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TAX INTERACTIONS WITH ASYMMETRIC INFORMATION AND NONLINEAR INSTRUMENTS

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Abstract

When different layers of government exert their taxing power upon a common base, the decisions made by one tier affect the receipts that the other policymakers can collect. Likewise, when same level authorities derive their receipts from a mobile tax base, a competition mechanism takes place that triggers externalities. This paper proposes a model where both horizontal and vertical interactions take place. Uncertainty concerning the base, that is, the amount of capital likely to be invested, is introduced and a generalization of taxation schemes is provided through the choice of the instruments, in order to assess the robustness of traditional analyses results in a more general and realistic scheme. With respect to a unique government framework, an excessively high level of taxation emerges from the simultaneous interplay of horizontal and vertical tax externalities.

Keywords : Vertical and horizontal tax externalities, Informational asymmetry, Tax competition, Common Agency, Nonlinear taxes.

JEL Classification : D72, D82, H23, H30, H32, H71, H77.

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1 Introduction

Mobile tax bases are at the root of strategic tax competition, both within and between countries. Vying for mobile tax bases has been shown to put downward pressure on the degree of taxation. Indeed, when a decisionmaker unilaterally and independently raises her tax rate, the mobile base can move into neighbouring jurisdictions, thereby reducing the amount of tax receipts that can be collected in the locality that implemented a hike. As a result, same-level benevolent governments that noncooperatively make their decisions tend to levy tax rates and provide a supply of public good that are inefficiently low. On the other hand, when policymakers are Leviathan, horizontal tax competition improves social welfare because it exerts a constraint on revenue maximizers (Brennan and Buchanan (1977)) [1].

Extensive literature has been devoted to fiscal competition between same-level jurisdictions. The vertical dimension of intergovernmental tax relationships also appears as a crucial issue. Actually, multileveled governments represent a common feature of fiscal arrangements, not only in such federations as Canada, where 70% of provincial goverments' tax receipts come from overlapping bases, but also in such centralized states as France, where this mechanism accounts for the greatest part of local tax revenue. When a layer of authority unilaterally chooses to raise its tax rate, it ignores the losses of receipts that the other levels suffer from the induced contraction of the shared tax base. Consequently, the full social marginal cost of raising tax revenue from the common base is not taken into account. Contrary to the horizontal-tax-competition case, a "race to the top" can emerge. Thus, the sharing of some tax bases by different levels of governments in multitiered tax architecture points to the existence of vertical externalities[2]. Because both horizontal and vertical fiscal external effects come into play in territorial organizations, it appears relevant to take them into account simultaneously and to analyse the interactions between them.

Some authors have introduced an important assumption in the analyses of tax competition. They have considered that the level of mobile tax base is not common knowledge, which involves informational asymmetries[3]. Indeed, informational issues can represent a key element in the relationship between tax-payers and governments. Besides, taxation problems in multilayer government schemes can be seen as multiprincipal problems. In some cases, the agent (i.e. the taxpayer) may have a better knowledge than governments concerning one relevant parameter of hers. Models analyzing the interactions between several principals can help improve the comprehension and knowledge of constitutional structures in which rival powers interact, especially as many principals (the governments) often contract with a unique and common agent (the taxpayer) [4]. Unlike perfect information frameworks, in such models, governments compete in

[1] Another kind of explanation of the interaction between same-level governments has received growing attention : the mechanism of political yardstick competition, which states that voters can use the performances of neighboring governments as a yardstick to assess the efficiency of their representative officials and decide accordingly whether to re-elect them or not. This mechanism can lead to higher tax rates than the levels that would be necessary to finance the amount of public good required by citizens, because some kind of collusion process can take place amongst them.

[2] A brief survey of these works is provided in Section 2.

[3] Martimort 1992, Laussel and Lebreton 1993, 1994).

[4] Martimort and Stole (2003).

tax schedules, that is, functions that link the level of taxes on capital to the amount of capital invested in each jurisdiction. Nonlinear instruments allow a better adjustment to uncertainty than do fixed tax rates when decisionmakers cannot commit to strategic variables. Such instruments permit jurisdictions to achieve higher expected payoffs and allow a formulation of the tax problem that more closely corresponds to the actual tax systems. Thus, we propose a model introducing uncertainty as to the amount of capital and addressing the problem as a principal-agent game, which enables us to examine the interaction of horizontal and vertical effects.

