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MUNICIPAL CONSTRUCTION SPENDING: AN EMPIRICAL EXAMINATION

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ABSTRACT

Despite widespread concern and discussion, no consensus exists concerning the causes of the "infrastructure crisis." We investigate several models of the determination of local public capital expenditures. Using Euler equation methods, we find that the hypothesis that construction spending is determined by unconstrained, forward looking municipal planning cannot be rejected. Consistent with this result, we find that the stochastic structure of own revenue and grant flows is an important feature of the determination of construction spending. Only unanticipated changes in a community's resources alter its demand for structures. An unanticipated increase in resources of one dollar increases current construction spending by about 5.5 cents.

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1. Introduction

Recently, substantial public and professional attention has been devoted to the possibility of an "infrastructure crisis" in the United States:

> For the last 20 years or so, capital spending on public works...has been competing with social services spending -- and losing. Our nation can no longer afford to lose. The problem has become a crisis because economic renewal depends upon an adequate infrastructure. (Associated General Contractors of America [1983].)

Indeed, the decline in the flow of real infrastructure spending by states and localities during the 1970's is well documented. For the United States as a whole, total annual construction spending by state and local governments fell in real terms by roughly 15.4 percent between 1970 and 1980. This overall decline is mirrored in the experience of the 167 municipal governments that are the subject of this study. (The data are described in greater detail in Section 3, below.) As indicated in Table 1, between fiscal years 1972 and 1980 average real construction spending per capita fell by 33.9 percent from $57.12 per capita (in 1977 dollars) to $37.76.[1] The decline from the peak in 1976 to 1980 was an even more dramatic 43.6 percent.[2]

However, there is no consensus about either the causes of this decline or its implications. Some analysts interpret reduced capital spending as a sensible reaction to changing economic and demographic conditions. Others view the decline with alarm and seek to "blame", for example, the macroeconomy, myopic state and local officials, or changes in the municipal bond market. In this paper we utilize panel data on municipal governments' construction spending during the 1970's in order to investigate a variety of models of municipal capital expenditures. While the issue of optimal maintenance of existing capital is an important one, our focus here is on the acquisition of new capital.

The next section sketches several alternative explanations for the behavior of capital spending over time, and formalizes them so that they are amenable to econometric testing. Section 3 describes the data and econometric issues. Section 4 contains a presentation of the empirical results. Our main findings are:

(i) Changes in local government investment spending are not very well described by models that rely only on common national and state events as explanatory variables.

(ii) One cannot reject the notion that construction spending follows a path consistent with forward looking, rational municipal planning.

(iii) The stochastic properties of own revenue and grant flows are an important feature of the determination of construction spending. Changes in these variables that are thought to be permanent have a much greater impact on current construction spending than those that are perceived to be transitory.

The final section is a summary and discussion of the policy implications of the results.

2. Models of Municipal Investment Spending

What explains the trends in municipal capital spending depicted in Table 1? This is related to the more general question of how communities make fiscal decisions. As Inman [1988] and others have emphasized, no universal theoretical model is available for answering this question. In the context of infrastructure spending, a variety of suggestions have been made, which reflect quite different views of the underlying determinants of public expenditure. Without drawing the line too distinctly, one can group the various suggestions for the decline of municipal investment expenditures into two broad classes.

The first class of explanations views capital formation at the local level as dominated by important national "events" that are common to all municipalities. For example:

a) The tax-exempt bond market moved away from its traditional role in financing local government capital formation during the 1970's. Instead, funds raised in this market were channeled to housing, hospitals, and the private sector (e.g. industrial development bonds). (See Petersen [1986].) Presumably, all municipalities are subject to the effects of this change.

b) During this period, the federal government required localities to increase social welfare expenditures; these "crowded out" capital spending.

c) In the aftermath of the tax revolt, local officials maintained current service levels without raising taxes by deferring both new and maintenance capital spending. (See Citrin and Green [1985].) To the extent that the tax revolt can be regarded as a uniform national phenomenon, it qualifies as such an event.

Items a) through c) imply that common national trends dictate the course of investment spending over time. A closely related notion is that for communities in the same states construction spending is dominated by the fixed institutional rules set by their state governments. From an econometric point of view, the key aspect of both these stories is that trends in community spending are determined by common national influences, and for communities within the same state, by common state sources. This suggests a straightforward econometric strategy. Let C_{it} be the level of construction spending for community i in year t. Let k index states in the sample and define $STATE_k=1$ if community i is in state k, and zero otherwise. Let

$YEAR_{72}$=1 if the observation is from 1972, and zero otherwise. Define $YEAR_{73}...YEAR_{80}$ analogously. Then regress C_{it} on a constant and both the state and year dichotomous variables. (Of course, one variable from each category must be omitted to avoid collinearity.) To the extent that municipal construction spending reacts to swings in national output, interest rates, bond market developments, or the national "mood", these effects will be captured by the YEAR variables. In the same way, variations in construction across municipalities that are due to differences in state institutional environments should be reflected in the estimated coefficients of the STATE variables. Of course, it may be that the state effects vary from year to year. Thus, for completeness, we also investigate a model which includes a complete set of interactions between the YEAR and STATE variables.

The second class of explanations for the decline of infrastructure spending deals more carefully with the decision-making processes of the communities themselves. For example, Hulten and Peterson [1984] argue that the decline in observed spending patterns is simply a sensible reaction to changing demographics (particularly the decline in the school-age population) and falling rates of real income growth. Consistent with this view is a model in which capital spending is the outcome of a rational, forward looking decision process. Although the idea of municipal governments acting as if they are maximizing some intertemporal objective function may strike some as incredible, our conversations with several local officials have indicated that their time horizons are longer than just a single year budget cycle. Of course, this does not prove that the model is correct; it only suggests that the model should not be dismissed out of hand.[3]

In contrast to Hulten and Peterson, Inman [1983] regards the decline of infrastructure spending as a consequence of a myopic or backward looking decision-making process that leads to suboptimal outcomes.[4] Specifically, Inman argues that when resources available to the community fall, infrastructure spending is hurt disproportionately because of the absence of effective political coalitions that favor such expenditures.

In the absence of direct observations of the actual and desired level of public capital, a model of investment spending is required in order to discriminate among these alternative hypotheses. We consider two variants of a dynamic, stochastic model of investment spending. The first allows one to test the joint hypotheses that agents are forward looking and face no credit market constraints, without estimating "structural" parameters. The second variant, on the other hand, yields estimates of an investment function.

