The Dynamics of Municipal Fiscal Adjustment

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Abstract: The dynamic fiscal policy adjustment of local jurisdictions is investigated empirically using a panel of more than 1000 U.S. municipalities over a quarter of a century. Distinguishing own-source revenue, grants, expenditures, and debt service, the analysis is carried out using a vector error-correction model which takes account of the intertemporal budget constraint. The results indicate that a large part of the adjustment in response to fiscal imbalances takes place by offsetting changes in future expenditures. In addition, the results show that fiscal imbalances are financed to a significant extent by subsequent changes in grants. Decomposition of the sample according to average city population reveals that the basic pattern of fiscal adjustment is robust, although intergovernmental grants play a much more pronounced role in maintaining budget balance for large cities.

JEL-Classification: H70, H72, H77

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1 Introduction

Our goal in this paper is to shed new light on the dynamics of local government policymaking, with specific reference to the fiscal policies of municipal governments in the United States. The U.S. federal system, of which local governments are an important part, is a durable institutional structure which decentralizes significant portions of public-sector decisionmaking authority to subnational governments. Governments at all levels within this structure operate under a variety of constraints, and these constraints create the incentives that, in part, elicit the observed behavior of policymakers. The fiscal policies of subnational governments are important in themselves, but they also illuminate the nature of the constraints which these governments face and thus the institutional structure of the public sector itself.

Local governments in the U.S. are numerous, diverse, and economically important.[1] The services performed by these governments, their financing, and their relationships with the national and state governments have evolved over time in a complex process involving the interplay of all branches of government (executive, legislative, and judicial) at all levels of government (federal, state, and local), all against the background of ongoing demographic, technological, economic, and social change and widely-varying local circumstances.

Occasionally – but rarely, in U.S. experience – local fiscal policies result in crises in which a government's financial obligations to creditors, vendors, and employees cannot be met from existing revenues. In such situations, local authorities, as units of government subordinate to states, are often subjected to special oversight mechanisms even as the state government assists the locality with additional funding to meet its most pressing contractual and public-service delivery obligations. The financial crises of New York City in the 1970s and of Philadelphia, Orange County, California, and Washington DC in the 1990s provide well-known examples of local fiscal policies gone awry, and smaller localities also encounter fiscal distress

[1] The Bureau of the Census publishes a quinquennial *Census of Governments*. As of the 1997 census, there were over 3,000 counties, almost 20,000 municipalities, almost 35,000 special districts, almost 14,000 school districts, and almost 17,000 townships, making almost 90,000 units of local government in total. Total public expenditure by all localities amounted to $837 billion, of which municipalities – the focus of the present analysis – accounted for $275B, school districts $257B, counties $198B, special districts $89B, and townships $28B. Total local government spending in 1997 amounted to some 10.1 % of GDP. In 1995 local government spending amounted to 26.9 % of all public expenditures in the US.

from time to time.[2] These events, though noteworthy, are nonetheless exceptions to the rule. Somehow, despite (or perhaps in part because of) the conflicting demands imposed upon them by taxpayers, interest groups, creditors, vendors, state governments, and others, local policymakers face an incentive structure that, in equilibrium, results in behavior that for the most part preserves the financial integrity of local governments. Whether the fiscal policies chosen by local governments are economically desirable according to normative criteria (efficiency, equity) is a separate and very important question. Leaving this question aside, one can observe that the institutional structure of American federalism has created a system of local governments that pass a basic survival test while permitting a relatively high degree of local fiscal autonomy – a fundamental requirement for any fiscally-decentralized public sector.

Since fiscal viability cannot be taken for granted at all times and places, it is a matter of some importance to understand better how these governments manage the financial stresses to which they are inevitably exposed. Our analysis is intended to shed new light, from an empirical viewpoint, on the dynamics of municipal fiscal adjustment. Quantitatively speaking, how do municipal governments adjust their revenues, expenditures, and debt policies over time? What role do transfers from higher-level governments play in their fiscal dynamics? U.S. municipal governments present an exceptionally attractive subject for the systematic empirical analysis of decentralized fiscal policies. We have assembled a balanced panel of annual fiscal data for more than 1000 municipalities for over a quarter-century. These data have been collected using consistent definitions and, though they are of course subject to imperfections, they likely represent the best available collection of fiscal data on such a large number of governmental units.[3]

[2] See GAO (1995) for series of case studies of localities in fiscal distress, some findings of which are summarized in Holloway (1996a, 1996b). The infrequency of formal municipal bankruptcy proceedings in the U.S. is quite remarkable. Since the passage of the Municipal Bankruptcy Act in 1937, there have been fewer than 500 bankruptcy filings. Municipal bankruptcies are a minuscule fraction of all bankruptcies. Of the total of 1.2 million bankruptcy proceedings commenced in the 12 months preceding Sept. 30, 2000, 6 were filed under Chapter 9 (the portion of the bankruptcy code governing municipalities). A large portion of Chapter 9 filings that do occur are accounted for by small special districts (such as water or sewer districts), and bankruptcies by municipalities proper are therefore even more rare. See Administrative Office of the US Courts (2000a, b, Table F-2)) and National Bankruptcy Review Commission (1997).

[3] Numerous studies have examined fiscal policymaking at the level of state governments; see, for example, Poterba (1994), Bohn and Inman (1996), and McCarty and Schmidt (1997). At the municipal level, data on *large* municipalities are more readily available and have been a principal subject of previous analyses; see, e.g., Inman (1989). An exception is Holtz-Eakin *et al.*(1991) which use a sample of 171 municipalities drawn randomly from the Census of Governments. Large municipalities are clearly of great importance because they account for a large fraction of total municipal fiscal activity, but, as we shall see below, their behavior differs in significant ways from that of smaller cities.

Our analysis utilizes methods that have been exploited previously in macroeconomic analyses devoted to the study of intertemporal government budget constraints for national governments (e.g., Wilcox, 1989, Trehan and Walsh, 1991). Previous studies have generally focused on testing for the stationarity or "sustainability" of fiscal policies; by contrast, we pay closer attention to the adjustment process that maintains this balance. Suppose, for example, that municipal revenue declines, such that the local deficit is increased. Long-run budget balance requires some offsetting adjustment to this increased deficit. What form does this adjustment take, and when does it occur? Do municipalities with low revenue tend to reduce spending in order to restore balance? Do they simply run bigger deficits for a period of time, delaying adjustments in taxes and spending? Do lower revenues trigger additional transfers from higher-level governments, enabling municipalities to maintain spending without having to raise local taxes? Or is lower revenue in one period simply offset in subsequent periods, reducing the need for further adjustment? Any of these types of fiscal adjustment, or some combination of all of them, is conceivable, and the same can be said about possible paths of fiscal adjustment in response to fiscal imbalances due to innovations in grants, spending, or debt service.