This article has the following structure : The first two sections summarize the main findings of traditional literature and introduce the model we use to address tax competition. Section III displays the benchmark case, that is the setting of the unique government. The framework adopted involves uncertainty concerning the amount of capital likely to be locally invested and generalizes taxation schemes *via* the design of nonlinear instruments. Section IV is dedicated to the analysis of the vertical external effect while the last section investigates the interaction between horizontal and vertical tax externalities.

2 Main findings about vertical tax externalities

Vertical tax externalities represent a growing concern as the number of multitiered-governments settings expands (in federal or unitary states as well as in organizations such as the European Union). As they become more and more complex, it seems relevant to deepen and improve the our understanding not only of vertical effects but also of their interplay with horizontal tax competition.

2.1 Excluding horizontal tax externalities

The mechanism of vertical tax externality stemming from the co-occupancy of tax bases between several tiers of government was first analysed by Cassing and Hillman (1982). The federal government of Australia levies taxes both on export and output. Tax receipts are thus collected on the coal transported by train up to the harbour. Meanwhile, the state of Queensland holds a monopoly on railroads and taxes freight. With respect to a cooperative situation, the competition between these two Leviathan public decisionmakers leads to a shrinkage in the potential amount of tax receipts and increases the deadweight losses as a same resource is taxed twice. These conclusions were highlighted by the pionner work of Flowers (1988). Based on Brennan and Buchanan (1980), this model examines a situation in which two different layers of government eager to maximize their fiscal revenue tax a common mobile base. With respect to a unique government setting, the addition of a second authority endowed with tax powers induces an erosion of the common base. As each layer ignores the revenue losses incurred by the other policymaker when he raises his rate, the marginal cost of raising tax revenue from the common base is underestimated and the global tax rate is thereby excessively high. Besides, as demonstrated by Sobel (1997), the distorsion is strengthened in a sequential framework. In fact,

the Stackelberg leader anticipates the revenue reduction and seeks to compensate for this effect through a hike in his tax level. The study performed by Keen (1998) in a framework of consumption taxes posts an exhaustive presentation of the main effects stemming from tax stacking. The author shows that when the lower level is Leviathan, federal and local taxes are strategic complements if the price-elasticity of the good demand is constant. If local decisionmakers are benevolent, two additional effects appear : The decrease of demand for the good because of the consumer price rise (which lessens the loss of consumer welfare), and the reduced production of the local public good due to the shrinkage of the tax base (which makes the increase of local public good through higher tax rates more attractive). These main conclusions were generalized by Flochel and Madiès (2002) in a context borrowed from industrial organization[5]. With Leviathan governments and imperfect mobility of the taxed base, that is capital, the global tax rate to which the common base is subject results as a growing function of stacked layers.

In order to check the existence of such effects in a hierarchically nested governments framework, Besley and Rosen (1998) lead an empiric analysis on excise taxes in United States. They estimate the impact of changes in federal tax policy on states tax decisions. Four kinds of reaction can appear : a revenue effect that describes the local government reaction to maintain his revenue when the federal government raises his tax rate, the deadweight loss effect related to the fact that, all things equal, the marginal disutility of tax increases with the rate (that is taxes are complement), the tax complement or substitution effect when demand cannot be differentiated, and a spending effect according to which tax receipts decrease when the federal tax rate is raised. An increase of 10% in the unitary federal tax rate on cigarettes triggers an increase of 2,8% of the local unitary tax rate ; the same increase for gasoline induces a 4,1% rise of the local tax. Esteller-Moré and Solé-Olé (2001) analysed personal income and general sales taxes. They found that US state taxes reacted positively to increases in federal taxes. Likewise, examining Canadian income taxes, Esteller-Moré and Solé-Olé (2002) stressed a positive response of provincial tax rates to changes in the federal tax rates. On the other hand, Hayashi and Boadway (2001) found a negative correlation, also enhanced by Goodspeed (2000) in a panel of OECD countries. Empirical work yields results that vary according to the assumptions of the model studied.

2.2 Combined horizontal and vertical tax externalities

Keen (1995) shows that both externalities point in different directions when a tax base overlap is combined to horizontal tax competition and that the economy ends up on the downward sloping side of the Laffer curve.

