Exerting local tax effort or lobbying for central transfers?

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Abstract

This paper studies moral hazard in local tax collection under a tax-sharing regime. We provide empirical evidence from Argentina.

Keywords: Fiscal federalism - Intergovernmental transfers - Adverse selection - Moral hazard - Reforms.

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1 Introduction

In many countries fiscal decentralization characterizes the relationship among different levels of government. In those countries, local authorities have the prerogative to tax the population within their jurisdiction. However, fiscal decentralization is seldom balanced in terms of tax and expenditure assignments. In order to equalize tax capacities, to internalize spillovers or to achieve national policy objectives, central governments often provide transfers to lower levels of government.

These transfers may affect the incentives of lower levels of government to manage or to improve their fiscal performance. Specifically, according to Litvack, Ahmad and Bird (1998), such transfers may induce low 'tax effort' in the regions. The purpose of this paper is to investigate theoretically this relationship between intergovernmental transfers and local tax effort.

An initial problem to deal with is the definition of 'tax effort' in itself. First, one can associate tax effort to high tax rates. Smart (1998) asserted that such association is inadequate. Basing his analysis in the Canadian Equalization System, he showed that high tax rates may indeed mean low tax effort. Second, one can measure tax effort using actual tax revenues or the difference between tax revenues and the predicted value coming from a regression explaining tax capacity. This approach has been mainly adopted by the empirical literature on tax effort [e.g. Bahl (1971), Chelliah, Baas and Kelly (1975), Bird and Wallich (1992)] and on the relationship between intergovernmental transfers and local tax effort [Baretti, Huber and Lichtblau (2000), Von Hagen and Hepp (2000), Jha, Mohanty, Chattergee and Chitkara (1999), Sagbas (2001)]. Although tax revenue is an accurate and observable variable, still one can hardly say that it is a good estimate of tax effort. The reason is for a given region in a given time period tax revenue is affected by a myriad of potential variables outside the control of local governments (like idiosyncratic shocks to some specific tax bases) which are seldom well controlled for in estimates of tax capacity.

In practice tax effort made by local governments encompasses a broad set of actions. One of them is clearly the battle against tax evasion. In spite of the importance of the enforcement of the local tax laws, this problem has been only recently addressed by the local public finance literature. In their working paper, Bordignon, Manasse and Tabellini (1996), presented a model where a local government exerts costless effort to catch tax evader workers and they showed how intergovernmental transfers affect tax enforcement. The drawback of this model is that, in reality, tax enforcement is not costless and the cost depends upon other variables chosen by local authorities, like the efficiency of the local tax administration. Although Prud'homme

(1995) and Tanzi (1996) have informally warned against the fact that local tax administrations may be less efficient than central ones, there has been little mention in the theoretical or in the empirical literature on this issue. The purpose of this paper is precisely to incorporate such dimension in the assessment of the relationship between intergovernmental transfers and local tax effort.

We develop a theoretical model where these other dimensions of the tax policy are endogenously determined. In each region there is one representative habitant and a local government. The habitant posses a low or a high-valued property. The local government maximizes tax revenues. In a first stage, the local government invests resources to improve the efficiency of the tax administration or to lobby the central government in order to obtain discretionary transfers. This decision is affected by the political cost of reforming the tax administration (which is higher in case of divided government) and on the ability of the local government to negotiate with the central government (which depends on the political representation of the region in the Congress). Thus, in our model, intergovernmental transfers are endogenous and simultaneously determined with the reform of the local tax system. In a second stage, the local government sets the property tax schedule. But, as the local government is unable to observe the value of the property, it has to rely on the habitant announcing this value. Finally, in the third stage, the local government decides to enforce the tax law by randomly auditing such announcement. If the habitant is discovered having misreported, the local government sets the corresponding property tax and imposes a penalty. We assume that audit is perfect but costly; the cost depending on the efficiency of the local tax administration.

We solve the model backwards. As the local government cannot commit to the auditing probability when it designs its tax policy, the equilibrium of the audit-report game is in mixed strategies, with auditing and tax evasion. Then we find the optimal tax schedule. In order to reduce the stake for tax evasion, the local government distorts downwardly the high-valued property tax. Finally, we solve for the decision of the local government regarding how much resources to invest for improving the level of efficiency of the tax administration. We find that this decision is negatively associated with the domestic political and positively with the political representation in the Congress.

The rest of the paper is organized as follows. Next section presents the model. In Section 3, we solve the model backwardly. Then we conclude.