Given the complexity of the political and market constraints under which municipal authorities operate, it is difficult to justify strong prior expectations about which particular form of adjustment must dominate, and our goal here is to examine the dynamics of fiscal adjustment with a minimum of prior structure. We do this using a vector error-correction approach, outlined in Section 2. Section 3 describes the data and estimation approach, and provides specification tests as well as further background information about the interpretation of the basic model. Section 4 presents the results of the empirical analysis, using the entire sample. These results indicate that municipalities respond differently to fiscal imbalances originating from different sources. As an illustration, we find that higher municipal public spending is typically followed by offsetting expenditure changes in subsequent periods, with relatively modest adjustments in other fiscal variables; by contrast, imbalances associated with municipal revenue tend to persist and to be followed by substantial changes in municipal spending.

For reasons of institutional structure and political economy, the incentives for fiscal adjustment may differ significantly across municipalities, in particular, between large and small cities. Because our sample contains a large cross-section of municipalities, it is possible to analyze sub-samples with differences in population size separately, as is done in Section 5. We find, in fact, that the basic pattern of fiscal adjustment is robust across cities of different sizes, but intergovernmental grants play a much more pronounced role in maintaining budget balance for large cities.

Section 6 summarizes the main findings and discusses some of the many directions for interesting future research that they suggest.

2 A Framework for Analysis of Fiscal Adjustment

In order to examine the process of budgetary adjustment with a minimum of prior restrictions, we analyze the evolution of fiscal flows like revenues, expenditures, and debt service, as well as their interrelationship over time, by means of a vector autoregression. Although fiscal adjustments might in principle take place at any future date, a now-standard approach in macroeconomic analysis is to fit a time-series model that captures the most significant interrelationships between the variables with a limited number of lags. If municipalities, on average, pursue fiscal policies consistent with intertemporal budget balance, the components of their budgets will display a cointegrating relationship, and, hence, the deficit will be stationary (e.g., Trehan and Walsh, 1988). In order to model the dynamic adjustment to changes current in fiscal imbalances, one can exploit this stochastic implication of the intertemporal budget constraint and employ a vector error-correction framework, relating the change of expenditures, revenues, and debt service to the lagged deficit. Bohn (1991), for example, conducts such an analysis of fiscal policy at the level of the US Federal government, and we utilize a similar approach at the city level. Unlike macro models applied to national governments, however, it is necessary to recognize that local governments obtain substantial amounts of revenue not only from own-sources like taxes, but from higher levels of government; in our sample, about 28% of municipal revenue, on average, is obtained from intergovernmental transfers. Furthermore, as already pointed out in the introduction, those transfers may be crucial in restoring the balance of the budget. We therefore explicitly decompose the revenue side of the budget into own-source and intergovernmental revenue.

Formally, the empirical analysis focuses on a four-dimensional vector of budgetary components $Y_t = (G_t, DS_t, R_t, Z_t)'$, where G_t is "primary" government expenditure, DS_t denotes current debt service expenditures, R_t is own-source revenue, and Z_t is intergovernmental revenue. The current deficit D_t is defined as

$$D_t \;\equiv\; b'Y_t \;=\; G_t + DS_t - R_t - Z_t, \quad \text{with} \quad b' = (1, 1, -1, -1)\,. \tag{1}$$

Following the literature, the empirical model assumes that the current deficit is stationary, and describes the changes of the elements of the vector Y_t as a function of lagged changes of Y_t as well as of its lagged level, *i.e.* the lagged deficit

$$A\,(L)\,\Delta Y_t \;=\; \gamma\, b'Y_{t-1} \;+\; u_t, \tag{2}$$

where Δ is the difference operator and $A\,(L)$ is a polynomial in the lag operator. The lagged deficit term captures the error-correction property of the system, implying that deficits or surpluses lead to budgetary adjustments reflected in ΔY_t; the parameter vector γ describes the magnitude (and sign) of the impact of the previous year's deficit on the current changes in the budget components and thus the speed of the error-correction process. This approach can be utilized only if the deficit is stationary, which must be verified empirically. It does not, however, impose any *a priori* restrictions on the direction or magnitude of the adjustments of individual budget components; instead, by estimating these adjustments empirically, the analysis yields insights about how each of the components of the fiscal policy vector Y_t reacts, over time, to innovations in itself or in one of the other components.

As in a vector autoregressive system, dynamic adjustments to deficit shocks can be described by impulse-response functions. More specifically, the system can be used to trace the fiscal adjustment to temporary imbalances, *i.e.* to surpluses or deficits, which cannot be traced back statistically to previous changes in the budget components.[4] Graphs of impulse-response functions offer visual displays showing the time-paths of budgetary adjustment for fiscal variables (see Buettner and Wildasin (2003)). To summarize the fiscal adjustment process in a more compact and quantitative fashion, one can compute the *present value*

[4]Note that these temporary imbalances are not "structural" shocks in the terminology of standard VAR analysis, because a deviation in any one budget component may be accompanied by an immediate adjustment in other budget components.

of the response of each variable with respect to shocks in every other variable.

Following Bohn (1991) we can state the intertemporal budget constraint in terms of innovations as (see Buettner and Wildasin (2003) for details)

$$\widehat{PV}_t(\Delta R) + \widehat{PV}_t(\Delta Z) - \widehat{PV}_t(\Delta G) = \widehat{G}_t + \widehat{DS}_t - \widehat{R}_t - \widehat{Z}_t, \tag{3}$$

where $\widehat{X}_t$ denotes the innovation in a variable X_t, *i.e.*, the change in its expected value. $\widehat{PV}_t(\Delta X)$ is the expected present value of all changes in this variable in the future. Accordingly, the innovations in the budgetary components on the right-hand side should evoke an offsetting linear combination of innovations in the present value of the responses.

More specifically, based on an estimate of system (2), we can compute the present value of the projected changes of each budgetary component in response to innovations in itself and in any other budgetary component. Let $\pi(Y[i], Y[j])$ denote the present value of the impulse-response function of variable $Y[j]$ given a unit innovation in variable $Y[i]$. Following equation (3) a unit innovation in each of the budgetary components triggers offsetting responses of the components of the primary surplus such that

$$\pi(Y[i], R) + \pi(Y[i], Z) - \pi(Y[i], G) = b[i], \tag{4}$$

where $b[i]$ is the i-th component of b defined in (1).

Since equation (4) follows from the definition of the intertemporal budget constraint, one might think of it as an exact relationship. However, aside from possible inconsistencies in the data, this is not necessarily the case, empirically. Whereas the underlying intertemporal budget constraint assumes a given interest rate to discount future budgetary flows, the interest rate is generally not known with certainty, and it may also vary over time. In addition, as discussed further below, the data display significant variation in the size of municipalities, which requires scaling fiscal variables in per-capita terms. As a consequence, the appropriate discount rate is a function of both the interest rate as well as the rate of population growth and, hence, differs from the interest rate (see Buettner and Wildasin (2003) for details). Finally, it is possible that intertemporal budget balance, in practice, is achieved over much longer time periods than the roughly 25-year horizon of our data, and hence could not be detected in a model with a lag structure of only a few years. For all of these reasons, the intertemporal budget constraint, applied to the available data, does not hold as an accounting identity within the context of our empirical model. Despite these qualifications, we shall see that the adjustment pattern found in the present study follows the predictions of equations (3) and (4) rather closely.

