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TAX MIX CORNERS AND OTHER KINKS

**Federico Revelli**

Fiscal Federalism

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**TAX MIX CORNERS AND OTHER KINKS \***

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**ABSTRACT:** This paper models the local tax mix determination process in the presence of state-wide tax limitations and shows how excess sensitivity of local public spending to grants (the conventionally and somewhat misleadingly called flypaper effect) arises in the endogenously generated constrained tax mix and cannot in general be taken as a symptom of local government overspending. By means of a panel data switching regression approach that allows for fixed effects and endogenous selection, the paper exploits the clustering of Italian Provinces at the corners produced by upper and lower tax limitations, and provides evidence of considerable cap-generated excess sensitivity.

JEL Codes: C23, C25, H72

Keywords: Flypaper effect, excess sensitivity, tax mix, switching regression, endogenous selection.

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## 1. Introduction

The overall size as well as the tax revenue bundle of the local public sector in multi-tiered structures of government are the outcomes of the decentralized decision-making process subject to the fiscal rules set by central (state) governments. As documented by Anderson (2006) and Wolman *et al.* (2008) for the US, and by Joumard and Kongsrud (2003) and Sutherland *et al.* (2005) for the OECD countries, top-down tax and expenditure limitations (TEs) are frequently so tight and pervasive as to jeopardize the very principle of local fiscal autonomy.<sup>2</sup>

This paper aims at investigating how state-wide revenue raising limitation rules shape local governments' budget constraints, focusing in particular on the kinks that are typically generated by tax floors and caps, and at evaluating their effects on the determination of the local tax mix and on the response of local public expenditures to grants. As far as the latter issue is concerned, a vast literature (most recently reviewed by Inman (2009)) has investigated and sought to explain the anomalously high response of local spending to grants relative to the response to private income - the so-called flypaper effect by which money from central government sticks where it hits.<sup>3</sup>

Two broad kinds of explanations of the flypaper effect have been offered in the literature (Hines and Thaler, 1995). The first has to do with a variety of specification and estimation errors that applied researchers would have kept making for decades. Those errors range from mistakenly treating matching grants as if they were lump-sum to the omission of important variables - such as unobserved population characteristics or spatial lags of other governments' policies - that are simultaneously correlated with grants and local public expenditures. The second explanation relies on the argument that the political representation process is substantially richer than the one postulated by the standard neoclassical

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<sup>2</sup>According to Nechyba (1997), though, state command on local fiscal choices (in terms of income tax-funded grants and state-imposed caps on local property tax rates) arises in equilibrium as an optimal outside enforcement when a collusive agreement to simultaneously introduce local income taxes is not self-enforcing.

<sup>3</sup>According to Inman (2009), over 3,500 research papers exist documenting and seeking to explain the flypaper effect. Payne (2009) offers an insightful wide-ranging review of the more recent research into the mirror phenomenon of crowd-out.

model: asymmetric information, loss aversion, fiscal illusion, separate mental accounting, special interest groups, and citizens' inability to write complete contracts with their elected officials would be responsible for the lack of fungibility between public and private uses of money, and would cause the observed large flypaper effect.

This paper models for the first time the local tax mix determination process in the presence of state-wide tax limitations - the decentralized government finance archetype - and shows how excess sensitivity of local public spending to grants arises in the endogenously generated constrained tax mix. In particular, the paper shows that the effect of private community income on public spending should be expected to be tiny or nil in the presence of binding limitations on all local tax revenue sources, while grants should be predicted to have a large - actually, a one-for-one - impact on local expenditures. Interestingly, a binding cap on just one of the available own revenue sources is enough to generate some form of flypaper effect, in the sense of an excess sensitivity of local spending to grants, and the above result holds when either upper or lower tax limitations are in place. Finally, since excess sensitivity of local public spending should be predicted to arise and generally tends to manifest itself both when grants increase and when they decrease, the flypaper effect label seems an inappropriate or even misleading one. In fact, excess sensitivity of local public expenditures to grants cannot in general be interpreted as a sinister symptom of overspending.

While the existing literature seems to have almost universally overlooked the potential impact of tax and expenditure limitation systems on the sensitivity of local public spending to exogenous variations in grants, two recent papers have brought the fiscal limitations issue into the investigation of the flypaper effect. Lutz (2010) conjectures that previous evidence of a flypaper effect might have arisen from state constraints preventing local governments from selecting their preferred bundle of public goods, and provides evidence of equivalence between grants and income from a school finance reform in New Hampshire – “one of only five states with no state-imposed limitations on the taxing or

spending power of local governments” (Lutz, 2010, p. 317). Brooks and Phillips (2010) represent the first formal statement and empirical test of the hypothesis that restrictive fiscal institutions might be responsible for the flypaper effect. They use data on the US Community Development Block Grant (CDBG) program and argue that state TELs may systematically force city governments to underprovide local public goods and therefore increase the stimulative effect of federal grants on city spending. However, since they do not observe either the municipal tax bundle or whether a revenue raising constraint is binding in any given city, they have to rely on a state-level index of fiscal constraints and ignore altogether both the municipal choice as to own revenue source diversification and the issue of endogenous selection of a city government into the fiscally constrained status.<sup>4</sup>

This paper concludes with an application to Italian provincial governments’ panel data. An attractive feature of Italian Provinces is that their own tax revenue sources (a tax on vehicle registrations, a tax on electricity consumption for business uses, and a waste management surcharge) are subject to strict and frequently binding upper as well as lower tax rate limitations. The empirical analysis exploits the clustering of provincial authorities at the corners produced by those tax limitation rules, and estimates the effect of grants on local expenditures for two groups of authorities - those severely affected by tax limits and those that are only mildly affected, - showing that the former authorities exhibit a sensitivity of spending that is significantly higher than the latter.

The paper is organized as follows. Section 2 sets up a model for the analysis of the local tax mix in the presence of right and left constrained tax instruments. Section 3 develops the model’s empirical implications and outlines the econometric strategy and section 4 tackles the issue of endogenous selection. Finally, section 5 reports and discusses the estimation results on the Italian Provinces’ panel data, and section 6 concludes.

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<sup>4</sup>Interestingly, Brooks and Phillips (2010) find excess sensitivity of spending to grants in a period of dramatic retrenchment, while they comprehensibly find limited evidence of an effect of overall state-level tax limitations on municipal governments’ response to the collapse in CDBG grants.

## 2. Communicating vessels

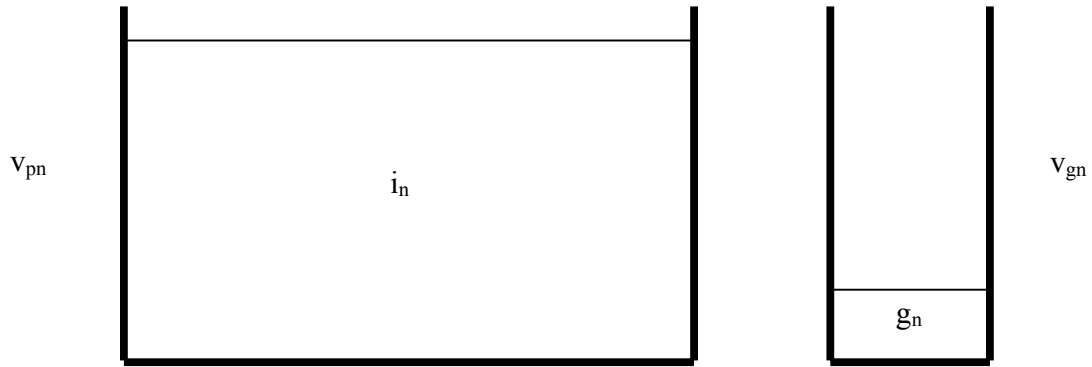
Consider the two vessels in figure 1. Say that vessel  $v_{pn}$  represents consumption of private goods out of community  $n$  private income  $i_n$  ( $n=1,\dots,N$ ) and vessel  $v_{gn}$  represents consumption of local public services. The structure depicted in (1.a) amounts to a perfect tax centralization arrangement, where expenditures on local public services are entirely funded by central government grants  $g_n$ , and nothing ensures that the allocation of resources to private and public uses reflects the preferences of the local community or that the marginal benefit from private consumption equals the marginal benefit from public consumption.

In the central picture (1.b), the two vessels are allowed to communicate via local tax revenues. In order for the local public goods to be provided optimally, and given that the marginal rate of transformation between private and public goods is constant and equal to one, the marginal utility in the two vessels has to be equalized. Just like communicating vessels, where the force of gravity requires hydrostatic pressure to be balanced out in the two vessels regardless of their relative sizes, the welfare optimization forces make resources flow from  $v_{pn}$  to  $v_{gn}$  at the tax rate  $\tau_n = \frac{t_n}{i_n}$ . Once the equilibrium level is attained in the two vessels, whether additional resources are poured into  $v_{pn}$  or into  $v_{gn}$ , the same allocation of private and public consumption will result by the law of communicating vessels.

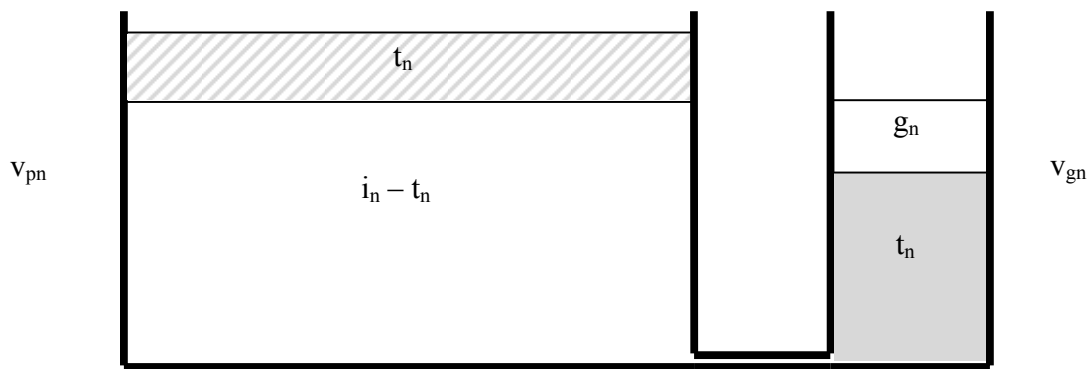
In the lower picture (1.c), local jurisdiction  $n$  is subject to a tax rate cap equal to  $h = \frac{t_{hn}}{i_n}$ , with the cap binding if  $t_{hn} < t_n$ . The Samuelson condition for optimal public good provision will not be satisfied if the tax cap is binding, meaning that more resources ought to flow from  $v_{pn}$  to  $v_{gn}$  in order to equate the pressure in the two vessels. An additional unit of private income will raise the consumption level at rate  $1 - h$  in  $v_{pn}$ , and at the rate  $h$  in  $v_{gn}$ . If additional grants are poured into (pumped out of)  $v_{gn}$ , the level will rise (fall) in  $v_{gn}$  only. The flypaper effect, so to say.