2 The model

The nation The country is composed by two regions $r = j, k$, each ruled by a local authority. Until Section6, we concentrate our attention in one region. So we eliminate the subscripts r from the variables.

Habitant There is one representative habitant in the region. He might be of two different types $i = \ell, h$, with respective probability μ and $1 - \mu$. The habitant's type concerns its property. We assume that, in a (not modeled) previous stage, the habitant i inherited a house of value v_i. These values verify $v_\ell < v_h$: the house can be low-valued (v_ℓ) or high-valued (v_h). The utility of a habitant i is thus

$$U_i = v_i - t_i$$

where t_i is a property tax.

The local authority Before the first stage of the model, the local authority is endowed with a budget B. With this budget, her goal is to maximize the expected net revenue

$$\mathbb{E}NR = T + \mathbb{E}LTC$$

where T is a transfer from the federal government and $\mathbb{E}LTC$, the expected tax collection.

In the first stage, the local authority chooses the amount of resources θ devoted to improve her tax administration. From now on, we will consider that the amount θ can be assimilated to an efficiency parameter of the local tax administration. The rest of the budget $B - \theta$ can be used to lobby the federal government to obtain an increase in the transfer T.

In the second stage, the local authority chooses a property tax with the goal to maximize the (expected) local tax collection. But, as the local authority is unable to observe v_i, she has to rely on the habitant announcing $\widetilde{v}_i$.

In order to enforce the tax law, in a third stage, the local authority audits the announcement $\widetilde{v}_i$ with probability $\pi(\widetilde{v}_i)$. Auditing is costly: when the local authority audits, she bears the cost $c(\theta, z)$, where z represent regional geographical characteristics that have an impact on the cost of auditing. This function verifies

$$\frac{\partial c(\theta, z)}{\partial \theta} < 0, \frac{\partial^2 c(\theta, z)}{\partial \theta^2} > 0, \frac{\partial c(\theta, z)}{\partial z} > 0$$

Therefore, z is related to the degree of difficulty to audit. For example, z represents a more dispersed population or more geographical accidents, both characteristics that increase the cost of audit.

We assume that audit is perfect: after an audit, the true level of v_i is discovered. If the habitant is discovered having misreported, the local government sets the property tax that corresponds to his true value v_i and a fine F (that we define later). We denote the property tax schedule by $t_i = t(\widetilde{v}_i)$ and the probabilities of auditing by $\pi_i = \pi(\widetilde{v}_i)$.

There are institutional constraints that prevent the local authority from exploiting the habitant, so $U_i \geq 0$.

Timing of the model we gather the previous comments in the timing of the model

1. The local authority chooses the local tax administration's efficiency θ
2. The local authority designs the property tax schedule $\{t_\ell, t_h\}$
3. The habitant reports his type and the local authority audits this announcement

We solve the model backwards. First we completely characterize the solution of the report-audit game. Then we find the optimal property tax schedule. Finally, we characterize the optimal choice of the local tax administration's efficiency θ.

3 The report-audit game

Due to institutional failures, the local government cannot commit to its auditing policy. Moreover, we assume that the report-audit game is simultaneous.

Let's consider that the local authority has designed a tax schedule verifying $t_\ell < t_h$.[1] Therefore, a ℓ-habitant will never misreport. But this is not the case for a h-habitant, which may be tempted to understate his true value v_h. In this last case, if he is caught after an audit, the local authority imposes him to pay his due tax (t_h) and a fine $F = \lambda |t_h - t_\ell|$, which is proportional to the evaded tax. The following proposition characterizes the equilibria of this game.

Proposition 1 *If $(1-\mu)(1+\lambda)(t_h - t_\ell) \leq c(\theta, z)$, the Nash equilibrium is in pure strategies: the local authority never audits and the h-habitant always misreports. If $(1-\mu)(1+\lambda)(t_h - t_\ell) > c(\theta, z)$, the equilibrium is in mixed strategies. The local authority audits with probability $\widehat{\pi} = \frac{1}{1+\lambda}$ and the h-habitant misreports with probability $\widehat{p} = \frac{c(\theta,z)}{(1-\mu)(1+\lambda)(t_h - t_\ell)}$.*

[1] We will show later that this asumption is without loss of generality.

When the cost of audit is above the benefit of auditing, the local authority never audits and there is always tax evasion. But when the cost of audit is low, the local authority starts auditing and the h-habitant misreports. Therefore, in this model, there is fraud *cum* auditing in equilibrium, provided the cost of audit is low.