The net impact of the interaction between horizontal and vertical externalities appears rather ambiguous and assumption-dependent. Keen and Kotsogiannis (2002), (2004) tackle this issue through a model of benevolent governments, based on Zodrow and Mieszkowski (1986) with the addition of a higher level of policymaker and an endogeneized supply of capital. They

[5]The authors develop a Salop spatial competition model in which local jurisdictions are uniformly distributed and firms are represented by a continuum of investors that sequentially make their location in function of the central tax rate and then of the local tax rate and local variables.

show that the final effect depends on the elasticity of savings supply, capital demand, the level of income taxation, households' preferences for local or national public goods, the degree of mobility of the tax base... Brülhart and Jametti (2004) adopt a similar aproach in an international setting. The domination of the vertical externality depends on the part of the local public good in the utility function, of the relative elasticity of capital... In a Leviathan policymakers framework, Keen and Kotsogiannis (2003) prove that receipts are strictly higher for both local and federal governments if the tax rate is reduced by at least one of them. Furthermore, when the public goods provided by the different tiers of governments are substitute, social welfare also increases.

Through an industrial organization point of view, Flochel and Madiès (2002) also analyze the resulting effect of simultaneous horizontal and vertical competition in a federal government in which decisionmakers seek to maximize their revenue. They show that the competition between same level policymakers reduces the cumulated tax rate but cannot totally offset the vertical externality.

Thus, these analyses suggest that the vertical effect tends to dominate.

3 A model of taxation with nonlinear instruments : Framework and main assumptions

We propose a model that takes information asymmetries into account and that studies tax interactions among different layers of governments, with one of them being composed of many jurisdictions competing for firms. This is a common agency game setting in which the agent, that is the firm, holds a private information about the amount of capital available, whereas the governments are the unperfectly informed principals[6].

3.1 Choice of the instruments

In common agency settings, two types of externalities may arise : a direct effect *via* a common parameter, and a contractual externality as the actions taken by one principal necessarily affect the situation of the other ones (Martimort and Stole, 2002). Besides, one principal may induce the agent to misrepresent to other principals, which can make truthful equilibria disappear and thus prevents the use of the Revelation Principle. In a one-principal setting, a nonlinear schedule can replicate the same outcome as any deterministic direct communication process ; there is no loss of generality in confining to strategically decentralized menus of relevant contracting parameters : This is the Taxation Principle (Guesnerie, 1981, 1995, and Rochet, 1986). In multiprincipals frameworks, this Principle becomes the Delegation Principle.

[6]In such all-or-nothing games in which the agent cannot restrict to contract with only some of the principals, diversifying investment is a better strategy for the firm than instead investing locally all the capital she owns (either in only one or in both jurisdictions) or directing it to the alternative economic area.

In this paper, we choose to endogeneize the instruments used, that is we consider nonlinear taxes which allow a better analysis of the firm's investment choices and governments' policies. This choice is justified not only from a theoretical point of view (as the firm holds private information) but also rests on practical grounds. Indeed, though corporate taxes are usually proportional, often tax advantages are offered that make them depart from mere proportional taxes (deductible capital allowances, tax exemptions...) and support the use of nonlinear instruments. As explained by Olsen and Osmundsen (2001), governments should be less informed than the firm concerning some features of hers because of the international nature of major enterprises, of interfirm transactions, of complex technologies that imply obstacles for the authorities to ascertain the firm's efficiency... As a result, the instruments are not lump-sum, they depend on the agents' choices and involve incentive effects.

3.2 The players

We consider an organization made of two same-level governments, the jurisdictions, supposed to be identical in all relevant aspects, and of an upper-tier authority. All decisionmakers are considered to be endowed with independent spending and taxing powers. Local governments can contract with the firm on the amount of capital she invests in the jurisdictions. The higher-level government can tax the whole amount of capital locally invested. Tax authorities are supposed to be Leviathan[7].

We assume there is a unique firm that can invest its capital either in one locality or in both of them, or else dedicate it to another use. The amount of capital available for investment, θ, is a private information of the agent. θ is a continuous parameter that belongs to the set $\Theta = \left[\underline{\theta}; \overline{\theta}\right]$. The prior of the governments relative to θ are described by a common knowledge law represented by the continuous distribution function $G(\theta)$ and the strictly positive density function $g(\theta)$, with the the MLRP being satisfied $\frac{d}{d\theta}\left(\frac{1-G(\theta)}{g(\theta)}\right) < 0$. Besides, $\frac{d}{d\theta}(g(\theta))$ is nonnegative.