Figure 1 Communicating vessels

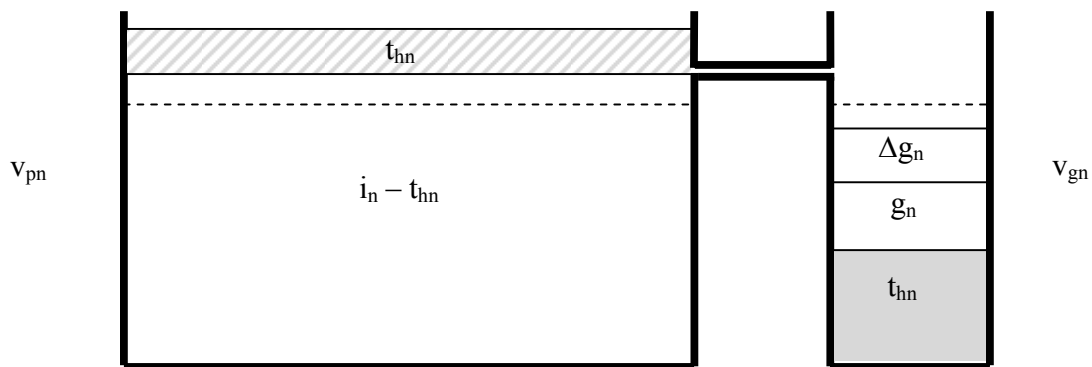
(1.a)



(1.b)



(1.c)





## 2.1 The one-tax case

According to the standard local public finance framework that is conventionally employed to analyze the decentralized tax-expenditure decision process (Inman, 2009), the welfare of jurisdiction  $n$  ( $n=1,\dots,N$ ) can be expressed as a quasi-concave function exhibiting decreasing marginal benefits from local public expenditures as well as increasing marginal cost of raising own revenues:

$$W_n = V(z_n; \mathbf{x}_n) - C(\tau_n b_n; i_n) \quad (1)$$

In general terms,  $z_n$  equals local public spending, local tax revenues are raised by setting a flat tax rate  $\tau_n$  on a local tax base  $b_n$ ,  $\mathbf{x}_n$  is a vector of community characteristics reflecting preferences for local public services, and  $i_n$  represents some meaningful measure of community income. Assume further that local authorities abide to a balanced budget rule:

$$z_n = g_n + \tau_n b_n \quad (2)$$

where  $g_n$  equals lump-sum grants from central government.<sup>5</sup> Maximization of (1) subject to (2) leads jurisdiction  $n$  to select the optimal tax rate-spending pair  $(\tau_n^*, z_n^*)$  as a function of the assumed exogenous variables  $g_n$ ,  $i_n$ , and  $b_n$ .<sup>6</sup> An exogenous increase (decrease) in grants would provoke an increase (decrease) in spending by a certain proportion of the grant itself, depending on the shape of the welfare function. Actually, a change in  $i_n$  by the same amount as the change in  $g_n$  should have an identical effect on  $z_n$ : when this does not happen, and in particular if a change in grants turns out in practice to provoke a much larger reaction in spending than a change in income does, a flypaper effect is said to exist (Hines and Thaler, 1995).

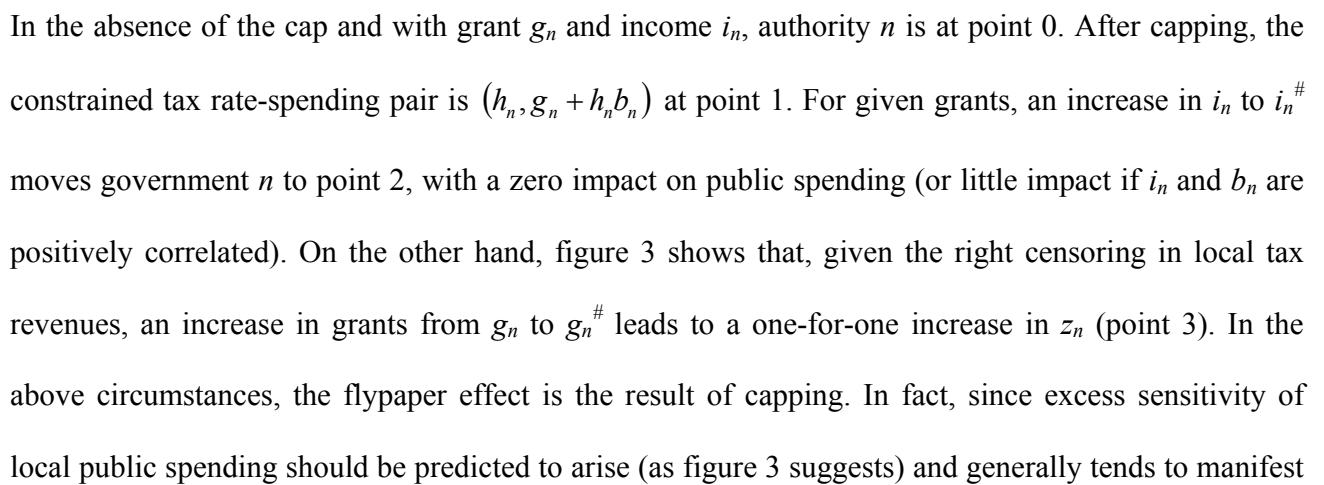
Consider now the introduction of a tax rate cap such that  $\tau_n \leq h_n$ , and assume that  $\tau_n^* > h_n$ , meaning that local government  $n$  is at a corner solution. The constrained optimization problem is depicted in

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<sup>5</sup>It is usually convenient to interpret all monetary variables in (2) as measured in per capita terms, thus implying that publicly provided services entering the welfare function (1) are private (rival) in nature.

<sup>6</sup>Tax base endogeneity is allowed for in the next section.

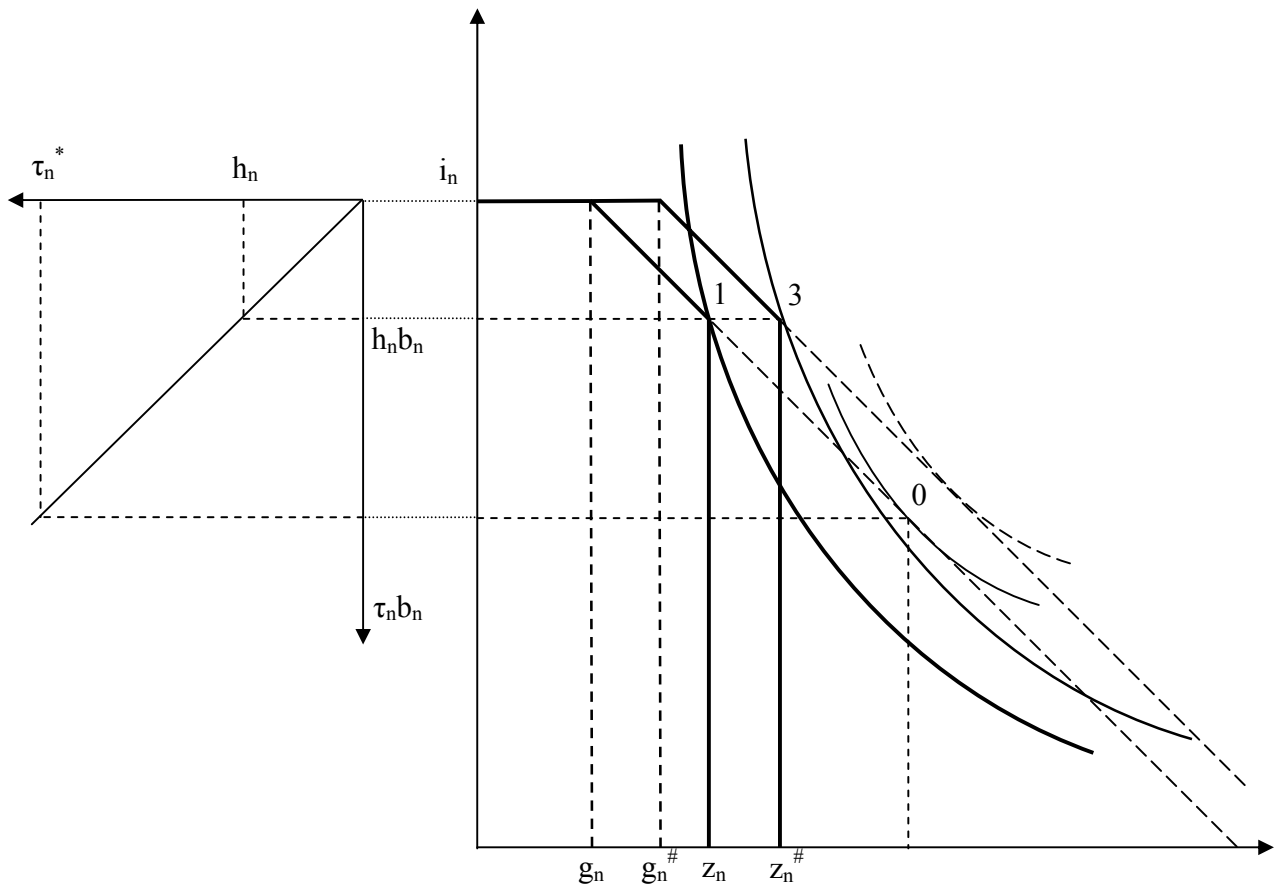
Figure 2 One tax: income change



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Gamkhar and Oates, 1996), the flypaper effect label seems an inappropriate or even misleading one.<sup>8</sup>

Figure 3 One tax: grant change



## 2.2 The multiple-tax case

Consider now the case of government  $n$  relying on  $M \geq 2$  own tax revenues. Dropping the  $n$  subscript to save on notation, and denoting by  $\tau^m$  the rate set on tax base  $m$  ( $b^m$ ), the budget constraint is:

<sup>8</sup>Interestingly, the fiscal limitation approach can also explain the somewhat sparse evidence of excess smoothness of local public spending in response to grant cuts - what is improperly termed the asymmetric flypaper effect (in fact, the flypaper effect metaphor seems to be asymmetric by definition). In the presence of centrally mandated services, local public spending should be expected to exhibit little or no sensitivity to grants (excess smoothness) in periods of retrenchment.

$$z = g + \tau' \mathbf{b} = g + \sum_{m=1}^M \tau^m b^m \quad (3)$$

Allowing for heterogeneous marginal costs of raising revenues from the potentially endogenous  $M$  tax sources (Hettich and Winer, 1988), the welfare function can be expressed as:

$$W(\tau; \mathbf{q}) = V(g + \tau' \mathbf{b}; \mathbf{x}) - C(\tau^1 b^1, \dots, \tau^M b^M; i) \quad (4)$$

where:  $\mathbf{q}' = [g \ i \ \mathbf{x}']$ . Letting  $\varepsilon^m \equiv \frac{\tau^m}{b^m} \frac{\partial b^m}{\partial \tau^m}$  be the own tax rate elasticity of tax base  $m$ , the first order conditions for maximization of (4) require equalization of the marginal contribution to welfare of spending an additional unit of own tax revenue on local public services  $\left( v(g + \tau' \mathbf{b}; \mathbf{x}) = \frac{\partial V}{\partial \tau^m} \frac{1}{b^m (1 + \varepsilon^m)} \right)$  to the marginal costs of raising revenues across all tax bases  $\left( c^m = \frac{\partial C}{\partial \tau^m} \frac{1}{b^m (1 + \varepsilon^m)}, m = 1, \dots, M \right)$ , resulting in a vector of optimal tax rates and expenditure level:

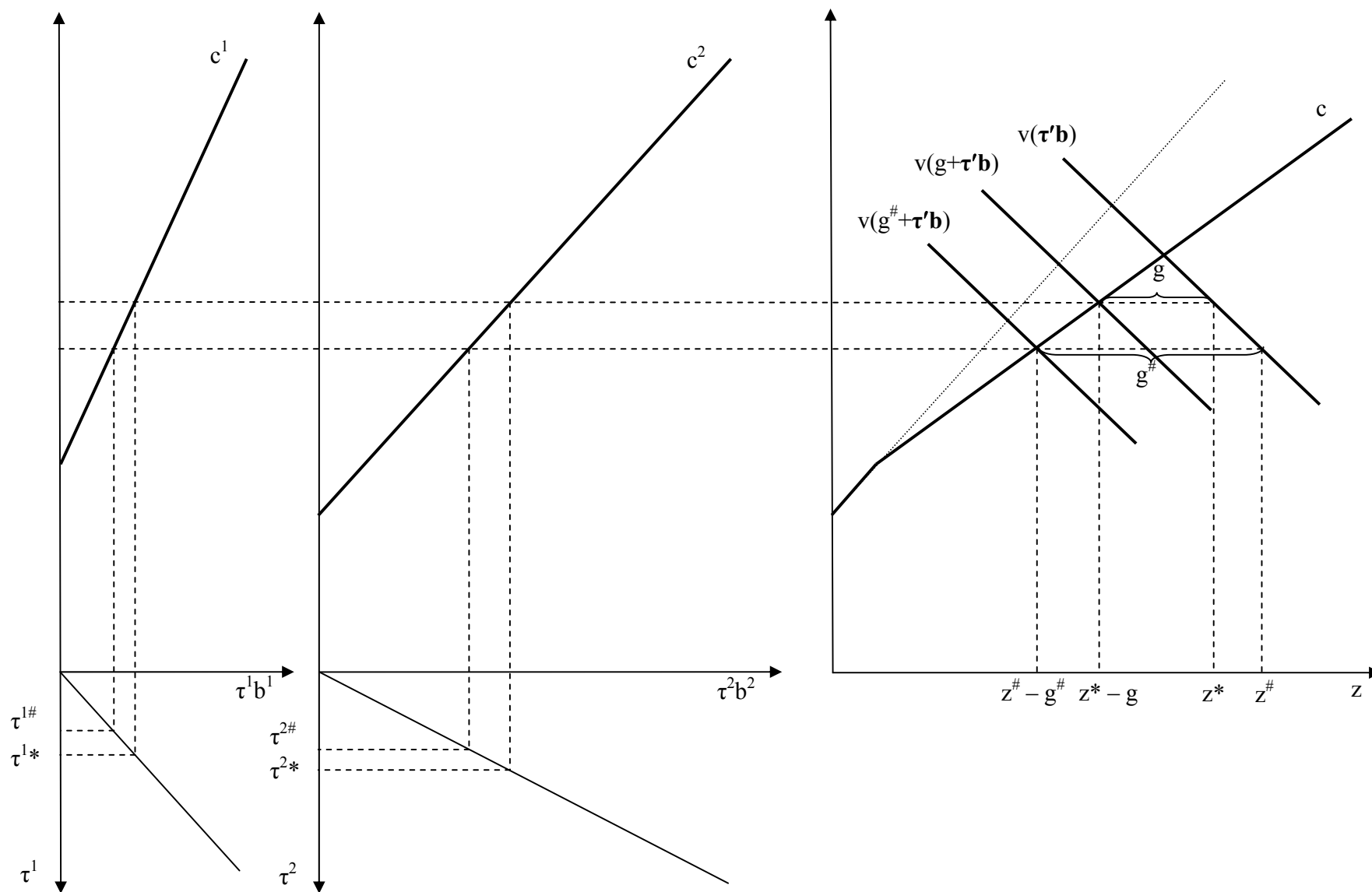
$$\tau^*(\mathbf{q})' = [\tau^{1*}(\mathbf{q}) \dots \tau^{M*}(\mathbf{q})] \quad (5)$$

$$z^*(\mathbf{q}) = g + \sum_{m=1}^M \tau^{m*}(\mathbf{q}) b^m(\mathbf{q}) \quad (6)$$

Figure 4 shows a graphical representation of the optimal tax mix determination problem under the simplifying assumption that the marginal cost of raising revenues from tax  $m$  is independent of  $\tau^j$  for  $j \neq m$  (Hettich and Winer, 1984). We assume here that  $M=2$ , and let the marginal cost and benefit functions be linear for graphical convenience. Given grants  $g$ , the optimal tax rates and spending vector is  $[\tau^{1*} \ \tau^{2*} \ z^*]$ . Similarly to the one-tax case, an exogenous increase in grants, say from  $g$  to  $g^\#$ , is expected to bring about an increase in spending as well as a decrease in reliance on both own tax sources  $[\tau^{1\#} \ \tau^{2\#} \ z^\#]$ , with the direction and intensity of the tax mix adjustment depending on the slope of the marginal cost functions.<sup>9</sup>

<sup>9</sup>When grants go from  $g$  to  $g^\#$ , the  $v$  function shifts left by  $(g^\# - g)$ . It is easy to show that an identical increase in community's private income shifts the marginal cost function  $c$  to the right by  $(g^\# - g)$ , and should therefore be expected to have the same impact on local public spending as the grant increase.

Figure 4 Two taxes: no tax limitations



Consider now the consequences of central government imposing the following tax rate limitations ( $m=1, \dots, M$ ):

$$0 \leq l^m \leq \tau^m \leq h^m \quad (7)$$

Given the welfare function (4) and the constraints (7), and letting  $\lambda' = [\lambda^{h1} \dots \lambda^{hM} \lambda^{l1} \dots \lambda^{lM}] \geq 0$  be the vector of Lagrange multipliers, we can write the Lagrangian function as:

$$L(\tau, \lambda) = W(\tau; \mathbf{q}) + \sum_{m=1}^M \lambda^{hm} (h^m - \tau^m) + \sum_{m=1}^M \lambda^{lm} (-l^m + \tau^m) \quad (8)$$

The necessary Kuhn-Tucker conditions for the tax rate vector to be an optimum are:<sup>10</sup>

$$\nabla_{\tau} L(\tau, \lambda) = 0 \quad \nabla_{\lambda} L(\tau, \lambda) \geq 0 \quad \lambda \nabla_{\lambda} L(\tau, \lambda) = 0 \quad (9)$$

or, for  $m=1, \dots, M$ :

$$\frac{\partial L(\tau, \lambda)}{\partial \tau^m} = \frac{\partial W(\tau; \mathbf{q})}{\partial \tau^m} - \lambda^{hm} + \lambda^{lm} = 0 \quad (10)$$

$$\frac{\partial L(\tau, \lambda)}{\partial \lambda^{hm}} = h^m - \tau^m \geq 0 \quad \lambda^{hm} (h^m - \tau^m) = 0 \quad (11)$$

$$\frac{\partial L(\tau, \lambda)}{\partial \lambda^{lm}} = -l^m + \tau^m \geq 0 \quad \lambda^{lm} (-l^m + \tau^m) = 0 \quad (12)$$

The Kuhn-Tucker conditions (10)-(11)-(12) show that when  $\tau^m = h^m$ , the gradient of the welfare function is positive  $\left(\frac{\partial W(\tau; \mathbf{q})}{\partial \tau^m} = \lambda^{hm}\right)$ , meaning that the unconstrained optimal tax rate lies to the right of  $h^m$ . Similarly, if  $\tau^m = l^m$  the gradient of the welfare function is negative  $\left(\frac{\partial W(\tau; \mathbf{q})}{\partial \tau^m} = -\lambda^{lm}\right)$ , so that the unconstrained optimal tax rate lies to the left of  $l^m$ .

Figures 5 and 6 offer a graphical representation of the constrained optimization process and illustrate how corner solutions arise.<sup>11</sup>

<sup>10</sup>Provided that (4) is concave, the Kuhn-Tucker conditions are sufficient.

<sup>11</sup>Interestingly, all of the tax mix corners depicted in figures 5 and 6 turn out to be relevant in the empirical application in section 5.

