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Inferring Preferences From Secret Ballots*

by

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I. INTRODUCTION

Local elections and referenda provide the raw data for a variety of investigations of public choice and voter behavior. Voting patterns on spending and taxing issues hold a special interest because of the possibility of gaining insight into citizen demands for local public goods and for publicly provided private goods. With few exceptions, however, the empirical test of any economic theory of voting behavior is based upon some aggregate outcome at the ward, precinct or jurisdiction level -- say the proportion of voters choosing a given candidate or voting "yes" on a ballot initiative -- and a vector of the average (or median) characteristics of ward, precinct, or town populations.[1] However, the anonymity of the polling place, while fortunate for political democracy, generates unfortunate statistical consequences. Inferences about preferences may be quite inaccurate because the aggregate characteristics of ward residents may be quite unrepresentative of the characteristics of those making choices.

If the individuals actually voting in an election were a random sample of residents, the secrecy of the ballot box would not pose insurmountable problems for the analysis of voting behavior.[2] Almost certainly, however, the propensity

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[1] An alternative approach, and one that is applied more widely by political scientists and sociologists, relies upon direct surveys of the preferences of a sample of residents. For the analysis of citizen demands, there are some clear advantages to such an approach. The statistical complications of voter turnout (discussed below) are lessened considerably. It may be possible to assess a wider range of preferences, and the survey questions can be better tailored to specific issues. However, there are some real disadvantages. Such surveys are quite costly, and the accuracy of survey reports of preferences is highly questionable since no budget constraint is imposed on respondents. (See, however, Rubinfeld [1977] for an economic application using a survey of preferences.)

to vote varies substantially and systematically for different individuals in the population. This systematic component of differential voting propensities leads to a serious errors-in-variables problem in empirical work based upon aggregate census tract or voting district data. The problem of aggregation arises directly from sample selectivity, yet it differs in important ways from the "standard" sample selectivity bias problem which has been analyzed in the context of observations on individual behavior (e.g., Heckman, 1976). This paper develops alternative methods of overcoming the statistical problems inherent in testing hypotheses about individual voting behavior using aggregate population data.

The empirical analysis considers specifically the relationship between voting and economic self-interest, and, for this purpose, the particular referendum we analyze is almost ideal. The issue on the ballot, a Cleveland tax referendum decided in 1970, proposed relying more heavily on local income taxes and less heavily on property taxes, effectively a question of tax substitution. Prior to casting their ballots, individual citizens could compute, at least in principle, the effect of the measure on their net tax liabilities, holding public service provision constant. Our analysis considers the relationship between proposed changes in the tax liabilities of individuals and their degree of support or opposition to the initiative.

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[2] For example, if the behavioral relationships are linear in the relevant parameters that affect preferences or demands, then the implications of estimation using aggregate data are well-known. Estimates of the parameters governing individual behavior derived from median tract or precinct data would be less efficient than the estimates derived from a sample of individual voters and their characteristics, but such analyses would yield unbiased and consistent estimators of the underlying behavioral parameters. If the underlying distributions of the variables of interest were symmetric, then of course an analysis based on average tract or precinct characteristics would yield unbiased and consistent estimators of the behavioral parameters.

II. VOTING PROPENSITIES AND STATISTICAL COMPLICATIONS

Consider a general model relating the probability that an individual i will support some ballot initiative to those individual socio-economic characteristics which determine constituent preferences on the issue. We write this as:

(1) $P(p_i) = \text{prob } (p_i = 1) = f(\underline{z}_i' \, \underline{\gamma})$,

where $P(p_i)$ is the probability that individual i will support the initiative, and p_i is the recorded vote (1 if "yes," 0 if "no"). The voter's socioeconomic characteristics are given by the vector $\underline{z}_i = (z_{1i}, z_{2i}, \ldots, z_{Ki})$ and the parameters affecting preference preference by the vector $\underline{\gamma} = (\gamma_1, \gamma_2, \ldots, \gamma_K)$.

If individual votes were observed, the underlying preference parameters $\underline{\gamma}$ could be estimated, conditional upon some assumptions about the underlying probability distribution. The economic content of this model would consist of hypotheses about the vector of $\underline{z}_i$'s to be measured, the signs and magnitudes of the estimated parameters, and the functional form of the relationship.

Suppose, however, that we do not have a sample of individuals, but rather we observe the aggregate outcome by voting district, as well as summary data describing the average (or median) characteristics of district residents. The observed voting outcomes reflect the preferences of the self-selected group in the eligible population that participates actively in the election by registering and going to the polls. The statistical issue arises from the relationship between the voting population and the resident population: except in unusual circumstances, precinct averages (or medians) of the characteristics of the resident population differ systematically from the characteristics of the actual voters. Statistical analyses relating observed aggregate votes to *population* as opposed to *voter* characteristics will yield inconsistent estimates of preference parameters. Thus even if one is concerned solely with the determinants of preference or demands, it is still necessary to account for the propensity to vote and to incorporate this information in the estimation.