2.1 An Euler Equation Model

Recent discussions of intertemporal planning in the face of uncertainty (see Hall [1978]) approach this problem as follows: Assume that an agent in the municipality maximizes an intertemporal utility function in the presence of uncertainty concerning the future flow of resources. The solution to this problem places restrictions on the lag distribution of the choice variable (construction spending). Analyze the time series data on the choice variable to determine whether or not these restrictions are violated. If not, it suggests the presence of rational, forward looking planning. Alternatively, if the restrictions are violated, then myopia, borrowing constraints, or backward looking behavior may be present. Importantly, this procedure does not produce estimates of a structural model for the choice variable. It merely tests one implication of the structural model.

The first step is to specify an objective function. We assume that the government maximizes the expected present value of a utility function that depends upon the flows of after tax income and government services in the community:

$$(2.1) \qquad E_t \{ \sum_{s=0}^{\infty} \beta^s U(x_{t+s}, g_{t+s}) \}$$

where E_t denotes expectations taken using information available at the beginning of period t, $\beta \equiv 1/(1+\pi)$ and π is the pure rate of time preference, x_t is after tax income available for purchases of private goods, g_t is the level of municipal services in period t, and U(.,.) is the utility function, which we assume to be separable between x_t and g_t. (For the sake of clarity, we temporarily suppress the i subscript.) An attractive feature of this approach is that it does not require us to identify whose preferences are represented by U(.,.). For example, it might be the utility function of a "representative" resident or it might depict the preferences of a bureaucrat whose utility depends on the size of his budget. In any case, maximization of U(.,.) need not be consistent with an efficient level of government services, although it might be. A possible problem with this formulation is the assumption that preferences are stable over time. Perhaps the identity of the decisive voter or the decision-making bureaucrat changes over time. In the econometric work presented below, we investigate this possibility by testing for time-stability of the parameters that govern spending on structures.

Next we consider the decision-maker's constraints. Municipal services are produced with capital available at the end of the previous period, K_{t-1}, and labor, L_t, according to the production function:

(2.2) $g_t = f(K_{t-1}, L_t)$.

As we show in Section 4.2 below, one cannot reject the hypothesis that the production function is separable in capital and labor. Hence, we will assume

(2.2') $g_t = f^1(K_{t-1}) + f^2(L_t)$.

The capital stock evolves via the identity

(2.3) $K_t = (1-\delta)K_{t-1} + C_t$

where C_t is construction and δ is the geometric rate of depreciation net of maintenance. Labor receives w_t in each period and construction costs q_t per unit. We assume the presence of adjustment costs that increase with investment spending.[5] Thus,

(2.4) $q_t = q(C_t)$ and $dq/dC_t > 0$.

To finance its expenditures, the government raises R_t in own-source revenue and receives G_t in grants from outside sources.[6] Individual income before local taxes is y_t; after tax income is $x_t \equiv y_t - R_t$. Finally, let NA_t be the community's end of period net financial assets. Then, the government must satisfy the present value budget constraint

(2.5) $NA_t + \sum_{s=0}^{\infty} D^s (R_{t+s} + G_{t+s} - w_{t+s}L_{t+s} - q_{t+s}C_{t+s}) = 0$

where $D \equiv 1/(1+r)$ and r is the (constant) real rate of interest.[7] The government chooses a sequence of planned revenues $\{R_{t+s}\}$, construction $\{C_{t+s}\}$, and labor employment $\{L_{t+s}\}$ to maximize (2.1) subject to the constraints (2.2) through (2.5). Provided that the elasticity of q_t with respect to capital spending is locally constant and greater than or equal to one, it can be shown that the optimal solution is characterized by the Euler equation:

$$(2.6) \quad \frac{E_t\ [(\partial U/\partial g_{t+2})\ (\partial f/\partial K_{t+1})]}{E_t\ [(\partial U/\partial g_{t+1})\ (\partial f/\partial K_t)]} = \frac{E_t\ [(1+r)q_{t+1} - (1-\delta)q_{t+2}]}{E_t\ [(1+r)q_t - (1-\delta)q_{t+1}]} \frac{(1+\pi)}{(1+r)} .$$

(This is shown in an Appendix, available upon request.) In words, the marginal rate of substitution between services from capital in adjacent periods equals the intertemporal relative prices, where prices incorporate the rate of time preference, the rate of interest, and adjustment costs. Note that q_t (which appears on the right side of equation (2.6)) is a function of C_t, and C_t depends on both K_t and K_{t-1} via the identity (2.3). Hence, the effective price of the last unit of K_t embodies both the cost of adjusting from K_{t-1} to K_t, and from K_t to K_{t+1}. Similarly, the effective price of K_{t+1} involves K_t, K_{t+1}, and K_{t+2}. As a consequence, the Euler equation that relates K_t and K_{t+1} implicitly defines the expected relationship among K_{t+2}, K_{t+1}, K_t, and K_{t-1}, conditional upon information available at the start of period t.

According to equation (2.6), the values of K_t in various periods can in principle be related to each other in a rather complicated fashion. For tractability, we approximate equation (2.6) as a linear relationship among the capital stocks in successive time periods. The econometric strategy discussed below allows us to test whether the assumption of linearity is consistent with the data. Finally, if we assume further that community i has an "individual effect", f_i, which captures those characteristics unique to municipality i that are unobserved by the investigator, equation (2.6) is approximated as:

$$(2.7) \qquad K_{it} = f_i + \alpha_1 K_{it-1} + \alpha_2 K_{it-2} + \alpha_3 K_{it-3} + \mu_{it}$$

where μ_{it} is an expectational error.[8]

An important issue is whether any other lagged variables belong on the right side of equation (2.7). Consider first a model with no marginal adjustment costs, so that the Euler equation links the current capital stock to only its lagged value. If so, K_{it-1} captures all forecastable information concerning the current capital stock. Put differently, μ_{it} is orthogonal to all information available at the beginning of time period t-1. Accordingly, if we regress K_{it} on K_{it-1}, no other lagged variable dated t-2 or earlier should be significantly related to K_{it}.[9] Of particular importance in this context are lagged values of other variables from the community's budget constraint -- revenues, grants, assets, and debts. In addition, given our assumption of separability in production (equation (2.2')), lagged values of labor should not appear in equation (2.7).