Figure 5 Two taxes: left and right constrained tax mix outcomes

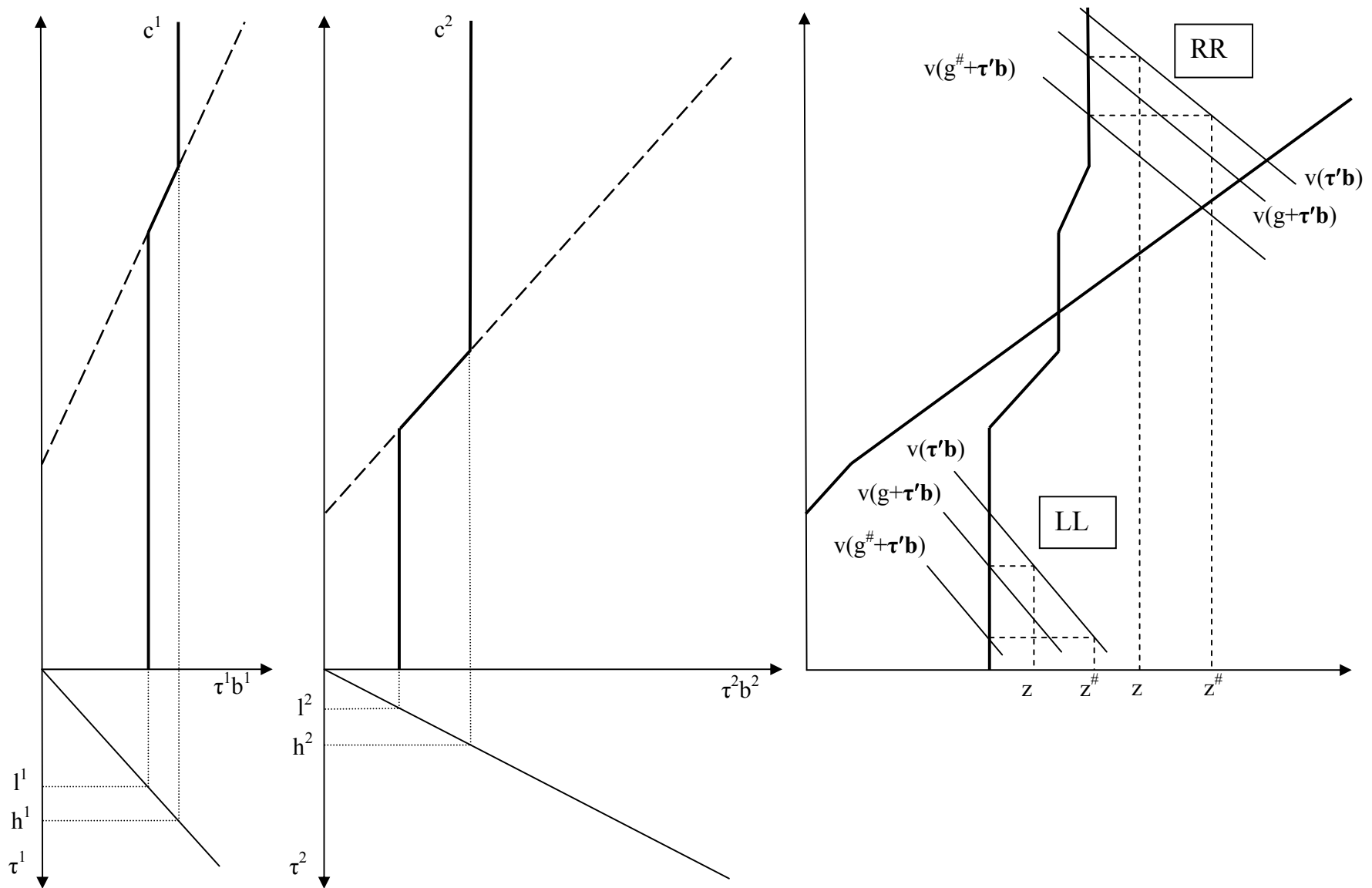
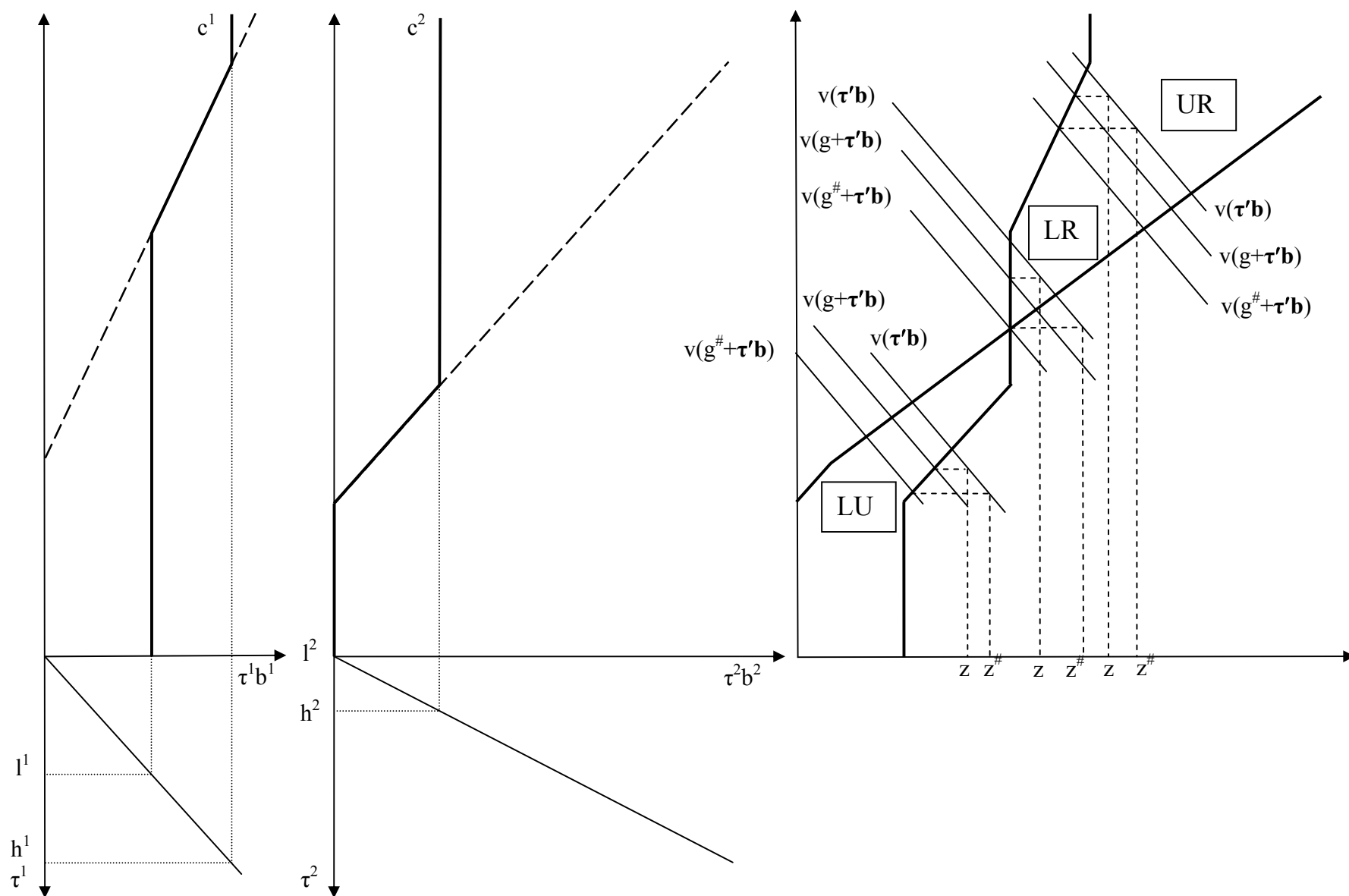


Figure 6 Two taxes: other constrained tax mix outcomes





In particular, figure 5 focuses on the following two cases:

- Constrained tax mix RR: both tax rates are right-constrained, meaning that an authority's optimal tax rates lie to the right of the upper limits.
- Constrained tax mix LL: both tax rates are left-constrained.

On the other hand, figure 6 illustrates the following three cases:

- Constrained tax mix UR: one of the tax rates is unconstrained and the other is right-constrained.
- Constrained tax mix LU: one of the tax rates is left-constrained and the other is unconstrained.
- Constrained tax mix LR: one of the tax rates is left-constrained and the other is right-constrained.

Let us ask again what effect an exogenous change in grants would have on local public spending. When both revenue sources are constrained - cases RR and LL in figure 5, and LR in figure 6 - any change in grants necessarily translates into an identical change in spending levels, with no variation in  $\tau^1$  and  $\tau^2$ .

Local public expenditure displays an excess sensitivity to grants.

When only one of the two fiscal instruments is at a corner - cases UR and LU in figure 6 - the change in spending will typically be smaller than the change in grants. However, the binding constraint on one of the available tax revenues makes the total marginal cost of raising revenues steeper than it would be in the absence of constraints. Since local authorities can rely on fewer tax instruments, the cost of raising revenues is more sensitive to changes in the budget requirement: as a result of the increase in grants, the impact on public expenditures is larger than would occur if both tax rates could freely adjust. Of course, excess sensitivity of spending will be observed both when grants increase and when they decrease.

The above results can be summarized as follows.

- In a fully constrained tax mix, local public spending exhibits little or no sensitivity to private income changes; on the other hand, local public expenditures respond to changes in grants on a one-for-one basis.

- As long as changes in exogenous sources of revenue do not provoke a segment jump, upper-constrained authorities ( $\tau^m = h^m, \forall m$ ), lower-constrained authorities ( $\tau^m = l^m, \forall m$ ), and lower and upper-constrained authorities ( $\tau^m = l^m, m = 1, \dots, \bar{m}; \tau^m = h^m, m = \bar{m} + 1, \dots, M$ ) exhibit the same sensitivity of public spending to grants.
- In a partially constrained tax mix: a) the total marginal cost of raising revenues is flatter and the sensitivity of local public spending to grants is smaller than it is in a fully constrained tax mix; b) the total marginal cost of raising revenues is steeper and the sensitivity of local public spending to grants is larger than it is in the absence of binding tax limitations.

### 3. Empirical implications and econometric approach

The theoretical model sketched in section 2 above prompts the estimation of the sensitivity of local public expenditures to changes in exogenous revenue sources, while allowing for heterogeneous responses depending on the degree to which local governments face financing constraints. In fact, the empirical investigation of the excess sensitivity of local government spending to grants bears a striking similarity with two well developed lines of research.

