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# Public Investment, Revenue Shocks, and Borrowing Restrictions

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## Abstract

This paper lays out a theory of taxation and public investment in an intertemporal setting under conditions of revenue shocks. Without borrowing restrictions, the optimal policy is characterized by smooth time paths of taxes and public investment. While the introduction of formal borrowing restrictions leads to some precautionary savings, it gives rise to fluctuations in public investment in response to adverse but also favorable revenue shocks. This theoretical result is tested empirically using data on public investment of more than 1,000 US municipalities in the period from 1972 to 1997 in various states that impose or do not impose borrowing restrictions on municipalities. The empirical results are supportive, indicating that in presence of borrowing restrictions public investment is becoming responsive to the deficit and is stronger affected by revenue shocks.

# 1 Introduction

Government fiscal policies are made within ever-shifting economic environments. Expenditure demands fluctuate over time, most dramatically because of external security threats leading to wars (as emphasized in Barro, 1979) but, on more modest scales, because of policy changes arising from economic, demographic, technological, and other factors. On the revenue side, fluctuations in incomes, population, and other revenue determinants produce swings in tax revenues over time. In some cases, unanticipated revenue shortfalls or windfalls may be accompanied by unanticipated changes in expenditures, for example by programmatic adjustments, hiring or wage freezes, or the deferral of capital expenditures, or the reverse. Similarly, unanticipated expenditure needs may be financed through short-run revenue-enhancements such as increases in fees or charges.

Of course, revenue and expenditure flows need not coincide precisely in any given period. As a matter of fundamental fiscal policy, as well as to meet short-run cash flow requirements, governments continuously adjust their financial and non-financial assets and liabilities. When revenue flows are high relative to current public-service provision commitments, governments may accumulate liquid assets, pay off outstanding liabilities, undertake added infrastructure expenditures, or acquire new assets such as buildings, land or other natural resources, or public enterprises. In the face of revenue shortfalls, governments may deplete financial reserves, defer or cancel planned capital expenditures, liquidate public assets, sell public enterprises, or otherwise reduce net assets. Of course, explicit government borrowing also plays an important role in bridging the gap between revenues and expenditures, as does implicit government borrowing or asset accumulation through the funding or underfunding of pension systems, insurance reserves, and other similar policy adjustments that

shift the balance between present and future cash outflows and inflows.

Exactly how governments manage to determine their long- and short-run policy objectives while complying with basic accounting cash flow constraints in a dynamic and uncertain environment – subject at all times to conflicting political imperatives – is not well understood. The institutional structure within which governments operate typically include annual budgeting for expenditures, compliance with accounting standards for the disclosure of expenditures, revenues, and asset and liability acquisitions and dispositions, adjustments of tax and other revenue-generating policies through the actions of legislatures or other governance bodies, and constraints imposed by financial and other markets, all plausibly play some role in determining the evolution of fiscal policies. Our objective in this paper is to present a theoretical and empirical analysis of the dynamic evolution of government finances in an explicitly intertemporal setting, within which governments may accumulate or decumulate real and financial assets while facing fundamental economic uncertainties that produce revenue fluctuations. In our theoretical model and in the accompanying empirical analysis, governments have at least some limited access to capital markets and financial instruments that can be used to shield “fundamental” fiscal policies from unanticipated shocks.

Our research builds upon the influential work by Barro (1979) on the use of government debt as an instrument for tax smoothing, a now familiar idea in the analysis of intertemporal fiscal policy. Tax smoothing models generally exploit the idea that governments can and do choose to reduce the deadweight loss from taxation by using financial policies – debt accumulation and decumulation – so as to avoid extremely high and distortionary taxes tax rates in some periods relative to other periods. We augment this model by recognizing that large fluctuations over time in public service provision may also entail efficiency losses, and that governments, at least efficient ones, would

therefore engage in “expenditure smoothing” by maintaining levels of public service provision over time that are less variable than would be the case if intertemporal financial transactions could not be used to offset temporary fiscal shocks. More particularly, with an eye to our empirical analysis, we develop a model in which government revenues are used to finance expenditures on public infrastructure or other real assets that produce a flow of services over time, and in which random fluctuations in the level of the public capital stock result in efficiency losses.

In this setting, both taxes and expenditures are jointly optimized and, in the absence of stochastic shocks, would be time invariant. However, we recognize that random fiscal shocks make it impossible for both revenues and expenditures to be perfectly smoothed over time. We allow for economic shocks that give rise to stochastic fluctuations in revenues, which in turn implies that government capital spending must vary accordingly except insofar as capital market transactions – borrowing and saving – are utilized to “detach” current expenditures from current revenues. With free access to capital markets, optimal government policy entails adjustments in capital spending over time that spreads the impact of revenue shocks across all future periods, via the gradual spending of windfall revenue gains and gradual reductions in future spending due to windfall revenue losses. On the other hand, if governments may face borrowing constraints, whether due to constitutional or statutory requirements (balanced-budget rules or debt limitations) or to market-imposed borrowing limits, governments choose lower levels of public capital investment, particularly in the early periods of the planning horizon, and will build financial reserves (“rainy day funds”) that enable them to absorb revenue shocks with smaller disruptions to capital spending. Nevertheless, the time path of capital spending will become more sensitive to revenue shocks under borrowing restrictions and even in the absence of adjustment cost will temporarily divert from the optimal long-term level.

This theoretical framework provides the foundation for an empirical analysis of a 25-year panel of more than 1000 municipal governments in the US. As expected, municipal government capital expenditures depend on lagged fiscal variables that reflect long-run fiscal optimization but also on lagged deficits, an indication that the current state of the budget is an additional determinant of capital spending. Furthermore, these impacts are especially pronounced when municipalities are subject to restrictions on access to capital markets. Capital expenditures are also more sensitive to contemporaneous revenue fluctuations in the presence of such restrictions, further evidence that the availability of financial tools with which to manage fiscal shocks affects “real” public sector investment decisions.

The present analysis is related to several earlier strands of research in public economics and macroeconomics. As already noted, it incorporates endogenous tax smoothing, which itself arises because governments must adhere to long-run intertemporal budget constraints, as examined, for example, in Bohn (1991) and, at the municipal level, in Buettner and Wildasin (2006), and in references cited therein. Holtz-Eakin and Rosen (1991) examine public capital spending in a stochastic dynamic optimization framework within which public service provision would optimally be smoothed over time; their analysis also allows for adjustment costs in capital investment that would lead to some smoothing in the level of capital expenditures. However, these authors do not incorporate tax smoothing in their analysis, presuming instead that revenues are adapted as desired in response to changing fiscal requirements. By contrast, we postulate that taxes are chosen in advance of the realization of stochastic revenue shocks, which implies that shocks affect current capital expenditures except insofar as they are offset by financial transactions (borrowing or saving). In this way, our analysis is related to previous studies on privatization that emphasize the financial incentives that

governments may face to liquidate (or, the reverse of privatization, to acquire) real assets such as public enterprises, natural resources, real estate, and the like.

The issues examined here are relevant for a number of policy issues. In particular, it highlights the importance of access to capital markets not only for purposes of long-run optimization of taxation and infrastructure-related public service provision but for purposes of adjustment to short-run stochastic shocks. Even when fiscal policies are optimized over long planning horizons, governments must still adjust to short-run shocks, and, in doing so, they face trade-offs between the pursuit of long-term goals and compliance with short-run constraints. Restrictions on access to capital markets change the financial environment within which long-term decisions are made and implemented as well as the capacity of governments to adapt to temporary stochastic fluctuations.

## **2 Optimal Public Investment, Tax, and Financial Policy**

This section presents a model of government tax and expenditure policy in a stochastic, dynamic environment. In this model, policies are chosen to maximize expected utility subject to an intertemporal budget constraint. To begin with, the analysis proceeds under the assumption that there are no restrictions on government access to capital markets; the implications of such restrictions are examined later.

## 2.1 The Basic Model

The objective function for the optimization problem may be viewed as that of a representative household, a natural specification in a world where the government serves a population of identical households. The objective function may also be interpreted as an “as if” representation of the more complex reality of political decisionmaking in a world of heterogeneous agents.<sup>2</sup>

The instantaneous utility of the household is  $\phi(x_t) + U(K_t) + V(G_t)$  where  $\phi(x_t)$  is a strictly increasing function of consumption of private goods  $x_t$ ,  $U(K_t)$  is a strictly increasing and concave function of the stock of public sector capital  $K_t$ , and  $V(G_t)$  represents the utility derived from other public expenditures  $G_t$ . Because the analysis focuses on the intertemporal aspects of public policy choices, it is convenient to abstract from issues relating to private intertemporal consumption smoothing by postulating that instantaneous utility is quasilinear in private consumption, so that  $\phi(x_t) \equiv x_t$ . For the same reason, it is convenient to treat the stream of other government expenditures  $G_t$  as exogenously fixed. Instantaneous utility is discounted in accordance with the pure time preference factor  $\beta$ , so that expected discounted utility is

$$\mathbb{E}_t \left[ \sum_{s=t} \beta^{s-t} \{x_s + U(K_s) + V(G_s)\} \right].$$

Risk in this model arises from random (and uninsurable) fluctuations in revenue. Revenue consists of two components:  $\tau_t$  captures the deterministic part reflecting the tax collection effort of the government and  $z_t$  is a stochastic component. Following Barro (1979), the collection of  $\tau_t$  is assumed

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<sup>2</sup>The “representative agent” justification for the expected utility approach is frequently used in macroeconomic analyses of entire nations. In the empirical analysis of Section 5, this model is applied to municipal government policies in the US.



to be associated with administrative or efficiency cost equal to  $h(\tau_s)$  where  $h(\cdot)$  is increasing and convex. As in Barro (1979), we assume that tax distortions and collection costs are deterministic, since they usually follow from the statutory tax structure. In addition, we allow for a stochastic component of revenues, reflecting the fact that the revenue realized from a given tax structure is not known in advance.