3 Data and Model Specification

The empirical analysis employs annual data for individual municipalities from all over the U.S. obtained from the quinquennial Census of Governments (COG) and the accompanying Annual Survey of Government Finances (ASOGF). In order to trace budgetary adjustments across time the analysis focuses on a subsample of all cities annually reported in the COG/ASOGF, yielding a balanced panel for 1270 cities over 26 years from 1972 to 1997 for a total of 33,020 city-year observations.[5] The dataset comprises four fiscal variables, which are constructed from Bureau of Census fiscal classifications as shown in Table 1. There are two revenue variables, own-source revenue and intergovernmental revenue ("grants") obtained from higher-level governments. There are also two variables on the expenditure side, general expenditure and net debt-service expenditures. In addition to fiscal transfers from higher-level governments, small amounts of municipal expenditures and revenues are payments to or receipts from other local governments; the net amount of these payments is included as part of general expenditure. Many municipalities hold significant interest-bearing financial assets, but, since asset values are not always reported in the data, it is not possible to determine net indebtedness. It is therefore preferable to utilize the flow of net debt service.

[5] Although the data are available in digital form, their preparation for analysis is non-trivial, particularly because they are not coded uniformly across years. The final data have been checked for consistency with state-level aggregates reported in Census publications. The Census Bureau makes occasional revisions in these data without, however, updating the publicly-available data. Since the revisions by the Census Bureau are not reported, preliminary regressions have been run to detect influential observations. If a further inspection of these observations revealed apparent inconsistencies with previous and subsequent observations, the corresponding city was completely removed from the dataset. As a result, 76 cities were removed from the 1346 cities in the basic balanced sample.

Table 1: Definition of Fiscal Variables

	Variable	Components (*Bureau of Census categories)*
(i)	Own Revenue (R_t)	*Total Taxes, Total General Charges,* *Total Miscellaneous General Revenue* excluding *Interest Revenue.*
(ii)	Grants (Z_t)	*Intergovernmental Revenue* *from Federal Government* and *from State Governments*
(iii)	General Expenditure (G_t)	*Total General Expenditure* including *Intergovernmental Expenditure* net of *Local Intergovernmental Revenue,* and excluding *Interest on General Debt.*
(iv)	Debt Service (DS_t)	*Total Interest on General Debt* net of *Interest Revenue*
(v)	General Deficit (D_t)	(iii) + (iv) - (i) - (ii)

Table 2 presents some descriptive statistics with fiscal variables scaled in terms of population size. The mean of real per-capita expenditures is $756. There is, however, strong variation in expenditures, with a standard deviation of $534. The debt service, defined net of interest earnings, shows a mean around zero. The figures for expenditure correspond to the mean values on the revenue side, *i.e.* own revenue of $553 and intergovernmental revenues of $213. The mean of the residual difference between the first four components (denoted as general government deficit) is at minus $8, indicating that on average the cities run a small surplus. However, there is marked variation in the sample between a per capita deficit of as much as $2,464 and a surplus of $1,771. This variation in budget outcomes is also reflected in differences in the debt service, where some cities show high spending whereas others actually report positive net interest earnings. The fiscal variables show modest mean values of annual growth in expenditures and revenues, and again substantial variation between rather large extremes.

The bottom of Table 2 reports statistics for population and income showing that the average population size is around 75,000. Population size ranges from below 1,000 to almost 8 million (New York City) indicating strong variation in the dataset.[6] Thus, to model the fiscal adjustment process, fiscal variables should be scaled with the size of the considered jurisdiction; since income data are only available at the

[6]The population data reported in the COG/ASOGF public use files do not correspond strictly to the year of the fiscal data. In addition, they are generally not updated on an annual basis. Therefore, the population data have been smoothed by a moving average using a cubic trend polynomial (Kendall and Stuart, 1976:381f).

Table 2: Descriptive Statistics

	Mean	Std.Dev.	Min.	Max.	Median
Fiscal variables	Levels per capita, 1972-1997				
Own Revenue	0.553	0.399	0.004	7.501	0.445
General Expenditure	0.756	0.534	0.005	7.826	0.596
Grants	0.213	0.233	0.000	3.150	0.136
Debt Service (net)	0.002	0.051	-0.530	1.104	-0.000
General Deficit	-0.008	0.164	-1.771	2.464	-0.018
	Annual change per capita, 1973-1997				
Own Revenue	0.014	0.102	-1.441	1.486	0.009
General Expenditure	0.017	0.191	-2.348	2.485	0.011
Grants	0.004	0.104	-1.412	1.610	0.000
Debt Service (net)	-0.001	0.032	-0.527	0.463	-0.001
Other variables	1972-1997				
Income in \$10,000 per capita	1.920	0.516	0.722	6.737	1.838
Population (in 1,000)	74.77	267.1	0.671	7922	31.38

Statistics for pooled observations for 1270 cities in 1996 dollars (deflated with common US GDP deflator). Fiscal variables in $ 1,000 per-capita.

county level the analysis utilizes per-capita figures.[7] However, variations in absolute population size are used in Section 5 to decompose the sample in order to determine whether there are important differences in the budgetary adjustment pattern in large and small cities.

Estimation of the system outlined in Section 2 is basically carried out by means of regressions of the annual changes in each of the budgetary components, *i.e.* in own revenue, grants, general expenditures, and in debt service, on the deficit in the previous year and on lagged values of the changes in each of the budget components, such that the basic set of estimation equations is:

$$\begin{aligned}
\Delta G_{i,t} &= \gamma^1 D_{t-1} + a_0^1 + \sum_{k=1}^{p} a_{1,k}^1 \Delta G_{i,t-k} + \sum_{k=1}^{p} a_{2,k}^1 \Delta DS_{i,t-k} + \sum_{k=1}^{p} a_{3,k}^1 \Delta R_{i,t-k} + \sum_{k=1}^{p} a_{4,k}^1 \Delta Z_{i,t-k} + u_{i,t}^1 \\
\Delta DS_{i,t} &= \gamma^2 D_{t-1} + a_0^2 + \sum_{k=1}^{p} a_{1,k}^2 \Delta G_{i,t-k} + \sum_{k=1}^{p} a_{2,k}^2 \Delta DS_{i,t-k} + \sum_{k=1}^{p} a_{3,k}^2 \Delta R_{i,t-k} + \sum_{k=1}^{p} a_{4,k}^2 \Delta Z_{i,t-k} + u_{i,t}^2 \\
\Delta R_{i,t} &= \gamma^3 D_{t-1} + a_0^3 + \sum_{k=1}^{p} a_{1,k}^3 \Delta G_{i,t-k} + \sum_{k=1}^{p} a_{2,k}^3 \Delta DS_{i,t-k} + \sum_{k=1}^{p} a_{3,k}^3 \Delta R_{i,t-k} + \sum_{k=1}^{p} a_{4,k}^3 \Delta Z_{i,t-k} + u_{i,t}^3 \\
\Delta Z_{i,t} &= \gamma^4 D_{t-1} + a_0^4 + \sum_{k=1}^{p} a_{1,k}^4 \Delta G_{i,t-k} + \sum_{k=1}^{p} a_{2,k}^4 \Delta DS_{i,t-k} + \sum_{k=1}^{p} a_{3,k}^4 \Delta R_{i,t-k} + \sum_{k=1}^{p} a_{4,k}^4 \Delta Z_{i,t-k} + u_{i,t}^4
\end{aligned}$$

[7] The income figures report per-capita income for the corresponding county or county area as reported by the Bureau of Economic Analysis.