3.3 Problem of the investor

The firm θ receives the output (prices are normalized to one) minus the taxes and the profit writes

$$U(\theta) = \{f(k_1) - T(k_1) + f(k_2) - T(k_2) - \tau(k_1 + k_2) + M(\theta - k_1 - k_2)\}.$$

$T(k_i)$ designs the taxe levied by the local government of jurisdiction i (i=1,2) on the amount of capital invested there : $k_i(\theta)$. The upper-tier applies a tax $\tau(\cdot)$ upon the whole local investment $\sum_{i=1}^{2} k_i(\theta)$. We consider that capital cannot be subsidized, that is marginal taxes are necessarily positive.

[7] According to Brennan and Buchanan (1980), if self-interested policymakers undertake inappropriate expenditure or use them inefficiently, capital mobility may limit these inefficiencies and constrain the expansionary tendencies of the public sector.

We denote $f(k_i(\theta))$ the output in jurisdiction i as a function of the capital locally invested. $f(\cdot)$ is three times continuously differentiable, $f'(\cdot) > 0$, $f(0) = 0$, $f''(\cdot) < 0$: the production function is assumed to be monotonously increasing in capital with decreasingly profitable successive units of capital as the capital stock expands.

$M(\theta - k_1(\theta) - k_2(\theta))$ represents the opportunity benefit of not investing locally all the capital available. $M(\cdot)$ is exogenous, increasing and strictly concave : $M'(\cdot) > 0$, $M"(\cdot) < 0$. Besides, we assume that $M'''(\cdot) > 0$[8].

The firm faces countervailing incentives. On the hand, she is eager to appear as a low-type firm in order to reduce the tax requirements she is addressed. On the other hand, it may be beneficial for her to report having a high amount of capital available in order to appear likely to reschedule investment.

We consider there is a unique homogenous good produced by the jurisdiction and taken as *numeraire*. The only production factor is capital (for a simplicity stake, we do not make the assumption of a fixed factor). The good can be either consumed or used as an input in the production of the local public good.

4 Benchmark situation : A Unique Decisionmaker

We assume there is a unique revenue-maximizing government.

An investor has to choose the level of capital to be invested in each jurisdiction (under the constraint not to invest more capital than what she owns).

Whatever his type $\theta \in \Theta$, an agent that accepts the contract makes an announcement θ^a and is thus required to pay a tax $t(\theta^a)$, while he is induced to invest a fraction $k(\theta^a)$ of the capital at his disposal. The best choice for the firm being to tell the truth,

$$U(\theta) = \max_{\theta^a} \{f(k(\theta^a)) - t(\theta^a) + M(\theta - k(\theta^a))\}.$$

The following conditions are necessary and sufficient for the contract to be incentive :

$$\begin{aligned} \dot{U}(\theta) &= M'(\theta - k(\theta)), \\ \dot{k}(\theta) &> 0. \end{aligned}$$

The Taxation Principle allows the implementation of incentive nonlinear schemes, making the optimal tax depend on the amount of capital invested $\{T(k(\theta))\}$.

[8]It would be sufficient for the problem to be concave that the following condition be satisfied :

$$\frac{M'''(\theta - k)}{M''(\theta - k)} < m < \frac{1}{\frac{1 - G(\theta)}{g(\theta)}} \times \left[1 - \frac{\frac{d}{d\theta}\left(\frac{1 - G(\theta)}{g(\theta)}\right)}{1 - \dot{k}}\right], \quad \forall\, \theta, k, \ \forall m \in R_+^*.$$

$k(\cdot)$ is a strictly monotonically increasing function, so it can be inverted to yield θ as a function of k. $\{T(k)\} = t(k^{-1}(\theta))$, tax schedules are assumed to be deterministic and twice continuously differentiable. We consider indirect mechanisms.