To focus on the public sector side of the model, assume for the moment that there is no private savings or borrowing (this assumption may be relaxed, see below), so that private consumption is equal to income net of taxes and deadweight loss, *i.e.*,  $x_s = Y_s - \tau_s - h(\tau_s)$ , where household income  $Y_s$  may be subject to random shocks.

The stock of public capital evolves according to

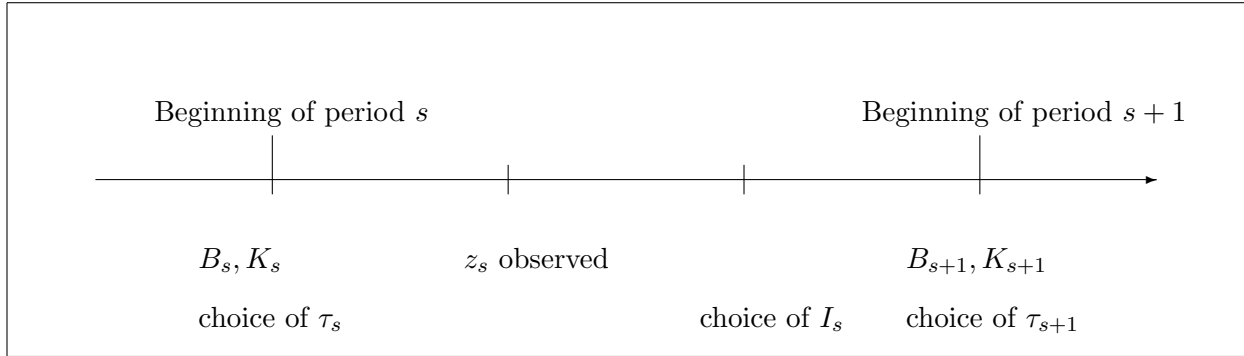
$$K_{s+1} - K_s = I_s - \delta K_s \tag{1}$$

where  $I_s$  is gross investment in period  $s$ , chosen *after* the realization of current revenues, and where  $\delta$  is a constant proportional rate of depreciation. The government operates subject to a budget identity that states that current government expenditure must be equal to current revenue plus the increase in debt, *i.e.*,

$$I_s + rB_s + G_s = \tau_s + z_s + B_{s+1} - B_s, \tag{2}$$

where  $B_s$  is the stock of government debt at the beginning of period  $s$  and  $r$  is the constant rate of interest. (Note that debt may be negative, in which case it represents positive net holdings of financial assets.)  $z_s$  denotes the stochastic component of tax revenues, where we leave the stochastic process unspecified but assume that the government knows the expected value.

Figure 1: Sequence of Events



As depicted in Figure 1, the government begins each period with some stock of capital and debt. It then chooses the taxes for the period, whereupon uncertainty about total revenues is resolved. The level of investment is then chosen, which determines the stock of capital in the next period. It also determines the stock of debt at the beginning of the next period. Thus, stochastic shocks to revenues  $z_s$  may lead to adjustments in investment spending  $I_s$  that insure satisfaction of the government's cash flow constraint, but these impacts can be offset by financial operations (accumulation or decumulation of financial assets or liabilities) that affect  $B_{s+1}$ .

Starting with initially given stocks of capital and debt and an exogenously given level of other government expenditures  $G_s$ , the government at each time  $s$  chooses its fiscal and financial instruments  $(\tau_s, I_s, B_{s+1})$  to maximize expected discounted utility subject to (1) and (2). Substituting from the former into the latter to eliminate  $I_s$ , the government may equivalently be modeled as choosing  $(\tau_s, K_{s+1}, B_{s+1})$  in each period  $s$  subject to a single constraint

$$B_{s+1} - K_{s+1} - ([1 + r] B_s - [1 - \delta] K_s) - (G_s - \tau_s - z_s) = 0 \quad (3)$$

so that the Lagrangian for the intertemporal optimization problem is

$$\mathcal{L} = \mathbf{E}_t \left[ \sum_{s=t}^{\infty} \left\{ \beta^{s-t} [Y_s - \tau_s - h(\tau_s) + U(K_s) + V(G_s)] \right. \right. \\ \left. \left. + \beta^{s+1-t} \lambda_{s+1} [B_{s+1} - K_{s+1} - ([1+r]B_s - [1-\delta]K_s) - (G_s - \tau_s - z_s)] \right\} \right]$$

where  $\lambda_{s+1}$  is the Lagrange multiplier corresponding to (3). This multiplier represents the shadow value of government revenue in period  $s$ .<sup>3</sup> The first-order conditions from this optimization are<sup>4</sup>

$$\frac{\partial \mathcal{L}}{\partial \tau_s} = -\mathbf{E}_t [1 + h'(\tau_s)] + \beta \mathbf{E}_t [\lambda_{s+1}] = 0 \quad (4)$$

$$\frac{\partial \mathcal{L}}{\partial K_{s+1}} = -\mathbf{E}_t [\lambda_{s+1}] + \mathbf{E}_t [U'(K_{s+1})] + \beta(1-\delta) \mathbf{E}_t [\lambda_{s+2}] = 0 \quad (5)$$

$$\frac{\partial \mathcal{L}}{\partial B_{s+1}} = \mathbf{E}_t [\lambda_{s+1}] - \beta(1+r) \mathbf{E}_t [\lambda_{s+2}] = 0. \quad (6)$$

Let us also impose a transversality condition for the stock of debt:

$$\lim_{s \rightarrow \infty} \rho^{s+1-t} \mathbf{E}_t [B_{s+1}] = 0,$$

where  $\rho$  is the discount factor  $\rho \equiv \left(\frac{1}{1+r}\right)$ . Using condition (3) we can use the transversality condition in order to derive the intertemporal budget constraint in expected value terms

$$\mathbf{E}_t \left[ \sum_{s=t} \rho^{s-t} (\tau_s + z_s) - \sum_{s=t} \rho^{s-t} \underbrace{\left[ K_{s+1} - (1-\delta)K_s \right]}_{I_s} - (1+r)B_t \right] - \bar{G}_t = 0, \quad (7)$$

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<sup>3</sup>This notation is also used by Chow (1997).

<sup>4</sup>The expressions make use of the ‘‘Law of Repeated Expectations’’ (e.g., Chow, 1997 p. 22, Ljungqvist and Sargent, 2004 p. 24).

where the second summand reflects the present value of investment spending and where  $\overline{G}_t$  denotes the present value of exogenous non-capital expenditures.

Next, let us assume, for simplicity, that the interest rate is equal to the subjective rate of time preference, *i.e.*,  $(1+r)\beta = 1$ . Under this assumption, it follows from (6) that the expected shadow value of government revenues is constant. From (4), we then see that the expected marginal deadweight loss from taxation in all periods is the same, a condition for an optimal intertemporal tax structure.

From the first-order conditions for  $\tau_s$  and  $K_{s+1}$  we can characterize the optimal policy as a combination of taxes and capital stock that obeys<sup>5</sup>

$$E_t [U' (K_{s+1})] = (r + \delta) E_t [1 + h' (\tau_s)] . \quad (8)$$

This rule for optimal investment states that the expected marginal benefit from an addition to the capital stock in the next period is equal to the cost of capital  $r + \delta$  adjusted upward to take into account the marginal deadweight loss of taxation. Note that with a constant level of taxes, the right-hand side of this expression would be time invariant, and hence the expected marginal benefit of a larger public capital stock would be the same in all periods.

Finally, recall that the formal setup of the dynamic optimization problem above has assumed that private consumption is equal to after tax net income in each period. Given the assumed equality between the rates of interest and time preference and the assumption that instantaneous utility is quasilinear in private consumption, however, expected utility is unaffected by changes in the timing

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<sup>5</sup> We make use of the fact that with  $(1+r)\beta = 1$  we can replace  $\frac{1-\beta(1-\delta)}{\beta}$  by  $r + \delta$ .

of private consumption. Thus, while the assumption that private consumption is equal to current net income has simplified the exposition, it is inessential, given the other assumptions of the model.

## 2.2 Linearizations

In order to derive more explicit characterizations of optimal investment, tax, and financial policies, let us use quadratic approximations to the utility function and deadweight loss functions:

$$U(K_s) = \eta \left( K_s - \frac{1}{2} K_s^2 \right)$$

$$h(\tau_s) = \frac{h}{2} \tau_s^2.$$

Now the marginal benefit and marginal deadweight loss functions are linear and we can immediately derive from equation (4) and (8) that the expected time paths for the optimal taxes and the capital stock are flat

$$\mathbf{E}_t[\tau_{s+1}] = \mathbf{E}_t[\tau_s] \tag{9}$$

$$\mathbf{E}_t[K_{s+1}] = \mathbf{E}_t[K_s]. \tag{10}$$

The first of these conditions is a stochastic version of the standard tax smoothing result (as in Barro (1979) and Bohn (1990)), since  $\mathbf{E}_t[\tau_{t+1}] = \tau_t$ . Whereas these and other analyses of dynamic fiscal policy typically assume that the time path of government expenditure is exogenously determined, however, the preceding analysis allows for optimization of government investment expenditures, and the second condition above shows that these policies are also smoothed over time. In particular, the

expected public capital stock is time invariant which means, from (1), that expected future public investment expenditures are also time invariant. Optimal government fiscal policies, in other words, are characterized by both tax *and* expenditure smoothing, in a stochastic sense.<sup>6</sup> Furthermore, the expected future capital stock is a linear function of expected taxes<sup>7</sup>

$$\mathbb{E}_t [K_{s+1}] = \left( \frac{\eta - (r + \delta)}{\eta} \right) - \left( \frac{(r + \delta) h}{\eta} \right) \mathbb{E}_t [\tau_s]. \quad (11)$$

Conditional on the optimal tax policy, infrastructure capital is larger and the capital stock is increased as  $\eta$  and, thus, the marginal benefit of the capital stock, increases. Similarly, the capital stock is also increased as the deadweight loss from taxation  $h$  diminishes, again conditional on the optimal tax policy.