Next consider the case of positive marginal adjustment costs. In this case, there is no reason to expect μ_{it} to be orthogonal to information available at the beginning of time period t-1. In the presence of marginal adjustment costs, the appropriate value of K_{it} depends on the costs of adjusting from K_{it-1}; by implication, new information from periods t-1 and t-2 will affect K_{it} even after including K_{it-1}, K_{it-2}, and K_{it-3} in the regression.[10] However, if decision-making is rational, variables from period t-3 and earlier should be excluded from the regression.

To summarize: If marginal adjustment costs are zero and the production function is separable, then the autoregression for K_{it} will contain only one lag and all other lagged variables will be excluded. On the other hand, if marginal adjustment costs are positive, then the autoregression for K_{it} will contain three lags and other lagged variables dated period t-3 or earlier will be excluded.

Note that equation (2.7) ignores intertemporal changes in the relative cost of public goods. Such changes, which are not ruled out by the theoretical model, might arise from modifications in matching rates of federal grant programs, for example. The econometric procedure described below controls for this possibility by permitting the intercept in the equation to vary over time. Because changes in federal grant rules are common to all communities, they are captured in these year specific intercepts.

Equation (2.7) embodies strong predictions concerning the dynamic structure of the public sector capital stock. These predictions are derived from equally strong assumptions concerning the determination of investment spending: time separable utility functions, no capital market constraints, linear functional form, etc. Nonetheless, as in other contexts, the model provides a useful benchmark and a good starting point for the empirical work below.

2.2 Demand for Structures Function

Recall that equation (2.7) is derived from the Euler equations for an interior solution to the intertemporal maximization problem posed in Section 2.1. In the literature on personal consumption spending, such a set-up provides the basis for the permanent income theory of consumption. In analogy to this literature, we define "permanent own revenues" as the discounted present value of all expected future own revenue flows, and "permanent grants" analogously. Then one can imagine solving the Euler equations to find a function that relates the desired level of the capital stock to the previous value of the capital stock (if adjustment is costly), permanent own revenues (denoted R_t^P), permanent grants (G_t^P), and the stock of net financial assets at the start of the planning period (NA_{t-1}). Since explicitly solving for the desired capital stock is difficult, we assume that the relationship is linear, _viz_.:

$$(2.8) \quad K_{it} = g_i + \beta_1 K_{it-1} + \beta_2 X_{it}^P + \beta_3 NA_{it-1} + v_{it}$$

where g_i is an individual effect as above, X_{it}^P is the vector of permanent own revenues and grants, and v_{it} is an error term.[11] As written, equation (2.8) allows the coefficient on net assets to differ from that on the permanent value of resource flows. Strictly speaking, however, there is no reason for β_2 and β_3 to differ -- both represent the propensity to spend on structures out of wealth. However, rather than impose this constraint _a priori_, in Section 4 we test to see if it is consistent with our data.

Note that unlike the three lags in the Euler equation model (2.7), the demand for structures function contains only the most recent lag of the capital stock. Intuitively, this is because the Euler equation summarizes the optimal rate of change of the marginal utility of capital; i.e. the optimal marginal changes from period to period. Thus, it contains information on adjustment costs for two different time periods. In contrast, the demand for structures function summarizes the optimal level of the capital stock in each period and contains only information on adjustment costs in the current period.

Finally, note that equation (2.8) does not include the relative price of construction spending. In practice, in any given year all the communities face about the same federal matching rates. As suggested above, their impact is well captured by a set of year effects, which are therefore included in all of our estimates.[12]

2.3 Stocks versus Flows

Both the Euler equation (2.7) and the demand for structures equation (2.8) are defined in terms of the stock of structures. Our data contain flows of spending on structures, not the stocks. (See Section 3.1, below.) We employ the perpetual inventory identity to convert from stock to flow relationships. Thus, if C_{it} is the flow of construction spending in community i during year t, then:

$$(2.9) \qquad C_{it} \equiv K_{it} - (1-\delta)K_{it-1}$$

where δ is the net rate of depreciation. That is, δ embodies the net effects of deterioration of the structures and any offsetting maintenance expenditures.[13] To see the implications of equation (2.9), consider the following generic econometric specification which includes both equations (2.7) and (2.8) as special cases:

$$(2.10) \qquad K_{it} = h_i + Z_{it}\theta + \epsilon_{it}$$

where h_i is an individual effect. Substituting (2.10) into (2.9) yields:

$$(2.11) \qquad C_{it} = \delta h_i + (Z_{it}-(1-\delta)Z_{it-1})\theta + \epsilon_{it} - (1-\delta)\epsilon_{it-1}$$

One must further difference equation (2.11) to eliminate the individual effect. This produces:

$$(2.12)\qquad C_{it}-C_{it-1} = (Z_{it}-Z_{it-1})\theta - (1-\delta)(Z_{it-1}-Z_{it-2})\theta + (\epsilon_{it}-\epsilon_{it-1})-(1-\delta)(\epsilon_{it-1}-\epsilon_{it-2})$$

An important special case is when the net depreciation rate, δ, equals zero. In this case, $C_{it} = K_{it} - K_{it-1}$, and substituting (2.10) into (2.9) yields:

$$(2.13)\qquad C_{it} = (Z_{it}-Z_{it-1})\theta + \epsilon_{it}-\epsilon_{it-1}$$

Comparing (2.13) to (2.12), we see that when δ is non-zero the equation contains an additional year of lags, a more complex error structure, and is nonlinear in the parameters. In subsequent sections, we design and execute tests for whether the simpler specification is consistent with the data. To anticipate our results, we find that one cannot reject the hypothesis $\delta = 0$. In this case, applying equation (2.13) to our capital stock equation (2.8), we obtain

$$(2.14)\qquad C_{it} = \beta_1 C_{it-1} + \beta_2 \Delta X^p_{it} + \beta_3 \Delta NA_{it} + v_{it} - v_{it-1}.$$

Now, by definition, all changes in permanent resources are unexpected. This suggests that in the process of estimating the construction spending function (2.14), we can also perform another text of the intertemporal utility maximization hypothesis. Define X^u_{it} to be the vector of unanticipated flows of own revenues and grants, and let X^e_{it} be the vector of expected own revenues and grants. Then if we estimate

$$(2.15)\qquad C_{it} = \beta_1 C_{it-1} + \beta_2' X^u_{it} + \beta_2'' X^e_{it} + \beta_3 \Delta NA_{it} + (v_{it} - v_{it}),$$

under the null hypothesis, β_2'' is zero. That is, with intertemporal utility maximization and no credit market constraints, only unanticipated resource flows affect current construction spending.