The programme of the government becomes :

$$\max_{\{U(.),k(.)\}} \int_{\underline{\theta}}^{\overline{\theta}} T(k(\theta)) g(\theta) d\theta \tag{1}$$

subject to

$$U(\theta) = f(k(\theta)) - T(k(\theta)) + M(\theta - k(\theta)) \geq 0 \tag{2}$$

$$\dot{U}(\theta) = M'(\theta - k(\theta)) \tag{3}$$

$$\dot{k}(\theta) > 0. \tag{4}$$

The informational gap stemming from the firm's better knowledge of a relevant characteristic induces the government to give her a rent in order to prevent a misrepresentation of her true type[9].

$$\int_{\underline{\theta}}^{\overline{\theta}} U(\theta) g(\theta) d\theta = \int_{\underline{\theta}}^{\overline{\theta}} \frac{1 - G(\theta)}{g(\theta)} M'(\theta - k(\theta)) g(\theta) d\theta.$$

Consequently, the level of tax receipts collected by the government is decreasing :

$$\int_{\underline{\theta}}^{\overline{\theta}} \left\{ f(k(\theta)) + M(\theta - k(\theta)) - \frac{1 - G(\theta)}{g(\theta)} M'(\theta - k(\theta)) \right\} g(\theta) d\theta.$$

from which we can derive the first order condition :

$$f'(k(\theta)) = M'(\theta - k(\theta)) - \frac{1 - G(\theta)}{g(\theta)} M"(\theta - k(\theta))$$

Besides, from the envelope theorem, the unitary marginal tax rate $T'^U(\cdot)$ expresses as :

$$T'^U\left(k^U(\theta)\right) = f'(k(\theta)) - M'(\theta - k(\theta))$$

Direct computations yield the following unitary equilibrium tax

$$T'^U\left(k^U(\theta)\right) = -\frac{1 - G(\theta)}{g(\theta)} M''\left(\theta - k^U(\theta)\right) \tag{5}$$

[9]In the perfect information case, as the government would know the amount of capital available for investment, it would be equivalent to make taxes depend on k or on θ, and he could restrict to direct contract.

Remark : it is important to check whether marginal tax rates are an increasing or a decreasing function of the amount of capital invested[10].

$$T^{"U}\left(k\left(\theta\right)\right)=-\frac{d}{d\theta}\left(\frac{1-G\left(\theta\right)}{g\left(\theta\right)}\right)\frac{M''\left(\theta-k\left(\theta\right)\right)}{\dot{k}\left(\theta\right)}+\frac{1-G\left(\theta\right)}{g\left(\theta\right)}M'''\left(\theta-k\left(\theta\right)\right)\left[1-\frac{1}{\dot{k}\left(\theta\right)}\right]\leq 0\ .$$

The more the firm invests in the jurisdiction, the less the marginal tax rate can be raised. Not only the mobility of the agent but also and above all his private information strongly affect the government's ability to implement its preferred tax policy.

5 Concurrent taxation of a common base

We consider that two different levels of government, with only one decisionmaker a layer, simultaneously and non cooperatively levy taxes on firms. Both bottom-up and top-down tax externalities can arise.

The profit of a firm θ writes

$$U\left(\theta\right)=f\left(k\left(\theta\right)\right)-T\left(k\left(\theta\right)\right)-\tau\left(k\left(\theta\right)\right)+M\left(\theta-k\left(\theta\right)\right).$$

The programme of government i is the following one

$$\max_{k(\theta)}\int_{\underline{\theta}}^{\overline{\theta}}T\left(k\left(\theta\right)\right)g\left(\theta\right)d\theta\ =\int_{\underline{\theta}}^{\overline{\theta}}\left[f\left(k\left(\theta\right)\right)+M\left(\theta-k\left(\theta\right)\right)-\tau\left(k\left(\theta\right)\right)-U\left(\theta\right)\right]g\left(\theta\right)d\theta$$

subject to

$$\begin{aligned}U\left(\theta\right) &= f\left(k\left(\theta\right)\right)-T\left(k\left(\theta\right)\right)-\tau\left(k\left(\theta\right)\right)+M\left(\theta-k\left(\theta\right)\right)\geq 0 \\ \dot{U}\left(\theta\right) &= M'\left(\theta-k\left(\theta\right)\right) \\ \dot{k}\left(\theta\right) &> 0.\end{aligned} \tag{7}$$