The first concerns the inquiry into the role of financing and liquidity constraints in explaining the elasticity of investment to cash-flow in Q models of the firm (Bond and Meghir, 1994; Fazzari et al., 1988, Hu and Schiantarelli, 1998, Kaplan and Zingales, 1997, Cummins et al., 2006).<sup>12</sup> The second relates to the borrowing constraint interpretation of the excess sensitivity of private consumption to disposable income in permanent income/life cycle frameworks (Runkle, 1989, Zeldes, 1991, Jappelli et al., 1998).<sup>13</sup>

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<sup>12</sup>In their flypaper effect review, Hines and Thaler (1995) mentioned the liquidity constraint explanation of flypaper-like effects in the private sector. However, they did not consider the possibility that local tax and expenditure limitations might be the root cause of the flypaper effect.

<sup>13</sup>Borge and Tovmo (2009) test whether liquidity constraints imposed by balanced-budget rules affect the intertemporal spending behavior of Norwegian local governments, and find that departures from rational forward-looking public

In the empirical investment and consumption literatures, the conventional approach consists in splitting the sample according to an *a priori* index of financing/liquidity constraint (typically related to the dividend payout or liquid assets to capital stock ratio for firms, and to the asset-income ratio for consumers), and compare the switching regression estimates of the sensitivity of investment (consumption) to cash flow (income) for the constrained and unconstrained subsamples (Fazzari et al., 1988; Kaplan and Zingales, 1997, and Runkle, 1989).

Similarly, in order to test on panel data whether the local public spending response to changes in exogenous sources of revenue is affected by the tax limitation regime a local government is subject to, a time-invariant selection criterion can be employed and authorities assigned to either of two subsamples based on whether they are consistently constrained (or not constrained) during the whole period of observation ( $t=1, \dots, T$ ):

$$z_{nt} = \mathbf{q}'_{nt} \boldsymbol{\beta}^1 + \zeta_n^1 + \eta_{nt}^1 \text{ if } K_n = 1 \quad (13)$$

$$z_{nt} = \mathbf{q}'_{nt} \boldsymbol{\beta}^0 + \zeta_n^0 + \eta_{nt}^0 \text{ if } K_n = 0 \quad (14)$$

where:  $\mathbf{q}'_{nt} = [g_{nt} \ i_{nt} \ \mathbf{x}'_{nt}]$ ,  $\boldsymbol{\beta}^{1'} = [\beta_g^1 \ \beta_i^1 \ \boldsymbol{\beta}_x^{1'}]$ ,  $\boldsymbol{\beta}^{0'} = [\beta_g^0 \ \beta_i^0 \ \boldsymbol{\beta}_x^{0'}]$ , and  $\zeta_n^1$  and  $\zeta_n^0$  are fixed jurisdiction effects that might be correlated with  $\mathbf{q}_{nt}$ . The switching indicator  $K_n$  is defined as:

$$K_n = \begin{cases} 1 & \text{if } \tau_{nt}^m \in \{l^m, h^m\}, \forall m, t \\ 0 & \exists t : \tau_{nt}^m \in \{l^m, h^m\}, \forall m \end{cases} \quad (15)$$

According to the sample separation criterion (15), parameter  $\beta_g^0$  in equation (14) captures the response of spending to grants by authorities that are not structurally constrained (i.e., authorities that never have all constraints binding in any of the  $T$  observation years), while parameter  $\beta_g^1$  in equation (13) measures the response by authorities that are structurally capped, in the sense that tax limitations are binding for all revenue sources and in all years.

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consumption smoothing can in part be explained by financing constraints.

One potential problem with the above approach is sample selection bias, in the sense that the splitting variable  $K_n$  might be correlated with spending  $z_{nt}$ . However, since selection effects can only occur through correlation between  $K_n$  and the time-invariant authority-specific effects  $\zeta_n^1$  and  $\zeta_n^0$ , any selection bias is cancelled by differencing them away in equations (13)-(14). Consequently, a linear panel data fixed effects estimator can be applied to the two subsamples (Charlier et al., 2001).

A disadvantage of the separation rule (15), though, consists in the fact that it implies freezing the sample and renouncing to using information on governments that switch from one regime to the other over the period of observation (Hu and Schiantarelli, 1998).

An alternative empirical approach - based, among the others, on Bond and Meghir (1994), Jappelli et al. (1998), Zeldes (1989) and Cummins et al. (2006) - consists in allowing for a time-varying constraint status as in (16) below:

$$K_{nt} = \begin{cases} 1 & \text{if } \tau_{nt}^m \in \{l^m, h^m\}, \forall m \\ 0 & \exists m : \tau_{nt}^m \notin \{l^m, h^m\} \end{cases} \quad (16)$$

giving rise to the switching regression model:

$$z_{nt} = \mathbf{q}_{nt}'\boldsymbol{\beta}^1 + \zeta_n^1 + \eta_{nt}^1 \quad \text{if } K_{nt} = 1 \quad (17)$$

$$z_{nt} = \mathbf{q}_{nt}'\boldsymbol{\beta}^0 + \zeta_n^0 + \eta_{nt}^0 \quad \text{if } K_{nt} = 0 \quad (18)$$

Clearly, though, whether an authority is at a tax mix corner solution might in principle be determined endogenously. This would occur in the presence of unobserved shocks to expenditures pushing local authorities towards the corners.

Given the sample separation rule (16), the endogenous selection problem is somewhat mitigated here by the fact that the constrained regime for which  $K_{nt}=1$  includes high spenders hitting the upper tax bounds (constrained tax mix RR), low spenders hitting the lower tax bounds (constrained tax mix LL) and authorities hitting lower and upper bounds on different tax rates at the same time (constrained tax mix LR). As a result, it is unclear *a priori* whether and how would  $K_{nt}$  be correlated with unobservable

shocks to  $z_{nt}$ . However, the endogenous selection issue is developed further in the next section.

#### 4. Endogenous selection

In order to explore the endogenous selection issue in greater depth, the selection process (16) needs to be given an explicit stochastic structure. We do so by following the Wooldridge (1995) two-stage procedure for fixed effects panel data, with a selection equation being consistently estimated in the first stage, and the main spending equation being estimated in the second stage after correcting for selection bias.<sup>14</sup> The Wooldridge (1995) approach relies on estimation in levels, and has the great advantage relative to econometric approaches based on pairwise differencing on units for which  $K_{nt}=K_{ns}=1$ ,  $t \neq s$  (Kyriazidou, 1997) of not requiring any exclusion restrictions in the main equation. In fact, since the constrained optimization model in section 2 predicts the level of spending  $z_{nt}$  and the capping regime  $K_{nt}$  to be determined simultaneously as a function of the vector of exogenous variables  $\mathbf{q}_{nt}$ , exclusion restrictions in the  $z_{nt}$  equation would be logically inconsistent.<sup>15</sup>

Let us focus on selection into the fully constrained regime  $K_{nt}=1$ . A sufficient condition for the fixed effects estimator of equation (17) on the unbalanced panel to be consistent is that the selection process be strictly exogenous conditional on  $\zeta_n^1$  and  $\mathbf{q}_n$ :

$$E(\eta_{nt}^1 | \zeta_n^1, \mathbf{q}_n, \mathbf{K}_n) = E(\eta_{nt}^1 | \zeta_n^1, \mathbf{q}_{n1}, \dots, \mathbf{q}_{nT}, K_{n1}, \dots, K_{nT}) = 0 \quad (19)$$

As clearly shown by equation (16),  $K_{nt}$  depends in a structural way on  $M$  distinct tax rate realizations, where the process underlying the determination of each tax rate  $\tau_{nt}^m$  ( $m=1, \dots, M$ ) can be expressed in a latent variable form as:

<sup>14</sup>Dustmann and Rochina-Barrachina (2007) give a simple illustration and an application of the Wooldridge (1995) and related procedures.

<sup>15</sup>In addition, the Kyriazidou (1997) pairwise differencing estimator has the data-shrinking shortcoming of using only those observations for which the linear index in the selection equation is approximately equal in periods  $t$  and  $s$  (see equation (24) below).

$$\tau_{nt}^m = \begin{cases} h^m & \tau_{nt}^{m*} \geq h^m \\ \tau_{nt}^{m*} & \text{if } l^m < \tau_{nt}^{m*} < h^m \\ l^m & \tau_{nt}^{m*} \leq l^m \end{cases} \quad (20)$$

$\tau_{nt}^{m*}$  in (20) is the partially unobserved optimal tax rate of authority  $n$  in year  $t$ , whose non-stochastic component descends directly from the model sketched in section 2:

$$\tau_{nt}^{m*} = \mathbf{q}_{nt}' \boldsymbol{\gamma}^m + \xi_n^m + a_{nt}^m \quad (21)$$

where:  $\boldsymbol{\gamma}^{m'} = [\gamma_g^m \ \gamma_i^m \ \gamma_x^m]$ , and  $\xi_n^m$  is an authority and revenue-source specific effect that might be correlated with  $\mathbf{q}_{nt}$ . In fact, correlation between fixed effect and regressors in (21) can be accommodated by assuming - as in Mundlak (1978) - a linear relationship between  $\xi_n^m$  and the time averages of  $\mathbf{q}_{nt}$ :

$$\tau_{nt}^{m*} = \mathbf{q}_{nt}' \boldsymbol{\gamma}^m + \bar{\mathbf{q}}_n' \boldsymbol{\theta}^m + u_{nt}^m \quad (22)$$

where:  $\xi_n^m = \bar{\mathbf{q}}_n' \boldsymbol{\theta}^m + j_n^m$ ,  $\bar{\mathbf{q}}_n = \frac{1}{T} \sum_{t=1}^T \mathbf{q}_{nt}$ , and  $u_{nt}^m \equiv (j_n^m + a_{nt}^m)$  is normally distributed and is independent of  $\bar{\mathbf{q}}_n$ .