In order to estimate equation (2.15), it is necessary to decompose revenues and grants into expected and unexpected components. Following what has become standard practice, we assume that expectations are generated by a vector autoregression (VAR). (See Pagan [1984].) We estimate the parameters of a VAR for the variables in question. The one period ahead forecast of each variable is the "expected" value; the difference between the actual value and the expected value is our estimate of the "unexpected" value of the variable.

3. Data and Estimation Issues

In this section we discuss the data, and then turn to the econometric problems.

3.1 Data

Our data set is constructed from the finance files of the 1972 and 1977 Census of Governments, and the Annual Survey of Governments for 1973 to 1976 and 1978 to 1980.[14] A random sample of municipalities was drawn from the 1979 Annual Survey and matching records drawn, when possible, for the remaining years. Because school finance is such an important component of local government spending, we examine only those municipalities responsible for their own education spending. Retaining only those communities that reported non-zero school expenditures reduced both the number of available municipalities and the number of states represented in the sample. After eliminations due to missing data, the result was a panel of 167 municipalities over nine fiscal years.[15]

Construction spending was deflated to 1977 dollars using the GNP implicit price deflator for purchases of structures by state and local governments. The remaining variables were deflated using a region specific consumer price index. End of year holdings of financial assets and liabilities were corrected from par to market value using indices constructed by Eisner and Pieper [1985]. Finally, all variables were converted to per capita terms.

3.2 Econometric Issues

A number of econometric issues arise in the estimation of both the Euler equation and the demand for structures function:

a) Testing for first versus second differencing. As suggested above, the estimation problem is simplified if the net depreciation rate, δ, is zero. If so, a specification of the type in equation (2.13) is appropriate. If not, the more complicated specification (2.12) must be employed. To test which of these models is consistent with the data, we follow the procedure proposed by Holtz-Eakin [1988]. This requires estimating the model both with and without second differencing (using the set of instrumental variables appropriate in each case) and then comparing the results. Intuitively, if δ=0, then the two sets of estimates will be similar and will yield similar values for the minimized value of the objective function.

The results in Section 4 indicate that the data do not reject the hypothesis of δ=0. Does this make sense? First, recall that δ is depreciation net of maintenance; hence, the finding that δ = 0 does not mean that public sector capital is indestructible. Second, the failure to reject the hypothesis that δ = 0 is probably more a consequence of the fact that it is imprecisely estimated than that its true value is zero.

In any case, given δ = 0, we can employ equation (2.13), and the Euler equation (2.7) becomes:

$$(3.1) \qquad C_{it} = \alpha_1 C_{it-1} + \alpha_2 C_{it-2} + \alpha_3 C_{it-3} + \Delta\mu_{it}.$$

Similarly, as shown above, the construction spending function becomes

$$(3.2) \qquad C_{it} = \beta_1 C_{it-1} + \beta_2' X^u_{it} + \beta_2'' X^e_{it} + \beta_3 \Delta NA_{it-1} + \Delta v_{it}.$$

The remainder of this section focuses on these equations.

b) Serially correlated errors. Equations (3.1) and (3.2) both have serially correlated error terms. In the presence of lagged dependent variables, ordinary least squares produces inconsistent estimates. We employ an instrumental variables estimation procedure suggested by Holtz-Eakin, Newey, and Rosen [1988]. It exploits the fact that even in the presence of serially correlated errors, sufficiently early lags will be uncorrelated with the error term.[16] The procedure uses these orthogonality conditions to form a generalized method of moments estimator that is efficient in the class of linear estimators. Moreover, the procedure produces a chi-square statistic that can be used to perform a variety of specification tests, including tests for parameter stationarity over time, and tests for higher order serial correlation in the errors.

c) Heteroskedasticity. We correct for heteroskedasticity using White's [1980] method.

d) Functional Form. As stressed above, equation (2.7) is a linear approximation to the exact Euler equation. If this linearization is inadequate, then in effect higher order powers of the lagged capital spending will be grouped with the error term. Similarly, if the production function is not separable between capital and labor, the error term will contain past values of labor input. Such situations would induce a correlation between the error term and the instrumental variables, thus violating the orthogonality conditions. Hence, as a specification test, we examine the appropriateness of the overidentifying orthogonality conditions.

Another important aspect of the functional specification is the assumption that the parameters are stationary over time. If stationarity is incorrectly imposed, then each time period's error term will contain a component that depends on the true values of the parameters and the right hand side variables. The latter produces a correlation between the error terms and the instrumental variables and, again, the orthogonality conditions are violated. Thus, the test of the overidentifying orthogonality conditions also serves as a test for parameter stationarity.[17]

e) Decomposition of variables into expected and unexpected components. To do this we employ a two step procedure: i) estimate a forecasting equation for each of the variables; and ii) define the one period ahead forecast as the expected value and the residual as the unexpected value. Of course, one could estimate the forecasting and construction equations jointly; perhaps imposing the cross-equation constraints implied by the assumption of rational expectations. (See, for example, Hansen and Sargent [1980].) We prefer this computationally simpler limited information approach because errors in the specification of the forecasting equations do not directly bias estimates of the parameters of the construction spending function. We correct the standard errors in the second stage for the fact that the decomposition is estimated in a first stage regression using the method suggested by Pagan [1984].

Employing panel data raises a complication not present in analysis of a single time series of data. One cannot distinguish between the magnitude of the individual effect and the average size of each municipality's expectational error. We assume that the latter is zero for each community, an assumption consistent with typical practice in the time series literature -- on average, expectations are accurate.

f) <u>Simultaneity problems</u>. In the construction spending function (3.2), expected and unexpected own revenues and grants are explanatory variables. One might argue that this equation is subject to simultaneity bias. Let us consider, in turn, the coefficients on the "unexpected" and "expected" variables. One way to deal with simultaneity of the unexpected variables would be to employ instrumental variables. Unfortunately, the likely candidates for instrumental variables are those used to forecast own revenues and grants. These are, by construction, uncorrelated with the unexpected variables. Hence, there are no plausible candidates for instrumental variables with which to estimate the parameters. However, no instrumental variables are needed if the error term in the construction equation is orthogonal to unexpected own revenues and grants. We therefore assume that in equation (3.2), X^u_{it} is uncorrelated with Δv_{it}. This is analgous to the assumption used in the consumption function literature that the transitory component of consumption is orthogonal to the innovation in income. (See, for example, Blinder and Deaton [1985].)