Individual behavior is described by two relationships: one describing voter turnout propensities and one describing preferences for the particular ballot issue. The former gives the probability that a person with given attributes will choose to go to the polls and vote:

$$(2)\quad P(t_i) = \text{prob}(t_i = 1) = g(\underline{x}_i{}'\,\underline{\beta}) \quad ,$$

where t_i is the observed act of voting (=1) or not voting (=0) for individual voter i, $\underline{x}_i = (x_{1i}, x_{2i}, \ldots, x_{Mi})$ is a vector of individual characteristics and $\underline{\beta} = (\beta_1, \beta_2, \ldots, \beta_M)$ is a vector of parameters. We assume a linear probability model such that:[3]

$$(2')\quad t_i = \underline{x}_i{}'\,\underline{\beta} + u_i$$

where u_i is a stochastic error, binomially distributed. Since only binary out-

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[3] This specification has several advantages as well as a few inherent drawbacks. It will be possible to derive from these individual probability equations expressions for expected ward proportions stated in terms of ward averages. Moreover, the coefficients in these equations are easily interpreted. However, as is well known, in this linear formulation probability estimates are not constrained to fall in the unit interval, and the particular functional form may be somewhat unrealistic when the voting probabilities are extreme. Only rather rarely, however, are turnout and voting fractions extreme.

comes are observed at the individual level, a stochastic element would remain even if the individual were completely described. In any case, we observe turnout only at the aggregate level. Let T_j be the proportion of people in ward j who vote in the election.[4] This proportion can be expressed in terms of the individual probabilities as:

$$(3)\quad T_j = (1/N_j)\ \Sigma\ t_i$$
$$= \underline{X}_j\ \underline{\beta} + U_j \quad ,$$

where $\underline{X}_j = (\Sigma x_{1i}/N_j, \Sigma x_{zi}/N_j, \ldots, \Sigma x_{Mi}/N_j)$ is a vector of aggregate precinct characteristics calculated by averaging elements of the vector $\underline{x}_i$ across the N_j eligible voters in precinct j, and similarly $U_j = \Sigma\ u_i/N_j$. U_j is bionomially distributed with variance:

$$(4)\quad E(U^2_j) = (1/N_j^2)[\Sigma\ P(t_i)\{1-P(t_i)\}]$$

The parameters of individual turnout behavior ($\underline{\beta}$) can be estimated directly from equation (3) as long as the voting proportion (T_j) and the aggregate characteristics of the eligible voting population ($\underline{X}_j$) are observed. Generalized least squares estimation, incorporating estimated error variances based on equation (4), will yield consistent and efficient estimates of the parameters $\underline{\beta}$, given the aggregate form of the data.

The preference relationship is given by equation (1). Again, we assume that the probability of favoring the referendum can be represented by the linear

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4 In our notation, lower case variables refer to data for a given individual i; upper case variables refer to aggregate data for district j, computed by summing across the individuals in a specific district.

probability model:

$$(1') \quad p_i = \underline{z}_i{}' \, \underline{\gamma} + \eta_i$$

where η_i is a random error, binomially distributed. Direct estimation of (1') is not possible. The votes of individuals are not available, and votes are only recorded for a subset of the population -- those who actually go to the polls. Thus, at the individual level, a vote for the ballot issue is recorded only when $t_i = 1$ and $p_i = 1$ jointly, precluding direct estimation of preferences from the available aggregate data.

At the individual level, a vote for the ballot issue can be written, from (1') and (2'), as:

$$(5) \quad \begin{aligned} v_i &= t_i{}' \, p_i \\ &= \underline{\beta}' \, \underline{x}_i \, \underline{z}_i{}' \underline{\gamma} + \underline{\beta}' \, \underline{x}_i \eta_i + u_i{}' \, \underline{z}_i{}' \, \underline{\gamma} + u_i{}' \, \eta_i \end{aligned}$$

Polling place secrecy implies that we only observe precinct aggregates. The aggregate "yes" vote for a specific tract j, in terms of individual behavior, is:

$$(6a) \quad \begin{aligned} V_j &= \Sigma v_i \\ &= \Sigma t'_i p_i \\ &= \underline{W}_j \gamma + \Omega_j \quad , \end{aligned}$$

where $\underline{W}_j = (W_{j1}, W_{2j}, \ldots, W_{jK})$ is a vector with elements

$$(6b) \quad W_{kj} = (1/N_j) \sum_{m=1}^{M} \beta_m \left(\sum_{i=1}^{N_j} x_{mi} \, z_{ik} \right)$$

and where Ω_i is a scalar

$$(6c)\ \Omega_j = (1/N_j)\ \{ \sum_{m=1}^{M} \beta_m \sum_{i=1}^{N_j} x_{mi}\, n_i + \sum_{k=1}^{K} \sum_{i=1}^{N_j} u_i\, z_{ki}\, \gamma_k + \sum_{i=1}^{N_j} u_i\, n_i \}$$

The key to estimation comes from careful consideration of Equation (6a-c). V_j is the observed aggregate vote in district j, a function of the unknown turnout and preference parameters ($\underline{\beta}$ and $\underline{\gamma}$) which are assumed to be constant across the population, of the covariances of the underlying determinants of turnout and preference ($\underline{x}_i\underline{z}_i'$) of the individuals in district j, and of covariances involving stochastic terms in preferences and voter turnout.