Indeed, given the assumptions of quadratic preferences and deadweight loss functions, it is possible to solve the model explicitly. Together with the intertemporal budget constraint (7), equations (9) and (11) can be used to solve for the level of the tax and the level of investment in period  $t$ . The characteristics of the optimal policy are summarized by the following proposition.

**Proposition 1** *The optimal tax in the initial period  $t$  is a linearly increasing function of the initial capital stock  $K_t$  and a linearly decreasing function of initial debt  $B_t$  and the present value of exogenous government expenditures  $\bar{G}_t$ . The expected future levels of the tax are equal to the*

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<sup>6</sup>In parallel with previous literature, the foregoing analysis has treated other government expenditures as exogenously fixed. These expenditures would also be subject to smoothing if chosen optimally. Since the subsequent empirical analysis focuses on investment spending, however, it simplifies the exposition to assume that other expenditures are exogenous.

<sup>7</sup>The expression follows from (8) since with the functional form assumptions

$$\eta - \eta \mathbb{E}_t [K_{s+1}] = (r + \delta) + (r + \delta) h \mathbb{E}_t [\tau_s].$$

current optimal tax level. The level of investment in period  $t$  and the capital stock in period  $t+1$  is a linearly increasing function of the current realization of the random component of revenues  $z_t$  and of the initial capital stock  $K_t$ , and is a linearly decreasing function of the initial stock of debt and of the present value of exogenous public expenditures. The expected future stock of public capital is equal to the level chosen upon the realization of current tax revenues.

**Proof:** We can use equation (11) to replace the sequence of investment in the intertemporal budget constraint by a sequence of taxes. Repeated substitution yields the following expression for the expected value of investment

$$\mathbf{E}_t [I_s] = \mathbf{E}_t [K_{s+1}] - (1 - \delta) \mathbf{E}_t [K_s] = \left( \left( \frac{\eta - (r + \delta)}{\eta} \right) - \left( \frac{(r + \delta) h}{\eta} \right) \tau_t \right) \delta, \quad s \geq t + 1.$$

With this expression we can rewrite the intertemporal budget constraint and obtain

$$\begin{aligned} & \tau_t \sum_{s=t} \rho^{s-t} + \sum_{s=t} \rho^{s-t} \mathbf{E}_t [z_s] + \left( \frac{(r + \delta) h}{\eta} \right) \tau_t \sum_{s=t} \rho^{s-t} + \left( \frac{(r + \delta) h}{\eta} \right) (1 - \delta) \tau_t \\ &= \left( \frac{\eta - (r + \delta)}{\eta} \right) \delta \sum_{s=t} \rho^{s-t} + \left( \frac{\eta - (r + \delta)}{\eta} \right) (1 - \delta) + (1 + r) B_t + \bar{G}_t - (1 - \delta) K_t. \end{aligned}$$

Rearranging terms we obtain

$$\begin{aligned} \tau_t \left[ \sum_{s=t} \rho^{s-t} + \left( \frac{(r + \delta)^2 h}{r \eta} \right) \right] &= (1 + r) B_t + \bar{G}_t - (1 - \delta) K_t \\ &+ \left( \frac{\eta - (r + \delta)}{\eta} \right) \left( \frac{\delta + r}{r} \right) - \sum_{s=t} \rho^{s-t} \mathbf{E}_t [z_s]. \end{aligned} \quad (12)$$

This proves the statements about the level of taxes. The statements about the capital stock follow since the stock of capital is a linear function of the level of taxes, see equation (11). ■

To summarize, the basic model shows how optimal government tax and expenditure policies are chosen in a dynamic stochastic environment when the government has access to perfect capital markets. Through its borrowing and savings decisions, it is able to smooth tax policies over time, independently of current expenditure requirements. In addition, it can use financial instruments to adjust to unanticipated fluctuations in revenues, although such fluctuations do also affect current capital expenditures, even in a fully forward-looking decisionmaking context. A key point to note, however, is that unanticipated shocks produce a change in the entire planned time path of future fiscal policies. Financial instruments make it possible for the government to spread the necessary adjustment to unanticipated shocks over the entire planning horizon, so that current investment expenditures do not bear the entire burden of such adjustments.

### 2.3 Capital Market Restrictions

Governments may be unable to save or borrow as much as desired at prevailing interest rates due to a variety of market imperfections. These may take a variety of forms relating to the operation of bond markets, banking, insurance, and other financial institutions, and to regulations such as balanced budget constraints and debt limitations. These issues are discussed in more detail below, but for the moment, in order to show formally what the effects of such imperfections may be, let us extend the previous analysis by adding a new constraint on the government's optimization problem that states that its debt cannot exceed some specified amount:

$$\bar{B}_t \geq B_s, \quad s > t.$$



To begin, let us restate the government optimization problem in the general case considered in Section 2.1. To derive the optimal policy we add a set of further conditions to the above Lagrangian:<sup>8</sup>

$$\begin{aligned} \mathcal{M} = & \mathbf{E}_t \left[ \sum_{s=t}^{\infty} \left\{ \beta^{s-t} [Y_s - \tau_s - h(\tau_s) + U(K_s) + V(G_s)] \right. \right. \\ & + \beta^{s+1-t} \lambda_{s+1} [B_{s+1} - K_{s+1} - ([1+r]B_s - [1-\delta]K_s) - (G_s - \tau_s - z_s)] \\ & \left. \left. + \beta^{s+1-t} \mu_{s+1} [\bar{B}_t - B_{s+1}] \right\} \right]. \end{aligned}$$

With this extension we get a slightly different first-order condition for  $B_{s+1}$

$$\frac{\partial \mathcal{M}}{\partial B_{s+1}} = \mathbf{E}_t [\lambda_{s+1}] - \beta(1+r) \mathbf{E}_t [\lambda_{s+2}] - \mathbf{E}_t [\mu_{s+1}] = 0, \quad (13)$$

$$\begin{aligned} \text{where} \quad \mu_{s+1} > 0 & \quad \text{if} \quad \tau_s + z_s - G_s + (1-\delta)K_s = (1+r)B_s + K_{s+1} - \bar{B}_t \\ \mu_{s+1} = 0 & \quad \text{if} \quad \tau_s + z_s - G_s + (1-\delta)K_s > (1+r)B_s + K_{s+1} - \bar{B}_t. \end{aligned}$$

With the simplifying assumption that  $1 = \beta(1+r)$  the extended version of the Euler equation (13) implies that the shadow value of funds is expected to decline over time  $\mathbf{E}_t [\lambda_{s+2}] = \mathbf{E}_t [\lambda_{s+1}] - \mathbf{E}_t [\mu_{s+1}]$ . The intuition is simply that the likelihood of facing a binding debt limit results in a higher shadow value of funds in the earlier periods.

This is, of course, also reflected in the time-path of the taxes. Making use of the above simplifying

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<sup>8</sup>Of course, this extension of the model is somewhat restrictive as it implies that a government will always obey any debt limitations regardless of the cost involved, or, equivalently, that the costs of noncompliance with these limitations is prohibitive.

assumptions about functional forms we obtain

$$\mathbf{E}_t [\tau_{s+1}] = \mathbf{E}_t [\tau_s] - \frac{\beta}{h} \mathbf{E}_t [\mu_{s+1}]. \quad (14)$$

Conditional on  $\mu_{t+1}$  taxes are thus expected to decline over time.

As above, optimal policy is characterized by a combination of tax rate and public capital stock, now satisfying the condition that

$$\mathbf{E}_t [U' (K_{s+1})] = (r + \delta) \mathbf{E}_t [1 + h' (\tau_s)] + \beta (1 - \delta) \mathbf{E}_t [\mu_{s+1}].$$

Because the likelihood of a deficit implies a positive expected value of  $\mu_{s+1}$  we can see that the debt limitation drives a wedge between the cost of raising public funds and the marginal benefits derived from these funds. Assuming quadratic utility and deadweight loss functions as in Section 2.2, the expected capital stock is a linear function of the expected taxes and of the expected cost associated with the debt limit

$$\mathbf{E}_t [K_{s+1}] = \left( \frac{\eta - (r + \delta)}{\eta} \right) - \frac{h (r + \delta)}{\eta} \mathbf{E}_t [\tau_s] - \frac{\beta (1 - \delta)}{\eta} \mathbf{E}_t [\mu_{s+1}]. \quad (15)$$

We can use equations (14) and (15) to replace the sequence of investment in the intertemporal budget constraint by sequences of taxes and of the shadow value of the debt limit. Together with the intertemporal budget constraint we can derive an optimal policy that differs in some important ways from the case without borrowing restrictions:

**Proposition 2** *For any given initial conditions, the current optimal level of taxation is higher, and the optimal public investment is lower, if there are limitations on the stock of government debt.*

**Proof:** Reformulation of equation (14) yields

$$\mathbf{E}_t[\tau_s] = \tau_t - \frac{\beta}{h} \sum_{r=t+1}^s \mathbf{E}_t[\mu_r]. \quad (16)$$

With (15) the expected value of investment in period  $s$  can be rewritten as

$$\mathbf{E}_t[K_{s+1}] - (1 - \delta) \mathbf{E}_t[K_s] = \left( \left( \frac{\eta - (r + \delta)}{\eta} \right) - \left( \frac{h(r + \delta)}{\eta} \right) \tau_t \right) \delta + A_s, \quad (17)$$

where  $A_s$  is a function of the expected shadow value of the debt limit in the periods starting in  $t + 1$  until  $s + 1$ :

$$A_s = \frac{(r + \delta) \beta \delta}{\eta} \sum_{r=t+1}^s \mathbf{E}_t[\mu_r] + \frac{(r + \delta) \beta (1 - \delta)}{\eta} \mathbf{E}_t[\mu_s] - \frac{\beta (1 - \delta)}{\eta} (\mathbf{E}_t[\mu_{s+1}] - (1 - \delta) \mathbf{E}_t[\mu_s]).$$