Turning now to the coefficients on the expected variables, recall that by construction they are orthogonal to the error term. Hence, simultaneity bias is ruled out. Incidentally, this observation suggests an alternative interpretation of the results. One can ignore the "unexpected variables" and simply interpret the estimated coefficients on the "expected variables" as standard instrumental variables estimates.[18] Another potential source of simultaneity bias in equation (3.2) is the presence of the lagged dependent variable and the change in net assets, both of which might be correlated with the error. To avoid inconsistent estimates, we use lags of construction and change in net assets as instrumental variables.

4. Results

We present estimates of the various models in the same order in which they appeared in Section 2.

4.1 Time and State Effects Model

The issue here is the extent to which infrastructure spending can be explained by dichotomous variables for years and states. Table 2 presents the resulting parameter estimates. The year effects suggest a trend toward less infrastructure spending per capita, an unsurprising finding given the figures in Table 1. Note that except for $YEAR_{79}$ and $YEAR_{80}$, the coefficients on the YEAR variables are insignificant at conventional levels. The fact that the time effects are not uniformly significant indicates that from year to year the communities' spending changes were by no means identical. Hence, attempts to explain individual communities' behavior must exploit information relating to the communities themselves. Of course, we are not faced with an either-or choice. It is quite possible that even in a behavioral model, time effects will be important. However, their magnitudes may be quite different from those in Table 2.

Turning to the state effects, only for New Jersey and Rhode Island do there appear to be significant differences among the municipalities of different states. Differences in state-wide institutions and conditions do not do a very complete job of "explaining" differences in infrastructure spending.[19] Thus, although an F-test rejects the hypotheses that the YEAR and STATE variables are jointly insignificant,[20] the results in Table 2 provide additional motivation for estimating equations that explicitly model the community decision-making process.

4.2 Euler Equations

We first investigate whether the univariate autoregressive structure of construction spending is consistent with the Euler equation under either free or costly adjustment of the capital stock. Then, we test the exclusion restrictions placed on lags of revenues, grants, assets, and debts.

To begin, recall that estimation is simplified if second differencing is not necessary to eliminate individual effects. To investigate this, we first specify an AR(4) model of construction spending (with stationary parameters) and test whether this model contains individual effects. Line (1) of Table 3 shows that the minimized chi-square statistic, Q, for the AR(4) with individual effects is 16.12 with 16 degrees of freedom, which suggests that this model is not overly parsimonious. In particular, the hypothesis that the parameters of the univariate relationship are stationary over time is not rejected. Note that if the preference function and/or the real interest rate changed markedly from period to period, or if the linearization embodied in equation (2.7) were inappropriate, the data would have rejected parameter stationarity.

When we impose the restriction that $\delta = 0$ (line (2)), Q rises to 23.77. The test statistic for the hypothesis that $\delta = 0$ is L, the change in Q induced by the restriction. Here, L is 7.65, which is distributed as a chi-square with 5 degrees of freedom. The data do not reject the hypothesis of $\delta=0$ at conventional significance levels. Accordingly, we conduct the remainder of the empirical investigation maintaining that $\delta=0$, i.e., that equations (3.1) and (3.2) are correct specifications of the Euler equation and demand for structures, respectively.

Notice that the AR(4) exceeds the lag length predicted by the theoretical model, which states that under the joint hypothesis of forward looking behavior and no borrowing constraints (and the other assumptions behind the derivation of equation (3.1)), a univariate autoregression for construction spending should have three lags if there are adjustment costs, and only one lag otherwise. To determine whether the data are consistent with this model, we next estimate an AR(3). Line (3) of Table 3 indicates that the fourth lag does not contribute significantly to the explanatory power of the equation. However, line (4) shows that the data reject an AR(2) specification. Thus, as predicted by the model, construction spending is an AR(3) (conditional on time effects). For completeness, we report the parameter estimates of the AR(3) model in panel (b) of Table 3.

While the results from the univariate construction equation are consistent with equation (3.1), they do not test all of the model's restrictions. Another important restriction is that the production function is separable between capital and labor (see equation (2.2')). To test this assumption, we augment the AR(3) model of Table 3 with three lags of labor inputs, and test the null hypothesis that the coefficients on lagged labor are jointly equal to zero.[21] The test statistic is 2.27 which is distributed as a chi-square with three degrees of freedom. The critical value at a 5 per cent significance level is 3.84. Thus, the assumption of separability is consistent with our data.

The final type of restriction that we test concerns the role of other lagged variables. Not only should exactly three lags of construction spending enter the equation, no other variables lagged three periods or more should be included. We now test the hypothesis that own revenues, grants, financial assets, and debts lagged three or more periods can be excluded from an equation with C_{it} on the left side and three lags of C_{it} on the right side.

To do so, we first estimate an equation that contains three lags of construction and is augmented by three lags each of own revenues, grants, assets, and debts.[22] We then repeat the exercise with only two lags of revenues, grants, assets, and debts; and then with only one lag. The results are recorded in panel (a) of Table 4. The table indicates that the lag lengths for own revenues, grants, assets, and debts can be reduced to 1 year. Therefore, the data do not reject the model that led to equation (3.1). That is, capital spending by the communities in our sample appears to be well characterized by the joint hypotheses of rationally formed expectations and no borrowing constraints.

4.3 Construction Spending Function

The discussion surrounding equation (3.2) suggested that its estimation requires a two-step procedure: generate expected and unexpected values of own revenues and grants by estimating a forecasting equation for each of the variables, and then use these decomposed series in a regression with construction as the dependent variable. Our forecasting equations for own revenues and grants contain two lags each of both own revenues and grants.[23]

Each equation is estimated in first differences to eliminate individual effects. The estimated parameters of the forecasting equations are available upon request to the authors.