In equation (6b), $\underline{W}_j$ is a (1 x K) vector whose elements are found by averaging $\underline{\beta}'\underline{x}_i\underline{z}_i'$ over all individuals in precinct j. ω_j is a composite error term found by averaging the last three elements of (5), which involve terms in u_i or n_i, across precinct j. The K terms of $\underline{W}_j$ correspond directly to the terms of Z_j and can be interpreted simply as the data for the preference variables aggregated across voters in tract j instead of across the entire population.

If the exogeneous preference determinants are independent of the errors in (1') and (2') and the errors across equations are uncorrelated, i.e., if $cov(u_i n_i) = 0$, the model can be consistently estimated. Suppose $\underline{\beta}$ were known. Then $\underline{W}_j$, the vector of estimated preference determinants for the *actual voters* in district j, as opposed to the determinants for all *potential voters*, could be computed directly from (6b). Equation (6a) could then be estimated using the proportion of eligible households voting in favor of the referendum as the dependent variable (V_j) and the computed terms ($\underline{W}_j$) as the independent variables.

Of course, $\underline{\beta}$ is not known, so the model must be estimated in two steps. First, the parameters of equation (3) are estimated by generalized least squares (GLS). The dependent variable is the fraction of eligible ward residents participating in the election (T_j); the independent variables are the aggregate characteristics of ward residents ($\underline{X}_j$), and the GLS weights are $[N_j/\hat{T}_j(1-\hat{T}_j)]^{\frac{1}{2}}$ where $\hat{T}_j$ is the OLS-predicted turnout for ward j. With the coefficients estimated from equation (3), it is possible to compute the terms in the vector $\underline{W}_j$, equation (6b) in terms of $\hat{\underline{\beta}}$, the GLS estimate of $\underline{\beta}$.

A comparison of this procedure with the conventional estimation of (5) illustrates the effects of measurement error of the variables affecting preferences. The OLS estimator using aggregate data is:

$$(8a)\quad \hat{\underline{\gamma}}_1 = (\underline{Z}'\underline{Z})^{-1}\,\underline{Z}'\,\underline{V} \quad ,$$

where the sth element of the vector Z is

$$(8b)\quad z_{sj} = (1/N_j) \sum_{i=1}^{N_j} z_{si}$$

and V is the vector of all precinct voting proportions V_j.

Since the population data differ systematically from the characteristics of the actual voters, the estimator proposed here is

$$(9)\quad \hat{\underline{\gamma}}_2 = (\underline{W}'\underline{W})^{-1}\,\underline{W}'\underline{V}$$

where the elements of W are

$$(9b)\quad W_{sj} = (1/N_j) \sum_{m=1}^{M} \beta_m \left(\sum_{i=1}^{N_j} x_{mi}\, z_{is} \right)$$

If the individuals who turnout to vote were a random sample of the eligible population, then $\underline{x}_i$ would be a scalar constant, equal across districts and $\underline{\beta}'\underline{x}_i$

would be the overall turnout probability. In this special case, the two estimators $\hat{\underline{\gamma}}_1$ and $\hat{\underline{\gamma}}_2$ would be identical. Note, however, that even when the same factors determine turnout and preferences (i.e., when $\underline{x}_i = \underline{z}_i$), direct estimation of the preference parameters is not possible. Ignoring the turnout issue and estimating preferences by (8) will yield parameters that are an unknown composite of $\underline{\beta}$ and $\underline{\gamma}$, as long as voter probabilities vary with the characteristics $\underline{z}_i$.

The problem of inferring the preferences of voters, given incomplete turnout, arises from sample selection bias in the analysis of aggregate data. Least squares regression requires for consistency that error terms be uncorrelated with the regressors. In the context of voting, this condition will be violated when voters are a nonrandom sample of the eligible population because individual decisions about whether or not to vote are systematically related to individual preferences about the issue being decided. In this case, which might be called "classic" selection bias, the bias is introduced because individuals are more likely to appear in the sample if they have a certain set of preferences about the outcomes.[5] However, the potential for selectivity bias in the context of voting analysis is more pervasive than this. Any selection process that causes voters to be a nonrandom sample of the population, even if it is unrelated to issue preference, will introduce errors into the measurement of the determinants of preferences. In this case the bias arises from the inability to observe individual data and from the necessity of combining aggregate data provided in diferent sources (i.e., polling records and population census data). Voter turnout behavior provides the sampling rule that generates polling records from population data.

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[5] This is, of course, exactly the problem encountered in the literature on wage determination for females. Females are more likely to appear in a sample of workers if their potential market wages are higher. See Gronau [1974] or Heckman [1976].