We use the same methodology as in the previous part. The resolution is straightforward and marginal taxes express as :

$$T'^{V}\left(k^{V}\left(\theta\right)\right)=\tau'^{V}\left(k^{V}\left(\theta\right)\right)=-\frac{1-G\left(\theta\right)}{g\left(\theta\right)}M''\left(\theta-k^{V}\left(\theta\right)\right) \tag{8}$$

[10] $\dot{k}\left(\theta\right)=\dfrac{M"\left(\theta-k\left(\theta\right)\right)\left[1-\dfrac{d}{d\theta}\left(\dfrac{1-G\left(\theta\right)}{g\left(\theta\right)}\right)\right]-\dfrac{1-G\left(\theta\right)}{g\left(\theta\right)}M'''\left(\theta-k\left(\theta\right)\right)}{f"\left(k\left(\theta\right)\right)+M"\left(\theta-k\left(\theta\right)\right)-\dfrac{1-G\left(\theta\right)}{g\left(\theta\right)}M'''\left(\theta-k\left(\theta\right)\right)}\in\left]0;1\right[$

$$T'^{V}\left(k^{V}(\theta)\right)+\tau'^{V}\left(k^{V}(\theta)\right)=2\times\frac{1-G(\theta)}{g(\theta)}M''\left(\theta-k^{V}(\theta)\right)$$

If we consider the following concave function $\varphi(k)=f(k(\theta))+M(\theta-k(\theta))-\frac{1-G(\theta)}{g(\theta)}M'(\theta-k(\theta))$, that reaches a maximun for $k=k^{U}$ (that is $\varphi'\left(k^{U}\right)=0$).

Then,

$$\varphi'\left(k^{V}\right)=T'^{V}\left(k^{V}(\theta)\right)=\tau'^{V}\left(k^{V}(\theta)\right)>\varphi'\left(k^{U}\right)=0\implies k^{V}<k^{U}$$

Because she is taxed twice, a firm is deterred from locally investing a substantial amount of capital.

As a by-product

$$T'^{V}\left(k^{V}(\theta)\right)=\tau'^{V}\left(k^{V}(\theta)\right)=-\frac{1-G(\theta)}{g(\theta)}M''\left(\theta-k^{V}(\theta)\right)<T'^{U}\left(k^{U}(\theta)\right)=-\frac{1-G(\theta)}{g(\theta)}M"\left(\theta-k^{U}\right)$$

Besides,

$$\text{As } T'(k)+\tau'(k)=\varphi'(k)-\frac{1-G(\theta)}{g(\theta)}M"(\theta-k),\ T'^{V}\left(k^{V}(\theta)\right)+\tau'^{V}\left(k^{V}(\theta)\right)>T'^{U}\left(k^{U}(\theta)\right)$$

The cumulated tax is higher than in the cooperative case

$$\tau'^{V}\left(k^{V}(\theta)\right)=T'^{V}\left(k^{V}(\theta)\right)<T'^{U}\left(k^{U}(\theta)\right)<T'^{V}\left(k^{V}(\theta)\right)+\tau'^{V}\left(k^{V}(\theta)\right)\tag{9}$$

The marginal tax rate that any policymaker can implement is reduced as less capital is invested. Yet, the global tax rate remains higher than the degree of taxation charged in the reference case : the vertical external effect dominates.

Proposition 1 : *The presence of another decisionmaker leads any tier of government to lower its tax rate with respect to a cooperative framework. However, each revenue-maximizer layer does not take into account the negative externality conveyed upon the other tier when taxes are raised. As a result, the cumulated tax rate ends up too high.*

Any authority that raises its tax rate without internalizing the global effect triggered by this decision upon the total amount of capital invested neglects the induced shrinkage in the common base that the other layer will suffer. Thus, the marginal cost of public funds is valued at a lower level than the true marginal cost, thereby leading to excessively high taxes. This is the *vertical tax externality*. The same conclusions as in perfect information cases emerge, but another effect exerts a downward impact. Actually, as both governments ignore the amount of capital available and take their decisions simultaneously and non-cooperatively, each of them

has to grant the agent an informational rent in order to provide her with incentives to reveal her true type and make the "appropriate" investment choices. As a result, there is also a stacking of rents, which further reduces the global tax rate that can be levied : this is the *asymmetry of information effect*, that nevertheless cannot offset the vertical externality.