With the forecasting equations in hand, we can decompose own revenues and grants into expected and unexpected components and estimate (3.2). According to our theory, all changes in the permanent values of own revenues and grants are contained in their unexpected components. Given the presence of these variables, their "expected" counterparts should provide no additional explanatory power. This prediction appears to be borne out by the results in column (1) of Table 5, which presents the parameter estimates. Note that: 1) The magnitudes of the coefficients of the unexpected variables are much greater than those of the expected variables. 2) The coefficients on unexpected grants and revenues exceed their standard errors by factors of more than 3.5. 3) In contrast, one cannot reject either the hypothesis that the coefficient of expected revenues or expected grants is zero.[24]

A more appropriate test of whether the expected variables "matter" is a joint test that their coefficients are zero. When we impose this restriction, the test statistic, distributed as a chi-square with 2 degrees of freedom, is 7.09. Using a one percent significance level, we cannot reject the null hypothesis, although this conclusion is reversed at the 5 percent level of significance. As usual, we do not have a well-specified loss function to tell us the "right" significance level to use. At this stage, it seems useful to impose the constraint that the "expected" variables have zero coefficients, and examine several more hypotheses. We first test the hypothesis that the coefficients on unexpected own revenues and unexpected grants are identical, and find that it cannot be rejected by the data. (The chi-square test statistic is 0.002.) Hence, in our data, total resource flows determine construction spending; the breakdown between grants and own source revenues is not important. The associated parameter estimates are shown in column (2) of Table 5.

For the sake of comparison, we also estimate a "naive" model in which resources are not decomposed into expected and unexpected components. The results are reported in column (3) of Table 5.[25] Comparing the coefficients to those in column (2), one finds that ignoring the stochastic nature of resource flows would lead one to underestimate the sensitivity of construction spending to community resources. The coefficient on total unanticipated resources of 0.065 from column (2) is more than double the coefficient on total (expected plus unexpected) resources of 0.023 from column (3).

So far, our results provide support for the notion that capital spending is guided by a "rational," unconstrained process. A further test is suggested by the observation that in the presence of capital market constraints, communities might react asymmetrically to positive and negative stocks in their resource flows. A positive change stimulates the current demand for structures to some extent, but some portion can also be saved for future spending. In contrast, with borrowing constraints, it would be difficult to smooth the effects of a negative change in resources, and spending would fall disproportionately. Thus, the coefficient on negative shocks would exceed that on positive shocks. To investigate this possibility, we permit the coefficients on positive unexpected resource flows (revenues plus grants) to differ from their negative counterparts, and then test for equality. The data do not reject equality of the coefficients. The chi-square test statistic (with 1 degree of freedom) is 2.02. This is further evidence that borrowing constraints do not prevent communities from smoothing spending over time.

As suggested in Section 2, if capital spending is done out of lifetime resources, then the coefficients on the change in net assets and unexpected resource flows are equal -- both represent the propensity to spend on structures out of wealth. When we impose this constraint, we find a chi-square test statistic (with one degree of freedom) of 1.90. Hence, equality of the coefficients cannot be rejected. The results that emerge when this constraint is imposed are reported in column (4) of Table 5. The coefficient of 0.056 on NA_{t-1} (and $(R_t^u + G_t^u)$) indicates that every dollar increase in community wealth increases construction spending by about 5.6 cents. Note that in column (4), the time effects are statistically significant. However, they differ considerably in magnitude from those in the model with <u>only</u> state and time effects (Table 2). Thus, even with a behavioral model, some portion of the decline in infrastructure spending can only be attributed to common features of the economic and political environment. Importantly, without the behavioral model, one obtains a misleading view of the nature of these effects.

In summary, our results show that year-to-year changes in the desired capital stock are governed only by unanticipated resource flows. Moreover, spending responds symmetrically to positive and negative shocks, and the coefficients on permanent income and net assets are the same. All of these are consistent with the view that municipal capital spending is generated by a forward-looking decision-making process unimpeded by capital market imperfections. This set of findings is in line with the story that emerged from our Euler equation analysis.

To get a better feel for the quantitative significance of our results, let us use them to compute the impact on the steady state municipal capital stock of a one dollar increase in permanent resources. (This might be due, for example, to the announcement of a federal grants program that is expected to last forever.) Recall from equation (2.8),

$$K_t = \beta_1 K_{t-1} + \beta_2 X_t^p + \beta_3 NA_{t-1},$$

where we have suppressed the i subscripts and the individual effect for clarity. Denoting the steady state value of capital $\bar{K}$ and setting $\beta_2 = \beta_3 = \beta$, we obtain

$$\bar{K} = \frac{1}{1-\beta_1} \beta(X^p + NA).$$

From column (4) of Table 5, $\beta_1 = 0.4368$ and $\beta = 0.0555$, so that $\beta/(1-\beta_1) = .0985$. Now, assuming an interest rate of 0.06, a one dollar permanent increase in resources increases community wealth by $16.66 dollars. Hence, the steady state capital stock increases by 1.64. It is difficult to say whether this response should be viewed as large or small. It seems pretty clear, however, that substantial permanent increases in resources would be required to induce a significant expansion in communities' capital stocks.

5. Summary and Conclusions

This paper has examined a variety of hypotheses concerning the decline in construction spending by municipal governments during the 1970's. We find little support for the view that community spending decisions can be explained solely by year and state effects. The data do appear to validate the notion that construction spending follows a path consistent with forward looking, rational municipal planning. We stress that this finding does not imply that the level of construction spending is efficient in the sense of maximizing social welfare. We do not know whether the objective function being maximized is the "right" one. However, our results do indicate that whatever the goals of community decision-makers, they are pursued in a coherent fashion.

Further, we find that the stochastic structure of own revenue and grant flows is an important feature of the determination of construction spending. Communities react differently to expected and unexpected resource flows. Specifically, consistent with the hypothesis of intertemporal utility maximization, changes in desired capital stocks are not affected by expected resource flows. However, a dollar increase in unanticipated resources increases construction spending by about 5.6 cents.

A lesson that follows from these results is that the stochastic nature of revenue sources affects both econometric practice and policy analysis. At the econometric level, ignoring this distinction leads to incorrect inferences regarding the sensitivity of infrastructure spending to changes in resource flows. Community decision-makers react differently to permanent and transitory changes. This suggests an important lesson for federal grant-in-aid policies. The federal government is likely to receive more "bang for the buck" from programs that are perceived as permanent. To the extent that the duration of a given program is unclear, local construction spending will be inhibited.