Our analysis concentrates on this second aspect of selectivity, which is an artifact of aggregation. The existing literature on sample selectivity has concentrated upon the first in the context of micro data. Importantly, the first issue cannot be ignored here and would become important if u_i and η_i were correlated. In the framework described below, however, it is possible to investigate this. In any event, the second issue, the errors-in-variables problem, cannot be neglected -- regardless of the covariance between the errors u_i and η_i in the data on individuals.[6]

III. EMPIRICAL ANALYSIS

In 1970, the ballot for the general election in the city of Cleveland included 13 referendum issues as well as the selection of candidates for Governor of Ohio and five other state offices. Voters also selected among candidates for the U.S. Senate, House of Representatives, the Ohio state senate, the state assembly, and several state judicial posts. As a part of Mayor Carl Stokes' tax reform program, the city chose not to submit the renewal of 5.8 mills of its property tax for voter approval during this election. The administration instead proposed to increase the city's income tax from 1 percent to 1.8 percent. Passage of this proposal, coupled with a reduction in property tax levies, would have resulted in a small increase in total revenues, but a larger redistribution of tax liabilities.

Legal requirements led the city to permit the property taxing authority to lapse at the end of the year, regardless of the outcome of the vote on the income

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[6] This errors-in-variables problem is often present when aggregate data are combined from divergent sources, such as surveys and census data. In the voting case, however, it is possible to model the process through which the errors arise.

tax measure. However, at the time it was doubtful that voters considered the measure a referendum on the size of government or the provision of services. Instead, it appears clearly to have been proposed, discussed, and voted upon as a tax substitution measure.[7]

The election on November 3, 1970 drew a rather large turnout; newspaper accounts attributed this enthusiasm to the gubernatorial election (which pitted John J. Gilligan against Roger Cloud) and the senate contest (in which Howard M. Metzenbaum opposed Robert Taft, Jr.). Gilligan and Metzenbaum each won election; The city administration's tax initiative lost by a wide margin--105,762 to 76,087.

Given the many candidates and issues on the 1970 election ballot, the partial effect of the tax issue could not be large in inducing voting,[8] and the assumption that $cov(u_i \eta_i) = 0$ seems reasonable. We return to this issue below.

We combined published information about voting outcomes by city precinct with census tract data for 1970 by relying upon city maps indicating the boundaries of precincts and census tracts. Precinct votes were aggregated to the tract level; where precinct boundaries fell across tract boundaries we aggregate tracts. Complete data were available for 166 tracts.

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[7] See, for example, contemporary newspaper accounts: "Stokes Takes to Airwaves to Plug for 1.8% City Tax," *The Plain Dealer*, October 30, 1970; Donald Sabath, "Growth Group Backs City Tax Hike," *The Plain Dealer*, October 22, 1970; "City Income Tax Heading for a Loss," *The Plain Dealer*, November 1, 1970; "City Needs Income Tax Boost," *The Plain Dealer* (editorial), October 18, 1970.

[8] Indeed, in the *Plain Dealer* discussion the issue seems almost to have been overlooked. Failure to pass this initiative was reported in small print on page one of the November 4 edition, but the initiative was not discussed until page 8.

We have no firm economic model of the determinants of voter turnout. On the basis of existing empirical evidence generated largely by political scientists (see The Appendix for details), we postulate that the propensity to vote is a function of income, education, race and ethnicity, age, and homeownership status.

The published version of the 1970 fourth count census provides census tract averages and frequency counts for these variables for the eligible population. Subject to standard aggregation concerns, the parameters governing turnout behavior are thus consistently estimated using census tract data.

Table 1 provides estimates of these models predicting voter turnout. The models differ in their measurement of income and education and in their inclusion or exclusion of measures of housing value and rent. The first two columns (model 1) report the results of the simplest models which include median household income and median education of adults along with the fraction non-white, the fraction native born, the age distribution of adults and the fraction of homeowners in the tract. There are only small differences between the OLS and GLS parameter estimates in this specification. This model, which explains about half of the precinct variation in the propensity to participate in the referendum, suggests strongly that those with more education, as well as homeowners, black adults and older citizens, are more likely to go to the polls. There is no evidence that the income of voters affected the propensity to vote, at least after other factors are held constant.

TABLE 1

TURNOUT EQUATIONS: DEPENDENT VARIABLE
(REFERENDUM VOTES/ADULT POPULATION)