With these results, we can compute the expected local tax collection $\mathbb{E}LTC$ (net of the cost of audit) when the local authority designs the property tax schedule. When $(1+\lambda)(t_h - t_\ell) \leq c(\theta, z)$,

$$\mathbb{E}LTC^P = t_\ell$$

where the superscript P denotes that the equilibrium is in pure strategies. When $(1+\lambda)(t_h - t_\ell) > c(\theta, z)$

$$\begin{aligned}\mathbb{E}TC^M = \quad & (1-\widehat{p})\widehat{\pi}\left[\mu t_\ell + (1-\mu)t_h - c(\theta, z)\right] \\ & +(1-\widehat{p})(1-\widehat{\pi})\left[\mu t_\ell + (1-\mu)t_h\right] \\ & +\widehat{p}\,\widehat{\pi}\left[\mu t_\ell + (1-\mu)[t_h + \lambda(t_h - t_\ell)] - c(\theta, z)\right] + \widehat{p}(1-\widehat{\pi})t_\ell\end{aligned} \tag{1}$$

where the superscript M denotes that the equilibrium is in mixed strategies. Rearranging and using the equilibrium values of $\widehat{\pi}$ and $\widehat{p}$, (1) becomes

$$\mathbb{E}LTC^M = \mu t_\ell + (1-\mu)t_h - \frac{1}{1+\lambda}c(\theta, z)$$

3.1 The optimal property tax schedule $\{\widehat{t_\ell}, \widehat{t_h}\}$

We have just seen that the equilibrium in the report-audit game depends upon the value of the cost of audit $c(\theta, z)$ and on the tax schedule $\{t_\ell, t_h\}$. In this section we completely characterize the optimal tax schedule $\{\widehat{t_\ell}, \widehat{t_h}\}$. In order to have a benchmark, consider the full-information case, when the local government observes v_i. The local tax collection is characterized by $t_\ell^* = v_\ell$ and $t_h^* = v_h$. Let's define the threshold $\underline{c} \equiv (1-\mu)(v_h - v_\ell)$.

Proposition 2 *When $c(\theta, z) \geq \underline{c}$, the optimal property tax schedule is such that the local authority never audits and thus $\widehat{t_\ell} = v_\ell$. When $c(\theta, z) < \underline{c}$, the optimal property tax schedule is*

$$\begin{aligned}\widehat{t_\ell} &= v_\ell \\ \widehat{t_h} &= \tfrac{v_h + \lambda v_\ell}{1+\lambda}\end{aligned}$$

Facing this tax schedule, the h-habitant misreports with probability $\widehat{p}$ and the local tax authority audits with probability $\widehat{\pi}$.

From now on, we will assume that $c(\theta, z) < \underline{c}$. One can easily show that $\widehat{t}_h = \frac{v_h + \lambda v_\ell}{1+\lambda} < t^*_h = v_h$. In order to prevent tax evasion, the local authority distorts downwardly the property tax for a habitant with a high-valued property. With these taxes, the expected local tax collection is

$$\mathbb{E}LTC = \frac{\mu + \lambda}{1+\lambda} v_\ell + \frac{1}{1+\lambda}[(1-\mu)v_h - c(\theta, z)]$$

We can now intuitively explain why imposing $t_\ell < t_h$ in Section 4 was not a binding constraint. The reason is that, even without this constraint, the local authority never chooses $t_\ell \geq t_h$ as an optimal tax schedule. Assume the contrary. Only the ℓ-habitant misreports and the equilibria of the report-audit game are qualitatively similar that the equilibria shown above. Either the local authority does not audit and thus her expected tax collection is $t_h \leq t_\ell \leq v_\ell$. Or the local authority audits and faces misreports. In this last case, because the cost of audit, the expected tax collection is strictly below $\mu t_\ell + (1-\mu)t_h \leq t_\ell \leq v_\ell$. Hence the local authority never designs a tax schedule $t_h \leq t_\ell$ because she obtains less than v_ℓ.

3.2 The trade-off between local tax administration's efficiency and lobbying for central transfers

Now we have to consider both regions $r = j, k$. In region j, the local authority chooses how to allocate her initial budget B to maximize the (expected) net revenue

$$\mathbb{E}NR_j = T_j + \mathbb{E}LTC_j$$

On the one hand, the local authority may allocate an amount θ_j of her budget to improve her tax administration's efficiency. This enables the local authority to reduce the cost of audit $c(\theta_j, z_j)$. But, to undertake such a reform, the local authority faces some political costs $o(\theta_j, d_j)$, where d_j represents a measure of how divided is the local government. we assume that this function verifies the following properties

$$\frac{\partial o(\theta_j, d_j)}{\partial \theta_j} > 0, \frac{\partial^2 o(\theta_j, d_j)}{\partial \theta_j^2} > 0, \frac{\partial o(\theta_j, d_j)}{\partial d_j} > 0 \text{ and } \frac{\partial o(\theta_j, d_j)}{\partial \theta_j \partial d_j} > 0$$

The higher is θ_j, the more opposition to improve the efficiency of her tax administration the local authority faces. Moreover, whenever the local government is more divided, the local authority faces more opposition to implement a marginal increase in θ_j.