Table 1

Mean Real Construction Spending Per Capita
(1977 Dollars)

Year	Construction
1972	57.12
1973	62.90
1974	57.86
1975	66.93
1976	60.86
1977	49.67
1978	49.80
1979	40.12
1980	37.76
1972-'80	53.67

Table 2

Year and State Effects on Construction*
(Dependent Variable is C_{it})

	Parameter Estimate	Standard Error
Intercept	63.9462	6.5883
$YEAR_{73}$	5.7842	5.0143
$YEAR_{74}$	0.7407	5.0172
$YEAR_{75}$	9.8110	6.2193
$YEAR_{76}$	3.7416	6.3232
$YEAR_{77}$	-7.4422	6.6843
$YEAR_{78}$	-7.3177	6.0552
$YEAR_{79}$	-16.9976	5.3292
$YEAR_{80}$	-19.3546	4.4529
Massachusetts	-11.5423	6.7623
Maine	-15.8930	8.5299
New Hampshire	-9.2830	9.8254
New Jersey	-32.9042	7.6481
New York	9.5165	13.4074
Rhode Island	-24.6541	10.2401
Tennessee	11.2392	7.0206
Virginia	4.8016	7.5628

$\bar{R}^2 = 0.09$

*The omitted categories are fiscal year 1972 and the state of Connecticut. Years in the sample are 1972-1980.

Table 3

Estimates of Euler Equation*
(a) Chi-Square Test Results

	Q^a	df	L^b	df
(1) AR(4)	16.12	16	16.12	16
(2) AR(4), $\delta = 0$	23.77	21	7.65	5
(3) AR(3), $\delta = 0$	28.28	24	4.51	3
(4) AR(2), $\delta = 0$	34.37	26	6.09	2

(b) Parameter Estimates
(Dependent Variable is C_{it})

	Parameter Estimate	Standard Error
Intercept	55.6701	5.0533
YEAR76	-7.8523	3.5990
YEAR77	-18.0516	5.2601
YEAR78	-17.7989	5.3047
YEAR79	-25.5547	4.3314
YEAR80	-26.1364	4.2360
C_{it-1}	0.0578	0.0780
C_{it-2}	0.0550	0.0368
C_{it-3}	0.0058	0.0181

*In panel (a), instrumental variables are intercept, time dummies and C_{it} for years 1972-1978. In panel (b), the sample consists of the years 1975-1980.

[a]Minimized chi-square statistic.

[b]Change in Q attributed to the restriction.

Table 4

Tests of Exclusion Restrictions*

(a) Chi-Square Test Results

	Q[a]	df	L[b]	df
(1) VAR Lag Length = 3	60.11	58	60.11	58
(2) VAR Lag Length = 2	64.09	62	3.98	4
(3) VAR Lag Length = 1	65.86	66	1.77	4
(4) VAR Lag Length = 0	78.78	70	12.92	4

(b) Parameter Estimates
(Dependent Variable is C_{it})

	Parameter Estimate	Standard Error
Intercept	24.3716	3.6819
YEAR77	-9.4508	2.5169
YEAR78	-7.1757	2.6705
$YEAR_{79}$	-12.3592	2.5555
$YEAR_{80}$	-9.2097	2.5264
C_{t-1}	0.3825	0.0299
C_{t-2}	-0.0150	0.0147
C_{t-3}	0.0282	0.0092
R_{t-1}	0.0018	0.0027
G_{t-1}	0.0048	0.0095
A_{t-2}	0.0257	0.0098
D_{t-2}	0.0012	0.0008

*Instrumental variables are intercept, time dummies, and other right hand side variables for the years 1973-1978. The sample consists of the years 1975-1980.

[a,b]See notes to Table 3.

Table 5

Estimates of the Construction Spending Function*
(Dependent Variable is C_{it})

	(1)[a]	(2)[a]	(3)[b]	(4)[a]
Intercept	22.29 (4.349)	30.25 (3.665)	18.65 (4.275)	29.55 (3.629)
C_{t-1}	0.4058 (0.0350)	0.4454 (0.0317)	0.2903 (0.0444)	0.4368 (0.0310)
R^e_t	0.0081 (0.0054)	-	-	
R^u_t	0.0598 (0.0156)	-	-	
G^e_t	0.0198 (0.0165)	-	-	
G^u_t	0.0841 (0.0219)	-	-	
ΔNA_{t-1}	0.0319 (0.0147)	0.0409 (0.0141)	0.0444 (0.0191)	0.0555 (0.0094)
$(R^u_t+G^u_t)$	-	0.0652 (0.0117)	-	0.0555 (0.0094)
(R_t+G_t)	-	-	0.0227 (0.0040)	
$YEAR_{77}$	-11.80 (4.617)	-11.12 (4.592)	- 9.836 (4.813)	-8.914 (4.305)
$YEAR_{78}$	-10.29 (3.704)	-11.00 (3.597)	-10.85 (4.045)	-10.67 (3.589)
$YEAR_{79}$	-16.92 (3.687)	-18.29 (3.622)	-16.61 (3.745)	-17.33 (3.555)
$YEAR_{80}$	-11.42 (3.493)	-12.91 (3.404)	-13.02 (3.873)	-12.62 (3.397)
$\bar{R}^2$	0.28	0.26	0.23	0.23

Table 5 (continued)

(Notes)

*Numbers in parentheses are standard errors.

[a] C_{t-1} and ΔNA_{t-1} are instrumented using C_{t-2} and ΔNA_{t-2}.

[b] C_{t-1}, (R_t+G_t) and ΔNA_{t-1} are instrumented using C_{t-2}, $(R_{t-2}+G_{t-2})$ and ΔNA_{t-2}. The sample consists of the years 1976-1980.

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Notes

1. This paper examines only construction spending and ignores other aspects of capital formation such as purchases of equipment. Construction accounts for roughly 95% of state-local capital formation. See Hulten and Peterson [1984].

2. The data used for Table 1 are converted from nominal to real dollars per capita using the GNP deflator for purchases of structures by the state-local sector. The results depend somewhat on the choice of deflator. For example, using a region-specific consumer price index one finds a slightly less dramatic decline in real spending, but the overall pattern is similar.

3. In this context, it is interesting to note that models assuming rational behavior have had some success in explaining federal government fiscal behavior. See Barro [1979] and Mankiw [1987].