166 Observations on Voting Precincts
(t ratios in parentheses)

Variable	Model 1 OLS	Model 1 GLS	Model 2 OLS	Model 2 GLS	Model 3 OLS	Model 3 GLS
Education						
Median (years)	0.027 (2.68)	0.033 (3.57)				
8-12 Years			0.471 (2.99)	0.589 (3.89)	0.447 (2.04)	0.558 (2.60)
12+ Years			0.445 (3.49)	0.651 (5.76)	0.374 (1.47)	0.595 (2.53)
Ethnicity						
Black	0.134 (3.47)	0.112 (3.21)	0.113 (2.99)	0.066 (1.97)	0.126 (2.68)	0.079 (1.85)
Native-Born	-0.180 (1.67)	-0.032 (0.32)	-0.191 (1.91)	-0.042 (0.46)	-0.225 (1.97)	-0.105 (1.02)
Age						
30-44 Years	-0.365 (1.18)	-0.545 (1.93)	-0.173 (0.57)	-0.181 (0.64)	-0.233 (0.66)	-0.159 (0.49)
45-64 Years	-0.181 (0.66)	-0.278 (1.08)	0.083 (0.30)	0.214 (0.79)	0.146 (0.44)	0.284 (0.89)
65+ Years	0.238 (0.86)	0.203 (0.77)	0.429 (1.49)	0.427 (1.54)	0.200 (0.44)	0.282 (0.85)
Tenancy						
Homeowner	0.419 (5.96)	0.429 (6.48)	0.326 (5.81)	0.327 (6.00)	-0.001 (0.00)	0.580 (0.68)
Constant	0.078 (0.28)	-0.063 (0.24)	-0.032 (0.12)	-0.276 (1.06)	0.371 (0.83)	0.214 (0.47)

TABLE 1

Continued....

TURNOUT EQUATIONS: DEPENDENT VARIABLE
(REFERENDUM VOTES/ADULT POPULATION)

166 Observations on Voting Precincts
(t ratios in parentheses)

Variable	Model 1 OLS	Model 1 GLS	Model 2 OLS	Model 2 GLS	Model 3 OLS	Model 3 GLS
Income						
Median	0.001	0.005				
(thousands)	(0.08)	(0.75)				
$3000-$5000					0.120	0.099
					(0.30)	(0.25)
$5000-$7000					0.052	0.095
					(0.15)	(0.29)
$7000-$10000					0.024	-0.144
					(0.77)	(0.48)
$10000-$15000					0.159	0.221
					(0.54)	(0.78)
$15000-$25000					-0.317	-0.281
					(0.91)	(0.83)
$25000+					0.351	0.298
					(0.40)	(0.36)
Rent						
$40-$60/mo.					-0.281	-0.509
					(0.60)	(0.98)
$60-$80/mo.					-0.403	-0.398
					(1.20)	(1.07)
$80-$100/mo.					-0.346	-0.552
					(1.00)	(1.44)
$100-$150/mo.					-0.312	-0.332
					(0.95)	(0.88)
$150-$200/mo.					-0.841	-0.734
					(1.35)	(1.24)
$200+/mo.					0.298	-0.190
					(0.25)	(0.18)
House Value						
$5000-$10000					-0.159	-0.798
					(0.22)	(0.97)
$10000-$15000					-0.101	-0.767
					(0.15)	(1.00)
$15000-$20000					0.010	-0.685
					(0.01)	(0.87)
$20000-$25000					-0.034	-0.749
					(0.05)	(0.96)
$25000-$35000					0.045	-0.608
					(0.06)	(0.72)
$35000+					0.832	-0.217
R^2	0.508		0.536		0.558	

Model 3 (columns 5 and 6) presents the results when income, rent, and housing value are all considered as potential determinants of the probability of voting in the 1970 election. The model includes variables reflecting the fraction of adults falling into 6 of the 7 income categories, 6 of the 7 rent categories, and 6 of the 7 housing value categories. The introduction of these 18 additional variables increases the explained variance of the regression by about two percent. None of these variables is, by itself, significant, and an F-test cannot reject the hypothesis that the coefficient of each of these variables is zero.[9]

The estimates of model 3 provide information about the determinants of the decision to vote and about the sample selectivity process which motivates the two step estimation procedure. The net economic costs of passage of the referendum to any citizen was a linear combination of income, rent, or housing value, yet each of the 18 coefficients of the income, rent and value categories is zero. This, of course, is evidence that the individual decision to vote was not itself motivated by potential economic gain,[10] and the self selection of voters from the eligible population was not on the basis of preferences about the outcome of this referendum. Thus, from table 1, voters are indeed a nonrandom sample of the eligible population even though the assumption that $\text{cov}(u_i n_i)$ is justified.

We conclude that model 2, the simple specification including education, race, ethnicity, and tenancy provides an adequate description of the propensity to vote in the election.

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[9] For the OLS model, $F(18,139)=0.37$; for the GLS model, $F(18,139)=0.49$.

[10] This finding about voter turnout is thus consistent with the "consumption" theory of voting rather than the "investment" theory. See the Appendix for details.

The econometric procedure involves combining these turnout parameters (β) with the distributions of precinct *population* characteristics to estimate the frequency distributions of precinct *voter* characteristics. As indicated in equation (7), this requires combining the variances and covariances of individual characteristics *within each tract*; thus, mean values or one-way frequency distributions of the relevant variables for each tract are insufficient. However, with categorical variables in the vectors $\underline{x}_i$ and $\underline{z}_i$ and with the hypothesized linear forms of the turnout and voting relationships, two-way tables of population counts by tract are *exactly* the required cross-product matrices.