On the other hand, the local authority may allocate her budget lobbying the federal government in order to obtain a discretionary transfer T_j. We formalize such activity using an 'special-interest politics' framework and denoting it by l_j. The federal government distributes, in a discretionary way, an amount T between both regions. So its budget constraint is $T_j + T_k = T$. The federal government maximizes

$$\mathcal{W} = W(T_j, T_k) + Rl_j$$

On the one hand, the federal government values the transfers to the regions according to a welfare function $W(T_j, T_k)$. For the sake of simplicity, we assume that

$$W(T_j, T_k) = V(T_j) + V(T_k)$$

where $V(\ )$ is an increasing and concave function satisfying $V(0) = 0$ and the Inada conditions. On the other hand, the federal government also derives utility from the lobby exerted by region j. This lobby can reprsent, for example, promises for future help in Congress. But this lobby is evaluated according to the degree of political over-representation $R \geq 1$ that the region has in the Congress.

Therefore, everything is as if the region proposes to the federal government a scheme $l_j(T_j)$, implying that the region commits to l_j if the federal government sets T_j. This scheme has to be accepted by the federal government. In order to obtain the minimum level of welfare $\mathcal{W}_0$ that the federal government will accept, consider what should be the transfers when no arrangement has been reached between the region and the federal government. In that case, the federal government solves

$$\begin{gathered} \underset{T_j, T_k}{Max} \quad V(T_j) + V(T_k) \\ s.t. \\ T_j + T_k = T \end{gathered}$$

The solution is straightforward: $T_j = T_k = \frac{T}{2}$. Hence the minimal level of welfare is $\mathcal{W}_0 = 2V(\frac{T}{2})$.

Thus, in order to implement the optimal decision, the region solves the following problem[2]

$$\begin{gathered} \underset{T_j, l_j}{Max} T_j - l_j - o(B - l_j, d_j) + \tfrac{\mu_j + \lambda_j}{1+\lambda_j} v_\ell + \tfrac{1}{1+\lambda_j}[(1-\mu_j)v_h - c(B - l_j, z_j)] \\ s.t. \\ \mathcal{W} \geq \mathcal{W}_0 \end{gathered}$$

[2]Let's denote by θ_j^* the optimal value when the region cannot lobby the federal government and by l_j^*, the optimal value when the region does not invest in reforming her tax administration. If both $\theta_j^* > B$ and $l_j^* > B$, due to the concavity oi the problem, it is without loss of generality to restraint our attention to the case $\theta_j + l_j = B$.

Clearly, at the optimum, $\mathcal{W} = \mathcal{W}_0$. So we know that if the region wants a transfer T_j, the amount of lobby should be

$$l_j = \frac{2V(\frac{T}{2}) - [V(T_j) + V(T_k)]}{R}$$

This pressure verifies

$$\frac{dl_j}{dT_j} = -\frac{1}{R}[V'(T_j) - V'(T_k)]$$

If we assume an interior solution (i.e. $\widehat{T}_j > \frac{T}{2}$), the first-order condition (FOC) of this problem is

$$1 + \frac{1}{R}[V'(\widehat{T}_j) - V'(T - \widehat{T}_j)][1 - \frac{1}{1+\lambda_j}c_1 - o_1] = 0$$

where the subscripts denote the partial derivative with respect to the first argument. The second-order condition (SOC) is

$$\begin{array}{l} \frac{1}{R}\left\{[V''(\widehat{T}_j) + V''(T - \widehat{T}_j)][1 - \frac{1}{1+\lambda_j}c_1 - o_1] \right. \\ \left. -\frac{1}{R}[V'(\widehat{T}_j) - V'(T - \widehat{T}_j)]^2[\frac{1}{1+\lambda_j}c_{11} + o_{11}\right\} \leq 0 \end{array}$$

With all these results, we can perform some comparative statics. The following proposition characterizes the first important result.

