Tax Competition and the Determination of the Quality of Public Goods

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Abstract
In this paper, the author analyzes the behavior of local governments in capital taxation when the financial choices in terms of the quality of public goods are made done by a central planner. More specifically, he asks the question of whether a local government has an interest in taxing the mobile factor in addition to the tax on representative households. Through a comparison of social welfare given the strategies chosen by local governments, the author shows that whatever the quality and cost of public goods, a local government always has an interest in taxing the mobile factor. This leads to a Nash equilibrium in the dominant strategy in their model.

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Keywords Tax competition; public goods; quality; welfare; taxation

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1 Introduction

Tiebout (1956) was the first author to explore the problem of tax competition. He considered an economy to consist of several jurisdictions that are in competition to attract mobile agents through a system of taxes and public spending. Tax competition is then defined as the non-cooperative fixing of tax rates by independent jurisdictions to attract the mobile factor, which is usually capital. These choices directly affect the budget constraints of jurisdictions and often lead to a lower tax rate on firms at the optimum level and in a production gap of public goods (Zodrow and Mieszkowski 1986, Wilson 1986, Wildasin 1989). The recurring question in all of these studies is to know whether there are interdependencies among tax bases and if the induced competition leads to a sub-optimal supply of public goods.[1] The answer is provided by some game models where the vector of strategies is considered as a jurisdictions budgetary or fiscal decisions. In these models, each jurisdiction chooses its capital tax rates to maximize the utility of the representative agent by considering the tax rates of other jurisdictions, which converges to a Nash equilibrium (Mintz and Tulkens 1986, Wilson 1986, Wildasin 1988,1991). A different vision of tax competition may come from the introduction of the quality notion as a second factor characterizing public goods. We can specify different standards of quality. First, that problem of the quality of public services arises so strongly today, this is not due to the local elected officials (who cannot exercise their services correctly) or to the total volume of credits (affected by central government to produce public services) which have declined; rather, the decisive elements of the quality of public services are explained by the following arguments: *(i)* it is obvious that the requirements of taxpayer/users increased: they accept less as "administered" and intend to be much more like customers, and *(ii)* taxpayers/users: suffer from numerous organizational and operational weaknesses: complexity and partitioning structures, the tangling of powers, hierarchical heaviness and rigidity of all types. Returning to the concept of quality, its definition appears to be intuitive and simple, but this apparent simplicity is deceptive. As soon as we seek to define it with minimum precision, we realize that this concept is actually complex and

[1] We use the terms “public services” and, “public goods” indiscriminately.

requires pre-arbitrations that have nothing mechanical, so that the definition of the criteria of quality is already a major choice (Haddad et al. 1997).

Existing representations of quality are also distinguished by their normative scale. Under this perspective, it should be possible to previously determine the quality standards to define the quality notion. According to Palmer et al. 1991), in the public health sector, the quality notion can be viewed as the production of better services to satisfy a population, taking into account the technological and resourceful constraints well as some specificities of consumers. For Roemer and Montoya-Aguilar (1989), the quality of a public good is measured by the level at which it meets predefined standards. These different definitions allow us to apprehend the concept of the quality of public health services that will transpose very cautiously to public goods, despite the difference between the two concepts. According to Samuelson (1954), public goods are not only destined to a final consumption but also help to support firm activities (knowledge, infrastructure, etc.), and they are sometimes necessary for transactions and markets (law of agreement, etc.).

Thus, in this work, we raise the concern about the importance of the quality of public goods in the context of fiscal competition. For example, the poor quality of public goods associated with a deficiency in the supply of public goods leads to an inefficient system of production and exchange in terms of productivity or transaction costs. Nevertheless, the quality of public goods is viewed as a real factor of development and the attractiveness of investment. In this context, the question of the quality of public goods is important, especially in the area of globalization. Furthermore, the quality of public goods ensures both the legitimacy of governments and the revealed preferences of the population. Various authors have tried to measure the impact of the quality of public services on the location of capital by relying on a dichotomy of this concept: "high quality, low quality." Jud and Watts (1981) tested and confirmed that there is a positive correlation between the quality of public services and housing prices. They concluded that a high quality of the public services in a jurisdiction implies an increase in housing demand and soaring rents. Hoyt and Jensen (2001) showed how the differentiation of the quality of education can improve the differential impacts of tax competition and consumers' welfare. Gabe and Bell (2004) suggest that a local fiscal policy of reduced government spending with decreased public services may attract fewer new businesses than a policy featuring additional spending (quality public services) and higher taxes (Henderson and Thisse 1997, Bénassy-Quéré et al. 2005, Fatica 2010).