From the magnetic tape version of the 1970 Census of Population and Census of Housing, Fourth Count, it is possible to extract the two-way frequency distributions of the relevant sociodemographic characteristics of adults for each tract. In particular, we were able to group individuals: into seven categories each for household income, housing value and monthly rent; into four categories for age; into three categories for education; and into two categories each for race, ethnicity and tenancy. For each census tract is was possible to construct the 34 by 34 matrix of the required two-way frequency distributions that are premultiplied by the coefficients ($\underline{\beta}'$) reported in column 2, Table 1 to yield the vector $\underline{W}_j$ for each tract.[11]

Table 2 compares the frequency distributions of the population characteristics of precinct adults with the distributions estimated for precinct voters. The first column presents estimates of the average socioeconomic characteristics of Cleveland adults (the vector $\underline{X}_j$ averaged across tracts). For example,

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[11] The 7+7+7+4+3+2+2+2 square matrix of the two way frequency distributions of the sociodemographic characteristics of residents (income-by-rent-value-age-education-race-and foreign born status) can be computed for each census tract. The raw data are described in Dual Labs [1972a, 1972b].

34.6 percent of adults had less than 8 years of schooling, 55.5 percent had 8 to 12 years of schooling, and 9.8 percent had more than 12 years of schooling. Each of these one-way population frequency distributions sum to one. Column 2 presents estimates of the socioeconomic characteristics of voters in the referendum (the vector $\underline{W}_j$ averaged across tracts). These estimates were generated using the GLS coefficients ($\underline{\beta}'$) reported for model 2 (column 4, table 1).

TABLE 2
COMPARISON OF RAW DATA ON PRECINCT ADULTS
WITH ESTIMATED DISTRIBUTIONS FOR REFERENDUM VOTERS

	Raw Population Mean X	Estimated Voter Mean $\hat{W}$	Estimated Fraction Of Turnout $\hat{W}/\Sigma\hat{W}$	Estimated Turnout Rate $\hat{W}/X$	Correlation X with $\hat{W}$
TENURE CLASS					
Homeowner	0.5029	0.2872	0.7183	0.5711	0.913
Renter	0.4969	0.1127	0.2818	0.2268	0.899
Sum	0.9999	0.3999	1.0000		
EDUCATION					
8 Years	0.3460	-0.0017	-0.0042	-0.0049	-0.541
8-12 Years	0.5554	0.3168	0.7654	0.5704	0.789
12+ Years	0.0984	0.0988	0.2389	1.0041	0.903
Sum	0.9998	0.4139	1.0000		
RACE					
Black	0.3529	0.2470	0.5792	0.6999	0.910
White	0.6471	0.1794	0.4208	0.2772	0.884
Sum	0.9999	0.4264	1.0000		
ETHNICITY					
Native born	0.7688	0.3122	0.7798	0.4061	0.491
Foreign born	0.2311	0.0882	0.2202	0.3817	0.881
Sum	0.9999	0.4004	1.0000		
AGE					
under 25 yrs	0.1183	0.0376	0.0943	0.3178	0.882
25-35 yrs	0.2943	0.0390	0.0979	0.1325	0.913
35-64 yrs	0.3962	0.1929	0.4838	0.4869	0.909
64 +	0.1910	0.1292	0.3241	0.6764	0.982
Sum	0.9998	0.3987	1.0000		

TABLE 2
Continued....
COMPARISON OF RAW DATA ON PRECINCT ADULTS
WITH ESTIMATED DISTRIBUTIONS FOR REFERENDUM

	Raw Population Mean X	Estimated Voter Mean $\hat{W}$	Estimated Fraction Of Turnout $\hat{W}/\Sigma\hat{W}$	Estimated Turnout Rate $\hat{W}/X$	Correlation X with $\hat{W}$
INCOME					
\$3,000	0.1700	0.0573	0.1435	0.3371	0.752
\$3,000-\$5,000	0.1013	0.0360	0.0902	0.3554	0.497
\$5,000-\$7,000	0.1161	0.0404	0.1013	0.3480	0.463
\$7,000-\$10,000	0.2218	0.0853	0.2136	0.3846	0.480
\$10,000-\$15,000	0.2544	0.1135	0.2844	0.4461	0.901
\$15,000-\$25,000	0.1179	0.0574	0.1439	0.4869	0.969
\$25,000+	0.0181	0.0093	0.0232	0.5138	
Sum	0.9996	0.3992	1.0000		
MONTHLY RENT					
\$40	0.0090	0.0011	0.0094	0.1222	0.982
\$40-\$60	0.0325	0.0060	0.0532	0.1846	0.895
\$60-\$80	0.0840	0.0165	0.1461	0.1964	0.892
\$80-\$100	0.1385	0.0296	0.2616	0.2137	0.828
\$100-\$150	0.2029	0.0509	0.4496	0.2509	0.838
\$150-\$200	0.0272	0.0078	0.0689	0.2868	0.966
\$200 +	0.0043	0.0013	0.0117	0.3023	
Sum	0.4984	0.1131	1.0000		
HOUSE VALUE					
\$5K	0.0137	0.0021	0.0073	0.1533	0.931
\$5K-\$10K	0.0524	0.0266	0.0934	0.5076	0.983
\$10K-\$15K	0.1528	0.0832	0.2920	0.5445	0.986
\$15K-\$20K	0.1873	0.1084	0.3802	0.5788	0.996
\$20K-\$25K	0.0727	0.0438	0.1538	0.6025	0.996
\$25K-\$35K	0.0275	0.0172	0.0602	0.6255	0.996
\$35K +	0.0059	0.0038	0.0133	0.6441	0.998
Sum	0.5123	0.2850	1.0000		