Since  $(r + \delta) \beta = 1 - (1 - \delta) \beta$  (see Footnote 5) we can simplify this expression and obtain

$$A_s = \frac{(r + \delta) \beta \delta}{\eta} \sum_{r=t+1}^s \mathbf{E}_t[\mu_r] - \frac{1 - \delta}{\eta} (\beta \mathbf{E}_t[\mu_{s+1}] - \mathbf{E}_t[\mu_s]). \quad (18)$$

Using (17) and (18) we can rewrite the intertemporal budget constraint as

$$\begin{aligned} \sum_{s=t} \rho^{s-t} (\mathbf{E}_t[\tau_s] + \mathbf{E}_t[z_s]) + \left( \frac{(r + \delta)^2 h}{\eta r} \right) \tau_t &= (1 + r) B_t + \bar{G}_t - (1 - \delta) K_t \\ &+ \left( \frac{\eta - (r + \delta)}{\eta} \right) \left( \frac{r + \delta}{r} \right) \end{aligned}$$

$$+ \sum_{s=t+1} \rho^{s-t} A_s - \frac{\beta(1-\delta)}{\eta} \mathbf{E}_t [\mu_{t+1}].$$

This expression is somewhat difficult to interpret since  $A_s$  contains a sum of all future shadow values of the debt limit  $\mathbf{E}_t [\mu_s]$  on the right-hand side. However, the last two terms can be reformulated as follows:

$$\sum_{s=t+1} \rho^{s-t} A_s - \frac{\beta(1-\delta)}{\eta} \mathbf{E}_t [\mu_{t+1}] = \frac{(r+\delta)\delta}{r\eta} \sum_{s=t+1} \beta^{s-t} \mathbf{E}_t [\mu_s] - \left( \frac{1-\delta}{\eta} \right) \lim_{s \rightarrow \infty} \beta^{s+1-t} \mathbf{E}_t [\mu_{s+1}].$$

Imposing a transversality condition for  $\mu_{s+1}$  ( $\lim_{s \rightarrow \infty} \rho^{s+1-t} \mathbf{E}_t [\mu_{s+1}] = 0$ ) we get

$$\begin{aligned} \sum_{s=t} \rho^{s-t} (\mathbf{E}_t [\tau_s] + \mathbf{E}_t [z_s]) + \left( \frac{(r+\delta)^2 h}{r\eta} \right) \tau_t &= (1+r) B_t + \bar{G}_t - (1-\delta) K_t \\ &+ \left( \frac{\eta - (r+\delta)}{\eta} \right) \left( \frac{r+\delta}{r} \right) \\ &+ \frac{(r+\delta)\delta}{r\eta} \sum_{s=t+1} \beta^{s-t} \mathbf{E}_t [\mu_s]. \end{aligned}$$

Replacing the expected value of the tax rate in period  $s$  using (16) we can solve for the tax rate in period  $t$  and obtain

$$\begin{aligned} \tau_t \left[ \sum_{s=t} \rho^{s-t} + \left( \frac{(r+\delta)^2 h}{r\eta} \right) \right] &= (1+r) B_t + \bar{G}_t - (1-\delta) K_t \tag{19} \\ &+ \left( \frac{\eta - (r+\delta)}{\eta} \right) \left( \frac{r+\delta}{r} \right) - \sum_{s=t} \rho^{s-t} \mathbf{E}_t [z_s] \\ &+ \frac{(r+\delta)\delta}{r\eta} \sum_{s=t+1} \beta^{s-t} \mathbf{E}_t [\mu_s] \\ &+ \frac{\beta}{h} \sum_{s=t+1} \rho^{s-t} \mathbf{E}_t \sum_{r=t+1}^s \mathbf{E}_t [\mu_r]. \end{aligned}$$

The first two rows are exactly identical to equation (12). The third row captures the expected

present value of the cost associated with the debt limit and the last row reflects the expected revenue losses from the decline in the tax rate over time. Since the last two terms are positive, in comparison with (12), we can clearly see that the level of taxation is higher. With higher taxes, however, we know from equation (15) that the capital stock is lower. ■

Having seen how the optimal levels of taxes and the capital stock change in the presence of budget restrictions, we finally examine the consequences of actual realizations in the budget for the time path of the optimal policy. Given our basic assumption about the timing of events we focus on the optimal capital stock and state another consequence of debt limits as:

**Proposition 3** *In the presence of borrowing restrictions, favorable (unfavorable) revenue shocks result in increases (decreases) in current investment expenditures that result in an increase (decrease) in the capital stock. These capital stock adjustments are expected to be partially reversed in the following period.*

**Proof:** While we have assumed that tax policy is set *ex ante*, *i.e.*, before the actual revenue is realized, current investment is set *ex post*. The implications can be seen from the first order condition for the capital stock before and after revenue is realized. Before realization, we have

$$\mathbf{E}_t [U' (K_{t+1})] = \mathbf{E}_t [\lambda_{t+1}] - \beta (1 - \delta) \mathbf{E}_t [\lambda_{t+2}],$$

where the shadow value obeys  $\mathbf{E}_t [\lambda_{t+2}] = \mathbf{E}_t [\lambda_{t+1}] - \mathbf{E}_t [\mu_{t+1}]$  and thus

$$\mathbf{E}_t [U' (K_{t+1})] = (1 - \beta (1 - \delta)) \mathbf{E}_t [\lambda_{t+1}] + \beta (1 - \delta) \mathbf{E}_t [\mu_{t+1}].$$

After uncertainty about the stochastic component of revenues  $z_t$  is resolved the Euler equation becomes  $\mathbf{E}_{t+1} [\lambda_{t+2}] = \lambda_{t+1} - \mu_{t+1}$  and we have

$$U'(K_{t+1}) = (1 - \beta(1 - \delta)) \lambda_{t+1} + \beta(1 - \delta) \mu_{t+1}.$$

With this new set of information the capital stock in period  $t + 2$  is equal to

$$\mathbf{E}_{t+1} [U'(K_{t+2})] = (1 - \beta(1 - \delta)) \mathbf{E}_{t+1} [\lambda_{t+2}] + \beta(1 - \delta) \mathbf{E}_{t+1} [\mu_{t+2}].$$

Now, consider the time path of the optimal capital stock given the realization of revenues

$$U'(K_{t+1}) - \mathbf{E}_{t+1} [U'(K_{t+2})] = (1 - \beta(1 - \delta)) (\lambda_{t+1} - \mathbf{E}_{t+1} [\lambda_{t+2}]) + \beta(1 - \delta) (\mu_{t+1} - \mathbf{E}_{t+1} [\mu_{t+2}]).$$

Inserting the Euler equation for the shadow value of public funds we obtain

$$U'(K_{t+1}) - \mathbf{E}_{t+1} [U'(K_{t+2})] = (1 - \beta(1 - \delta)) \mu_{t+1} + \beta(1 - \delta) (\mu_{t+1} - \mathbf{E}_{t+1} [\mu_{t+2}]). \quad (20)$$

Without debt limits  $\mu_{t+1} = 0$  and  $\mathbf{E}_{t+1} [\mu_{t+2}] = 0$ . Therefore, (20) shows that the capital stock is immediately set at its new steady-state level after the realization of  $z_t$  in the absence of debt limits, confirming Proposition 1.

With debt limits, the right-hand side of (20) is generally either positive or negative, depending on the realization of  $z_t$ . Favorable realizations of  $z_t$  result in positive revenue shocks such that  $\mu_{t+1}$  is relatively low or zero and the right hand side of (20) is negative, whereas the opposite case occurs

when there are unfavorable revenue shocks. In the former case, the level of current investment spending results in a value of  $K_{t+1}$  below its expected future value, while the reverse is true in the latter case. ■

Figures 2 and 3 illustrate and compare the results of Propositions 1 and 3 by showing the time paths of the expected capital stock adjustment in response to a favorable revenue realization. Figure 2 refers to the case where capital market constraints are absent and shows that there is no expected future adjustment to the capital stock once it responds to a revenue shock. As is depicted in Figure 3, if there are such constraints, however, the immediate adjustment of the capital stock is partially reversed (in expectation) in the next following period.

## **2.4 Capital Market Institutions, Intergovernmental Transfers, and Intergovernmental Regulation**

The preceding analysis has assumed, first, that the government has access to a capital market where it can borrow and lend as much as desired at a given interest rate of  $r$ . It then examines the implications of a very simple departure from a “perfect” capital market, in the form of rigid limits on the amount of government debt. The real-world institutions through which government infrastructure spending is financed are of course much more complex than this simple model allows. In the case of municipal government infrastructure spending, which is the focus of the subsequent empirical analysis, it is important to recognize that external sources of finance for government expenditures include both debt (bonds and other financial instruments issued by municipalities and their subordinate agencies) and intergovernmental transfers (explicit grants as well as implicit subsidies from