The paper is organized as follows. After presenting some assumptions about the theoretical model of tax competition (Section 2), we subsequently compare each of our results in terms of social welfare (Section 3). We examine the possibility of determining a dominant strategy equilibrium (Section 4). Further, we raise concern about the decision of the central government for the quality of public goods in an equilibrium situation. Section 5 concludes.

2 The model

We consider a set of M jurisdictions $M \geq 2$ divided into two groups: $i, j \in \{1, ..., M\}$, $(\forall i \neq j)$, which are supposed to be identical and homogenous. Each member of the sedentary population is normalized to unity. The representative resident possesses the whole of the local lands and has a fraction of the capital stock K_i available in the economy. The capital is perfectly mobile between jurisdictions without the cost. The global capital stock $\bar{K}$ is supposed to be fixed. The capital market equilibrium implies that the aggregate demand for the capital must be equal to the capital supply $\sum_{i=1}^{M} = \bar{K}$.

2.1 Preferences of residents and production technology

The representative resident of a jurisdiction i consumes a quantity c_i of a private good and a quantity g_i of a local public good. The quality standard of the public good is denoted by q; this quality is assumed to be fixed for the whole of the economy and imposed on all jurisdictions. The tax revenues of the local government are intended for funding a local public good where the low unit cost $C(q)$ is a function of q such as $C(q) = q^{\varepsilon}$ with ε as the cost-elasticity of quality. Consumer preferences are represented by a multiplicative utility function denoted $U_i(c_i, g_i, q) = c_i g_i q$. The properties of this function are: the marginal utility of private consumption increasing in both the quantity and the quality of public goods provision, and *vice versa*, as well as the marginal utility of public goods consumption increasing in private good consumption.[2] The production technology is carried by: capital inputs K_i, public good provision $(\bar{g}_i, \bar{q})$ and land.[3] Thus, firms have the use of a public good where its quality is equal to q. We consider a log-linear function of the production, i.e., its economic and mathematical properties are equivalent to the properties of the Cobb-Douglas' function of production $F_i(K_i, \bar{g}_i, \bar{q}) = \alpha \ln K_i + \beta \ln \bar{g}_i + \gamma \ln \bar{q}$, where α, β, γ are positive parameters, that determine the relative share of income going to capital and public goods. We suppose that the firms have a fixed use of a public good with the required quality standards denoted $(\bar{g}_i, \bar{q})$. The derivation of a constant is as follows: $\frac{\partial F_i}{\partial \bar{g}_i} = 0$, $\frac{\partial F_i}{\partial \bar{q}} = 0$ and $\frac{\partial F_i}{\partial K_i} = \alpha \frac{1}{K_i}$. Capital is mobile and attracted by jurisdictions that offer the best ρ return after any tax rate t_i. The arbitrage condition equals the net return of capital in each jurisdiction $\alpha / K_i - t_i = \rho$.

Characteristics of the supply of public goods and the budgetary constraints of jurisdictions

Here, we assume that the determination of the quality and the quantity of a public good is realized in *two steps*. First, the quality of a public good is fixed by the central government, then its quantity is determined by the local elects. The central government requires local governments to provide public goods with a *minimum quantity and quality* for the economic agents who live there.

In the *first step*, the central government establishes some standards which define the quality of a public good, i.e., the characteristics that should be respected by the transport infrastructures or the specific steps to improve the safety of the transport network. For instance, the organizations in the public education system are insured by the government and subject to the powers of the jurisdictions to the development of this public service. The central government requires certain expenditures called *pedagogical* qualities, which concern, for example, the equipment for computer

[2] The properties of this function are: $U_i = c_i g_i q$, if derivation $\frac{\partial U_i}{\partial c_i} = g_i q$; assume that $\frac{\partial U_i}{\partial c_i} = Q$ and $g_i = (t_i K_i + \bar{H}) / q^{\varepsilon}$. If we make the assumption that $(t_i K_i + \bar{H}) = \mu$, then $Q(.) = \mu / q^{\varepsilon} \Rightarrow \frac{\partial Q}{\partial q} = \mu (1 - \varepsilon) / q^{\varepsilon}$. If $\varepsilon = 1$, U_i is constant. If $\varepsilon < 1$, U_i is increasing and if $\varepsilon > 1$, U_i is decreasing.