Note that, although the matrix multiplication is not constrained, the estimated turnout rate summed across each demographic category comes close to the aggregate turnout rate -- as it should since each demographic category is exhaustive. The sums reported in the table, 39.9% (for income), 41.4% (education), 42.6% (race), 40.0% (ethnicity), 40.0% (tenure), 39.9% (age), 39.6% (rent and value), compare rather closely to the aggregate turnout rate of 39.2%. Column 2 presents estimates of proportions of adults who fall into each category and who vote. Column 3 indicates the average demographic characteristics of voters (each category is merely normalized by its sum). For example, among adults in the population the homeownership rate is 50.3%; Among voters, however, the rate is estimated to be 71.8%. About 9.8% of Cleveland adults had completed more than 12 years of education, but it is estimated that 23.9% of referendum voters completed more than 12 years of education. It is apparent that the estimated demographic distribution of voters differs substantially from the demographic distribution of the population at large.

The fourth column of Table 2 presents the propensities to vote for various demographic categories of the population. For example, among those earning less than $3,000, it is estimated that 33.7% vote (i.e., .0573/.1700), but for those earning more than $25,000, the estimate is 51.4% (i.e., .0093/.0181).

The last column in Table 2 provides another measure of the importance of the adjustment procedure. It indicates the correlation of the raw population proportions and the estimated voter proportions across the 166 voting districts. The key correlations are those pertaining to income, housing rent, and housing value since these are presumably the economic determinants preferences on the referendum. The housing value and rent proportions are quite closely correlated in the raw and in the adjusted data, but the income estimates are farther apart

-- the pattern of income levels at the tract level for voters differs noticeably from that for the population as a whole. This, of course, is an incomplete comparison since the effects of income and housing values depend upon the joint distribution of incomes and values (or rents) and not just on the cross-sectional correlation of one way frequencies.

Table 3 presents estimates of an economic model of self-interested voting behavior on this referendum. A "yes" vote on the referendum was reported by those voters who favored an increase in the (proportional) income tax rate and a decrease in the property tax rate to finance the services provided by local government. Hence, other things being equal, economic self-interest dictates that individuals with higher incomes will be less likely to favor the referendum. Holding other things (including income) constant, individuals who own more expensive homes are more likely to favor such a tax reform. Ceteris paribus, renters with higher rental expenditures are also hypothesized to favor the tax measure (at least as long as they perceive that any portion of the property tax is an excise tax).

TABLE 3
GENERALIZED LEAST SQUARES VOTE EQUATIONS: DEPENDENT VARIABLE
(YES VOTES/TOTAL VOTES)
166 Observations On Voting Precincts
(t ratios in parentheses)

	Using Adjusted Data, W	Using Raw Data, X
Income (thousands)		
$3.0-5.0	-2.105	-11.376
	(2.69)	(4.28)
$5.0-7.0	-0.759	-1.396
	(1.12)	(0.61)
$7.0-10.0	-2.940	-6.184
	(6.18)	(3.46)
$10.0-15.0	-3.020	-7.124
	(6.96)	(4.91)
$15.0-25.0	-3.774	-5.166
	(3.39)	(3.31)
$25.0+	-4.412	-10.307
	(3.22)	(3.03)
Home Value (thousands)		
LT $5	0.670	-0.783
	(1.24)	(0.13)
$5-10	0.993	-6.384
	(1.18)	(1.42)
$10-15	1.696	-5.169
	(2.22)	(1.18)
$15-20	1.630	-5.310
	(2.20)	(1.18)
$20-25	1.334	-4.860
	(1.71)	(1.07)
$25-35	2.308	-4.150
	(2.76)	(0.92)
$35+	-2.930	-6.750
	(0.21)	(1.32)
Rent		
$40-60	-0.290	-12.922
	(0.26)	(1.86)
$60-80	0.673	-1.295
	(0.89)	(0.27)
$80-100	1.073	-4.449
	(1.35)	(0.92)
$100-150	1.472	-3.369
	(1.94)	(0.73)
$150-200	-0.006	-13.566
	(0.01)	(2.30)
$200+	4.397	-7.370
	(2.37)	(0.90)
Constant	1.128	11.593
	(1.62)	(2.59)
R^2	0.611*	0.424*

*From OLS Model

The model presented in Table 3 includes the proportion of adults in six of the seven income categories and 13 of the 14 rent/value categories. When the regression is estimated from the data on the characteristics of those who go to the polls, there is indeed evidence that individuals vote their own self-interest. Those of higher income tend to vote against the referendum, holding housing expenditures constant, and those with higher priced homes or apartments tend to favor the referendum holding income constant. While there are some anomalies for specific categories, presumably reflecting the high correlation between income, home ownership and housing expenditures, the results provide strong support for the self-interested voter hypothesis.