Note that the basic system is formulated in first differences to take account of possible non-stationarity of the individual budgetary components.[8]

Each equation in this system relates the current change in one of the key fiscal variables to changes in the previous values of all fiscal variables and to contemporaneous shocks. These shocks, which trigger (possibly very complex) chains of future fiscal adjustments, can arise from several sources. For example, a positive shock to G might arise from a change in voters' tastes or incomes, or a change in demographic structure, that raises the demand for public spending. Alternatively, positive expenditure shocks could result from mandates imposed by state or federal mandates (including those imposed by the judicial system). Technological changes (e.g., information systems, civil engineering technology) could result in negative expenditure shocks (due to cost savings) or positive ones (due to the costs of system upgrades or of newly-feasible policies). Similarly, fluctuations in interest rates or financial management shocks (in a celebrated case, Orange County lost money in the derivatives markets) could cause unpredictable fluctuations in debt service (resulting in a shock in the second equation); changes in business investment, housing prices, or employment could produce positive or negative revenue shocks, as could tax-limitation requirements (the third equation); and new programmatic initiatives by higher-level governments, fluctuations in state or federal revenues that are shared with municipalities, and court-ordered fiscal assistance could cause shocks to intergovernmental revenues (the fourth equation). These sources of fiscal disturbance, as well as many others, require offsetting fiscal adjustments over time if municipal finances are to maintain long-run balance (which they do, as we confirm empirically). Our empirical estimates, presented below, show how municipalities make these adjustments in practice, from the many feasible adjustment paths permitted by the general 4-equation system. We also investigate some of the possible sources of fiscal disturbances – a subject which, however, warrants more attention than we are able to devote to it here.

Estimation of the VECM (2) requires specification of the lag length. Given the limited overall time dimension of the dataset (26 years), we begin with a lag of 4 years in the differenced data, subsequently testing for possible reductions in the number of lags. As shown in Table 3, a reduction of the lag length

[8] Unit root tests have been carried out using a statistic suggested by Im *et al.* (2002). As expected, non-stationarity of the levels cannot be rejected, but stationarity is not rejected for the deficit and for the first differences of all of the four budgetary components (details presented in Buettner and Wildasin (2003)).

Table 3: Specification Tests

lag length	2	3	4
indiv.eff (χ^2 (5076))	4019	4186	4437
lag order reduction (χ^2 (16))	1518	711.0	571.7

Likelihood ratio statistics on cross-equation restrictions.

is always rejected. This suggests employing a model with four lags.[9]

Typically, panel data studies allow for individual effects capturing differences in the characteristics of individual units.[10] The following analysis deals essentially with first differences of fiscal flow variables, and, in this respect, will not be affected by cross-sectional differences in local characteristics. The fiscal deficit variable, however, is entered in levels. The presence of individual effects would imply that the jurisdictions converge to different (per-capita) deficit levels. Comparing estimation with and without individual effects it turns out that joint tests reject the presence of individual effects, regardless of lag lengths (see Table 3).[11] This indicates that cities are commonly converging toward the same level of deficit. As no indication of individual effects is found, it is appropriate to estimate individual equations of the system (2) separately with OLS; in this case, joint estimation does not improve efficiency as the set of regressors is the same across equations.[12]

4 Empirical Results

Since the system is a four-dimensional vector error-correction model, estimation produces a large number of parameters. Central parameters are the coefficients of the error-correction term in the individual equations.

[9] Estimates of models with 5 and 6 lags (available upon request) did not show major differences in the adjustment pattern.

[10] The literature on dynamic panel data has emphasized biasedness of standard panel data approaches in the presence of lagged endogenous variables and suggests the use of instrumental techniques (e.g., Holtz-Eakin *et al.*, 1991). With the rather long time period available in our sample, the Nickell (1981) bias should not be a significant problem, and it is neglected in the tests for the presence of individual effects.

[11] Testing is carried out using individual fixed effects for all equations since Hausman tests rejected the use of a random effects model for the own-source revenue and expenditure equations.

[12] Avery (1977) has emphasized that in the presence of individual error components, estimation of individual equations separately is not efficient and proposed simultaneous estimation techniques (see, also, Baltagi, 1995:103pp).

Table 4: Estimates for the Error-Correction Term

Equation	γ	(Std.err.)
Own Revenue	.098	(.013)
Gen. Expend.	−.297	(.018)
Debt Service	.013	(.003)
Vert. Grants	.069	(.009)

Heteroscedasticity robust standard errors in parentheses.

As shown in Table 4, the results clearly confirm convergence toward the intertemporal budget constraint, since a higher deficit shows a positive impact on own revenue and on grants received, whereas a higher deficit shows a negative impact on expenditures. The positive impact on debt service is consistent with the fact that the deficit results in a rise in debt levels and thus creates higher debt service in the subsequent period. Given a constant rate of interest, and in the absence of population growth, the coefficient of the deficit in the debt service equation should reflect the real interest rate.[13]

One way to trace the estimated adjustment pattern resulting from the complete model is to compute impulse-response functions showing how the necessary adjustment actually takes place given an initial fiscal disturbance. The proper interpretation is that the impulse responses trace the adjustment to a fiscal imbalance hypothetically arising from changes in the individual budget components. Later, we discuss the possible sources of these imbalances.

A convenient way to summarize the impulse responses is to calculate the total response to temporary imbalances in present-value terms, as outlined in Section 2.[14] In order to calculate the present values, we fix the discount rate at 3 %.[15] The columns of Table 5 show the long-run response given unit innovations in per-capita values of the fiscal variables, expressed in present-value terms. The table also displays standard

[13]With a constant rate of interest r, and denoting the rate of change in population with n, the change in debt service per-capita can be expressed as

$$\Delta\left(\frac{DS_t}{P_t}\right) = \left[1 - \frac{n}{1+n}\right] r \frac{\Delta B_t}{P_{t-1}} - \frac{n}{1+n} r \frac{B_{t-1}}{P_{t-1}}.$$

As population growth shows an average rate of 0.98 % in the sample, the impact of a change in debt per capita on the debt service is less than proportional to the real interest rate (Even with a constant interest rate this relationship is only an approximate one, because of the difficulty of measuring government assets and liabilities).

[14]Detailed estimates of the VAR system are available on the *Journal of Public Economics* website. The precise time-path of adjustment can be illustrated graphically by plotting impulse-response functions (Buettner and Wildasin (2003)).

[15]Probably due to the fact that most of the adjustment takes place in the first periods, the qualitative results are not sensitive to the actual value of the discount rate.

errors obtained by sampling from the normal joint distribution of the VECM estimates and computing the corresponding distribution in the impulse-response functions as suggested by Sims (1987) and Hamilton (1994:337).[16]

It is instructive to consider the findings reported in Table 5 from two different perspectives. Reading down the columns of the table shows how innovations in any one fiscal variable affect the subsequent adjustments of itself and the other variables. Reading across the row for any one fiscal variable shows how responsive it is to changes in its own value or in that of other fiscal variables.