Figure 2: Investment Response to a Favorable Revenue Shock: Unconstrained Case

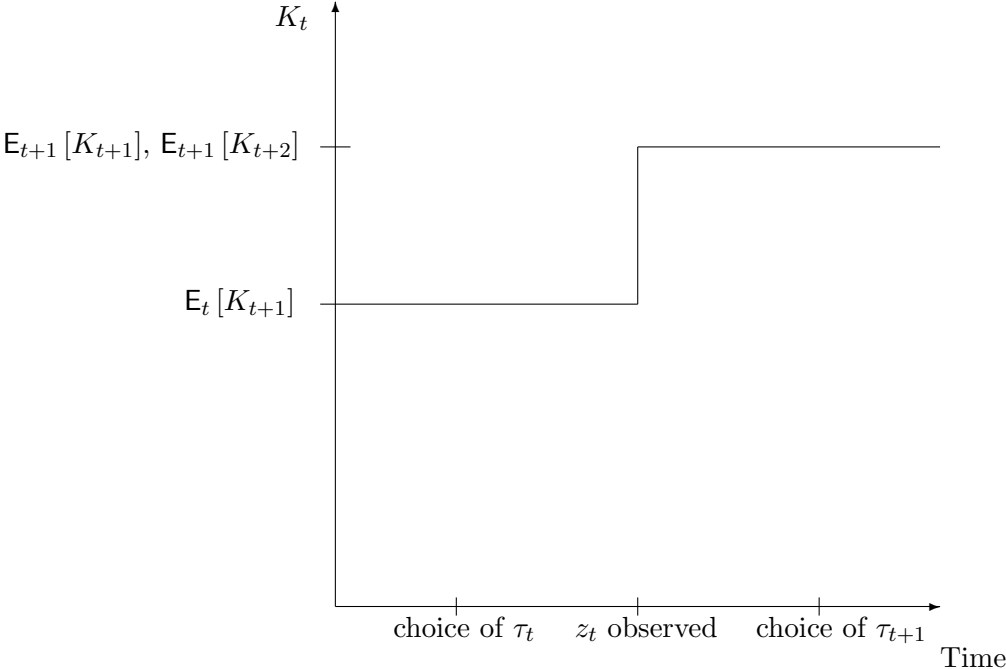
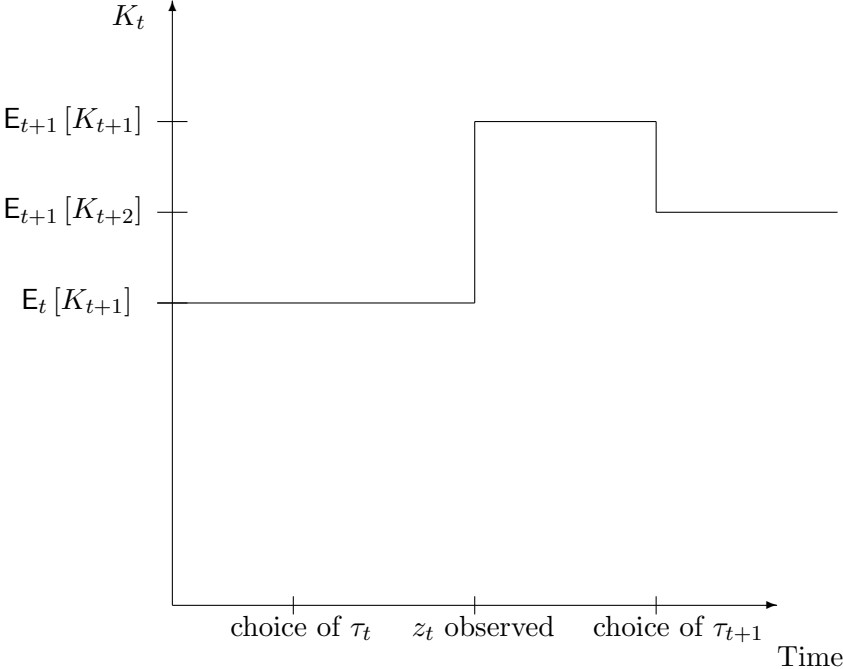


Figure 3: Investment Response to a Favorable Revenue Shock with Debt Limitation





higher-level governments). These inter-related funding sources constitute the institutional structure within which municipal finances and expenditures are managed and determined.

As has been discussed in the literature on optimal credit contracts, capital markets exhibit a wide range of contract forms, reflecting not only the riskiness of different kinds of debt but also incentives arising from informational asymmetries. In a more general framework than that developed above, credit contracts would be described by the amount of credit offered,  $B$ , together with a possibly nonlinear or discontinuous schedule  $r(B, \theta)$  showing the interest to be paid as a function of the amount of credit offered, contingent on the state of nature  $\theta$ , where  $\theta$  is now interpreted quite generally to be any random variable that is relevant for credit contracting, including but not limited to stochastic revenue shocks such as those represented by  $z_s$  in the model above. Simple forms of credit rationing that limits the total amount of credit, such as has been incorporated in the model above, would then be characterized by a schedule  $r(\cdot)$  such that the interest rate becomes prohibitively high above some credit limit  $\bar{B}$ . In a world with many competing borrowers and lenders, this limit would be endogenously determined by market forces but would be taken as parametrically given by any one borrower. Within the entire class of credit contracts  $B, r(B, \theta)$ , of course, far more complex contract structures are possible, but it goes beyond the scope of the present analysis to derive the structure of equilibrium credit contracts. The more limited goal of the present analysis has been to demonstrate how departures from the simplest assumptions of perfect capital markets can interact with real investment decisions by governments, and to provide a foundation for the empirical analysis to follow. In the empirical analysis, constraints on borrowing derive from readily-observable regulations governing the conditions under which debt can be issued by the municipal governments that are the subject of that investigation.

As noted, intergovernmental transfers can be a significant source of funds for municipalities and other subnational governments. Sometimes these take the form of simple grants, which might be captured in the model as a direct augmentation of revenues available for capital expenditures. Such grants can be incorporated into the preceding model with only minor modifications of notation, and would not affect the basic results. In practice, higher-level governments also sometimes assist lower-level governments by offering loans at concessionary rates, with an implicit subsidy or net intergovernmental transfer equal to the difference between the market interest rate and the terms on which credit is extended to the lower-level government.<sup>9</sup> Of course, to the extent that a borrower is able to obtain financing at a favorable rate, it will do so. The foregoing model could thus be applied in situations where the interest rate  $r$  is actually the concessionary rate offered by a higher-level government, and  $B_t$  is the amount borrowed at this concessionary rate.

If a government faces a sufficiently favorable concessionary interest rate, government borrowing and capital spending would increase, perhaps very substantially. In the extreme, if the interest rate were zero, capital stock would rise without bound (or up to the satiation level), and the superior government that offers such favorable terms would have to cap the amount of any loans.<sup>10</sup> A zero-interest loan with a cap is effectively equivalent to a lump-sum intergovernmental grant of an amount equal to the cap, say  $\bar{B}$ . Of course, many intergovernmental grants are much more complex than this, involving possibly nonlinear and discontinuous subsidies. However, just as a thorough

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<sup>9</sup>In the US, favorable tax treatment of the interest on municipal bonds allows these governments to borrow at below-market rates, giving rise to an annual tax expenditure now estimated at approximately \$27 billion (USGPO *Analytical Perspectives, Budget of the United States Government, Fiscal Year 2008*, 296).

<sup>10</sup>Subsidized borrowing by subnational governments creates incentives for them to exploit arbitrage opportunities by becoming financial intermediaries, borrowing at low rates and lending at high rates, a phenomenon that in the US has led to Federal statutes that restrict the amount of “private activity bonds” that each state may issue. In 2005, for instance, each state was allowed to issue such bonds up a limit of \$240 million or, if larger, up to \$80 per capita (Belmonte, 2005).

analysis of optimal credit contracts goes beyond the scope of the present paper, we do not attempt to model the full complexity of intergovernmental fiscal relations here.

Many subnational governments receive intergovernmental grants, are able to borrow at concessionary rates, and borrow or invest in financial markets simultaneously, presumably adjusting along all of these margins depending on the terms offered by market participants and by higher-level governments subject to basic statutory, constitutional, and other institutional constraints. In analyzing the investment decisions of municipalities or other subnational governments in the US and elsewhere, it should be kept in mind that intergovernmental transfers as well as capital market transactions provide funds for long-term capital projects as well as for short-run adjustment to stochastic shocks, and that these two main sources of financing, public and private, are thus somewhat substitutable for one another. No simple model can capture the full complexity of these institutions, but the preceding analysis has nonetheless demonstrated three key points. First, as shown in Proposition 1, unrestricted access to capital markets allows governments to pursue intertemporal tax and capital expenditure policies that reflect long-run efficiency considerations as well as to adapt to short-run stochastic shocks. Second, as shown in Proposition 2, restrictions on access to capital markets create incentives for governments to raise taxes, to reduce the level of capital investment, and to accumulate liquid assets in an attempt to limit the impact of short-run shocks on real investment decisions over time. Third, restrictions nevertheless raise the sensitivity of investment to short-run stochastic shocks and provide an incentive to deviate temporarily from the optimal future time path of tax and investment policies.

### 3 Empirical Implications for Public Investment

As the above theoretical discussion has shown, a straightforward stochastic model using relatively mild assumptions about functional forms allows us to predict that borrowing restrictions have noticeable implications for public investment. Without debt limits and in an environment without disturbances economic theory suggests that the government would choose a capital stock such that the marginal benefit is equal to the marginal cost, which consist of the capital cost, the sum of interest and depreciation rates, evaluated at the marginal cost of raising public funds. In the absence of adjustment cost, an optimal policy would be implemented in period  $t$  and would cause a steady situation from period  $t+1$  onwards. In this rather standard setting, the realization of revenue shocks has straightforward implications for tax policy and investment. With new information arriving in period  $t$ , the optimal policy would result in new steady-state levels of the tax rate and the capital stock and tax policy and investment would immediately start to adjust to these new levels even if this results in temporary budget deficits or surpluses. With borrowing restrictions, however, these predictions change. The risk of incurring deficits leads to some precautionary savings, which would result not only in a higher tax rate but also in a lower capital stock. Moreover, in response to revenue shocks we would observe fluctuations in investment since with borrowing restrictions the optimal stock of capital would temporarily deviate from the steady state level.

How can we use this theory to predict public investment? Empirically, the theory suggests that the capital stock in the current period should be a function, first of all, of the marginal benefit of infrastructure and of the cost. The latter consisting of the current tax effort and of the capital cost. Since the amount of public services that can be provided at a specific level of tax effort depend

on the tax base and on other sources of revenue, the decision about the tax effort also reflects expectations about all those sources of revenue.