[3] Lands are not considered because we assume no substitution with the other factors.

sciences and electronic, audiovisual or other technologic equipment for teaching and having all high-quality media. Quality is a real factor of development and the attractiveness of investment (the transparency of public institutions, stability, the predictability of policy, rule of law and the regulatory environment).

In the *second step*, the local elected officials determine the quantity of a public good that is locally produced, taking into account the quality that will be financed via their tax revenues.

Local governments and the optional taxation of capital

The tax revenues of local governments come, on the one hand, from a flat tax on households imposed by the jurisdictions corresponding to a right of residence which we denote H_i; and on the other hand, they also come from the capital employed in the production process, which is taxed with a rate t_i. Local governments can use "tax weapon" to attract a private investment and choose the available capital taxation as a strategy. We assume that this tax rate is $0 \leq t_i \leq \bar{t}$. Without a loss of generality, we will explain the two extreme cases: *(i)* if the local government decided to partially tax the capital or not $(t_i \geq 0)$, this case corresponds to a reduction of the tax, in a partial or total way. More illustrative examples include tax exemptions, deductions, and tax cuts that are designed to totally or partially reduce the tax. The implementation of this measure should allow firms to reduce their tax burden. This form of exemption may be total, i.e., all taxable income is exempt from paying taxes or partial taxes, i.e., a percentage of the results can be taxed, *(ii)* the jurisdictions can either tax the capital with a maximum rate or not $(t_i \leq \bar{t})$, the idea behind this choice is that as long as the marginal tax rate increases, the tax revenues increase to a maximum jurisdiction $\bar{t}$, because from this maximum rate, there is a decrease of the efficiency of these tax revenues. In other words, economic agents reject or practice tax evasion to avoid too heavy taxation.[4] The local budget constraints are written as $g_i = t_i K_i + \bar{H}/q^{\varepsilon}$ with $t_i \in [0, \bar{t}]$.

[4] The theory of the Laffer curve .

2.2 Behavior of jurisdictions, firms and consumers

We assume that the residents of a jurisdiction i consume a private good of a quantity c_i. The purpose of a local government is to maximize the social welfare of residents in accordance with its budget constraints. The following program shows this.

$$\mathrm{MaxU}_i(c_i, g_i, q)$$
$$\text{b/c}\left|\begin{array}{l} c_i = F_{K_i}(K_i, \bar{g}_i, \bar{q}) - (\rho + t_i)K_i + \rho(\bar{K}/M) - H_i \\ \qquad\qquad q^{\varepsilon} g_i = t_i K_i + H_i \end{array}\right.$$

The amount $(F_{K_i}(K_i, \bar{g}_i, \bar{q}) - (\rho + t_i)K_i)$ corresponds to the property income paid by business owners to residents' return of the land use. The share of the investment returns from capital is deployed by an individual independently to his place of residence, which is measured by the value $\rho(\bar{K}/M)$.

When the local government raises a very low rate on capital, it funds the amount of public goods according to the quality standards that are required by the central government; therefore, a significant portion of this funding is based on the tax on households $\bar{H}$.[5] We will observe what the issues are associated with each decision on the allocation of the capital stock in the economy and the social welfare of the residents of i.

3 Strategic tax interactions and the social welfare of residents of i

Suppose that governments plan to exercise competitive tax rates that affect mobile capital. They then adopt a selfish strategy. The local elected officials may choose between the possibilities mentioned above in terms of capital taxation. However, the current international situation regarding the taxation of capital can be analyzed as a result an of insurance game to attract private investments. Without a loss of generality, we consider various players represented among others by local governments or states that have the choice between the following strategies to tax the capital factor: *taxed at a higher rate or not taxed*. If we assume that M

[5] We suppose that jurisdictions always opt for a maximum level of taxing the households $(H_i = \bar{H}, \forall i)$.

jurisdictions are divided into two groups $i, j \in \{1,...,M\}$, $(\forall i \neq j)$, four scenarios are conceivable. By hypnosis, every group of jurisdictions is in tax harmonization.[6]

• *The first two cases are asymmetrical: the two groups choose to conduct opposite fiscal policies. One group chooses to impose a maximum tax rate on capital, the other not.*

• *The other two situations are symmetrical: both groups choose to launch the same tax policy or either to impose a maximum tax rate on capital or not.*

To resolve this game, each situation can be held, one after another and take care of the case where each player has an interest in changing his strategy if the others players do not. The economic analysis of the consequences of tax competition mechanisms in terms of the collective welfare of the jurisdiction is in question.