The estimates based upon the raw data on adult populations do not provide the same support at all for the economic model. There is little overall support for the self-interested voter hypothesis; indeed, there is no consistent pattern of estimated coefficients across income, rent or housing values.

In summary, the results presented in Table 3 provide clear evidence that voting models using the theoretically preferred approach offer an advanrtage for the analysis of *this* body of data. This evidence is even more striking when it is recognized that the theoretically "correct" and "incorrect" bodcies of data are so highly correlated in this sample.

In explaining voting behavior, the key issue is clearly the perceptions of the individual voters with respect to potential tax liabilities. In the case of renters, this is particularly important since calculation of tax liabilities is almost always an imputation based upon imperfect market information. (Perhaps the only clear exception is the case in which rental contracts include explicit property tax escalation clauses). From these data, it appears that renters perceive that any property tax adjustments will indeed be reflected in their rents. This is also noteworthy since passage of the referendum would have reduced property tax liability.

CONCLUSIONS

Referendum data provide direct observations about citizen preferences. However, because voter turnout is nonrandom, inferences about preferences based upon the relationship between voting outcomes and population characteristics are likely to be biased and misleading.

This paper develops methods to provide consistent estimates of the parameters of voter preferences. The estimation method focuses on the errors-in-variables problem that is inherent in selective turnout combined with the necessity of using aggregate data. The heart of the method is the use of estimated turnout models to adjust the variance-covariance matrix of the variables affecting citizen turnout and voter preference. This adjustment provides estimates the aggregate characteristics of *voters* as opposed to those of the population of potential voters.

A crucial assumption in this estimation is that the errors in the preference equation are uncorrelated with the errors in the voter turnout equation. This would be the case when exogeneous factors or preferences for other issues or electoral candidates motivate the decision to appear at the polling place (see the Appendix for a further discussion). The appropriateness of this assumption can be tested; in this instance it appears to be valid.

The estimation method is applied to a particularly intriguing referendum --

the substitution of a higher level of income tax for property taxes in order to support the local government activities. This allows a fairly precise test of the proposition that citizens vote their private economic self-interests, and allows explicit consideration of the perceptions and choices of voters on tax instruments.

The empirical analysis suggests that the statistical adjustments are indeed important, at least for the economic analysis of this body of data. Further, when considered within the context of an appropriate methodology, the economic model of voting behavior is confirmed.

APPENDIX

Determinants of Voter Turnout

Two approaches to analyzing the problem of voter turnout dominate the literature. One view, popularized by Anthony Downs [1957] and Gordon Tullock [1968], considers voting as an investment act. A citizen participates in an election because the expected private gains exceed the costs of voting. These expected benefits depend, not only on the return to the voter associated with the election of an individual or the passage of a referendum, but also on the closeness, *ex ante*, of the election and the expected number of participants. Clearly, even if an individual expects the election to be quite close, the expected gain to voting will be quite small if the number of voters is even moderately large. Thus if there are any costs to voting, the investment model suggests that the incentive to participate in an election is trivially small. A somewhat stronger "investment" incentive for voting was proffered by Ferejohn and Fiorino (1974) who argued that a minimax regret criterion for participation (choose the act which minimizes the worst possible outcome) instead of an expected gain criterion would more typically result in electoral participation.

It is hard to think of behavior according to the minimax regret criterion as "investment," and are many convincing rebuttals of this proposition, e.g., Goodin and Roberts (1975).

An alternative view, presented by Riker and Ordeshook [1968], considers the act of voting to be primarily a consumption good. According to this view, an individual votes to satisfy the demands of civic duty or to enjoy the act of participation in the political process. Thus, although an individual may have strong preferences relating to the outcome of an election, participation is not affected by perceptions of affecting the outcome.

The two models do have different implications. If the consumption model is appropriate, we would expect to see the same group of individuals voting, no matter what the issues involved. Under the investment theory, however, those individuals having the most to gain or lose are the most likely to vote, holding voting costs constant. Under the investment model, as the issues being decided change, so do the characteristics of those who choose to vote.

If the consumption model is correct, voting costs are negligible (Neimi, 1975) and voting is a normal good, then we would expect to see a disproportionate number of people from higher income classes voting. More generally, the pattern of voter participation by income level depends upon the income elasticity of demand for voting and the elasticity of voting costs with respect to income. If the principal voting costs are informational, we may expect larger turnouts from groups with higher levels of education. If the issue being contested affects lower income households more than higher income households, and if the investment model is correct, then holding costs constant we would expect to find lower income groups over-represented at the polls.

Whichever model is correct, as an empirical matter it is clearly implausible to assume that those who actively participate in an election are a random sample of the eligible population. A broad variety of empirical analyses (Seidle and Miller [1975], Settle and Abrams [1976], Tollison, Caring, and Panther [1975], Silberman and Durden [1975], Barzel and Silberburg [1973], Brody and Page [1973], Craine and Deaton [1977], Tollison and Willett [1975]) have indicated that citizen turnout varies by age, education, tenancy and other demographic characteristics.

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