Consider first the own-revenue column. This column shows how a \$1 increase or decrease in revenues in one period affects the subsequent evolution of expenditures, intergovernmental transfers, debt service, and revenues themselves, all expressed in present-value terms. To illustrate, suppose that revenues increase by \$1 resulting in a current deficit reduction (or current surplus increase) of \$1, What kind of subsequent fiscal adjustment can we predict on basis of our statistical model? The revenue column shows that an innovation to own revenue by \$1 is followed by an increase in future expenditures by 51 cents and to reductions of own revenue and grants of 35 and 9 cents respectively, all measured in present-value terms.

Since part of the adjustment to a change in each of the fiscal variables takes the form of an offsetting change in its own future value, it is also instructive to assess the response to a *permanent* \$1 increase in each variable. Dividing by the permanent component of the innovation in own revenue $(1 - .348)$, it turns out that 78 cents of a permanent increase in own revenue by \$ 1 is translated into higher spending (cf. the bottom panel of Table 5), whereas intergovernmental grants are reduced by 13 cents.

Following the predictions of equation (4), the innovations in each of the budgetary components will be fully balanced by the present value of changes in own revenue, grants, and expenditures, which make up the primary surplus. For example, summing across the first three rows in the first column, an additional dollar of own revenue is estimated to result in an offsetting change of 94 cents in the primary surplus. Computing the present value of adjustments in the primary surplus to innovations in expenditures and

[16] Sims (1987) argues that a possible deficiency of this approach is that it ignores the randomness of the estimated covariance matrix of the errors. However, in the current context, this estimate is obtained from a large cross-section as in seemingly unrelated regression analysis. Note that the sampling is carried out using a heteroscedasticity consistent estimate of the variance-covariance matrix of the VECM.

Table 5: Present-Value Responses

Response	Innovation to			
	Own Revenue	Gen. Expend.	Grants	Debt Service
Own Revenue	-.348 (.026)	.162 (.019)	-.144 (.023)	.145 (.037)
Gen. Expend.	.508 (.027)	-.716 (.020)	.338 (.027)	-.370 (.037)
Grants	-.086 (.012)	.082 (.010)	-.473 (.017)	.049 (.016)
Debt Service	-.005 (.005)	.019 (.004)	-.015 (.004)	-.387 (.014)
	response to permanent increase			
Own Revenue		.571 (.040)	-.273 (.044)	.236 (.059)
Gen. Expend.	.780 (.021)		.641 (.043)	-.604 (.063)
Grants	-.131 (.019)	.287 (.033)		.079 (.026)
Debt Service	-.008 (.008)	.068 (.014)	-.028 (.008)	

Standard errors in parentheses obtained by sampling from the normal joint distribution of the VECM estimates based on a heteroscedasticity consistent estimate of the variance-covariance matrix.

grants yields similar figures of \$ 0.959 and \$ 0.955, respectively. For innovations in debt service, the sum of the present value of changes in expenditures, revenues, and grants is much lower (\$ 0.564). But, future changes in the debt service play a major role in balancing the budget, indicating strong temporal fluctuations in the debt service. With regard to permanent increases in the debt service by \$ 1, the present-value response of the primary surplus amounts to \$ 0.919. Given that the intertemporal budget constraint holds only approximately in empirical data, as the true interest rate, its time path, and the amount of non-interest bearing assets of the municipalities are not known, these figures are indicative of reasonable properties of the empirical model of municipal fiscal adjustment.

But the results also indicate that jurisdictions do not respond solely with the components of their primary surplus to innovations in budgetary components. A small but statistically significant fraction of additional grants, 2.8 cents out of a permanent increase of \$1, is used to lower the debt burden. In addition, an increase in expenditures is followed by an increase in debt service by 6.8 cents per dollar of additional permanent expenditures.

Generally, the results show that innovations in the components of the budget tend to be partly offset by future changes in the same component. This is particularly true for expenditures, where more than two thirds of a change are balanced with an offsetting change in the present value of future expenditures. Considering permanent innovations in budgetary components, Table 5 displays a key role of expenditures for fiscal adjustment, where we find that three quarters of each dollar in additional own revenue and almost two thirds of each dollar in additional grants show up in the form of added spending. Changes in debt service also have much larger effects on expenditures than on own revenue. Nevertheless, smaller but still significant parts of the adjustment are obtained by changes in own revenue and grants, in the sense that lower revenues and higher expenses are balanced with significant future increases in own revenue as well as grants.[17]

So much for the interpretation of the columns of Table 5. Next, reading across the rows in Table 5, one can see that each fiscal variable adjusts in the expected direction to innovations in the others, but by varying degrees. Own revenue, for example, adjusts more strongly to an innovation in expenditures than to an innovation in grants or debt service. The third row, showing the response of grants, is of particular interest. Many theoretical and empirical studies highlight the role of intergovernmental transfers as instruments through which higher level governments can influence the behavior of recipient governments. However, as recent discussions of soft-budget constraints have emphasized it may also be the case that recipient governments can induce higher fiscal transfers from donor governments through their own policy actions. The third row of the table shows that fiscal transfers from higher-level governments do indeed respond quite significantly to innovations in municipal own revenues and expenditures, but not very strongly to debt service burdens.

The results in Table 5 provide a picture of a coherent fiscal adjustment mechanism, showing how cities adapt, in accordance with the constraint of long-run fiscal balances, to unpredicted changes in key fiscal variables. Our analysis has left open, however, what the sources of these unpredicted changes actually are. Indeed, each such change might itself be the result of underlying exogenous shocks to local economic

[17] It may be of interest to relate the response to an innovation in grants to the discussion of the "flypaper" effect, according to which the public sector has a high propensity to spend out of grants is (for overviews see Gramlich, 1977, and Hines and Thaler, 1997). The results in Table 5 indicate that the response in spending to a permanent increase in grants by one dollar amounts to 64 cents, which generally is in accordance with the results in the literature (see Hines and Thaler, 1997). This result differs, however, from Holtz-Eakin *et al.* (1991) who use a panel VAR (with only large municipalities) to estimate the relationship between the levels of fiscal variables, and do not find a positive effect of an innovation in grants on spending.