For  $K_{nt}=1$ , let  $\bar{m}$  be the number of binding lower constraints and  $M - \bar{m}$  the number of binding upper constraints, with  $0 \leq \bar{m} \leq M$ . According to (16), (20) and (22), and letting  $\phi^M(\mathbf{u}_{nt})$  be the multivariate distribution of the vector of error terms from the  $M$  tax rate equations, the probability that authority  $n$  is fully constrained can be expressed as:

$$P(K_{nt} = 1) = \underbrace{\int_{-\infty}^{l^1 - \mathbf{q}_{nt}' \boldsymbol{\gamma}^1 - \bar{\mathbf{q}}_n' \boldsymbol{\theta}^1} \dots \int_{-\infty}^{l^{\bar{m}} - \mathbf{q}_{nt}' \boldsymbol{\gamma}^{\bar{m}} - \bar{\mathbf{q}}_n' \boldsymbol{\theta}^{\bar{m}}} \dots}_{\tau_{nt}^m = l^m} \underbrace{\int_{h^{\bar{m}+1} - \mathbf{q}_{nt}' \boldsymbol{\gamma}^{\bar{m}+1} - \bar{\mathbf{q}}_n' \boldsymbol{\theta}^{\bar{m}+1}}^{+\infty} \dots \int_{h^M - \mathbf{q}_{nt}' \boldsymbol{\gamma}^M - \bar{\mathbf{q}}_n' \boldsymbol{\theta}^M}^{+\infty}}_{\tau_{nt}^m = h^m} \phi^M(\mathbf{u}_{nt}) du_{nt}^1 \dots du_{nt}^M \quad (23)$$

Estimation of (23) is complicated by the need to evaluate an M-dimensional integral.<sup>16</sup> For reasons of tractability, we therefore focus on the reduced form of the observed selection outcome  $K_{nt}$ :

$$K_{nt} = 1[K_{nt}^* = \mathbf{q}_{nt}'\boldsymbol{\delta} + \mu_n + \varepsilon_{nt} > 0] \quad (24)$$

meaning that  $K_{nt}=1$  if  $K_{nt}^* > 0$ , where  $K_{nt}^*$  is a latent variable and  $\mu_n$  is a time-invariant authority-specific effect that can be allowed to be correlated with the explanatory variables in a linear way:

$$K_{nt} = 1[K_{nt}^* = \mathbf{q}_{nt}'\boldsymbol{\delta} + \bar{\mathbf{q}}_n'\boldsymbol{\alpha} + v_{nt} > 0] \quad (25)$$

with:  $\mu_n = \bar{\mathbf{q}}_n'\boldsymbol{\alpha} + \kappa_n$ ,  $\bar{\mathbf{q}}_n = \frac{1}{T} \sum_{t=1}^T \mathbf{q}_{nt}$ , and  $v_{nt} \equiv (\kappa_n + \varepsilon_{nt})$  is normally distributed and is independent of  $\bar{\mathbf{q}}_n$ .<sup>17</sup>

Wooldridge (1995) suggests the following procedure. Assume:

$$E(\eta_{nt}^1 | \mathbf{q}_n, v_{nt}) = E(\eta_{nt}^1 | \mathbf{q}_{n1}, \dots, \mathbf{q}_{nT}, v_{nt}) = E(\eta_{nt}^1 | v_{nt}) = \rho_{\eta} v_{nt} \quad (26)$$

$$E(\zeta_n^1 | \mathbf{q}_n, v_{nt}) = E(\zeta_n^1 | \mathbf{q}_{n1}, \dots, \mathbf{q}_{nT}, v_{nt}) = \bar{\mathbf{q}}_n'\boldsymbol{\psi} + \rho_{\zeta} v_{nt} \quad (27)$$

According to (26),  $\eta_{nt}^1$  is mean independent of  $\mathbf{q}_n$  conditional on  $v_{nt}$ , and its expectation is linear in  $v_{nt}$ , while (27) is a linearity assumption on the conditional expectation of the fixed effect  $\zeta_n^1$ . No distributional assumptions are imposed on  $\eta_{nt}^1$  and  $\zeta_n^1$ . Consequently, upon defining  $\rho_t \equiv \rho_{\eta} + \rho_{\zeta}$ , and given that  $v_{nt}$  is not observed, but the selection index  $K_{nt}$  is, equation (17) can be written as:

$$E(z_{nt} | \mathbf{q}_n, K_{nt} = 1) = \mathbf{q}_{nt}'\boldsymbol{\beta}^1 + \bar{\mathbf{q}}_n'\boldsymbol{\psi} + \rho_t E[v_{nt} | \mathbf{q}_n, K_{nt} = 1] \quad (28)$$

The procedure consists in estimating (25) by Probit, obtaining the inverse Mills ratio ( $\lambda_{nt}$ ), and replacing it in (28):

<sup>16</sup>See Heien and Wessells (1990), Shonkwiler and Yen (1999), Golan et al. (2001), and Yen and Lin (2006).

<sup>17</sup>In performing the Wooldridge (1995) procedure, the Mundlak (1978) correction seems preferable in this context to the alternative Chamberlain (1982) approach. The latter consists in expressing fixed effects as a linear combination of the explanatory variables from all time periods:  $\mathbf{q}_{n1}'\boldsymbol{\alpha}_1 + \dots + \mathbf{q}_{nt}'\boldsymbol{\alpha}_t + \dots + \mathbf{q}_{nT}'\boldsymbol{\alpha}_T$ . Assuming instead, in the Mundlak (1978) spirit, that the fixed effect depends only on the time average of  $\mathbf{q}_{nt}$  greatly conserves on parameters, at the cost of imposing

$$z_{nt} = \mathbf{q}_{nt}'\boldsymbol{\beta}^1 + \overline{\mathbf{q}}_n'\boldsymbol{\psi} + \rho_t\lambda_{nt} + o_{nt} \quad (29)$$

Wooldridge (1995) proves that pooled OLS on (29) leads to consistent estimates of the parameter vector of interest  $\boldsymbol{\beta}^1$ .

## 5. Empirical implementation

### 5.1 Local tax limitations in Italy

The impact of tax limitations on the sensitivity of local public spending to grants is tested on panel data for the Italian Provinces through the years 2000 to 2007. The Italian system of local government is organized as a three-tier structure, with the 103 Provinces constituting the intermediate level of government between the regional (20 Regions) and the municipal (over 8,000 Municipalities) ones. Provinces have responsibility for intermunicipal road construction and maintenance, local transportation systems, secondary education schools, waste management and environmental protection. Provincial expenditures rose considerably in recent years, mostly due to the devolution of functions from the national and regional governments. In fact, average per capita spending increased by about 25% in real terms between 2000 and 2007.

Over 3/4 of total current provincial spending is funded by grants from upper levels of government (State and Regions), with the proportion of grant-funded expenditures remaining roughly constant through the 2000-2007 period. State grants are for the most part general and formula-based. They rely on the definition of a standardized spending level for each Province built on exogenous needs indicators falling into three broad areas (age structure of the resident population; geomorphological complexion; socioeconomic deprivation), as well as of a fiscal capacity index capturing the ability of each Province to raise own and shared revenues.<sup>18</sup> In particular, Provinces are divided into four

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the parameter restriction:  $\boldsymbol{\alpha}_1 = \dots = \boldsymbol{\alpha}_t = \dots = \boldsymbol{\alpha}_T = \frac{1}{T}\boldsymbol{\alpha}$  in equation (25).

<sup>18</sup>Shared revenues crowd-out grants one-for-one, and are therefore subsumed into the latter.



demographic bands, and average service cost indices for a number of mandated provincial functions and average tax bases are periodically computed (usually every three years) for each band. Expenditures on non-mandated provincial services do not enter the grant distribution scheme and must be entirely funded by own revenues. On the other hand, regional grants typically finance specific functions that were devolved to Provinces during the decentralization process of the late 1990s.

As a result of the above institutional arrangement, State and regional grants can to a large extent be considered exogenous with respect to own funding decisions by provincial governments. In particular, given the infrequent central assessment of spending needs and fiscal capacity, changes in provincial socioeconomic conditions are not promptly reflected into State grant adjustments.<sup>19</sup> Moreover, the fact that State grants are based on a Province's needs and fiscal capacity indices relative to its demographic band mean should alleviate the potential problem of grant endogeneity arising from shocks moving grants and local expenditures in the same direction.<sup>20</sup>

The rest of current spending is funded by three own tax revenue sources: the vehicle registration tax, the electricity consumption tax, and the waste management tax. The vehicle registration tax represents over 50% of total own tax revenues. All brand new vehicles - as well as used vehicles in case of change of ownership - are liable to the payment of the tax the first time they are registered in the provincial archive under a given owner's name. The total tax due is made of a lump-sum amount plus a variable component that is related to the size, power and destination of the vehicle. As shown in table 1, central government establishes a lower and an upper bound on the vehicle tax parameters that Provinces can set, with the upper bound corresponding to a 20% higher tax burden (raised to 30% in 2007) than the one corresponding to the lower bound. Consequently, the decision of each Province basically consists

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<sup>19</sup>Gordon (2004) exploits the infrequent updating of poverty data used in the US federal education grants to school districts (Title I). However, since Title I grants also depend on state education spending, she computes a purely Census-determined grant change measure and uses it as an instrument for actual Title I revenue change - a step that seems unnecessary in our simpler context.

<sup>20</sup>A similar point is made in Brooks and Phillips (2010).

in determining autonomously the surcharge  $\tau^v$ .

The electricity consumption tax is applied by Provinces on business uses of electricity. As shown in table 1, Provinces set a tax rate  $\tau^e$  between a minimum of 9.3 and a maximum of 11.4 Euro cents per kW. Electricity tax revenues correspond to above 1/3 of total own tax revenues. Finally, the waste management tax is a surcharge applied by Provinces on the waste collection bill charged by the municipalities located in the province on all households and businesses. Table 1 shows that the surcharge  $\tau^w$  must lie between 1% and 5% of the municipal levy. Revenues from the waste management tax amount to about 10% of total provincial own tax revenues.

Table 1 Lower and upper tax limitation rules

		2000-6	2007
Vehicle registration tax $\mathcal{L}^v$ (% surcharge on national rate)	$l^v$	0	0
	$h^v$	20	30
Electricity consumption tax $\mathcal{L}^e$ (Euro cents per kW)	$l^e$	9.3	9.3
	$h^e$	11.4	11.4
Waste management tax $\mathcal{L}^w$ (% surcharge on municipal levy)	$l^w$	1	1
	$h^w$	5	5

Table 2 reports the number of authorities setting tax rates at the lower and upper limits respectively, while table 3 rates the authority-year observations based on how severely they are affected by the tax rate limitations.<sup>21</sup> More than half of the observations in the dataset (416 out of 720) correspond to fully bound instances, with all available tax sources being set at left or right corners, while in only 9 observations none of the constraints is binding. For about 40% of the observations either one or two tax limitations are binding, and in over 1/3 of the observed tax mix outcomes a lower and an upper limit are simultaneously binding.