Proposition 3 *When the federal budget for discretionary transfers decrease, the regional lobby decreases*

This proposition states that fiscal effort depends negatively on the possibility of obtaining dicretionnary transfers from the federal government. When the federal budget for such transfers converges to zero, the region adopts a more efficient fiscal behavior. This result contradicts the conventional wisdom that a tax sharing regime generates low tax effort. If the federal government can commit to the amount of tranfers, the local level of tax effort will be optimal. It is the lack of such commitment that makes the local authority to exert a lower level of tax effort, specially in the form of having an inefficient tax administration.

The other results are gathered in the following proposition

Proposition 4

1. *When the local representation increases, the regional lobby increases*

2. *When the degree of geographical characterisitcs increases, the effect on the regional lobby is ambiguous.*

3. *When the regional authority faces a more divided local government, the regional lobby increases*

The first and the last part of the proposition state intuitive results. Regions with comparative advantage in lobbying the federal government or with a high degree of divided government will seldom engage in improving the local tax administration. The second part of the proposition shows an ambiguous result because the final outcome depends crucially on the functional assumptions of the cost $c(\theta_j, z_j)$.

4 Conclusion

This paper analyzes the impact of discretionary transfers made by a Federal Government on the incentives of the regional authority to levy its taxes. Usually, the literature considers only the level of tax collection as a proxi of local 'tax effort'. We developed a theoretical model where many other dimensions of the tax policy are endogenously determined, namely the investment in resources to improve the efficiency of the tax administration, the property tax schedule and the audit policy. The most important point concerns the fact that, instead of investing in reforming its tax administration, the local authority can also lobby the central government to obtain discretionary transfers. This decision depends upon the ability of the local government to negotiate with the central government (which depends on the political representation of the region in the Congress). Thus, in our model, intergovernmental transfers are endogenous and simultaneously determined with the reform of the local tax system.

We solve the model backwards. As the local government cannot commit to the auditing probability when it designs its tax policy, the equilibrium of the audit-report game is in mixed strategies, with auditing and tax evasion. Then we find the optimal tax schedule. In order to reduce the stake for tax evasion, the local government distorts downwardly the high-valued property tax. Finally, we solve for the decision of the local government regarding how much resources to invest for improving the level of efficiency of the tax administration. We find that this decision is negatively associated with the domestic political and positively with the political representation in the Congress. These results open the door for econometric tests.

5 Appendix

5.1 Proof of Proposition 1

We find the equilibria of the game between the local authority and the habitant. As the habitant has two possible types $i = \ell, h$ with respective probability μ and $1 - \mu$, the report-audit game is Bayesian. As we have assumed that the habitant knows his type whereas the local authority only knows the distribution of types, we adopt an *interim* approach. In the following tables we show the payoffs of the report-audit game. In each cell, the payoffs are, from the left to the right, those of the local authority (L.A.), the h-habitant (h) and the ℓ-habitant. The pure strategies for the local authority are audit (A) and not audit (NA); for the habitant, report truthfully (T) and misreport (M).

If the ℓ-habitant reports truthfully, the payoffs are

L.A. \ h	T	M
A	$\mu t_\ell + (1-\mu)t_h - c(\theta, z)$, $v_h - t_h$, $v_\ell - t_\ell$	$\mu t_\ell + (1-\mu)(t_h + F) - c(\theta, z)$, $v_h - t_h - F$, $v_\ell - t_\ell$
NA	$\mu t_\ell + (1-\mu)t_h$, $v_h - t_h$, $v_\ell - t_\ell$	t_ℓ, $v_h - t_\ell$, $v_\ell - t_\ell$

If the ℓ-habitant misreports, the payoffs are

L.A. \ h	T	M
A	$\mu(t_\ell + F) + (1-\mu)t_h - c(\theta, z)$, $v_h - t_h$, $v_\ell - t_\ell - F$	$\mu(t_\ell + F) + (1-\mu)(t_h + F) - c(\theta, z)$, $v_h - t_h - F$, $v_\ell - t_\ell - F$
NA	t_h, $v_h - t_h$, $v_\ell - t_h$	$\mu t_h + (1-\mu)t_\ell$, $v_h - t_\ell$, $v_\ell - t_h$

First, we observe that for any pair of strategies of the local authority and the h-habitant, truthfull report is a dominant strategy for a ℓ-habitant. Hence, from now on, we will work with the first matrix of payoffs. Moreover, recall that $F = \lambda\,|t_h - t_\ell|$.