Table 6: Significance of Conditioning Variables

	Equations			
Conditioning Variables	Own Reven.	Gen.Expend.	Grants	Debt Serv.
Period-specific effects	399 (20) ⋆	346 (20) ⋆	581 (20) ⋆	970 (20) ⋆
Predicted change in tax revenue[a]	292 (1) ⋆	45.3 (1) ⋆	1.06 (1)	0.05 (1)
Predicted change in expenditure[a]	211 (1) ⋆	396 (1) ⋆	123 (1) ⋆	1.18 (1)
Predicted change in fed. grants[a]	0.38 (1)	14.9 (1) ⋆	117 (1) ⋆	0.82 (1)
Change in employment[a]	0.01 (1)	0.34 (1)	1.68 (1)	0.61 (1)
Change in income[a]	8.56 (1) ⋆	2.49 (1)	4.54 (1) ⋆	3.69 (1)

Likelihood-ratio statistics for restricting the respective set of conditioning variables to zero. [a] Period-specific effects included as further conditioning variables. Significance at the 5 % level is marked with a star, degrees of freedom in parentheses.

conditions, macroeconomic conditions, or any number of other factors. In order to clarify the sources of shocks to municipal fiscal variables, we include some additional conditioning variables in our basic model. Table 6 reports likelihood-ratio statistics, which provide a natural way to summarize the gain in the predictive power from the inclusion of additional variables.[18] In the first row of Table 6 we report statistics for the inclusion period-specific effects. The effects would include macroeconomic conditions such as GDP growth, unemployment, and financial market conditions such as interest rates.[19] We see that period-specific effects do partly account for the unpredicted changes in fiscal variables to which municipalities must adjust; this is especially true for the debt-service equation, probably indicating the importance of fluctuations in interest rates as determinants of municipal borrowing costs.

As we have seen, municipal own source and intergovernmental revenues trigger significant adjustments in municipal finances. There may be also common factors that affect the evolution of revenues for all municipalities nationwide and that are thus exogenous to individual cities. These nationwide trends will affect individual municipalities differently, depending on their individual revenue structures and, thus, act as exogenous fiscal shocks. To examine the relationship with the fiscal imbalances empirically, we use

[18] More precisely, the likelihood-ratio statistics indicate whether implicit restrictions in the basic, unconditional model can be rejected on statistical grounds.

[19] Note that we do not use period-specific effects in the basic equation, as this would imply to model only adjustments to idiosyncratic innovations, although the intertemporal budget constraint requires adjustments to all innovations. Moreover, the inclusion of period-specific effects would tend to limit the comparability between the results for different subsamples as carried out below.

detailed data on the budget structure in order to compute averages of annual nationwide trends in the components of tax revenue and federal grants, weighted by the specific share in tax revenue or federal grants received by the individual municipality. Inclusion of these variables enables us to determine the extent to which nationwide trends in these subcategories of the budget account for contemporaneous innovations in municipal budget.[20]

As shown in Table 6, the national trends in municipal tax revenues have a large impact on the own-source revenues of individual cities; additionally, they have a significant though more modest impact on expenditures. It is notable that it has no significant effect on grants or municipal debt service. Similarly, the national trends in federal grants have a large impact on municipal grant revenues, but no strong effects on other municipal fiscal variables. These results indicate that national trends in tax revenues and federal grants are reasonable proximate determinants of innovations in the revenues of the individual cities. As we have seen in Table 5 these innovations have large and persistent effects on all components of municipal budgets; common national trends in individual revenue components thus emerge as important shocks, exogenous to individual cities, to which municipal finances must adjust.

One might also expect that local fiscal imbalances, including innovations in local revenues, depend importantly on local economic and demographic conditions (in addition to other possible idiosyncratic factors). To investigate this possibility, we use county-level data on the change of employment and personal income, both in per-capita terms.[21] As shown in the last two rows of Table 6, these variables have only weak predictive power; in fact, changes in employment demonstrate no significant effect at all. For changes in income we find some limited though significant effects on municipal revenues.

To summarize, the analysis shows that imbalances in municipal revenue, whether own-source or intergov-

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[20] If $\Delta X_{i,t}$ denotes the annual change in one of the budgetary components, its prediction can be obtained as a weighted average of the national trends in each of the sub-categories of the COG/ASOGF data making up the budget components, where the weights are the shares of each sub-category. Formally

$$\widehat{\Delta X_{i,t}} = \sum_{j=1}^{n} a^j_{i,t-1} \Delta \overline{X}^j_t,$$

where $a^j_{i,t-1}$ is the share of sub-category j in the respective budget component in municipality i and $\Delta \overline{X}^j_t$ is the national per-capita change in component j. The predicted change in tax revenue is an average of national trends in each of the 18 different types of taxes reported in the data. The predicted change in federal grants distinguishes 12 sub-groups.

[21] The data has been taken from the Bureau of Economic Analysis.

ernmental, trigger significant adjustments in all components of municipal budgets, and that these imbalances are importantly influenced by common national trends, exogenous to individual cities. Somewhat surprisingly, shocks to local economic variables have only small impacts on municipal fiscal imbalances.

5 Fiscal Adjustment and City Size

Our analysis so far has imposed the assumption that all U.S. municipalities follow a common fiscal adjustment process, and, indeed, the empirical findings of Section 4 lend support to this view. The institutional environments within which different cities choose their fiscal policies are not necessarily all the same, however. For example, large cities, which have been the focus of most previous studies of municipal finances, may face quite different administrative and political constraints than smaller ones. On the one hand, they may be able, effectively, to lobby higher-level governments for fiscal assistance or other special treatment. On the other hand, all states distinguish cities into size classes for purposes of state statutes and administrative regulations concerning fiscal policies, personnel management and staffing rules, financial accounting and management procedures, and other controls.[22] Since municipalities of different sizes may thus operate in quite different, fiscal, political, and regulatory regimes, it is natural to wonder to what extent our estimates of fiscal adjustment parameters are robust with regard to city size.

Results from estimating the system separately for large and small cities are reported in Table 7. (Results for cities in the 25th to 75th percentiles by population size are omitted to save space, but are generally in accordance with those reported for the entire sample.) With regard to the innovations on the revenue side the results are generally similar to those above. An innovation in own revenue is offset to a slightly greater extent by future revenue reductions for small cities. Moreover, the response to an innovation in

[22] Cities of the "first class", for example, are those with the largest populations, the next size category defines the cities of the "second class", and so forth. The preamble to the Pennsylvania Intergovernmental Cooperation Authority Act for Cities of the First Class, a law which set up elaborate financing (a "bailout") and fiscal control mechanisms for Philadelphia during its fiscal crisis in the 1990s, exemplifies the potential importance of city size: "It is hereby declared to be a public policy of the Commonwealth ... to foster the fiscal integrity of cities of the first class to assure that these cities provide for the health, safety, and welfare of their citizens; pay principal and interest owed on their debt obligations when due; meet financial obligations to their employees, vendors, and suppliers; and provide for proper financial planning procedures and budgeting practices." "Cities of the first class" in Pennsylvania are those with populations in excess of 1.5 million. Philadelphia is the only city in this class; the second largest city in the state is Pittsburgh, with a population of less than .4 million.