First of all, we will study the effect of the choice of i when other jurisdictions j $(\forall j \neq i)$ choose a very low tax rate $(t_j \geq 0)$ on the capital factor to observe the effects induced for the social the welfare of residents of i.

3.1 Other jurisdictions choose $t_j \geq 0$, $(\forall j \neq i)$

In this case, there are two situations to consider. Jurisdictions i behave either with the same way as to that of other jurisdiction j or behave in a different manner.

Jurisdictions i behave in the same way as other jurisdictions j

Suppose that i chooses $t_i \geq 0$, with $t_i = t_j$ and all jurisdictions have the same tax rate and the same marginal productivity $\alpha/K_i - t_i = \alpha/K_j - t_j$ they have the same performance when the capital is equally distributed. The share of capital in i is determined from the equality $K_i(\alpha - t_j K_j) = K_j(\alpha - t_i K_i)$; therefore, we have

$$K_i = \frac{(\bar{K} - K_i) - t_i K_i (\bar{K} - K_i) - t_j K_i (\bar{K} - K_i)}{M - M/2} \tag{1}$$

[6] The idea of a fiscal harmonization of tax jurisdiction is a simplified assumption in our model.

The tax rate and the utility of consumer i [7]

$$t_i = \frac{2t_j K_i^2 - 2K_i (M + t_j \bar{K}) + \bar{K}M}{MK_i (\bar{K} - K_i)} \tag{2}$$

$$\hat{\Delta} U_i^{(t_i > t_j; t_i = t_j)} = U_{i|t_i > 0}^{(t_i > t_j)} - U_{i|t_i \geq 0}^{(t_i = t_j)} \tag{3}$$

Proposition 1. If both groups of jurisdictions $i, j \in M$, $(\forall i \neq j)$ identically increase the tax rate on the mobile capital $t_i = t_j$ with $t_i > 0$, then the capital stock is equally shared between jurisdictions $K_i = K_j$, increasing their social welfare.

Proof. Suppose that $t_i = t_j = 0$ (1). This gives a return on the capital equal to $\alpha / K_i = \alpha / K_i$, which implies that $K_i = K_j$. Because $(t_i = t_j = 0)$ for all jurisdictions, this configuration creates social welfare illustrated by $U_{i|t_i \geq 0}^{(t_i = t_j)} = \bar{H} c_i q^{1-\varepsilon}$. Now, when jurisdictions $i, j \in M$, $(\forall i \neq j)$ identically increase the tax rate on the mobile capital $t_i = t_j$ with $t_i > 0$, it is easy to see that the capital stock can be equally shared between jurisdictions $K_i = K_j$. Thus, the social welfare increases compared with situation (1). This increase is quantified as follows $\hat{\Delta} U_i^{(t_i > t_j; t_i = t_j)} = \bar{\Delta} t_i K_i^{(t_i = t_j)} c_i q^{1-\varepsilon}$. Q.E.D.

We shall consider the case where i chooses the opposite strategy $t_i > t_j$ than all other jurisdictions j for all $j \neq i$. Then, we compare the previous results with new analyses to determine, according to each case, the best response of i when the group j continues to adopt the same tax policy.

[7] Notation: $U_i^{(t_i = t_j)}$ denotes the utility of a representative consumer of jurisdictions i. When all jurisdictions i $(i \neq j)$ choose respectively equal rates, this notation depends on the choice of i in terms of the taxation of capital and $\hat{\Delta} U_i^{(t_i > t_j; t_i = t_j)} = t_i K_i c_i q^{1-\varepsilon}$ is the variation of the social welfare for a representative consumer of i. The case $(t_i = t_j = 0)$ will not be discussed in this analysis.

Jurisdictions i behave differently from other jurisdictions j $(t_i \neq t_j)$

Specifically, the jurisdictions i adopt a tax rate $t_i > t_j$, while the jurisdictions j are in the same tax policy $t_j < t_i$, $\forall j \neq i$. The level of capital stock must fit in jurisdictions i as the net return ρ capital. In jurisdictions j, the return on capital is equal to the marginal productivity of capital α / K_j, and in jurisdictions i, the return on capital is α / K_i. We therefore have $\alpha / K_j - t_j > \alpha / K_i - t_i \Leftrightarrow \rho_j > \rho_i$ because, $t_j < t_i$, $\forall j \neq i$. Because jurisdictions j follow the same tax policy of capital, they have an identical capital level $K_j = \frac{\bar{K} - K_i}{M - M/2}$, the rest of the capital stock is equally divided between the members of i.