Table 2 Number of authorities (N=90) at lower and upper limits

		2000	2001	2002	2003	2004	2005	2006	2007
$\tau^v$	$l^v$	25	15	9	7	7	5	4	3
	$h^v$	55	65	71	72	73	77	79	43
$\tau^e$	$l^e$	66	54	43	37	34	27	18	15
	$h^e$	16	29	39	45	47	52	59	64
$\tau^w$	$l^w$	3	2	2	3	3	2	3	3
	$h^w$	66	64	66	65	65	66	66	68

Table 3 Tax limitation intensity

	Fully constrained												total
	(h,h,h)	(h,h,l)			(h,l,l)			(l,l,l)					
$\tau^v$	$h^v$	$h^v$	$h^v$	$l^v$	$h^v$	$l^v$	$l^v$	$l^v$					
$\tau^e$	$h^e$	$h^e$	$l^e$	$h^e$	$l^e$	$h^e$	$l^e$	$l^e$					
$\tau^w$	$h^w$	$l^w$	$h^w$	$h^w$	$l^w$	$l^w$	$h^w$	$l^w$					
obs.	238	6	130	0	3	0	28	11					416
	Moderately constrained												
	(h,h)			(h,l)					(l,l)				
$\tau^v$	$h^v$	$h^v$	$\tau^{v*}$	$h^v$	$l^v$	$h^v$	$l^v$	$\tau^{v*}$	$\tau^{v*}$	$l^v$	$l^v$	$\tau^{v*}$	
$\tau^e$	$h^e$	$\tau^{e*}$	$h^e$	$l^e$	$h^e$	$\tau^{e*}$	$\tau^{e*}$	$h^e$	$l^e$	$l^e$	$\tau^{e*}$	$l^e$	
$\tau^w$	$\tau^{w*}$	$h^w$	$h^w$	$\tau^{w*}$	$\tau^{w*}$	$l^w$	$h^w$	$l^w$	$h^w$	$\tau^{w*}$	$l^w$	$l^w$	
obs.	61	60	27	36	3	0	0	1	39	32	0	0	
	(h)			(l)									
$\tau^v$	$h^v$	$\tau^{v*}$	$\tau^{v*}$	$l^v$	$\tau^{v*}$	$\tau^{v*}$							
$\tau^e$	$\tau^{e*}$	$h^e$	$\tau^{e*}$	$\tau^{e*}$	$l^e$	$\tau^{e*}$							
$\tau^w$	$\tau^{w*}$	$\tau^{w*}$	$h^w$	$\tau^{w*}$	$\tau^{w*}$	$l^w$							
obs.	1	15	4	1	15	0							295
	Not constrained												
$\tau^v$	$\tau^{v*}$												
$\tau^e$	$\tau^{e*}$												
$\tau^w$	$\tau^{w*}$												
obs.	9												9
													720

<sup>21</sup>The data refer to the 90 Provinces (out of 103) for which all information from 2000 to 2007 is available.

## 5.2 Time-invariant splitting indicator

The sample is first split based on a time-invariant indicator  $K_n$  that equals 1 if Province  $m$  is constrained on all own tax revenue sources for the entire period of observation, and equals 0 if the authority never has all constraints binding. This accords with the splitting criterion (15). By doing so, we rule out the effect of yearly changes in grants on the capping status, and focus on the difference in the response of local public expenditures to grant changes. Moreover, since selection effects occur through correlation between  $K_n$  and the time-invariant authority-specific effects  $\zeta_n^1$  and  $\zeta_n^0$  in (13)-(14), any selection bias is cancelled by applying a fixed effects estimator on the two subsamples.

Application of the splitting criterion (15) yields  $K_n=1$  for 24 provincial authorities, and  $K_n=0$  for 20 authorities in the 2001-2006 period, the rest of the observations being discarded (to be used later on) because of changing regime during the period. This leaves us with 264 observations.<sup>22</sup> Of the 24 structurally capped authorities, 17 were at the upper bounds on all three own tax rates for the entire period, 5 were hitting two upper bounds and one lower bound, one Province was at one upper and two lower bounds, and one Province was consistently at the three lower bounds. On the other hand, the authorities in the  $K_n=0$  regime have one to two constraints binding.

We first estimate the switching regression model (13)-(14)-(15) as a single equation, with  $K_n$  working as a switcher, thus allowing us to test the difference between the  $\beta^0$  and  $\beta^1$  coefficient vectors:

$$z_{nt} = \mathbf{q}'_{nt} \beta^0 + K_n \times \mathbf{q}'_{nt} (\beta^1 - \beta^0) + \zeta_n^0 + \eta_{nt}^0 + K_n \times ((\zeta_n^1 + \eta_{nt}^1) - (\zeta_n^0 + \eta_{nt}^0)) \quad (30)$$

where  $z_{nt}$  equals current spending per capita in real terms, and the vector of explanatory variables

$\mathbf{q}'_{nt} = [g_{nt} \ i_{nt} \ \mathbf{x}'_{nt}]$  includes:

$g_{nt}$ : per capita grants = all current financial transfers from upper levels of government (State and Regions), including the fixed shares of national tax revenues devolved to Provinces (national personal

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<sup>22</sup>In order to preserve the size of the  $K_n=1$  sample, it seems sensible to exclude the last year in the sample because of the vehicle tax cap relaxation that occurred in 2007 (from 20% to 30%). Similarly, the first year (2000) is excluded since

income tax and national motor-vehicle insurance tax);

$i_{nt}$ : per capita consumption of electricity for domestic uses as a proxy for private income;

$\mathbf{x}_{nt}$ : population size to control for economies of scale in service provision; demographic composition of the resident population (share of the population aged 0 to 4 years and aged over 65 years); a binary election year indicator to allow for opportunistic policy manoeuvring prior to elections;<sup>23</sup> a binary government ideology indicator to capture a partisan cleavage in spending policy between right-wing and left-wing governments.<sup>24</sup>

The fixed effects estimation results of equation (30) are reported in table 4, while table 5 reports the separate estimation results of equations (13) and (14) for the two subsamples. All equations include year dummies. Descriptive statistics and data sources for all variables are reported in the Appendix.

Interestingly, all authorities exhibit what would be termed a flypaper effect according to conventional criteria in the literature. The results in table 4 show that the grant effect is large and highly significant, while the coefficient on the income proxy is hardly different from zero. In fact, the  $K_n=0$  subsample is far from being unconstrained in practice, given that those authorities are capped on one or two tax rates along the period. However, structurally capped authorities' expenditures react to grants to a significantly larger extent, actually on a one-for-one basis. The estimate of the effect of grants on spending is around 0.7 for the moderately constrained subsample (columns (4.2), (4.4) and (4.6) in table 4; columns (5.2), (5.4) and (5.6) in table 5), while the coefficient estimate virtually equals 1 for structurally bound Provinces (columns (5.1), (5.3) and (5.5) in table 5).<sup>25</sup>

The results are robust to the introduction of various controls, none of which, though, due to their comprehensibly limited variation over the relatively short time period and the overwhelming role of

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several Provinces became consistently capped from the year 2001 on.

<sup>23</sup>Provincial elections take place every five years with direct election of the President of the Province. The provincial election schedule is asymmetric, meaning that Provinces hold elections at different points in time.

<sup>24</sup>In particular, we use a right-wing control dummy. In most instances, the President of the Province is backed by a well-defined right-wing or left-wing coalition.

<sup>25</sup>When estimating a constant elasticity specification (results not reported in full, but available upon request), the grant and

grants, contributes much to further explaining the pattern of spending.

Table 4 Time-invariant splitting criterion ( $K_n$ )

	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.6)
grants	0.844** (0.035)	0.722** (0.046)	0.840** (0.034)	0.716** (0.046)	0.842** (0.035)	0.731** (0.049)
income			0.040* (0.021)	0.055* (0.025)	0.033 (0.023)	0.042 (0.030)
population					-0.091 (0.081)	-0.142 (0.124)
age 0-4 share					-2.147 (5.896)	-5.750 (7.569)
age 65+ share					-3.789 (3.340)	-6.076 (5.217)
election					0.300 (1.356)	-0.315 (1.784)
right-wing					2.176 (2.881)	6.767 (6.662)
$K_n \times$ grants		0.253** (0.069)		0.258** (0.069)		0.259** (0.073)
$K_n \times$ income				-0.047 (0.045)		-0.027 (0.050)
$K_n \times$ population						0.094 (0.163)
$K_n \times$ age 0-4 share						15.520 (12.217)
$K_n \times$ age 65+ share						10.066 (7.047)
$K_n \times$ election						0.898 (2.718)
$K_n \times$ right-wing						-5.677 (7.393)
Observations	264	264	264	264	264	264
Authorities	44	44	44	44	44	44

Notes: Dependent variable: real current spending per capita. Fixed Province and year effects included; year effects interacted with the switching indicator  $K_n$  in columns (4.2), (4.4) and (4.6).  $K_n$  defined in equation (15). Standard errors in parentheses. \*\*: p-value < 0.01; \*: p-value < 0.10.

One might wonder at this point whether the grant coefficient estimate is in fact inflated by spurious correlation between local expenditure and grants due to omitted variables driving both. However, a grant coefficient estimate of around 1 in the fully constrained sample is hardly surprising. Given that

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income elasticities equal 0.8 and 0.1 in the  $K_n=1$  sample, and around 0.6 and 0.5 in the  $K_n=0$  sample.

other sources of revenue (including balances) constitute a negligible average share of total provincial revenues, equation (6) represents a reasonable approximation to the actual budgeting choice, meaning that  $\frac{\partial z^*(\mathbf{q})}{\partial g} \cong 1$  if all tax rates are frozen at their (upper or lower) limits. As for the moderately constrained sample, an endogeneity bias would most likely play against the point we are making here, in the sense of driving up the estimate of  $\beta_g^0$  and narrowing the gap between the two subsamples.