Table 7: Decomposition with Respect to City Size

Response	Innovation to							
	Own Revenue		Gen. Expend.		Vert. Grants		Debt Service	
	small cities (bottom quartile)							
Own Revenue	-.420	(.047)	.204	(.040)	-.188	(.049)	.306	(.082)
Gen. Expend.	.443	(.049)	-.696	(.039)	.262	(.051)	-.319	(.084)
Vert. Grants	-.075	(.023)	.056	(.018)	-.502	(.029)	-.018	(.034)
Debt Service	-.002	(.008)	.015	(.006)	-.012	(.007)	-.337	(.027)
	response to permanent increase							
Own Revenue			.673	(.070)	-.378	(.097)	.462	(.117)
Gen. Expend.	.765	(.044)			.525	(.094)	-.482	(.129)
Vert. Grants	-.130	(.040)	.184	(.059)			-.027	(.051)
Debt Service	-.004	(.014)	.050	(.020)	-.025	(.014)		
	large cities (top quartile)							
Own Revenue	-.320	(.062)	.115	(.031)	-.132	(.039)	.058	(.079)
Gen. Expend.	.511	(.069)	-.696	(.039)	.404	(.057)	-.298	(.084)
Vert. Grants	-.112	(.026)	.148	(.023)	-.424	(.040)	.180	(.037)
Debt Service	-.014	(.010)	.029	(.007)	-.033	(.008)	-.408	(.025)
	response to permanent increase							
Own Revenue			.380	(.075)	-.230	(.071)	.098	(.132)
Gen. Expend.	.752	(.048)			.702	(.069)	-.503	(.144)
Vert. Grants	-.165	(.044)	.487	(.060)			.304	(.063)
Debt Service	-.021	(.015)	.096	(.026)	-.057	(.015)		

Sample decomposition based on the quartiles of the long-run distribution of population. Small cities have populations between 1 and 15 thousand, while large cities have populations between 63 thousand and 7.4 millions. Standard errors in parentheses obtained by sampling from the normal joint distribution of the VECM estimates based on a heteroscedasticity-consistent estimate of the variance-covariance matrix.

grants differs by city size: in small cities, own revenues fall more, and expenditures rise less, as compared to large cities. Generally speaking, however, the results concerning innovations in own-source and intergovernmental revenue confirm the findings for the entire sample.

The situation is different when it comes to innovations arising on the expenditure side. As reported in the second column, small cities raise own revenue more in response to an innovation in expenditures than do large jurisdictions. For example, small jurisdictions respond to a permanent expenditure increase of \$1 with an increase in own revenue of about 67 cents, whereas large jurisdictions raise their own revenue by only 38 cents. By contrast, large cities rely much more on transfers from higher-level governments to finance permanent increases in expenditures. For small municipalities, only about 18 cents out of a dollar, or 18 %, of a permanent increase in spending is financed by increased grants, whereas the corresponding figure for large municipalities is almost 49%. It is interesting to compare these adjustment responses to the average shares of expenditures financed by grants. Larger jurisdictions, on average, depend more on grants: grants as a share of expenditures are 31% for large cities and only 26% for small cities. For large cities, then, *innovations* in municipal expenditures are even more substantially financed by increased intergovernmental transfers than the already higher *average* share of grants in total expenditures suggests. Conversely, for smaller cities, innovations in municipal expenditures are even less substantially financed through transfers than is indicated by the relatively low share of grants in total expenditures. Expressed somewhat differently, the "marginal" response of grants to innovations in expenditures *magnifies* the existing "average" differential importance of grants in the finances of cities in different size categories.

The response of fiscal transfers to an innovation in debt service is particularly noteworthy. We find that small cities tend to respond by raising own revenue, whereas large cities do not. Instead, innovations in debt service give rise to large increases in grants for large cities, where almost a third of the innovation is offset by transfers from higher-level governments. For other cities this response is negligible. Evidently, grants play an unusually important role in the fiscal adjustment process for large cities.

Taken together, these results suggest that our principal findings from Section 4 are robust with respect to city size. Table 5's summary statistics about the fiscal adjustment of municipalities in response to fiscal shocks on the revenue side are essentially confirmed. On the expenditure side we do see, however, some important differences. Expenditure and debt service innovations for large cities tend to be much more offset by intergovernmental transfers, whereas for small cities the main adjustment occurs through changes in own revenues.

These differences in the dynamics of fiscal adjustment for large and small cities cannot conclusively demonstrate that large cities operate under soft budget constraints. They do, however, demonstrate that the fiscal adjustment process for large cities, especially in its intergovernmental dimensions, differs from that for small cities, suggesting that the institutional structure of intergovernmental fiscal relations also varies by city size. One implication of this finding is that empirical analysis of large cities, useful though it may be because of their quantitative importance, may lead to findings that are unrepresentative of municipalities in general.

6 Conclusion

The preceding analysis has investigated empirically the dynamic fiscal policy adjustment of U.S. municipalities using a vector error-correction model which takes account of government intertemporal budget constraints. The results point to an important role of expenditures in maintaining intertemporal budget balance, especially in response to shocks in own-source and intergovernmental revenues. We find that an additional dollar of own-source revenue gives rise to 78 cents of additional expenditures, expressed in present-value terms. In response to an additional dollar of grant revenue, expenditures rise by 64 cents, in present value. However, revenue-side adjustments are significant, too; it is particularly interesting to note that grants from higher-level governments are quite sensitive to municipal fiscal imbalances. A sample decomposition shows that these patterns are generally robust with respect to city size. However, it is noteworthy that small cities tend to rely more on own-source revenue whereas additional revenue from grants play a much larger role in restoring budget balance for large cities – much larger than the budget share of grants in the finances of these cities would suggest. Thus, intergovernmental transfers seem to "cushion" the process of fiscal adjustment for municipalities generally. Since municipalities use "external" funds to balance their budgets, it is possible that this apparent softening of budget constraints distorts local policy decisions. If so, our results suggest that this effect may be particularly relevant for larger cities.

The statistical methods that we have used do not test for the importance of any particular institutional, economic, or other determinants of municipal fiscal adjustment, but rather shed light on the empirically-relevant contours of the underlying institutions as revealed in the dynamic adjustment process. Our findings have identified important empirical relationships, not previously discerned, the explanation of which presents new challenges and opportunities for future research. For example, why should expenditures and revenues play different roles in the dynamic adjustment process for municipalities? Since expenditure levels seem to be heavily influenced by changes in revenues, what does this imply about the impact of state-level regulatory constraints on the types of revenue instruments available to municipalities, or limitations on their utilization? Would these types of policies or institutional constraints have more significant impacts on municipal spending than, say, budget oversight or review agencies which, at first glance, might appear to be more directly related to expenditure policy? Why should intergovernmental transfers interact with municipal finances as they do? Why should fiscal adjustment for large cities differ from that of small cities? As indicated in some of the preceding discussion, there are many interesting hypotheses that might be examined in an attempt to explain these and other empirical results revealed in our analysis. An enhanced view of the empirical landscape should be of value in discriminating among competing theoretical models of local government policymaking in a federal structure, and, ultimately, in understanding better the complex institutional structures, interacting with underlying economic, demographic, and technological fundamentals, that produce the observed dynamic fiscal adjustment process.

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The Dynamics of Municipal Fiscal Adjustment: Appendix

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Appendix

This appendix provides the necessary calculations and detailed parameter estimates for the determination of the present-value responses described in our paper, "The Dynamics of Municipal Fiscal Adjustment".