Proposition 2. When jurisdictions i choose to raise the tax rate on capital compared with other jurisdictions j such that $t_i > t_j$, then: (i) The capital level in i decreases and becomes less than that in j, $K_i < K_j$, (ii) The social welfare of the residents of i relatively increases, $U_{i|t_i \geq 0}^{(t_i = t_j)} < U_{i|t_i > 0}^{(t_i > t_j)}$.

Proof. If $t_i > t_j$, we have the inequality: $\alpha / K_j - t_j > \alpha / K_i - t_i \Leftrightarrow \rho_j > \rho_i$, which does not give an exact calculation of K_i. In this case, we use the following equations:

$$K_i \left(\alpha - t_j K_j \right) = K_j \left(\alpha - t_i K_i \right) \tag{4}$$

$$\Leftrightarrow \alpha K_i - t_j K_j K_i = \alpha K_j - t_i K_i K_j \tag{5}$$

$$\Leftrightarrow \alpha K_i = \alpha K_j - t_i K_i K_j + t_j K_j K_i \tag{6}$$

Replacing K_j by its value in Equation (6) gives:

$$\alpha K_i = \alpha \left[\frac{\bar{K} - K_i}{M - M/2} \right] - t_i K_i \left[\frac{\bar{K} - K_i}{M - M/2} \right] + t_j K_i \left[\frac{\bar{K} - K_i}{M - M/2} \right] \tag{7}$$

$$\Leftrightarrow \alpha K_i \left(M - M/2 \right) = \alpha \left(\bar{K} - K_i \right) - t_i K_i \left(\bar{K} - K_i \right) + t_j K_i \left(\bar{K} - K_i \right) \tag{8}$$

From (8), we then have a second-degree equation:

$$\left(t_i - t_j \right) K_i^2 + t_j \bar{K} - t_i \bar{K} + \alpha \left(M - M/2 \right) K_i + \alpha \bar{K} = 0 \tag{9}$$

The solution of Equation (9) is:

$$K_i = \frac{1}{t_i - t_j}\left[\frac{1}{4}\left(\sqrt{\Delta} - M\alpha\right) + \frac{1}{2}\bar{K}\left(t_i - t_j\right)\right] \, if t_i - t_j \neq 0 \tag{10}$$

The tax rate of i is:

$$t_i = \frac{1}{4}\left(\frac{\sqrt{\Delta} - \alpha M - 2\bar{K}t_j + 4K_i t_j}{4K_i - 2\bar{K}}\right) \tag{11}$$

To analyze the reactions of i and j via the tax strategy $t_i > t_j$, we will try to measure the effect of an increase t_i on the tax base in jurisdiction i.[8]

$$\frac{\partial K_i}{\partial t_i} = \frac{1}{4}\frac{\left(\alpha M - \sqrt{\Delta}\right)}{\left(t_i - t_j\right)^2} < 0 \tag{12}$$

The first term of (12) denotes the derivative of capital relative to its cost. We observe the presence of a *negative fiscal externality* in jurisdictions i following the increase in its tax rate. Therefore, the *remuneration of capital* in i decreases $\alpha M < \sqrt{\Delta}$ because $t_i > t_j$. Increasing t_i will also have an impact on the tax base of jurisdiction j.

$$\frac{\partial K_j}{\partial t_i} = -\frac{1}{2}\frac{\left(\alpha M - \sqrt{\Delta}\right)}{M\left(t_i - t_j\right)^2} > 0 \tag{13}$$

Equation (13) is positive because $\alpha M < \sqrt{\Delta}$. The fact that an increase in tax rates in jurisdictions i leads to an increase in the tax base of jurisdictions j, it is interpreted as a *positive fiscal externality*. The social welfare of jurisdictions i is represented by

$$U_{i|t_i \geq 0}^{(t_i = t_j)} < U_{i|t_i > 0}^{(t_i > t_j)} \tag{14}$$

Q.E.D

[8] $\Delta = 4\bar{K}^2\left(t_i - t_j\right)^2 - \left(t_i + t_j\right)\left[\bar{K}\alpha\left(4M + 16\right)\right] - 8\bar{K}^2 t_i t_j + \left(M\alpha\right)^2$.

