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ABSTRACT

In this study, the median voter model is applied to the problem of predicting state public expenditures in five major categories: human services, elementary and secondary education, higher education, health services, and public safety. Demand functions for public services are derived within a formal utility-maximizing model. The resulting model is estimated using time-series data for a representative state and the model is used to predict state spending for fiscal year 1984. The results of the estimation are consistent with the predictions of the median voter model and the forecasts correspond closely to those made by the State Bureau of the Budget.

A FORECASTING MODEL FOR STATE EXPENDITURES

1. Introduction

While several models for forecasting state tax receipts appear in the literature, little attention has been directed toward the dual problem of forecasting state expenditure levels and composition. The rapid expansion of state public sectors in recent years underlines the importance of having available adequate models of state spending. Budget and tax planning at the federal, state, and local levels relies on accurate predictions of changes in demand for state services. It is with this purpose in mind that we propose a simple but effective model for forecasting the level of total state spending and the shares of the budget devoted to alternative purposes.

Our model is based on the theory of the median voter popular in public choice theory. If decisions are made by referendum in a society where each person has one vote and voters vote nonstrategically, then the median voter will be decisive in single-choice decisions. When majority rule is used to choose among several alternatives, the existence of a voting equilibrium depends on the pattern of preferences. Black (1948) showed that when the preferences of all voters are "single-peaked," the preference of the median voter will be preferred by a majority of all voters.[1] When preferences are "multiple-peaked," cycling may occur, and a unique majority equilibrium may not exist.[2]

If decisions are made by elected representatives, the decisiveness of the median voter is less clear. Assuming voters act to maximize their utility and representatives act to maximize votes, Downs (1957) developed a model of representative democracy in which the vote-maximizing party will choose the position of the median voter as long as preferences are single-peaked. More recent work by Romer and Rosenthal (1978) and Mackay and Weaver (1979) casts doubt on the decisiveness of the median voter in a world where decisions are influenced by bureaucrats and where non-competitive politics prevail.

Despite these attacks on the median voter theory, it has been used successfully in a number of empirical studies to predict the determinants of public expenditures.[3] In these studies, it is assumed that voters determine their demand for public expenditures based on predetermined tax shares and that the preferences of voters are single-peaked.[4] The median voter is usually taken as the voter with the median income, however this may not always be the case as shown by Bergstrom and Goodman (1973).

The two most important explanatory variables in these studies are median income and the median tax share. Median income is often measured by mean income when information on median income is not available. In estimating the tax share of the median voter, the approach of Borcherding and Deacon (1972) of approximating the tax share by 1/population is common. Other explanatory variables sometimes include population density, population change, percentage of owner-occupied dwellings, percent of the population over age 65, and other demographic variables.

In this study the median voter model is applied to the problem of predicting state public expenditures in five major budget categories: human services, elementary and secondary education, higher education, health services, and public safety. Our model departs from earlier ones by deriving the form of the demand functions for public services within a formal utility-maximizing model. We assume that the median voter maximizes a constant elasticity of substitution utility function defined over state public expenditures and after-tax income. The resulting demands for total state spending and for the budget shares by category are estimated using time-series data for a representative state. The model is then used to forecast state spending for fiscal year 1984 and the results are compared to forecasts by the state bureau of the budget. The model is presented in Section 2 and the results of the estimation appear in Section 3. Section 4 contains the model predictions and Section 5 is an evaluation of the results.

2. The Model

We assume that state budgets are decided within a representative framework which is competitive and democratic. In trying to capture votes, representatives attempt to emulate the views of the so-called median voter. Hence, budget decisions come to depend on the preferences of the median voter who we assume has the following constant elasticity of substitution (CES) utility function for government spending and personal income.

$$U^{1-\sigma} = \sum_{g=1}^{M} \beta_g G_g^{1-\sigma} + (1 - \sum_{g=1}^{M} \beta_g)(Y^m - T^m)^{1-\sigma} \qquad (1)$$

where G_g is government spending on the gth budget item, Y^m is the income of the median voter, and T^m is the median voter's tax liability.[5]

Assuming that state tax liabilities are best described by a proportional tax function, the proportional tax rate, t, is equal to the ratio of total income, Y, to total tax liability, T. Further, if the only sources of state funds are general tax revenues, T, and federal aid, F, it follows that the proportional tax rate is equal to (G-F)/Y where G is total state spending. Therefore, the tax liability of the median voter becomes:

$$(2) \qquad T^m = \left(\frac{G-F}{Y}\right)Y^m.$$

Maximizing the utility of the median voter subject to the tax constraint (2) yields the demand of the median voter for each of M government goods, G_j:

$$(3) \qquad G_j = \left(\frac{\beta_j}{\gamma}\right)^{\frac{1}{\sigma}}\left(\frac{Y^m}{Y}\right)^{\frac{\sigma-1}{\sigma}}(Y-G+F) \quad j=1, \ldots, M$$

where $\gamma = 1- \sum_{g=1}^{M} \beta_g$. Summing over government goods gives the median voter's aggregate demand for government spending as:

$$(4) \qquad G = \sum_{g=1}^{M} G_g = \sum_{g=1}^{M} \left(\frac{\beta_g}{\gamma}\right)^{\frac{1}{\sigma}}\left(\frac{Y^m}{Y}\right)^{\frac{\sigma-1}{\sigma}}(Y-G+F)$$

which shows aggregate demand as a function of the ratio of the median voter's income to total income, income after government spending, and the parameters of the utility function. Finally, dividing (3) by (4) expresses demand in terms of budget shares:

(5) $$\frac{G_j}{G} = \left(\frac{\beta_j}{Y}\right)^{\frac{1}{\sigma}} \Big/ \sum_{g=1}^{M} \left(\frac{\beta_g}{Y}\right)^{\frac{1}{\sigma}}$$

where G_j/G is the proportion of the total state budget going to purpose j. Note that each budget share is a function of the parameters of the utility function but not of economic variables. Unless the preferences of the median voter change over time, the budget shares demanded will remain constant.

Equations (4) and (5) describe our model, although they are not in estimation form. The aggregate demand for state spending can be transformed into estimation form by taking logs across equation (4). This gives:

(6) $$\ln \frac{G}{Y-G+F} = \alpha_0 + \alpha_1 \ln \left(\frac{Y^m}{Y}\right)$$

whose intercept is

$$\alpha_0 = \ln \sum_{g=1}^{M} \left(\frac{\beta_g}{Y}\right)^{\frac{1}{\sigma}}$$

and whose slope is:

$$\alpha_1 = \frac{\sigma-1}{\sigma} .$$

Assuming that the income of the median voter, which is unobserved, is proportional to the income of the average voter, the independent variable may be written $k\overline{Y}/Y$ where k is a constant of proportionality and $\overline{Y}$ is the income of the average voter. Multiplying top and bottom by population divided by income, P/Y, allows us to write the independent variable as k/P. Substituting into equation (6) gives our estimation equation for the demand for total spending as:

$$(7) \qquad \ln \frac{G}{Y-G+F} = \alpha_0 + \alpha_1 \ln k - \alpha_1 \ln P.$$

The equation states that either a redistribution of income raising the ratio of median to mean income or a decrease in population will bring about an increase in the demand for total state spending. In estimating (7) we assume that the ratio k is constant; i.e., that income has not been significantly redistributed over our estimation period. This assumption is necessary since k is not observed.

In order to determine how total spending will be divided among budget categories, equation (5) is expanded to include variables related to changes in the preferences of the median voter over time. We assume that preferences for budget shares are related to income per capita and population. The new demand for budget shares can be written as:

$$(8) \qquad \ln \frac{G_j}{G} = \beta_0 + \beta_1 \ln \overline{Y} + \beta_2 \ln P$$

where $\overline{Y}$ is income per capita and P is population. The estimation of equations (7) and (8) is reported in the next section.

3. The Estimation

The model is estimated using single equation techniques. Although a case could be made for estimating the budget share equations using seemingly unrelated least squares because of the possibility of intercorrelated disturbances, there is no gain in efficiency when the set of explanatory variables is identical across equations. Hence, our estimation technique was ordinary least squares.

The data for the estimation were for the State of Illinois for the period 1973 through 1983 and were measured annually. The expenditure data pertained to the fiscal year as did the Illinois personal income data. Total state expenditures are measured exclusive of transportation expenditures which are financed through an earmarked tax and violate the assumptions of our model. The population of Illinois pertained to the calendar year. This variable was lagged one year and averaged with the current year to make it comparable with the fiscal year data.

The resulting estimate of the aggregate demand for state spending is:

$$(9) \qquad \ln \frac{G}{Y-G+F} = \underset{(2.02)}{24.596} - \underset{(-2.21)}{2.883} \ln P$$

$$R^2 = .970 \quad D.W. = 2.015$$

where the figures in brackets are t-statistics. The coefficient of population is negative and significant as hypothesized by our model. The high R^2 indicates a good fit to the data and the Durbin-Watson statistic (D.W) close to 2 indicates that autocorrelation among the residuals is not a problem.[6]

Next, the budget share equations were estimated using the Illinois data. The budget categories included human services, elementary and secondary education, higher education, health services, and public safety. Human services was defined as the sum of public aid, aging, and children and family services; health services as the sum of public health and mental health and development disabilities; and public safety as the sum of law enforcement and corrections. The means and standard deviations of the budget shares appear in Table 1. As seen in the table, human services and elementary and secondary education consume roughly equal proportions of state spending and show the greatest variation relative to the other budget shares which remain fairly constant over time. Recall that total state expenditures exclude transportation expenditures.

The results of estimating the budget share equations are shown in Table 2. Per capita income is an important explanator in four of the five budget share equations. According to the results, increases in per capita income lead to reallocations in the budget toward elementary and secondary education and away from human services, higher education, and health services. With increases in per capita income, voters may perceive a reduced need for expenditures on human services and public health and an increased need for elementary and secondary education expenditures. The negative coefficient for the higher education budget share equation is harder to explain but may have to do with a substitution away from public and toward private higher education as income increases.