This suggests that in order to predict the capital stock we should use indicators capturing differences in the expected present value of revenue sources given the information available at the time of the investment decision. To begin with, this should include actual tax revenue collected and the level of per-capita income. Similarly, the level of grants received might serve as a reasonable predictor for future intergovernmental revenue. As the theory has emphasized the role of precautionary savings we should include a variable that captures differences in the available stock of liquid financial assets. To this end we employ an indicator of cash holdings including so-called “rainy-day” funds. Another variable that might be useful to predict local policies is the stock of debt, and, perhaps, the debt service that also captures differences in the interest rate. Furthermore, the theory suggests to include some variables that capture differences in the marginal cost of raising public funds; if, for instance, large jurisdictions face a less sensitive tax base than small jurisdictions the population size is inversely related to the marginal cost of funds. Besides these rather conventional variables (*cf.*, Holtz-Eakin, Rosen, 1991) the above theory suggests to employ an indicator of the leeway in the current budget, at least in the presence of budget restrictions. A useful variable in this regard might be the level of the deficit/surplus. In the light of the theory, we expect that this variable exerts a stronger impact on investment expenses of municipalities that face stronger budgetary restrictions. Since we need to condition on the information available at the time of the investment decision, we focus on the deficit/surplus and other fiscal variables as realized in the previous period.

Given our assumptions about the sequence of events, we also need to employ an indicator of revenue shocks in the current period. Of course, this raises a problem of simultaneity since tax

revenues in the current period will not only capture the information available at the time when investment decisions are taken. Unless the investment decision is taken at the last day of the budget period for which revenue flows are reported, current revenues would also capture immediate revenue consequences of these decisions. Moreover, current changes in revenues might also reflect discrete policy choices taken, for instance, to finance additional spending.

In order to test whether fluctuations in the realized budget or in some of its components do in fact exert stronger temporary effects on public investment if the government operates under a debt limit, it would be interesting to inspect the choice of the capital stock under different institutional settings. This calls for an analysis combining data for different governments. An excellent case to study is that of local governments in the US which operate under different constraints since the state laws governing local government administration differ in some significant ways as we will see below.

The basic regression approach used is

$$\text{inv}_{i,t} = a_i + b_1 \text{inv}_{i,t-1} + b_2 x_{i,t-1} + b_3 \text{def}_{i,t-1} + b_4 \Delta \text{rev}_{i,t} + c_t + v_{i,t} \quad (21)$$

$\text{inv}_{i,t}$  captures investment in municipality  $i$  in year  $t$ ,  $\text{def}_{i,t-1}$  refers to the lagged deficit/surplus,  $x_{i,t-1}$  to other fiscal variables including the lagged level of revenues, and  $\Delta \text{rev}_{i,t}$  depicts the change in revenues with regard to the previous year, all expressed in per-capita terms. This dynamic regression approach allows us to study the changes in investment spending triggered by previous deficits/surpluses, by the current revenue development, and by the variation of other determinants of local investment spending around some average level captured by the constants  $a_i$  and  $c_t$ .

To control for a possible simultaneity bias with regard to the change of revenues, we use an instrumental variable approach based on information about the specific tax structure of the individual municipalities. As a matter of fact, U.S. municipalities document substantial differences in their tax structure. In the balanced sample of U.S. municipalities used below, for instance, property tax revenues are reported to make up on average about 61% of total tax revenues. Yet half of all municipalities report a property tax revenue share below 36% or above 92%. Other important tax revenue sources are general sales, income, or public utility taxes. While the tax structure differs, due to common economic trends or shocks in the tax law the evolution of revenues for each specific type of tax is subject to some common factors for all municipalities nationwide that are exogenous for the individual municipalities. Depending on their individual revenue structures these nationwide trends will affect individual municipalities differently, and, thus, can be used to predict the revenues of the individual municipality. We will come back to this issue below.

In order to test whether the deficit and current revenues exert a stronger effect under conditions of formal budget restrictions we can extend the regression as follows

$$\begin{aligned} \text{inv}_{i,t} &= a_i + b_1 \text{inv}_{i,t-1} + b_2 x_{i,t-1} + b_3 \text{def}_{i,t-1} + b_4 \Delta \text{rev}_{i,t} \\ &+ b_5 (\text{dlim}_i = 1) \text{def}_{i,t-1} + b_6 (\text{dlim}_i = 1) \Delta \text{rev}_{i,t} + c_t + v_{i,t}, \end{aligned} \tag{22}$$

where  $\text{dlim}_i = 1$  in the presence of restrictions. Alternatively, we might give up the assumption that other slope parameters are constant and will compare the results for the above basic estimation equation (21) in various subsamples of municipalities that face different restrictions.

In both specification we employ not only fixed time effects but also municipal-specific fixed effects.

This is important for several reasons.

(i) One reason to include municipal fixed effects is the existence of possibly unobserved differences in the determinants of the public capital stock.

(ii) A related reason is the fact that we do not observe the level of the capital stock. What is usually reported is the level of public investment. In order to derive the stock of capital at the end of the period we would also need information about the existing stock of capital at the beginning of the period and about depreciation during the current period. With the aid of assumptions regarding depreciation and about initial stocks of capital we could, of course, use the public investment data and apply some standard techniques such as a perpetual inventory formula in order to provide own estimates of the public capital stock. However, as there is no information on initial stocks of public capital available, we take resort to the panel data feature of the data and capture variation in the stock of capital by means of municipal fixed effects combined with the lagged level of investment.

(iii) A third reason to include municipal fixed effects, however, relates to a fundamental identification problem in the analysis of institutions such as balanced–budget rules. Despite some evidence for a positive effect of budget rules on budgetary discipline, it remained difficult to say, whether this result is due to the institution itself or to the general attitude towards budgetary discipline which has lead to the implementation of formal rules (*e.g.*, Bohn and Inman, 1996, Poterba, 1994, Alesina and Perotti, 1999). From an econometric perspective, this is a problem of selection bias as municipalities operating in a specific institutional setting might “self-select” into this setting. If we treat  $a_i$  as individual specific fixed-effects, however, we can effectively control for selectivity in a panel context (Verbeek and Neyman, 1992).



An empirical estimation approach using panel data for U.S. municipalities, therefore, may allow us to study whether the deficit has a predictive power on investment and whether the impact of the deficit or alternative measures of current fiscal conditions becomes stronger in the presence of borrowing restrictions.

## 4 Data

The empirical analysis employs annual data for U.S. municipalities obtained from the quinquennial Census of Governments (COG) and the accompanying Annual Survey of Government Finances (ASOGF). We focus on a balanced panel data set for 1266 cities annually reported in the COG/ASOGF. The observations cover a period of 26 years from 1972 to 1997 for a total of 32,916 city-year observations.<sup>11</sup> Using the COG data we define several fiscal variables, which are constructed from Bureau of Census fiscal classifications as shown in Table 1. Investment comprises spending on construction and other capital outlays. There are two revenue variables, own-source revenue and intergovernmental revenue (“grants”) obtained from other governments. Many municipalities hold significant interest-bearing financial assets, but, since asset values are usually not reported in the data, it is not possible to determine net indebtedness. It is therefore preferable to work with several variables: (net) debt service, the stock of debt, and cash-holdings.

While the fiscal variables refer to the previous year, we also employ current changes in own revenues in order to capture the revenue development in the current year. As has been noted above, this indicator might suffer from different types of simultaneity biases. We, therefore, employ detailed

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<sup>11</sup>See Buettner and Wildasin (2006) for a description of the basic dataset. Observations for three municipalities were dropped due to data problems.

Table 1: Definition of Fiscal Variables

	Variable	Components ( <i>Bureau of Census categories</i> )
(i)	Investment	Expenditures on <i>Construction, Other Capital Outlays</i>
(ii)	Own Revenue	<i>Total Taxes, Total General Charges, Total Miscellaneous General Revenue</i> excluding <i>Interest Revenue</i>
(iii)	Grants	<i>Intergovernmental Revenue</i> from all other U.S. Governments
(iv)	Debt Service	<i>Total Interest on General Debt</i> net of <i>Interest Revenue</i>
(v)	General Deficit	(i) + (iv) - (ii) - (iii) + <i>General Expenditure</i> excluding <i>Interest on General Debt</i> and <i>Investment</i>
(vi)	Outstanding Debt	Stock of <i>General Debt</i> at the end of the year
(vii)	Cash Holdings	<i>Other Cash Holdings</i> (not related to <i>Insurance Trusts</i> ) and <i>Deposits</i>

data on the tax structure of each municipality to obtain a set of instrumental variables. More specifically, we assume that annual changes in own revenue partly reflect nationwide shocks to each of the various taxes employed by the municipality. Since each municipality entered the current period with a specific tax structure, the municipalities will all be differently affected by these shocks. Thus, the set of instruments is a vector of the revenue shares of the various taxes for each municipality in the previous period.<sup>12</sup> While a similar approach could be taken with regard to other sources of revenue, we focus on the tax revenue shares. Intergovernmental revenue or fees are often related to specific government activities and are subject to conditions that make it difficult to discern common factors.

Besides fiscal variables we control for differences in per-capita income (at county level) as an important indicator of current and future revenue potentials. To capture possible differences in

<sup>12</sup>Actually, we rely on a decomposition of local taxes in seven groups comprising the largest taxes (Census classification code in parentheses): property tax (T01), general sales tax (T09), alcoholic beverage tax (T10), public utilities tax (T15), other selective sales tax (T19), individual income tax (T40), and a residual category comprising motor fuels tax (T13), tobacco tax (T16), motor vehicle licenses (T24), and taxes taxes not elsewhere classified (T99).

the marginal cost of public funds we also include a population size variable.

Table 2 provides descriptive statistics. The seven fiscal variables are entered in US \$ 1,000 per resident. With regard to the deficit variable note that the negative mean indicates that on average the local budget displays a small surplus.