An increase in the tax rate on capital can increase the amount of public goods in jurisdictions i in the case where other jurisdictions act in the same manner. The increase in the productivity of capital related to an increase in public goods allows a strong increase in consumption; this leads to an increase in the utility of the representative household. Because each group of jurisdictions has an interest in deviating from this strategy by more taxing the capital, and given the specification of the functions, the strategies vector $((t_i = t_j), (\forall j \neq i))$ does not constitute an equilibrium.

3.2 Other jurisdictions choose to tax capital at rate $t_j > t_i$

We have two situations to study. Jurisdictions i behave either identically to j or differently.

Jurisdictions i and j behave differently, $t_i \neq t_j$

More precisely, jurisdictions i opt to tax capital at a rate of $t_i < t_j$, $\forall j \neq i$. Then, the level of capital will adjust in i.

Proposition 3. If the the residents of jurisdictions i keep the choice of the same taxing strategy of capital such that $t_i < t_j$, then a more significant share of the capital stock moves from j to i with $K_i > K_j$, and the social welfare of the residents of i decreases: $U_{i|t_i>0}^{(t_i<t_j)} < U_{i|t_i>0}^{(t_i>t_j)}$.

Proof. If jurisdictions j opt to increase its tax rate on capital, the net return on capital in i and j would adjust, so $\rho_j < \rho_i$ is equivalent to $\alpha/K_j - t_j < \alpha/K_i - t_i$. The reactions of capital in i and j are $\frac{\partial K_j}{\partial t_j} < 0$, $\frac{\partial K_i}{\partial t_j} > 0$. To determine the value of

K_j, following the increasing tax rate strategy in j, we replace K_i with K_j. We have the following equation[9]

$$K_j = \frac{1}{2M\left(t_i - t_j\right)}\left[M\alpha - \sqrt{\Delta} + 2\bar{K}\left(t_i - t_j\right)\right] with t_j \neq t_i \tag{15}$$

The tax rate j and the utility of residents i

$$t_j = \frac{1}{2}\left[\frac{M\alpha - \sqrt{\Delta} + 2\bar{K}t_i - 2MK_j t_i}{\bar{K} - 2MK_j}\right] \tag{16}$$

$$U_{i|t_i>0}^{\left(t_i>t_j\right)} > U_{i|t_i>0}^{\left(t_i<t_j\right)} \tag{17}$$

Q.E.D

From Proposition 2, it is appropriate to note that the level of capital increased in i. This increase is accompanied by a change in social welfare in i. Even jurisdiction j raises its tax rates, it is not harmful for i to take an opposite behavior. Now, consider the case where all jurisdictions tax the capital at the same rate $t_i = t_j = \bar{t}$.

Jurisdictions i and j behave identically, $t_i = t_j = \bar{t}$

We assume that all jurisdictions do not behave in the same way. Assume that jurisdiction j decides to have $t_j = \bar{t}$. It follows that the capital stock in the economy will equally divide among the different jurisdictions $K_i = K_j = \frac{\bar{K}}{M}$. The net return on capital is: $\alpha/K_j - \bar{t} = \alpha/K_i - \bar{t} = \rho$.

$$U_{i|t_i>0}^{\left(t_i>t_j\right)} \leq U_{i|t_i\leq\bar{t}}^{\left(t_i=t_j=\bar{t}\right)} \tag{18}$$

From Propositions 1, 2 and 3, we give the following corollary.

[9] $K_j = \left[\bar{K} - \left(\frac{1}{t_i - t_j}\left(\frac{\left(\sqrt{\Delta} - M\alpha\right)}{4} + \frac{\bar{K}\left(t_i - t_j\right)}{2}\right)\right)\right]/\left(M - M/2\right)$, which leads to $K_j = \frac{1}{2M\left(t_i - t_j\right)}\left[M\alpha - \sqrt{\Delta} + 2\bar{K}\left(t_i - t_j\right)\right]$ with $t_j \neq t_i$

Corollary 1 . *If both groups of jurisdictions $i, j \in M$, $(\forall i \neq j)$ identically increase a tax rate on the mobile capital $t_i = t_j$ with $t_i > 0$, then (i) the capital stock is equally shared between jurisdictions $K_i = K_j$ and (ii) the social welfare of i increases compared with the previous configurations* $U_{i|t_i \leq \bar{t}}^{(t_i = t_j = \bar{t})} > U_{i|t_i > 0}^{(t_i > t_j)} > U_{i|t_i > 0}^{(t_i < t_j)} > U_{i|t_i > 0}^{(t_i = t_j)} > U_{i|t_i = 0}^{(t_i = t_j = 0)}$.