Increases in population lead to an increase in the budget share for public safety and a decrease in the budget share for elementary and secondary education, but have insignificant effects on the other budget shares. The negative relationship between the share of the budget going to elementary and secondary education and population may

Table 1. Average Budget Shares for the Period FY 1973-FY 1983

Budget Categories	Mean Budget Share	Standard Deviation
Human Services	26.5%	1.0
Elementary and Secondary Education	23.7	1.7
Higher Education	10.4	0.5
Health Services	5.7	0.3
Public Safety	2.4	0.4
Other	31.3	
Total	100.0%	

Table 2. Estimated Budget Share Equations, FY 1973-FY 1983
(t-ratios in parenthesis)

Budget Category	Constant	Per Capita Income	Population	R^2	D.W.
Human Services	-30.959 (-1.67)	-.175* (-2.10)	3.215 (1.60)	.985	2.216
Elementary and Secondary Education	110.145** (6.56)	.386** (5.13)	-12.046** (-6.64)	.989	1.945
Higher Education	-24.292 (-1.21)	-.215* (-2.39)	2.409 (1.11)	.979	1.832
Health Services	-39.744 (-1.72)	-.277* (-2.67)	4.016 (1.60)	.972	2.074
Public Safety	-130.331** (-3.35)	.004 (.02)	13.564** (3.23)	.976	1.211

*Coefficient significant at .05 level.
**Coefficient significant at .01 level.

reflect the fact that as the population grows, it is also aging, leading to a reduced demand for education. The positive relationship between the budget share going to public safety and population is understandable in light of the increasing demands placed on public safety by an increasing population.

4. Forecasting Results

Next we used the model to predict total government spending and budget shares for FY 1984 and translated these into dollar budget predictions. These appear in column 1 of Table 3. To evaluate our predictions, we compared them to spending level predictions for FY 1984 made by the Illinois Bureau of the Budget. The predictions of the Bureau of the Budget are akin to actual budget figures since they are made in the spring, only a few months prior to the end of the fiscal year to which the predictions apply. Hence, most of the budget data are in by that time and the predictions are very accurate.

We compared the Bureau of the Budget predictions to those of our model by computing the percentage difference in the predictions. Our model over-predicts total spending by only 2.1 percent. Our most accurate prediction was for elementary and secondary education expenditures and our least accurate was for public safety. The model tended to over-predict public safety and higher education while it under-predicted human and health services, however the percentage errors in prediction were never large in any case.

Table 3. FY 1984 Budget Predictions
($ thousands)

Budget Categories	Model Prediction	BOB* Prediction	%** Difference
Human Services	$3,395,203	$3,355,489	-1.2%
Elementary and Secondary Education	2,608,386	2,606,834	0.0
Higher Education	1,277,902	1,308,652	+2.3
Health Services	720,298	710,061	-1.4
Public Safety	425,492	442,091	+3.8
Total Gov't spending	$12,742,351	$13,020,359	+2.1%

*Illinois Bureau of the Budget, Illinois State Budget 1985, Springfield, Illinois, Table I, pp. 292-299.

**Percentage Difference =

((BOB Prediction - Model Prediction) ÷ BOB Prediction) * 100

5. Concluding Comments

The purpose of this study was to apply the principles of behavioral public finance, or public choice, to the problem of predicting state budget levels. The demands for total state spending and for the shares of the budget going to particular purposes were derived from a model based on the assumption of a competitive political process responsive to the preferences of the median voter. This model was estimated using time-series data for the state of Illinois and the results of the estimation were used to forecast budget levels for the coming year.

The median voter model has been applied empirically by several researchers to the analysis of cross-section data, usually to explain the demand for municipal services. This study is one of the first applications of the median voter model to the analysis of time-series data on state spending. While the estimation was not meant to be a test of the median voter model, it is interesting to note the consistency of the estimation with the predictions of the median voter model and the accuracy of the model forecasts.

Future research should follow several directions. First, better and longer data series are needed on state expenditures by category. If longer series were available, additional explanatory variables such as the crime rate and the percent of the population over 65 could be used to improve the estimation. Second, supply factors such as the cost of providing public services and the constraints on supply due to bureaucratic influence need to be integrated into the demand analysis. Further study is also needed on the impact of federal grant provisions and the choice of financing instruments on state expenditure levels. Future research on these and other refinements will contribute to our growing understanding of collective decision-making and the role played by behavioral economic theory.[7]

FOOTNOTES

[1]If preferences are single-peaked, it will never be the case that the voter prefers the extremes to the central position.

[2]The pioneering work in this area was by Arrow (1951).

[3]For example, see studies by Ohls and Wales (1972), Bergstrom and Goodman (1973), Borcherding and Deacon (1972) and Inman (1978).

[4]Holcombe (1978) shows that if tax shares are not fixed, a higher level of public spending than that preferred by the median voter will result.

[5]Lovell (1978) also uses a CES utility function to describe voter preferences.

[6]The Durbin-Watson statistic exceeds the critical upper limit at the 1 percent confidence level so that the hypothesis of no autocorrelation cannot be rejected.

[7]See Deacon (1977) for a review of the recent literature on public sector demand analysis and suggestions for future research.

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