Data on budget institutions, on debt restrictions in particular, are taken from a report of the Advisory Commission on Intergovernmental Relations (ACIR) issued in 1993 that focuses on State laws governing municipal finances. This report provides information about state laws governing local government finances and administration in 1990 on a broad range of issues. The variables used in the current analysis are concerned with debt limits and balanced budget rules:<sup>13</sup>

**ACIR\_01** Debt limits imposed on cities (expressed as a percentage of assessed property value).

**ACIR\_04** State law requires a referendum for local bond issues.

**ACIR\_24a** State constitution or statutory law mandates a balanced budget (for cities).

**ACIR\_07** State law permits short-term borrowing by local units.

Similar to the situation at the state level, the ACIR report notes that these rules are not subject to many changes and, thus, are basically unchanged in the time period considered.

As depicted in the lower part of Table 2 the ACIR variables show that most jurisdictions operate in a context where the state actually limits local government debt. Quite often there is also a rule

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<sup>13</sup>Appendix E of ACIR Report 186 considers various state laws governing financial management of local governments. While there are 26 issues we focus on those four that are most closely related to restrictions on borrowing.

Table 2: Descriptive Statistics

	Mean	Std.Dev.	Min.	Max.
<i>Fiscal variables in \$ 1,000 per capita</i>				
Investment	0.144	0.156	0.000	2.720
Own Revenue	0.554	0.390	0.004	7.501
Grants	0.240	0.245	0.000	2.419
Debt Service (net)	0.001	0.050	-0.530	1.104
Deficit	-0.008	0.165	-1.770	2.464
Stock of Debt	0.828	0.971	-0.045	19.33
Cash Holdings	0.711	0.782	0.000	20.51
Own Revenue (Change)	0.014	0.255	-18.83	20.22
<i>Tax revenue shares</i>				
Property Tax (T01)	.617	.296	0	1
General Sales Tax (T09)	.156	.232	0	.969
Alcoholic Beverage Tax (T10)	.007	.031	0	.502
Public Utilities Tax (T15)	.070	.107	0	.945
Other Sel.Sales Tax (T19)	.016	.037	0	.713
Ind. Income Tax (T40)	.047	.165	0	.961
<i>Other variables</i>				
Income in \$ 10,000 per capita	1.932	0.525	0.722	6.608
Population (in 1,000)	74.32	266.7	0.671	7922
ACIR_01	0.939	0.240	0	1
ACIR_04	0.823	0.381	0	1
ACIR_24A	0.193	0.395	0	1
ACIR_07	0.695	0.460	0	1

Statistics for pooled observations for 1,266 cities in 1996 dollars (deflated with common US GDP deflator). <sup>a</sup> missing values encountered.

that a referendum is a precondition for local bonds issue. Much less states require all jurisdictions to maintain a balanced budget.

## 5 Results

Basic regression results are provided in Table 3. Columns (1) and (2) report results from a regression of investment expenditures on the controls without and with the deficit but without municipal fixed effects. The table reports standard errors that are robust against heteroscedasticity and also take account of possible error correlation between different observations of the same municipality over time. All fiscal variables, *e.g.* grants, own revenue, debt service, the stock of debt, and the stock of cash holdings exert significant effects. The signs are as expected such that investment rises with available funds. Only the stock of debt has some unexpected positive coefficient. Population characteristics such as the size of the jurisdiction and private income are not significant. The deficit shows a highly significant negative effect, indicating that a deficit in the previous year is associated with a reduction in investment spending.

However, as we have argued above, given the heterogeneity of jurisdictions in terms of the demand for infrastructure capital it is important to control for municipal specific effects. Column (3) and (4) report corresponding results. Again, fiscal variables show the expected effects and the unexpected positive effect of the stock of debt disappears. With fixed effects also household income proves significant pointing at a positive relation with the demand for public capital. The population size now enters with a positive sign which is consistent with the hypothesis of lower marginal cost of public funds in larger jurisdictions. While we control for the level of grants, an alternative

Table 3: Deficit and Investment Expenditures

	(1)	(2)	(3)	(4)
Deficit <sub>t-1</sub>		-.077 ** (.008)		-.039 ** (.010)
Investment <sub>t-1</sub>	.441 ** (.013)	.489 ** (.013)	.327 ** (.015)	.358 ** (.016)
Income <sub>t-1</sub>	.003 (.002)	.003 (.002)	.036 ** (.007)	.037 ** (.007)
Own Revenue <sub>t-1</sub>	.049 ** (.006)	.042 ** (.006)	.042 ** (.007)	.032 ** (.007)
Grants <sub>t-1</sub>	.045 ** (.006)	.037 ** (.005)	.060 ** (.011)	.042 ** (.010)
Debt Service <sub>t-1</sub>	-.132 ** (.038)	-.097 ** (.038)	-.134 ** (.040)	-.113 ** (.040)
Stock of Debt <sub>t-1</sub>	.007 ** (.003)	.006 ** (.003)	.002 (.003)	.002 (.003)
Cash-Holdings <sub>t-1</sub>	.019 ** (.003)	.018 ** (.003)	.019 ** (.004)	.019 ** (.004)
log Population <sub>t-1</sub>	.000 (.001)	.000 (.001)	.014 ** (.007)	.012 * (.007)
R-Sq	.3236	.3283	.3797	.3804
Munic. fixed effects	no	no	yes	yes

Dependent Variable: Investment spending per capita. Robust standard errors in parentheses, clustered at the level of municipalities, a star denotes significance at 10 % level, two stars at 5 %. 31,650 observations, 1,266 municipalities. All estimates include time fixed effects.

potential explanation could be a higher importance of matching grants for larger municipalities. The significant effect of the deficit is confirmed. To the extent that the other control variables fully capture the variation in the expected components of the intertemporal budget constraint, the significant negative effect of the deficit is in accordance with the existence of borrowing restrictions that prevent the use of debt as a means to smooth investment spending.

However, it would be interesting to see whether the deficit effects differ if there are explicit formal borrowing restrictions. In the light of the above theoretical discussion, in presence of those restrictions a deviation from a balanced budget in the previous period should trigger a stronger revision of investment plans. Table 4 provides further results for the role of formal borrowing restrictions. It depicts results of various regressions including the basic set of controls used in Table 3, but only reports estimates for the deficit and the interaction terms with the presence of formal borrowing restrictions.

All rules which restrict debt finance show a negative sign. This is in accordance with the theoretical presumption that investment spending is adjusted in the presence of temporary fiscal shocks in particular where it is more difficult to use debt. Especially, the debt limit ACIR\_01 exerts a strong effect. Also the requirements of a referendum for local bond issues ACIR\_04 and the requirement of a balanced budget ACIR\_24A prove significant even if included jointly with the existence of a debt limit. While the opposite sign is found for ACIR\_07 we should note that this variable captures the absence rather than the presence of a restriction on borrowing: as it indicates that the correlation with the deficit is weaker in states which authorize short-term borrowing it is in accordance with the theory. The last columns (6) to (8) report results where the considered rules are jointly interacted. In particular, borrowing restrictions in the form of debt limits and balanced budget rules prove

Table 4: Investment Spending, Deficits, and Formal Borrowing Restrictions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deficit <sub>t-1</sub>	-0.39 ** (.010)	.025 (.020)	-.012 (.023)	-.034 ** (.011)	-.063 ** (.017)	.072 ** (.032)	.043 * (.023)	.078 ** (.032)
Deficit <sub>t-1</sub> × ACIR <sub>-01</sub>		-.072 ** (.021)				-.084 ** (.021)	-.084 ** (.023)	-.085 ** (.024)
Deficit <sub>t-1</sub> × ACIR <sub>-04</sub>			-.036 (.028)			-.048 * (.028)		-.040 (.028)
Deficit <sub>t-1</sub> × ACIR <sub>-24a</sub>				-.040 * (.024)			-.052 ** (.024)	-.040 * (.024)
Deficit <sub>t-1</sub> × ACIR <sub>-07</sub>					.034 * (.020)			-.018 (.020)
R-Sq	.3804	.3809	.3806	.3806	.3807	.3813	.3812	.3818

Dependent Variable: Investment spending per capita. Robust standard errors in parentheses, clustered at the level of municipalities. A star denotes significance at 10 % level, two stars at 5 %. 31,650 observations, 1,266 municipalities. All estimates include the above set of control variables as well as time fixed and municipal fixed effects. The results for the basic set of controls are suppressed to save space, but are similar to those already reported.



to be jointly significant. Note that the positive effects of the deficit in Columns (6) to (8) simply reflect the lack of municipalities where all of the limitations are jointly absent.

So far our analysis has dealt with the impact of temporary fiscal imbalances on public investment spending, particularly, if some formal restrictions on borrowing are in place. While the results are in accordance with the above analysis, we have not considered so far whether empirical evidence also supports the view that limited access to debt has consequences for the empirical response of investment spending to revenue shocks. In order to do so, we need to include some further information in the analysis that captures current disturbances to the revenue side of budget. This calls for an inclusion of a current revenue indicator, or, given that lagged revenue is already included, for an inclusion of the current change in revenue.

Table 5 provides results of specifications that additionally employ the current change in own revenues. Regardless of whether the deficit is included, this variable shows a significant positive effect indicating that current policy responds strongly to current revenues. Of course, a difficulty in this context is whether a change in current revenues is really exogenous, rather than being the outcome of deliberate changes in policy or the immediate consequence of higher government spending.