4 Dominant strategies and the choice of quality by the central government

We make the hypothesis that all jurisdictions are exactly similar, and we therefore determine whether the previous analysis allows us to define a Nash equilibrium. From this perspective, the same behavior as other jurisdictions should be followed, even though the jurisdictions i have no interest in deviating. In addition, this must be a dominant strategy regardless of the strategy of other jurisdictions. This means that jurisdictions i have an optimal strategy that does not depend on what other jurisdictions do.[10]

Let S_i be set of strategies of jurisdictions i, and S_{-i} is the set of strategies of their opponents. A strategy $s^* \in S_i$ weakly dominates another strategy $s^\circ \in S_i$; if: $s_{-i} \in S_{-i}\left[U_i(s^*, s_{-i}) \geq U_i(s^\circ, s_{-i})\right]$. Similarly, s^* strictly dominates s° if: $s_{-i} \in S_{-i}\left[U_i(s^*, s_{-i}) > U_i(s^\circ, s_{-i})\right]$. The same reasoning is applied to our tax competition games, so it subsists the pair $(t_i^* = \bar{t}, t_j^* = \bar{t})$, which is a dominant strategy equilibrium.

Comparing Equations (3), (14), (17) and (18), we have:

$$\left\{ U_{i|t_i \leq \bar{t}}^{(t_i = t_j = \bar{t})} \geq U_{i|t_i > 0}^{(t_i > t_j)} > U_{i|t_i > 0}^{(t_i < t_j)} > U_{i|t_i > 0}^{(t_i = t_j)} \right\} \tag{19}$$

[10] The Nash equilibrium is a non-cooperative equilibrium, each player maximizes his gains by considering the behavior of others as given. Any Nash equilibrium is a dominant strategy equilibrium. This term refers to a situation where a player's strategy is the best response to all possible strategies of rivals. This strategy dominates all other strategies of players.

$\bar{\Delta} t_i K_i^{(t_i=t_j=\bar{t})}$ defines the variation in tax revenues for jurisdictions i when they choose the strategy $(t_i = t_j = \bar{t}, \forall j \neq i)$.

From Equation (19), we note that the interest of the residents of jurisdictions i is to tax at the maximum capital in addition to the immobile factor.[11] This leads to an improvement in the welfare of a representative household. To generalize, when M jurisdictions are identical, they will all simultaneously adopt the same fiscal behavior; therefore, the vector $(t_i = t_j = \bar{t}, \forall j \neq i)$ constitutes a dominant strategy equilibrium. From the symmetric analysis of tax rates, we obtain the following proposition.

Proposition 4. If the two groups of jurisdictions $i, j \in \{1, ..., M\}, (\forall i \neq j)$ adopt a maximum tax rate $(t_i^* = t_j^* = \bar{t})$, then this vector constitutes a fiscal Nash equilibrium for a tax competition game if and only if the following properties hold: *(i)* $\partial K_i / \partial \bar{t} = 0$ and *(ii)* $\partial K_j / \partial \bar{t} = 0$, the capital in i and j does not react at tax rates with $K_i^* = K_j^* = \frac{\bar{K}}{M}$.

4.1 The choice of quality by the central government

Because the central government knows that all jurisdictions will adopt the same behavior for taxing the capital $(t_i = \bar{t}, \forall i = 1, ..., M)$, it chooses a quality level of public goods related to the utility (or *welfare*) of a representative resident. This choice will depend essentially on the cost-elasticity of quality. Thus, the level of the quality of public goods in equilibrium is:

$$q^* = \left(\underbrace{\frac{1}{g_i} \frac{\hat{\Delta} U_i}{\hat{\Delta} c_i}}_{\phi constant} \right)^{1/\varepsilon - 1} \tag{20}$$

Where the term $\left(\frac{1}{g_i} \frac{\hat{\Delta} U_i}{\hat{\Delta} c_i} \right)$ represents the welfare of the residents of i. We therefore seek the relationship between quality and cost-elasticity. In Equation

[11] The social welfare of i increases compared the configurations $\bar{\Delta} \bar{t} (\frac{\bar{K}}{M})^{(t_i=t_j=\bar{t})} \geq \bar{\Delta} t_i K_i^{(t_i>t_j)} > \bar{\Delta} t_i K_i^{(t_i<t_j)} > \bar{\Delta} t_i K_i^{(t_i=t_j)}$