If $(1-\mu)(1+\lambda)(t_h - t_\ell) \leq c(\theta, z)$, the Nash equilibrium is in pure strategies: the local authority never audits and the h-habitant always misreports. If $(1-\mu)(1+\lambda)(t_h - t_\ell) > c(\theta, z)$, we look for a Nash equilibrium in mixed strategies. Let's denote by π the probability that the local authority audits and by p the probability that the h-habitant misreports. The h-habitant plays a mixed strategy provided the following equality holds

$$\underset{(\pi,1-\pi)}{\mathbb{E}}[\text{Truthful report}] = \underset{(\pi,1-\pi)}{\mathbb{E}}[\text{Misreport}]$$
$$\Leftrightarrow \; v_h - t_h = \pi(v_h - t_h - \lambda(t_h - t_\ell)) + (1-\pi)(v_h - t_\ell)$$

Hence, the h-habitant plays a mixed strategy $(p, 1-p)$ if $\widehat{\pi} = \frac{1}{1+\lambda}$. Next, the local authority audits if the following equality holds

$$\underset{(p,1-p)}{\mathbb{E}}[\text{Audit}] = \underset{(p,1-p)}{\mathbb{E}}[\text{No audit}]$$
$$\Leftrightarrow$$
$$(1-p)\left[\mu t_\ell + (1-\mu)t_h - c(\theta,z)\right] + p\left[\mu t_\ell + (1-\mu)(t_h + \lambda(t_h - t_\ell) - c(\theta,z)\right]$$
$$= (1-p)\left[\mu t_\ell + (1-\mu)t_h\right] + pt_\ell$$

So the local authority plays a mixed strategy $(\pi, 1-\pi)$ provided $\widehat{p} = \frac{c(\theta)}{(1-\mu)(1+\lambda)(t_h - t_\ell)}$ ■

5.2 Proof of Proposition 2

Let's define the functions $F(t_\ell) \equiv \frac{c(\theta,z)}{(1-\mu)(1+\lambda)} + t_\ell$ and $G(t_\ell) \equiv \frac{v_h + \lambda t_\ell}{1+\lambda}$. Then, in order to completely characterize the optimal property tax schedule $\{\widehat{t_\ell}, \widehat{t_h}\}$, recall that

- We are considering the case $t_\ell < t_h$.
- If $t_h \leq F(t_\ell)$, the Nash equilibrium is in pure strategies. The local authority never audits and the h-habitant always misreports; thus $\mathbb{E}LTC^P = t_\ell$.
- If $t_h > F(t_\ell)$, the equilibrium is in mixed strategies. The local authority audits with probability $\widehat{\pi} = \frac{1}{1+\lambda}$ and the h-habitant misreports with probability $\widehat{p} = \frac{c(\theta,z)}{(1-\mu)(1+\lambda)(t_h - t_\ell)}$. In this case, the expected tax collection is

$$\begin{aligned} \mathbb{E}LTC^M = \; & (1-\widehat{p})\widehat{\pi}\left[\mu t_\ell + (1-\mu)t_h - c(\theta,z)\right] \\ & + (1-\widehat{p})(1-\widehat{\pi})\left[\mu t_\ell + (1-\mu)t_h\right] \\ & + \widehat{p}\widehat{\pi}\left[\mu t_\ell + (1-\mu)[t_h + \lambda(t_h - t_\ell)] - c(\theta,z)\right] + \widehat{p}(1-\widehat{\pi})t_\ell \end{aligned}$$

- The tax schedule has to respect the limited liability constraints

$$\begin{aligned} & t_\ell \leq v_\ell \\ & t_h \leq v_h \\ & v_h - t_h - \lambda(t_h - t_\ell) \geq 0 \Leftrightarrow t_h \leq G(t_\ell) \end{aligned}$$

where the last expression reflects that, even after being audited and penalized, a h-habitant cannot be totally expropriated. As $G(v_\ell) = \frac{v_h + \lambda v_\ell}{1+\lambda} < v_h$, the constraint $t_h \leq v_h$ is redundant.

