\tau_B < \tau_B^*$ inequality (30) has solutions, and therefore it is optimal for government A to deviate from "τ_B-strategy" and set higher tax.*

Proof. We have to prove that for any a and b, such that $a > b$, there exists $\tau_B^* > 0$ that for any $\tau_B < \tau_B^*$ we can pick such $\epsilon > 0$ that inequality (30) is satisfied. Given τ_B, the left-hand side of inequality (30) is a function of ϵ:

$$f_{\tau_B}(\epsilon) = \tau_B + \epsilon - \ln(a+b(\tau_B+\epsilon)) + \ln(1+\tau_B) \,. \tag{31}$$

Let us find the derivative of this function:

$$f'_{\tau_B} = 1 - \frac{b}{a+b(\tau_B+\epsilon)} = \frac{a-b+b(\tau_B+\epsilon)}{a+b(\tau_B+\epsilon)} > 0 \;\forall \tau_B \geq 0,\; \forall \epsilon > 0 \,. \tag{32}$$

f_{τ_B} is increasing and converging to infinity when ϵ goes to infinity, therefore $\forall \tau_B \geq 0\; \exists \epsilon^* = \epsilon^*(\tau_B)\; \forall \epsilon > \epsilon^*\; f_{\tau_B}(\epsilon) > 0$ and $\forall 0 < \epsilon < \epsilon^*$ (if exists) $f_{\tau_B}(\epsilon) > 0$. It means as well that f_{τ_B} reaches its minimum at $\epsilon = 0$ for any τ_B. Therefore, if $f_{\tau_B}(0) \geq 0$ for some τ_B then there are no solutions to inequality (30). On the contrary, if $f_{\tau_B}(0) < 0$ then for any $\epsilon \in (0, \epsilon^*)$ $f_{\tau_B}(\epsilon) < 0$, and government A gets more revenue by deviating from the "τ_B-strategy" and by setting the higher tax.

Now let us find τ_B's, for which the solution exist. Denote:

$$f(\tau_B) = f_{\tau_B}(0) = \tau_B - \ln(a+b\tau_B) + \ln(1+\tau_B) \,. \tag{33}$$

[33] This condition can be relaxed to $a > b - b\ln b$. However, it complicates the proof significantly, while bringing no additional insight in the model. Therefore, a proof with this condition is omitted in the paper.

$$f' = 1 - \frac{b}{a+b\tau_B} + \frac{1}{1+\tau_B} > 0 \,. \tag{34}$$

Therefore f is always increasing. Moreover,

$$f(0) = -\ln a < 0 \;\Rightarrow\; \exists \tau_B^* = \tau_B^*(a,b)\; f(\tau_B^*) = 0, \text{ and } \forall \tau_B > \tau_B^*\; f(\tau_B) > 0 \,. \tag{35}$$

Now, if we take $\tau_B < \tau_B^*$:

$$\begin{aligned} &\tau_B - \ln(a+b\tau_B) + \ln(1+\tau_B) < 0 \Rightarrow \\ \Rightarrow\; &f_{\tau_B}(0) < 0 \;\Rightarrow\; \exists \epsilon^* = \epsilon^*(\tau_B) \text{ such that } f_{\tau_B}(\epsilon*) = 0 \\ &\text{and } \forall \epsilon < \epsilon^*\; f_{\tau_B}(\epsilon) < 0 \,, \end{aligned} \tag{36}$$

what was needed to prove.

Proposition 4 *Government B will never set higher tax than τ_A if it follows optimal strategy.*

Proof. Indeed, it is obvious that no firm will go to B if $\tau_A \leq \tau_B \leq a - 1 + b\tau_A$, since otherwise for any nonzero s f_s will pay higher tax and receive less public good. Let us check the case when $\tau_B > a - 1 + b\tau_A$.[34] Obviously, in this case country B may attract only the most public good indigent firms, since it produces more public good, and at the same time charges much higher tax. Therefore, if even the most "attached" firm in the set, f_1, will not be willing to invest in B, neither will other firms with smaller s. f_1 compares its profits in both countries:

$$-\tau_A + \ln(a+b\tau_A) \text{ vs. } -a+1-b\tau_A - \epsilon + \ln(a+b\tau_A+\epsilon) \,, \tag{37}$$

where $\tau_B = a - 1 + b\tau_A + \epsilon$, $\epsilon > 0$. Subtracting the right-hand side from the left-hand side in (37) we obtain:

$$\begin{aligned} &-\tau_A + \ln(a+b\tau_A) + a - 1 + b\tau_A + \epsilon - \ln(a+b\tau_A+\epsilon) = \\ &= a + b\tau_A + \epsilon - \ln(a+b\tau_A+\epsilon) - 1 - \tau_A + \ln(a+b\tau_A) \,. \end{aligned} \tag{38}$$

The expression (38), as a function f of ϵ is increasing. Moreover:

$$f(0) = a + b\tau_A - 1 - \tau_A > 0. \tag{39}$$

Therefore f_1 gets more profits in country A no matter how high is the tax, and the level of public good provision, in country B. So do the rest of the firms.

[34] Note that $a - 1 + b\tau_A > \tau_A$, since $a > 1$ and $b \geq 1$ by assumption.

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