6 Combining Horizontal and Vertical Interactions

The internal organization of countries often gives rise to both vertical and horizontal external effects. That's why it is important to analyse the interaction between them in a context involving asymmetry of information.

In order to examine how vertical and horizontal tax externalities interact, we consider an institutional structure made of two levels of policymakers and we assume that the hierarchically lower layer is composed of two governments : i = 1 and 2[11]. All the incumbents are supposed to be revenue-maximizers. They play simultaneously.

$$U(\theta) = \max_{k_i} \left\{ \sum_{i=1}^{2} \{ f(k_i(\theta)) - T_i(k_i(\theta)) \} - \tau \left(\sum_{i=1}^{2} k_i(\theta) \right) + M \left(\theta - \sum_{i=1}^{2} k_i(\theta) \right) \right\} \tag{10}$$

We successively examine the strategy of each layer of government.

6.1 Problem of the upper-tier authority

We can write the programme in function of the investment choice in one jurisdiction. Hence, if k represents the total amount the firm invests locally, that is in jurisdictions 1 and 2, and the levels invested in each of them respectively are k_1 and k_2, with $k_1 + k_2 = k$, then the profit of the firm writes

$$U(\theta) = \max_{k,k_1} \{ f(k_1) - T^*(k_1) + f(k - k_1) - T^*(k - k_1) - \tau(k) + M(\theta - k) \}. \tag{11}$$

As the governments play Nash, the upper-tier authority takes as given the tax rates set by the lower layer.

Optimizing with respect to k_1 yields the following equality

$$k - k_1 = k_1 = \frac{k}{2} \tag{12}$$

[11] For a simplicity sake, we assume that two symmetric localities, identical in all relevant aspects, compete for capital (investments in either jurisdictions are substitute). At equilibrium, tax rates converge and a same level of capital is allocated in both jurisdictions (this result critically depends on the assumption of decreasing marginal productivity of capital). It could be relevant to consider the case of asymmetric jurisdictions, which would be made possible thanks to differentiated technologies of production.

The problem can now be written in function of the total amount of capital locally invested and of the firm's endowment.

The problem of the higher-level government consists in

$$\max_{\{k_i;U(\theta)\}} \int_{\underline{\theta}}^{\overline{\theta}} \tau(k)\, g(\theta)\, d\theta = \max_{\{k_i;U(\theta)\}} \int_{\underline{\theta}}^{\overline{\theta}} \left\{ 2f\left(\frac{k}{2}\right) - 2T^*\left(\frac{k}{2}\right) + M(\theta - k) - U(\theta) \right\} g(\theta)\, d\theta.$$

After some computations and rearrangments, its marginal tax rate is :

$$\tau'(k) = -\frac{1 - G(\theta)}{g(\theta)} M"(\theta - k) \tag{13}$$

6.2 Problem of a local government

If we come back to the initial expression of the profit of the firm

$$U(\theta) = \max_{k_1,k_2} \{ f(k_1) - T(k_1) + f(k_2) - T(k_2) - \tau^*(k_1 + k_2) + M(\theta - k_1 - k_2) \}.$$

Optimizing with respect to k_2 implicitly defines k_2 as a function of k_1 and $\theta : k_2^*(k_1, \theta)$. As a by-product, the other same-level government (1) optimizes over the definition set a function the maximand of which is

$$f(k_1(\theta)) + f(k_2^*(k_1,\theta)) - T(k_2^*(k_1,\theta)) - \tau(k_1(\theta) + k_2^*(k_1,\theta)) + M(\theta - k_1(\theta) - k_2^*(k_1,\theta)) - U(\theta). \tag{14}$$

Slightly abusing notations and combining the results from the optimization processes, the tax rate set by any lower-level decisionmaker writes :

$$T'(k_2^*) = -\frac{1 - G(\theta)}{g(\theta)} M"(\theta - k_1 - k_2^*) \times \left[1 + \frac{\partial k_2^*}{\partial k_1} \right] \tag{15}$$

6.3 Global level of taxation

Let k^{HV} define the total amount of capital locally invested when both horizontal and vertical tax externalities are at work simultaneously.