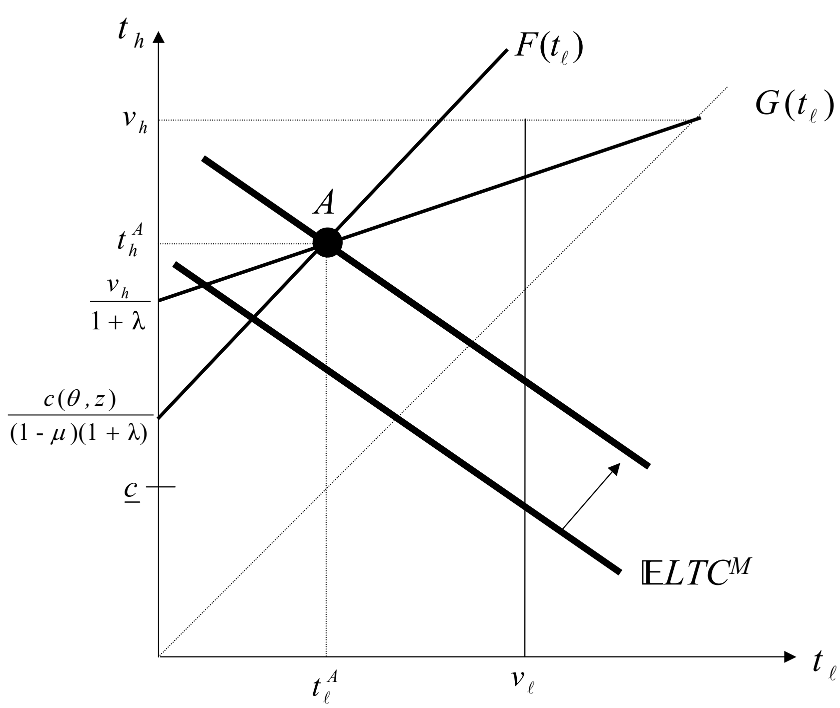
Let's define $\underline{c} \equiv (1-\mu)(v_h - v_\ell)$. With all this elements, we can easily characterize the optimal property tax schedule using graphics. Three cases have to be analyzed.

- CASE 1: $c(\theta, z) \geq (1-\mu)v_h$

  In this case, $t_h \leq G(t_\ell)$ implies $t_h < F(t_\ell)$. Hence the equilibrium is in pure strategies. The local authority maximizes the expected local tax collection $\mathbb{E}LTC^P = t_\ell$ by setting $\widehat{t_\ell} = v_\ell$.

- CASE 2: $c(\theta, z) \in]\underline{c}, (1-\mu)v_h[$

  In this case, we can visualize the solution in the following figure, which shows the (t_ℓ, t_h) space.



The values v_ℓ and v_h, the straight line with positive slope that represents the function $G(t_\ell)$ and the 45^o degree line characterize the set of feasible property tax schedules. Now the local authority can choose the property tax schedule $\{t_\ell, t_h\}$ so that the equilibrium of the report-audit game is either in mixed or in pure strategies.

Consider the first possibility. In this case, the bold lines with negative slope represent the iso expected local tax collection curves. Their levels increase in the direction shown by the arrow. An equilibrium in mixed strategies emerges when, for a given value of t_ℓ, $F(t_\ell) < t_h \leq G(t_\ell)$. The local authority maximizes the expected local tax collection by setting

$$t_\ell \to t_\ell^A = v_h - \tfrac{c(\theta,z)}{(1-\mu)}$$

$$t_h \to t_h^A = G(t_\ell^A) = v_h - \tfrac{\lambda}{(1+\lambda)}\tfrac{c(\theta,z)}{(1-\mu)}$$

This pair of values is represented in the graphic by the point A. With these values

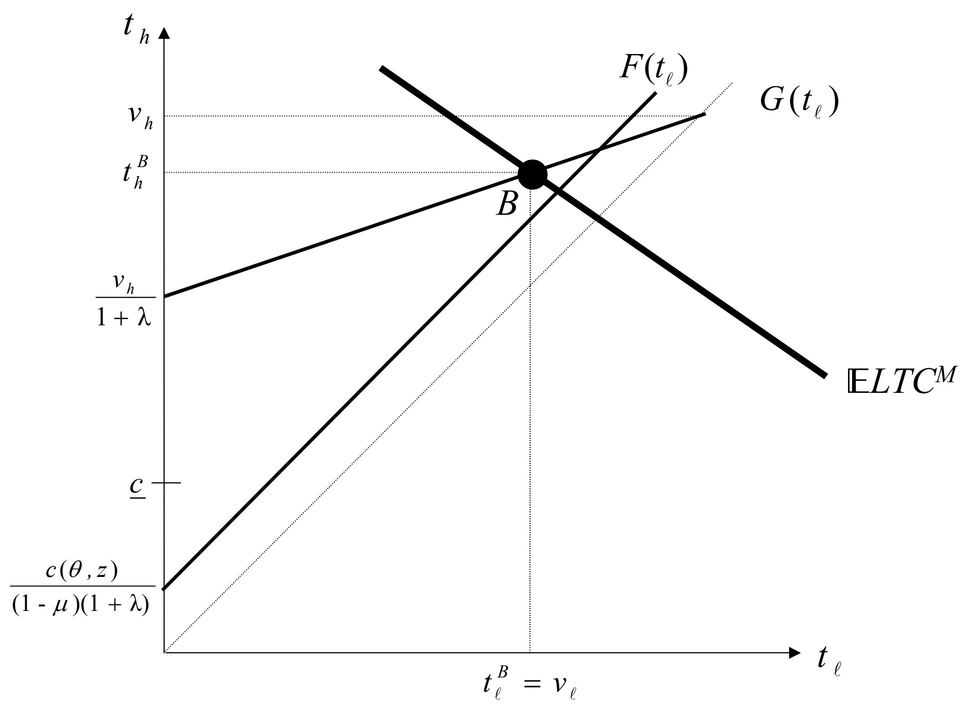
$$\mathbb{E}LTC^M \to v_h - \frac{c(\theta,z)}{(1-\mu)} < v_\ell$$