4. "Myopia" can be regarded as forward looking behavior with a very high discount rate. If so, why is myopia necessarily suboptimal? Presumably, the notion is that public sector decision makers employ a higher discount rate than would be used by an informed voter.

5. Equation (2.4) assumes that costs are a continuous function of the amount of construction. For any individual project, costs may be quite lumpy. However, our focus is on each community's aggregate construction expenditure; as usual, one expects that aggregation smoothes out adjustment costs.

6. To simplify the exposition, we assume that communities cannot export tax burdens and that all grants are in lump sum form. We discuss the role of matching grants below.

7. One might question equation (2.5) in light of the fact that municipalities face annual balanced budget requirements. However, communities are generally allowed to borrow for capital projects. Moreover, Inman [1983], Leonard [1986], and others have emphasized that these rules require balancing only *ex ante*. Hence, even for current spending, municipalities can circumvent these rules.

8. Unlike the case considered by Hall, the coefficients in the Euler equation (2.7) do not have an obvious economic interpretation. Rather, they depend upon the parameters of the utility, production, and adjustment cost functions in a complicated way.

9. One might think that changes in characteristics of the population should be included in the Euler equation. However, if revenues and spending are formed in a forward-looking fashion, these changes will be incorporated into the changes in revenues and spending. Consider, for example, the number of school-aged children per capita. This number could change due to either the aging of the existing population or due to net migration to the community. In the first instance, the change is predictable and will be incorporated into the adopted budget. In the latter case, the change may be unpredictable. If so, it forms part of the econometric error term in equation (2.7).

10. To see this algebraically, note that a linearized version of equation (2.6) yields:

$$E_t[\gamma_1 K_{t+2} + \gamma_2 K_{t+1} + \gamma_3 K_t + \gamma_4 K_{t-1}] = 0$$

or, equivalently:

$$E_{t-2}[\gamma_2 K_{t-1} + \gamma_3 K_{t-2} + \gamma_4 K_{t-3}] = 0$$

Rational expectations implies:

$$\gamma_1 K_t + \gamma_2 K_{t-1} + \gamma_3 K_{t-2} + \gamma_4 K_{t-3} = \xi_t$$

where $E_{t-2}[\xi_t] = 0$. However, rational expectations does not imply that $E_{t-1}[\xi_t] = 0$, which is why information dated t-1 or t-2 is not excludable.

11. In principle, equation (2.8) should include all variables that capture tastes for public capital. One potentially important variable in this context is the number of school-aged children per capita. Unfortunately, these data are not available for either all years or all the municipalities. For a subset of the municipalities, however, we have these data for the years 1970 and 1980. Comparing these two years, we find that changes in the school-aged population are typically small. On average, the fraction of school-aged children rose by 0.0047 per year, less than one-half a percentage point. Moreover, to the extent that these changes are anticipated, they will be incorporated into the history of revenues and grants and, thus, into our measures of expected resources. Thus, it is unlikely that excluding this variable from equation (2.8) will significantly affect our results.

12. Another possibility is that matching rates differ substantially across states, or that states have their own programs that affect the relative price of construction spending for their communities. If this were the case, we would expect to find that interactions of state and year effects have a significant impact on construction spending, but they do not. See footnote 20.

13. In principle, δ is endogenous to the community decision process. However, due to data limitations we do not attempt to model maintenance decisions.

14. The fact that the data are annual as opposed to (say) quarterly does not affect the econometric procedure. To be sure, if quarterly data rather than annual data were used, the point estimates of the coefficients in the Euler equation (2.7) would differ. Nevertheless, the appropriate lag length would be the same. If, for example, last period's spending contains all the available information about next period's spending, it does not matter whether the period is a quarter or a year.

15. In many states, school spending is the responsibility of local school districts rather than municipal governments. Importantly, communities cannot choose whether educational spending will be done by a school district or by the municipal government; this is determined by state law. Hence, no element of self-selection is present. Unfortunately, our data do not allow us to

isolate any possible differences in behavior between school districts and municipalities.

16. The discussion of section 2 suggested that in the Euler equation model, only variables dated t-3 or earlier are available as instrumental variables. In fact, using the methods described above, we were unable to reject the hypothesis that variables dated t-2 were uncorrelated with the error term. In order to sharpen our estimates, we therefore included variables dated t-2 in the set of instrumental variables.

17. Details of the test are provided in Holtz-Eakin, Newey and Rosen [1988].

18. In this spirit, one can view the construction spending function as one of a system of "structural" equations that jointly determine grants, revenues, and spending. Implicitly, identification is obtained by the assumption that lags of revenues and grants, which may appear elsewhere in the system, do not appear in the construction spending function.

19. As a further check, a second regression was estimated using the change in spending as the dependent variable. Again, the combination of YEAR and STATE variables provided little explanation of the variation.

20. The F-statistic for the joint test that the coefficients of all STATE variables are equal to zero is $F_{8,1486}=10.12$. The test statistic for the joint hypothesis that the coefficients of the YEAR variables are zero is $F_{8,1494}=6.01$. Both tests exceed the critical value at the 1% level. We also estimated a model which included a complete set of YEAR and STATE interactions. One cannot reject the joint hypothesis that all the interaction terms have coefficients of zero. The test statistic is $F_{64,1422}=0.81$.

21. Labor is measured as the number of full-time payroll workers in October of the fiscal year. The results are essentially unaltered when both full- and part-time workers are used to measure labor.

22. We measure assets and debts as beginning of period stocks. As instrumental variables we use lags 3 through 5 of each variable.

23. To avoid inappropriately excluding lags of variables, no attempt in made to reduce the lag lengths in the equations. In principle, any variable is a candidate for inclusion in the VAR. In practice, the history of revenues and grants is a good measure of the resource raising capabilities of the municipalities. We tested the hypothesis that the parameters of the VARs are stable over time. The associated chi-square statistics for own revenues is 24.83, which is distributed with 16 degrees of freedom. Hence, one cannot reject this hypothesis. For grants, the statistic is 16.81 and also has 16 degrees of freedom; again, parameter stationarity cannot be rejected.

24. We tested for time stability of the construction spending function parameters. The test statistic, distributed as a chi-square with 24 degrees of freedom, is 20.80. Thus, the null hypothesis is not rejected.

25. The naive model is estimated by instrumental variables. The instrumental variables employed are the lags dated t-2 of each right hand side variable.