To begin with, we rewrite the system of four equations as set up in Section 3 as a first-order VAR

$$X_t \; = \; \mathbf{B} \, X_{t-1} \; + \; v_t. \tag{A.1}$$

In order to express the system specified with four lags (p=4) in this way, we collect the coefficients into a (4×1) vector of error-correction terms, a (4×1) vector of constants, and four (4×4) matrices,

$$\gamma \equiv \begin{bmatrix} \gamma^1 \\ \gamma^2 \\ \gamma^3 \\ \gamma^4 \end{bmatrix}, \qquad a \equiv \begin{bmatrix} a_0^1 \\ a_0^2 \\ a_0^3 \\ a_0^4 \end{bmatrix}, \quad \mathbf{A}_i \equiv \begin{bmatrix} a_{1,i}^1 & a_{2,i}^1 & a_{3,i}^1 & a_{4,i}^1 \\ a_{1,i}^2 & a_{2,i}^2 & a_{3,i}^2 & a_{4,i}^2 \\ a_{1,i}^3 & a_{2,i}^3 & a_{3,i}^3 & a_{4,i}^3 \\ a_{1,i}^4 & a_{2,i}^4 & a_{3,i}^4 & a_{4,i}^4 \end{bmatrix}, \quad \text{where} \quad i = 1, ..4.$$

This allows us to reformulate the four estimation equations as

$$\Delta Y_t \; = \; \gamma \, D_{t-1} \; + \; a \; + \; \mathbf{A}_1 \Delta Y_{t-1} \; + \; \mathbf{A}_2 \Delta Y_{t-2} \; + \; \mathbf{A}_3 \Delta Y_{t-3} \; + \; \mathbf{A}_4 \Delta Y_{t-4} \; + \; u_t. \tag{A.2}$$

Next, we write the deficit as a sum of changes in the budget components and the preceding period's deficit

$$D_{t-1} = b' \Delta Y_{t-1} + D_{t-2}.$$

Following Bohn (1991) repeated substitution for the deficit in (A.2) yields the following parameter matrix

$\mathbf{B}$ and corresponding vectors of variables X_t and disturbances v_t of the first-order VAR system (A.1)

$$\mathbf{B} \equiv \begin{bmatrix} \mathbf{A}_1+\gamma b' & \mathbf{A}_2+\gamma b' & \mathbf{A}_3+\gamma b' & \mathbf{A}_4+\gamma b' & \gamma \\ \mathbf{I} & \mathbf{0} & \mathbf{0} & \mathbf{0} & 0 \\ \mathbf{0} & \mathbf{I} & \mathbf{0} & \mathbf{0} & \vdots \\ \mathbf{0} & \mathbf{0} & \mathbf{I} & \mathbf{0} & 0 \\ 0 & \ldots & 0 & b' & 1 \end{bmatrix}, \quad X_t \equiv \begin{bmatrix} \Delta Y_t \\ \Delta Y_{t-1} \\ \Delta Y_{t-2} \\ \Delta Y_{t-3} \\ D_{t-4} \end{bmatrix}, \quad \text{and} \quad v_t \equiv \begin{bmatrix} u_t \\ 0 \\ ... \\ 0 \end{bmatrix},$$

where $\mathbf{I}$ is a (4×4) identity matrix and $\mathbf{0}$ is a (4×4) zero matrix. Using the empirical results as displayed in Table A.1 below and assuming a specific initial innovation at period t we can employ the first-order VAR system (A.1) to predict the k-period-ahead value of the variable vector as

$$\widehat{X}_{t+k} \;=\; \mathbf{B}^k v_i,$$

where v_i is a 0-1 vector with zeros everywhere except for the i-th row, which is capturing a unit innovation in the i-th budget component. Hence, defining a 0-1 row-vector h_j which selects the j-th row of X_t we can determine the k-period-ahead impulse response in the j-th budget component as $h_j \mathbf{B}^k v_i$. Summing over an infinite number of periods and assuming a discount factor of $\rho \equiv (1+r)^{-1}$, where r denotes the given interest rate, we can compute the present value of the impulse response in the j-th budget component triggered by the unit innovation in the i-th budget component:

$$\widehat{\pi}\left(Y[j], Y\,[i]\right) \;=\; \sum_{k \geq 1} h_j \rho^k \mathbf{B}^k v_i \;=\; h_j \rho \mathbf{B} \left[1 - \rho \mathbf{B}\right]^{-1} v_i$$

The corresponding results are displayed in the upper part of Table 5 of the paper.

Table A.1: Detailed Estimation Results for Basic Model

Expl. Variable	Notation in (A.2)	Dependent Variable: Own Revenue		Gen. Expend.		Vert. Grants		Debt Service	
Deficit_{t-1}	γ'	.098	(.013)	-.297	(.018)	.069	(.009)	.013	(.003)
Own Revenue_{t-1}		-.156	(.024)	.028	(.026)	.039	(.010)	.017	(.004)
$\text{Gen. Expend.}_{t-1}$	$\mathbf{A}'_1$	-.021	(.012)	-.249	(.019)	-.020	(.009)	-.001	(.004)
$\text{Vert. Grants}_{t-1}$		.055	(.013)	-.000	(.025)	-.283	(.020)	.004	(.004)
$\text{Debt Service}_{t-1}$		.026	(.034)	.085	(.049)	-.055	(.022)	-.284	(.018)
Own Revenue_{t-2}		-.034	(.018)	.081	(.021)	.037	(.009)	.001	(.004)
$\text{Gen. Expend.}_{t-2}$	$\mathbf{A}'_2$	-.005	(.010)	-.155	(.016)	-.023	(.007)	.007	(.003)
$\text{Vert. Grants}_{t-2}$		.019	(.011)	-.042	(.023)	-.168	(.016)	-.001	(.004)
$\text{Debt Service}_{t-2}$		.029	(.035)	-.069	(.049)	-.031	(.019)	-.157	(.015)
Own Revenue_{t-3}		-.003	(.015)	.079	(.018)	.008	(.009)	.000	(.004)
$\text{Gen. Expend.}_{t-3}$	$\mathbf{A}'_3$	-.004	(.009)	-.093	(.014)	-.018	(.007)	.007	(.003)
$\text{Vert. Grants}_{t-3}$		-.006	(.010)	-.035	(.019)	-.095	(.011)	-.005	(.003)
$\text{Debt Service}_{t-3}$		-.040	(.035)	-.115	(.048)	-.033	(.020)	-.144	(.016)
Own Revenue_{t-4}		-.003	(.013)	.032	(.018)	-.016	(.007)	.000	(.003)
$\text{Gen. Expend.}_{t-4}$	$\mathbf{A}'_4$	.003	(.007)	-.040	(.011)	-.008	(.005)	.003	(.002)
$\text{Vert. Grants}_{t-4}$		-.003	(.009)	-.037	(.017)	-.066	(.010)	-.003	(.003)
$\text{Debt Service}_{t-4}$		-.022	(.032)	-.073	(.050)	-.002	(.019)	-.118	(.014)
Constant	a'	.021	(.001)	.017	(.001)	.003	(.001)	-.001	(.000)
Mean of Dependent Variable		.017		.016		.009		-.001	

Estimated coefficients for the basic estimation equations using four lags as described in Section 3. Heteroscedasticity robust standard errors in parentheses.