Table 5 Time-invariant splitting criterion: separate equations

	(5.1)	(5.2)	(5.3)	(5.4)	(5.5)	(5.6)
	$K_n = 1$	$K_n = 0$	$K_n = 1$	$K_n = 0$	$K_n = 1$	$K_n = 0$
grants	0.975** (0.048)	0.722** (0.050)	0.974** (0.048)	0.716** (0.050)	0.989** (0.051)	0.731** (0.053)
income			0.008 (0.035)	0.055* (0.026)	0.015 (0.037)	0.042 (0.032)
population					-0.048 (0.099)	-0.142 (0.133)
age 0-4 share					9.770 (8.986)	-5.750 (8.115)
age 65+ share					3.991 (4.439)	-6.076 (5.593)
election					0.583 (1.921)	-0.315 (1.913)
right-wing					1.090 (3.003)	6.767 (7.143)
Observations	144	120	144	120	144	120
Authorities	24	20	24	20	24	20

Notes: Dependent variable: real current spending per capita. Fixed Province and year effects included.  $K_n$  defined in equation (15). Standard errors in parentheses. \*\*: p-value < 0.01; \*: p-value < 0.10.

### 5.3 Endogenous time-varying selection

In order to implement the Wooldridge (1995) procedure and allow for endogenous selection into the  $K_{nt}=1$  regime and fixed Province effects, we now need to focus on the authorities that are observed to be switching between regimes over time. This allows us to proceed as discussed in section 4, and estimate the Probit selection equation (25) in the first stage, with  $K_{nt}$  as defined in equation (16).

After excluding Provinces that are consistently constrained or unconstrained over the entire time

period, as well as those observed in the fully constrained  $K_{nt}=1$  regime for less than two years, we end up with a balanced panel of 43 switching Provinces over the eight years 2000-2007. Importantly, since we aim at estimating the response of authority  $n$ 's spending to grants in year  $t$  provided that authority  $n$  stays on the same portion of its budget constraint, we require the fully constrained tax mix of authority  $n$  in year  $t$  to be identical as in year  $t-1$  in order for that observation to be selected into the  $K_{nt}=1$  regime (Bond and Meghir, 1994).

Table 6 Time-varying splitting criterion: switching Provinces

	(6.1)	(6.2)	(6.3)	(6.4)	(6.5)	(6.6)
	$K_{nt} = 1$	$K_{nt} = 0$	$K_{nt} = 1$	$K_{nt} = 0$	$K_{nt} = 1$	$K_{nt} = 0$
grants	0.986** (0.023)	0.792** (0.056)	0.986** (0.023)	0.785** (0.056)	0.979** (0.025)	0.793** (0.057)
income			0.004 (0.025)	0.042 (0.033)	0.001 (0.026)	0.047 (0.050)
population					0.044 (0.053)	0.026 (0.056)
age 0-4 share					-0.397 (5.353)	-15.957* (8.896)
age 65+ share					0.255 (2.405)	-2.318 (3.810)
election					1.126 (1.353)	0.160 (2.527)
right-wing					0.993 (2.461)	7.239 (5.747)
Observations	230	114	230	114	230	114
Authorities	43					

Notes: Dependent variable: real current spending per capita. Fixed Province and year effects included.  $K_{nt}$  defined in equation (16). Standard errors in parentheses. \*\*: p-value < 0.01; \*: p-value < 0.10.

Table 6 reports the benchmark fixed effects estimation results of the switching regression model (16)-(17)-(18) under assumption (19) of exogenous selection into the fully capped regime. It is remarkable that local authorities' expenditures exhibit the expected excess sensitivity when fully constrained ( $\beta_g^1 \cong 1$ ), while the sensitivity of spending to grants is significantly lower ( $\beta_g^0 < 0.8$ ) and the sensitivity



to income is higher ( $\beta_i^0 > \beta_i^1 \cong 0$ ) when the same authorities are only moderately constrained.

Table 7 Wooldridge two-stage approach ( $K_{nt} = 1$ )

	(7.1)	(7.2)	(7.3)	(7.4)
	First stage ( $K_{nt}$ )		Second stage ( $z_{nt}$ )	
	Probit (balanced)		Wooldridge correction	
	$q_{nt}$	$q_n$	$q_{nt}$	$q_n$
grants	-0.003 (0.004)	0.001 (0.005)	0.969** (0.045)	-0.039 (0.050)
income	-0.002 (0.004)	0.004 (0.004)	0.009 (0.044)	0.015 (0.047)
population	-0.010 (0.007)	0.010 (0.007)	0.090 (0.099)	-0.089 (0.100)
age 0-4 share	-4.086** (0.816)	4.168** (0.872)	6.408 (22.653)	-3.221 (21.597)
age 65+ share	-0.916* (0.389)	0.921* (0.395)	2.707 (6.127)	-0.363 (5.925)
election	0.292 (0.267)	-1.533 (1.619)	3.137 (2.832)	-14.817 (11.938)
right-wing	-0.626 (0.525)	0.317 (0.594)	-1.431 (5.519)	-0.677 (5.069)
$\lambda_{n2000}$			-11.337 (10.410)	
$\lambda_{n2001}$			-5.202 (12.476)	
$\lambda_{n2002}$			6.908 (13.097)	
$\lambda_{n2003}$			19.600 (21.033)	
$\lambda_{n2004}$			24.571 (20.813)	
$\lambda_{n2005}$			-16.283 (16.846)	
$\lambda_{n2006}$			-6.494 (14.890)	
$\lambda_{n2007}$			-3.103 (9.673)	
Observations	344		230	
Authorities	43			
Wald test $\rho=0$ (p value)			0.99 (0.44)	
Wooldridge test $\lambda_{nt}$ (p value)			-0.631 (0.95)	

Notes: Year effects included in all columns. Column (7.3): deviations from group means.  $K_{nt}$  defined in equation (16). Standard errors in parentheses. \*\*: p-value < 0.01; \*: p-value < 0.10.

Table 7 reports the two-stage estimation results allowing for endogenous selection and fixed authority effects both in the selection equation and in the main equation.

Probit estimation of the first-stage binary selection equation (16) - columns (7.1)-(7.2) - reveals that grants have no systematic impact on selection into the  $K_{nt}=1$  regime. This is to be expected due to the constrained regime heterogeneity including high spending authorities hitting the upper tax bounds and low spending authorities hitting the lower tax bounds: in fact, almost 40% of the observations in the selected  $K_{nt}=1$  sample hit at least one lower tax limit, making it difficult to predict the impact of the variables in the  $\mathbf{q}_{nt}$  vector on the reduced form selection index.

As far as the stochastic component of equation (16) is concerned, the second stage estimation results suggest that the selection process can be considered exogenous with respect to the local public spending pattern described by equation (17): the Wooldridge (1995) variable addition test reported at the bottom of table 7 is far from statistical significance.<sup>26</sup>

Finally, columns (7.3)-(7.4) reveal that performing the Wooldridge (1995) correction discussed in section 4 - equation (29) - has a negligible impact on the estimation results, including in particular the excess sensitivity of local public spending to grants.

## 6. Concluding remarks

By explicitly recognizing and incorporating the left and right corners that are typically produced by state-wide limitations on local tax rates, this paper has modelled the local tax mix determination process and shown how excess sensitivity of local public spending to grants arises in the endogenously generated constrained tax mix.

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<sup>26</sup>The test relies on fixed effects estimation of the spending equation for the unbalanced panel of  $K_{nt}=1$ , after adding the inverse Mills' ratio from the first stage Probit estimation on the balanced panel. The null hypothesis of the test is:  $E(\eta_{nt}^1 | \zeta_n^1, \mathbf{q}_n, \mathbf{v}_n) = 0$  against the alternative:  $E(\eta_{nt}^1 | \zeta_n^1, \mathbf{q}_n, \mathbf{v}_n) = \rho \mathbf{v}_{nt}$ , while no hypothesis is made on how  $\zeta_n^1$  depends on  $\mathbf{q}_n, \mathbf{v}_n$  (Wooldridge, 1995).

In particular, the paper has shown that the effect of private income on public spending should be expected to be tiny or nil in the presence of binding limitations on all local tax revenue sources, while grants should be predicted to have a large - actually, a one-for-one - impact on local expenditures. Interestingly, the above result holds when either upper or lower tax limitations are in place, and the analysis shows that a binding limitation on just one of the available own revenue sources is enough to generate some form of flypaper effect, in the sense of an excess sensitivity of local spending to grants. In fact, since excess sensitivity of local public spending should be predicted to arise and generally tends to manifest itself both when grants increase and when they decrease, the flypaper effect label seems an inappropriate or even misleading one.

By using panel data on the Italian Provinces over the years 2000s, the paper has exploited the clustering of provincial authorities at the corners generated by central government lower and upper tax limitation rules to estimate the sensitivity of local public expenditures to grants. The empirical evidence arising from a switching regression approach that allows for fixed effects and endogenous selection into the constrained sample consistently suggests that the response of local spending to grants is significantly higher for fully constrained authorities than for authorities that can manoeuvre at least one tax instrument. While not dismissing the role of alternative explanations of local public spending excess sensitivity, it seems that the intensity of tax and expenditure limitations ought not to be ignored when investigating the local tax mix determination process and the kinky reaction of local authorities to central government grant policy.

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## Appendix: Data description

Table A1 Variables used in the analysis: descriptive statistics

	obs.	mean	s.d.	min	max
Vehicle registration surtax rate (%)	720	17.7	7.2	0	30
Electricity consumption tax rate (€ cents per kW)	720	10.4	1.0	9.3	11.4
Waste management surtax rate (%)	720	4.5	1.1	1	5
Electricity (domestic consumption per capita, kW)	720	1089.7	113.3	771.5	1484.2
Population (,000)	720	567.9	631.6	89.0	4061.5
Aged 0-4 share	720	4.4	0.6	3.0	6.3
Aged 65+ share	720	20.4	3.1	12.0	27.5
Real current spending per capita (€)	720	146.1	46.1	56.9	291.9
Real grants per capita (€)	720	118.2	44.7	36.6	249.0
Election year (%)	720	15.4			
Right-wing control (%)	720	33.6			

Table A2 Variables used in the analysis: data sources

	Data source
Vehicle registration tax rate	Automobile Club Italy - Quattroruote
Electricity consumption tax rate	Italian Government, Ministry of Finance
Electricity (domestic consumption)	Terna Rete Elettrica Nazionale - S.p.A.
Waste management tax rate	Italian Government, Home Office
Current spending	Italian Government, Home Office
Grants	Italian Government, Home Office
Election year	Italian Government, Home Office
Right-wing control	Italian Government, Home Office
Population & demographics	National Statistics Institute



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