In order to test for a possible simultaneity bias, column (3) reports instrumental variable estimates. Assuming that the change in own revenues partly reflects nationwide shocks to each of the various taxes employed by the municipalities we employ a vector of tax-revenue shares in the previous period as instruments. Note that the first stage F-statistic points at a strong predictive power of the instrumental variables for the observed change in revenues. Also the test of overidentifying restriction does not indicate specification problems. While the signs of the own revenue effect and

Table 5: Investment Expenditures and Current Revenues

	(1)	(2)	(3)	(4)
$\Delta$ Own Revenue $_t$	.118 ** (.011)	.129 ** (.011)	.719 ** (.271)	.719 ** (.273)
Deficit $_{t-1}$		-.059 ** (.010)	-.144 ** (.041)	-.142 ** (.041)
Investment $_{t-1}$	.327 ** (.014)	.374 ** (.016)	.441 ** (.034)	.439 ** (.034)
Income $_{t-1}$	.030 ** (.007)	.031 * (.007)	.004 (.014)	.012 (.012)
Own Revenue $_{t-1}$	.062 ** (.008)	.050 ** (.007)	.132 ** (.038)	.138 ** (.040)
Tax Revenue $_{t-1}$				-.023 * (.013)
Grants $_{t-1}$	.058 ** (.011)	.031 ** (.010)	-.016 (.024)	-.013 (.023)
Debt Service $_{t-1}$	-.120 ** (.039)	-.087 ** (.040)	.052 (.077)	.053 (.077)
Stock of Debt $_{t-1}$	.001 (.003)	.001 (.003)	-.009 (.006)	-.009 (.006)
Cash-Holdings $_{t-1}$	.021 ** (.004)	.021 ** (.004)	.028 ** (.005)	.028 ** (.005)
log Population $_{t-1}$	.015 ** (.007)	.013 ** (.007)	.014 * (.008)	.013 (.008)
R-Sq	.3853	.3869		
First Stage F-Stat.			23.213 (6)	25.752 (6)
Overid.Restriction (J-Stat.)			7.834 (5)	7.387 (5)

Dependent Variable: Investment spending per capita. (1) to (3): OLS-regression results including fixed time and municipal effects. (4): IV-estimation results employing the predicted change in tax revenues as an instrument. Robust standard errors in parentheses, clustered at the level of municipalities. A star denotes significance at 10 % level, two stars at 5 %. 31,650 observations, 1,266 municipalities. First Stage F-Statistic (Kleibergen Paap Statistic in Parentheses) for weak instruments. Hansen J-Test for overidentifying restrictions

the deficit are unchanged the coefficients are much larger, suggesting that there is a substantial simultaneity bias in the OLS estimates. Since we use the revenue shares of various taxes as instruments, specification (4) also conditions on the lagged value of tax revenues, which proves weakly significant.

While the theoretical analysis above has suggested that current spending should always respond to an innovation in revenues, borrowing limitations are found to exacerbate this response. Therefore, within the current framework, we pose the following question: suppose current revenues do capture some innovation in the information set such that an increase reduces the need to ensure that the current budget is balanced and a decline raises the current budgetary pressures. Is the response of investment spending to revenue changes weaker in municipalities that face formal borrowing constraints?

To examine this question, we could, as above, employ interaction terms, and test whether the impact of current revenues varies depending on the institutional conditions faced by the municipalities. Corresponding regressions did not detect much effects of interaction terms between institutions and current revenue growth. However, this approach is not appropriate if the differences in the institutions give rise for differences also in other slope parameters. Therefore, we follow a more general approach and conduct an alternative set of IV regressions where we estimate our model using various subsamples comprising groups of municipalities that share the same borrowing restrictions.

Table 6 summarizes the empirical results. Each row of the table refers to a certain rule and reports estimated effects in the subsample where the corresponding rule is imposed as well as in the

Table 6: Exploring Formal Borrowing Restrictions using Subsamples

	imposed		not imposed	
	(ACIR)	$\Delta$ Own Rev. <sub>t</sub>	Deficit <sub>t-1</sub>	NoM.
Debt limits	(01)	.624 ** (.239)	-.139 ** (.037)	1188
Referendum req.	(01,04)	.483 ** (.229)	-.127 ** (.039)	964
Bal. budget rule	(01,04,24a)	.955 (.776)	-.233 ** (.117)	201
Short-term bor.	(01,04,24a,07)	-.096 (.396)	-.083 ** (.046)	113
	(ACIR)	$\Delta$ Own Rev. <sub>t</sub>	Deficit <sub>t-1</sub>	NoM.
	(no 01)	.096 (.802)	.032 (.112)	78
	(01 but not 04)	.086 ** (.383)	-.061 ** (.047)	224
	(01,04 but not 24a)	.663 (.208)	-.147 ** (.038)	763
	(01,04,24a but not 07)	.812 (.640)	-.262 ** (.131)	88

IV-estimation results for the current change in own revenues and the lagged deficit employing lagged shares of various taxes as instruments, see above. Robust standard errors in parentheses, clustered at the level of municipalities. A star denotes significance at 10 % level, two stars at 5 %. All estimates include the above set of control variables as well as time and municipal fixed effects. The results refer to various sub-samples with numbers of municipalities (NoM) as reported. For comparison the basic results using the total estimation sample (*cf.* col.(4) of Table 5) is based on 1266 municipalities (31619 observations) and show estimates of .719 (.273) for the change in own revenues and - .142 (.041) for the lagged deficit.

complementary subsample where this rule is not imposed.<sup>14</sup> For instance, in the first row, it can be seen that the empirical response to the current change in revenues shows a positive significant coefficient in the subsample where debt limits are imposed, but shows a negative, insignificant effect in the other. Also the deficit is insignificant for this group. Of course, since most municipalities are subjected to debt limits, the sample size is quite different with 1188 municipalities in the first group and only 78 municipalities in the second.

In the second row, we focus on the municipalities operating under debt limits, but distinguish a sub-group, where – in addition – a referendum is required for bond issuance, from another sub-group where no referendum is required. Again, we find marked differences indicating that the response to current revenues and the deficit is much larger in the first sub-group.

In the third row we focus on the additional imposition of balanced-budget rules and find that this is associated with much larger coefficients, even if only the deficit proves significant. The subgroup that only has debt-limits and referendum requirements shows smaller effects. Finally, in the fourth row, we consider the role of short-term borrowing and find that the deficit effect gets even stronger if short-term borrowing is not allowed.

Generally, the impacts of current revenue changes and the lagged deficit show stronger effects in the restricted subsamples. Strongest effects are found in the group of municipalities that face debt limits, referendum requirements, as well as balanced budget rules.

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<sup>14</sup>Note that the specification tests (not shown) approve all of the IV estimates for each sub-group.

## 6 Conclusions

In this paper we have laid out a theory of optimal public investment in a setting with revenue shocks. While the basic model supports the role of debt to smooth tax policy and investment, the introduction of borrowing restrictions is shown to change the predictions of the model. While the government will engage in some precautionary savings, facing adverse as well as favorable shocks to revenues the optimal time path of the capital stock and thus of public investment would, nevertheless, display fluctuations. While any realization of revenue that differs from the expected value would demand some fiscal adjustment in order to restore intertemporal budget balance, restrictions on debt introduce some additional short-run considerations that lead to an overshooting in the adjustment of public investments.

The empirical analysis of municipal public investment basically supports the implications of the theory. Generally, it is shown that U.S. municipalities do not perfectly smooth investment expenditures but rather adjust their spending policy to the temporary budget balance as captured by the deficit/surplus as well as to the current revenue development. A second set of results shows that municipalities in states imposing formal borrowing restrictions on local governments do in fact display a stronger response of investment spending to temporary fiscal imbalances and current revenues.

Of course, we have not discussed the reason why borrowing restrictions have been introduced. And, of course, there should be some benefits that motivate their existence. For instance, formal restrictions on borrowing might lower the risk of default and, hence, facilitates governments' access to credit. However, as our analysis suggests those restrictions place an important burden on

governments investment policy. A particularly important example is privatization, where short run considerations such as to meet a debt limit might result in rather costly deviations from the optimal policy.

Since we have developed the theoretical results under several simplifying assumptions, it seems reasonable to discuss possible extensions. An obvious one would be to allow for adjustment cost in the public capital stock. In the presence of these cost we would expect to see the adverse consequences of imposing borrowing restrictions aggravated. This would imply that even larger surpluses would be accumulated. However, due to cost of adjustment the fluctuations in investment spending might be dampened.

## References

- Advisory Commission on Intergovernmental Relations (1993), “State Laws Governing Local Government Structure and Administration”, *ACIR Report M-186*, Washington, DC.
- Alesina, A. and R. Perotti (1999), “Budget Deficits and Budget Institutions”, in J. M. Poterba and J. von Hagen (ed), “Fiscal Institutions and Fiscal Performance,” Chicago, 13–36.
- Barro, R. J. (1979), “On the Determination of Public Debt”, *Journal of Political Economy* 87, 940–971.
- Belmonte, C. (2007), “Tax-Exempt Bonds, 2005,” *Statistics of Income Bulletin*, Fall, 2007, 156–173.
- Bohn, H. (1990), “Tax Smoothing with Financial Instruments”, *American Economic Review* 80, 1217–1230.

- Bohn, H. and R.P. Inman (1996), “Balanced–Budget Rules and Public Deficits: Evidence from U.S. States”, *Carnegie–Rochester Conference Series on Public Policy* 45, 13–76.
- Buettner, T. and D. E. Wildasin (2006), “The Dynamics of Municipal Fiscal Adjustment”, *Journal of Public Economics* 90, 1115–1132.
- Chow, G. (1997), “Dynamic Economics: Optimization by the Lagrange Method”, Oxford.
- Holtz–Eakin, D., and H. S. Rosen (1991), “Municipal Construction Spending: an Empirical Examination”, *Economics and Politics* 5, 61–84.
- Ljungqvist, L. and T. J. Sargent (2004), *Recursive Macroeconomic Theory*, MIT Press, 2nd edition.
- Poterba, J. M. (1994), “State Responses to Fiscal Crisis: the Effects of Budgetary Institutions and Policy”, *Journal of Political Economy* 102, 799–821.
- Verbeek, M. and T. Nijman (1992), “Testing for Selectivity Bias in Panel Data Models”, *International Economic Review* 33, 681–703.