We obtain the following expressions for the marginal tax rates levied respectively by both layers of government

$$T'(k_j) = -\frac{1-G(\theta)}{g(\theta)} M"\left(\theta - k^{HV}\right)\left[1 + \frac{\partial k_i^*}{\partial k_j}\right], \forall i = 1,2, \forall j = 2,1 \tag{16}$$
$$\tau'\left(k^{HV}\right) = -\frac{1-G(\theta)}{g(\theta)} M"\left(\theta - k^{HV}\right)$$

which yields the cumulated tax rate

$$T'(k_j) + \tau'\left(k^{HV}\right) = -\frac{1-G(\theta)}{g(\theta)} M"\left(\theta - k^{HV}\right)\left[\underbrace{2}_{VE} + \underbrace{\partial k_i^*/\partial k_j}_{HE}\right], \forall i = 1,2, \forall j = 2,1 \tag{17}$$

Both vertical and horizontal tax externalities appear. When horizontal competition is introduced, the monopoly power of the upper tier is strengthened. Indeed, he can set a higher degree of taxation than the lower-level decisionmaker who is induced to soften its in order not to deter the firm from investing.

$$-1 < \frac{\partial k_i^*}{\partial k_j} < 0 \ , \ 0 < \frac{\partial k_i^*}{\partial k_j} + 1 = \frac{T'(k_j)}{\tau'\left(k^{HV}\right)} < 1$$

Remark : we can consider that lower-level tax competition leads to a symmetric equilibrium : $k_1 = k_2 = \dfrac{k^{HV}}{2}$.

Applying the same methodology as previously, it appears that

$$k^{HV} < k^U \text{ and } T'\left(k_j(\theta)\right) + \tau'\left(k^{HV}(\theta)\right) > T'^U\left(k^U(\theta)\right), \forall j = 2,1 \tag{18}$$

Proposition 3 : *In a multi-level government setting involving some competition between same-layer authorities, the degree of capital taxation appears higher than in the unique policy-maker case :* $T'\left(\dfrac{k^{HV}}{2}\right) + \tau'\left(k^{HV}\right) > T'\left(k^U\right)$. *Informational asymmetries and the downward pressure exerted by same-layer decisionmakers competition cannot offset the "race to the top" triggered by the simultaneous taxation of a common base by several levels of government.*

Likewise, whether the global degree of taxation is more or less important in such a setting than in the vertical case is also immediate :

$$\begin{array}{rcl} k^{HV} & < & k^V \\ -\left(2 + \partial k_i^*/\partial k_j\right) \times \dfrac{1-G(\theta)}{g(\theta)} M"\left(\theta - k^{HV}\right) & < & -2 \times \dfrac{1-G(\theta)}{g(\theta)} M"\left(\theta - k^V\right) \ . \end{array}$$

Proposition 4 : *The cumulated tax rate is set at an intermediary level between the taxes that are charged in the pure horizontal and vertical settings :* $T'\left(k^H\right) < T'\left(\dfrac{k^{HV}}{2}\right) + \tau'\left(k^{HV}\right) < T'\left(k^V\right)$.

7 Conclusion

Two kinds of tax externalities are at work in a multi-level territorial organization. The first one is a horizontal externality that arises between same-level governments. Each of them neglects the beneficial effect that raising its tax rate conveys on other jurisdictions (through the expansion of their tax bases), thereby leading to the equilibrium local tax and public good provision being inefficiently low. On the other hand, the reverse mechanism emerges in the vertical tax externality case. When two layers of government tax a common base, they do not take into account the damaging consequences of an increase in their tax rate for the other tier (*via* an erosion of the base), which yields overtaxation.

Most public organizations are characterized by both a stacking of governments and the existence of many policymakers at a same level. The interplay of both externalities softens the vertical effect but do not reverse it. Actually, local governments that cut taxes in a competitive context are induced to further decrease them in order to partially offset for the greater tax burden imposed upon firms when another level of government is added. The combination of both external tax effects can, to some extend, bring the outcome closer to the unitary solution. The introduction of information asymmetries modifies the outcomes because the principal has to give up a rent to the agent in order to elicit the private information. However, it cannot offset the vertical externality.

An issue was not tackled that nevertheless deserves being paid attention. We could consider that local jurisdictions are asymmetric. Thus, we would get an interesting result according to which the gap between marginal productivities at the local level would determine the domination of one effect.

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