(20), we assume that the constant is equal to $\phi = 10$, giving $q = 10^{1/\varepsilon - 1}$. Our analysis will be performed on this basis. However, this constant is measured relative to the unit.[12] If $\phi > 1$, this means that there is are enough welfare expressed by quality for the residents of i. Figure 1 shows that an increase in *cost-elasticity* ε causes a diminution of *quality* q. In this case, the central government chooses a minimum quality of public goods; therefore, the jurisdictions increase the quantity accordingly.

However, with $\phi < 1$, there is too little social welfare for the residents in i. On arbitrary grounds, we set, for example, $\phi = 0.1$, which leads to $q = 0.1^{1/\varepsilon - 1}$. In this context, the increase of ε has a positive impact on the quality of public good. The central government chooses to increase the quality of public goods that is detrimental to the quantity. This is explained by Figure 2.

Table 1 gives a synthesizing explanation of the choice of quality by the central government. We see the impacts of parameters ϕ, ε increasing or decreasing depending on the quality of public goods.

The welfare ϕ	Cost-elasticity ε	Quality $\mathbf{q}$	Quantity $\mathbf{g}_i$
$\phi > 1$	$\varepsilon \nearrow$	$\mathbf{q} \searrow$	$\mathbf{g}_i \nearrow$
$\phi = 1$	$\forall \varepsilon \neq 1$	constant	constant
$\phi < 1$	$\varepsilon \nearrow$	$\mathbf{q} \nearrow$	$\mathbf{g}_i \searrow$

Table 1. Choice of quality by the central government

[12] The welfare can take several values expressed by the constant ϕ such that: $(\phi = 1, \phi = 2, \phi = 3, \phi = 4, ..., \phi = 10)$.

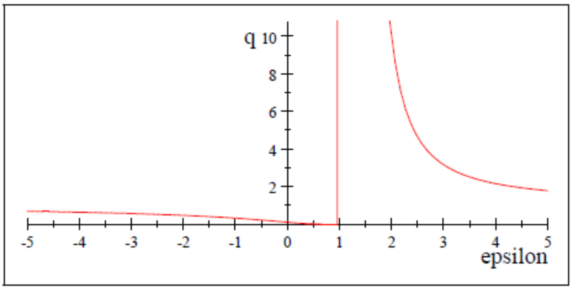

Figure 1

Relationship between quality and cost-elasticity of quality $(q, \varepsilon, \phi > 1)$

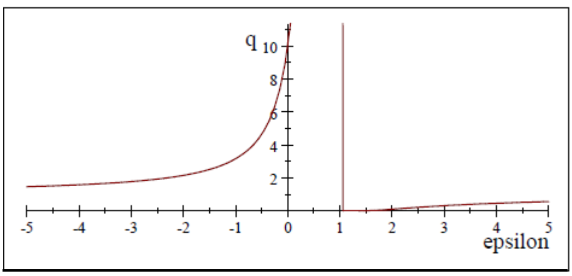

Figure 2

Relationship between quality and cost-elasticity of quality $(q, \varepsilon, \phi < 1)$

5 Conclusion

In this article, we have shown that regardless of the quality of public goods and their cost, jurisdictions always have an interest in taxing capital even if there is a possibility to reduce its quantity within their territory. Each group of jurisdictions has an interest to do so, and the dominant strategy allowed us to identify a Nash equilibrium in our model. At this equilibrium, the capital is taxed simultaneously by the jurisdictions, and the capital stock is distributed equally between jurisdictions. Furthermore, the upward tax rate competition – the race to the tax rate increase – seems to be a real incentive to increase the welfare of residents. The "race to the bottom" competition seems to create a reduction in the supply of public goods. Therefore, it is important for the central government to adapt its behavior to the cost-elasticity that is imposed by the quality on the supply of public goods. The rule is that if it weighs less on welfare, it will improve the situation of residents from different jurisdictions asking and opting for better quality; if the cost-elasticity is substantial with a decrease in welfare, it is better for the central government to choose to spend its tax revenues on increasing the quality of public services rather than the quantity. This model has a number of limitations, which constitute a fruitful area that we leave for future research. We could extend our analysis and research to other specifications of the utility function and the production function to determine whether the results of our analysis could be affected by other factors.

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