because $c(\theta,z) > \underline{c}$. Hence, the optimal property tax schedule is not $\{t_\ell^A, t_h^A\}$. Instead, the local authority will choose a property tax schedule so that the equilibrium in the report-audit game is again in pure strategies and thus $\widehat{t_\ell} = v_\ell$.[3]

- CASE 3: $c(\theta,z) \in [0, \underline{c}]$

  This third case is similar to the second one. In the second case, when the cost $c(\theta,z)$ decreases, there exists a value of $c(\theta,z)$ such that the solution t_ℓ^A is no longer below v_ℓ and thus not feasible (by limited liability). This value of $c(\theta,z)$ is precisely $\underline{c}$. The figure is as follows.

[3]In this case, the local authority is indiferent between any tax $t_h \in [v_\ell, G(v_\ell)]$.



Consider the local authority implementing a mixed strategy equilibrium in the report-audit game. This is possible again when, for a given value of t_ℓ, $F(t_\ell) < t_h \leq G(t_\ell)$. But now $t_\ell, \leq v_\ell$ is binding. Under this circumstance, the local authority maximizes the expected net revenue by setting

$$t_\ell \rightarrow t_\ell^B = v_\ell$$

$$t_h \rightarrow t_h^B = G(t_\ell^B) = \tfrac{v_h + \lambda v_\ell}{1+\lambda}$$

This pair of values is represented in the graphic by the point B. With these values

$$\mathbb{E}LTC^M = \frac{\mu + \lambda}{1+\lambda} v_\ell + \frac{1}{1+\lambda}[(1-\mu)v_h - c(\theta, z)] > v_\ell$$

because $c(\theta, z) < \underline{c}$.[4] Hence, the optimal property tax schedule is $\{t_\ell^B, t_h^B\}$. As $t_h^B = G(v_\ell) < v_h$, the local authority optimally distorts downwardly the property tax for a h-habitant ■

[4] When $c(\theta, z) = \underline{c}$ the local authority is indifferent between playing in pure or in mixed strategies.

5.3 Proof of Proposition 3 and 4

In order to prove these propositions, we differentiate totally the first-order condition and we use the Implicit Function Theorem. The results are as follows

$$\frac{\partial T_j}{\partial T} = \frac{\Delta V''(T-\widehat{T}_j) - \frac{1}{R}[V'(\widehat{T}_j) - V'(T-\widehat{T}_j)][V'(\frac{T}{2}) - V'(T-\widehat{T}_j)][\frac{1}{1+\lambda_j}c_{11} + o_{11}]}{\Delta[V''(\widehat{T}_j) + V''(T-\widehat{T}_j) - \frac{1}{R}[V'(\widehat{T}_j) - V'(T-\widehat{T}_j)]^2[\frac{1}{1+\lambda_j}c_{11} + o_{11}]} > 0$$

where $\Delta = 1 - \frac{1}{1+\lambda_j}c_1 - o_1 > 0$. As FOC must hold, the sign of Δ is clearly positive.

$$\frac{\partial \widehat{T}_j}{\partial R} = \frac{\Delta[V'(\widehat{T}_j) - V'(T-\widehat{T}_j)]\frac{1}{R^2}}{SOC} > 0$$

$$\frac{\partial \widehat{T}_j}{\partial z_j} = \frac{1}{SOC}\left(\frac{1}{R}[V'(\widehat{T}_j) - V'(T-\widehat{T}_j)]\frac{1}{1+\lambda_j}c_{12}\right) \gtreqless 0$$

$$\frac{\partial \widehat{T}_j}{\partial d_j} = \frac{1}{SOC}\left(\frac{1}{R}[V'(\widehat{T}_j) - V'(T-\widehat{T}_j)]o_{12}\right) > 0 \blacksquare$$

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