AN ABSTRACT OF THE THESIS OF

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Title: The Relationship Between Population and Residential Property Taxes in Oregon

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The relationship between population and residential property taxes is not well understood. This study is an attempt to discern the relationship.

The basic questions examined are: How does population affect tax bills? What are the short-run and long-run relationships between population and taxes? What reasons lie behind the answers to the first two questions?

Nearly all of a typical residential property tax bill is paid to the three units of local government, counties, cities, and school districts. The equation for determining the tax bill is the same for each unit of government: Total Expenditures minus other non-property tax revenues equals the Levy which divided by the total value of all property in the district equals the tax rate which multiplied by the value of a residence gives that residence's tax bill.

The relationships between each of the above variables and population are examined to facilitate understanding of the tax-population relationship. The model chapter provides a logical link between each variable and population and corresponding estimating equations to assess long-run and short-run relationships and the relative effect of population on the

separate tax variables. For long-run relationshps both simple linear and quadratic functions are used with population as the explanatory variable. For short-run equations, first difference estimates are computed. Elasticities are computed for comparing the relative effect of population on the tax variables.

The results obtained show that despite high R^2 values the large confidence intervals about the regression lines imply that substantial variation is left unexplained by population variables.

Generally, levies appear to be more responsive to population than does the value of all property as a whole resulting in a rate of growth in the levies which exceeds that of property values. Hence, tax rates tend to increase slightly with increases in population.

Higher residential property taxes are associated with larger populations. This appears to be due in part to the relatively more elastic response of residential values to population than all property values as a whole. Taxes appear to be shifting toward residential property owners.

Finally, short-run changes in taxes and variables composing the tax equation do not appear to be related to short-run changes in population.

The Relationship Between Population and Residential Property Taxes in Oregon

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Dean of Graduate School

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Typed by Dodi Snippen for Shepard C. Buchanan

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THE RELATIONSHIP BETWEEN POPULATION AND RESIDENTIAL PROPERTY TAXES IN OREGON

CHAPTER I

INTRODUCTION

In 1974 a typical residential property owner's tax bill paid to school, city, and county governments was $371.79. In 1976 the same property owner paid out $424.93, a $53.14[1/] increase. What caused the increase?

There are those who feel that population growth is to blame for rising property taxes. One argument is that the taxes paid by newcomers do not meet the increase in expenditures made by local governments to serve them. Others argue that growth helps keep taxes down because more people means more taxable property, and the more taxable property the lower the tax rate.

Just how are population and property taxes related? How does growth affect a typical residential property owner's tax bill? What are the short- and long-run effects of population growth on property tax bills? These are the basic questions addressed in this study.

While the introduction, development of the model, analysis and interpretation of empirical results, and conclusions are laid out one after the other in narrative fashion, some readers may find it helpful to skip around somewhat. After reading the introduction and conclusions, the reader ought to have a better feel of the problem and so more easily digest the model and results chapters. Due to the large number of separate relationships that must be analyzed, the middle three chapters

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1/ All figures are in 1976 dollars.

though not complex are somewhat lengthy.

The first chapter, the introduction, begins the formulation of the model. Some of the basic assumptions are set forth, the relationships to be examined are introduced, and the methodology of the study is presented.

Chapter II is an attempt at a theoretical model for estimating the tax-population relationship. Also included are citations from the literature. While there is much that is not new, its importance is its completeness. There have been studies of the effects of population on all the major variables in the model but none that I have found have put them all into one model. Chapter II begins with an overview of the basic population-tax relationship followed by closer examination of the separate parts of the model. The two blocks are analyzed separately, then an effort is made to theorize how the entire model will function. From the discussion several testable hypotheses emerge.

Chapter III is the first chapter in which results are presented. The simple equations for each unit of government are discussed in Chapter III. Oregon local government data is analyzed in a first-round attempt at answering questions raised in Chapter II.

Chapter IV continues the analytic process begun in Chapter III. Further results are analyzed and (hopefully) given some meaning. Inferences based on the analysis of data are presented in this chapter.

Finally, Chapter V is a summary of the first four chapters as well as comments about direction of further research.

Oregon Residential Property Tax Bills

A property tax bill is actually a set of tax bills for each taxing unit in which the property is located. In Oregon, there are three major taxing jurisdictions, although there are cemetery, fire, historical, and other districts with the power to tax. But virtually the entire tax bill goes to the county, city, and school district.

Although about 41 percent [2/] of Oregon residents live in unincorporated areas, it is assumed in this study that the typical resident lives in a city. Hence, the typical residential property tax bill is based on all three levels of government.

Briefly, here is how a tax bill is computed.[3/] Each governmental unit has a budget committee or similar body. After consideration of all planned expenditures (TEXP) a budget is produced which must by law be balanced. From the total figure are subtracted all nonproperty-tax revenues (NTR) expected to be received in the coming year. The result if greater than zero is the property tax levy (LEVY); that is, the amount of money to be raised through property taxes to balance the budget.[4/]

Each taxing unit is subject to the "six percent limitation". A taxing district has a "tax base" which is the maximum levy in the taxing district collected in the previous three years without voter approval. The tax base may be increased by six percent each year, but increases of more than six percent require voter approval. Because the legal limit is insufficient for many taxing districts, most levies now require voter approval.

2/ "Population Estimates", Oregon Center for Population Research and Census, Portland State University, Portland, Oregon, 1970-1977.

3/ For a more complete discussion see OSU Extension Circular 907.

4/ Strictly speaking this is not the final levy. From it are subtracted back taxes expected to be collected in the next year and to it are added taxes not expected to be collected. These adjustments are ignored in this paper because they are relatively small adjustments, must eventually balance anyway, and appear to have little effect on the analysis.

The tax rate (RATE) is computed by dividing the levy by the total true cash value of all real property (TCV) in the taxing district. The result is usually expressed as a dollars per thousand figure. Each taxing unit relevant to a piece of property has its own tax rate the sum of which multiplied by the individual's assessed property value yields a tax bill (TAX). For each taxing unit, then, the procedure is:

Total Expenditures = sum of planned expenditures

Property Tax Levy = total expenditure minus non-property tax revenues

Tax Rate = levy divided by total true cash value of property in district

Tax Bill = tax rate times assessed property value

Immediately, one can see there are two basic parts of the process. One is the government block involving the collection and spending of taxes. The other is the property block.

Now all the key variables have been identified. We need to ask again, how does population affect property tax bills, given the two major blocks, government and property. Figure 1 depicts that question with arrows indicating the (presumed) direction of causality. The picture helps point out that population and tax bills may be related through the government activities block, the property value block or both. Possibly there may be no effect on tax bills due to a cancelling effect of the two blocks. This line of reasoning leads to Figure 2, an expanded version of Figure 1. The underlying question involves the bottom leg of the flow. Clearly, though, the effect of population on

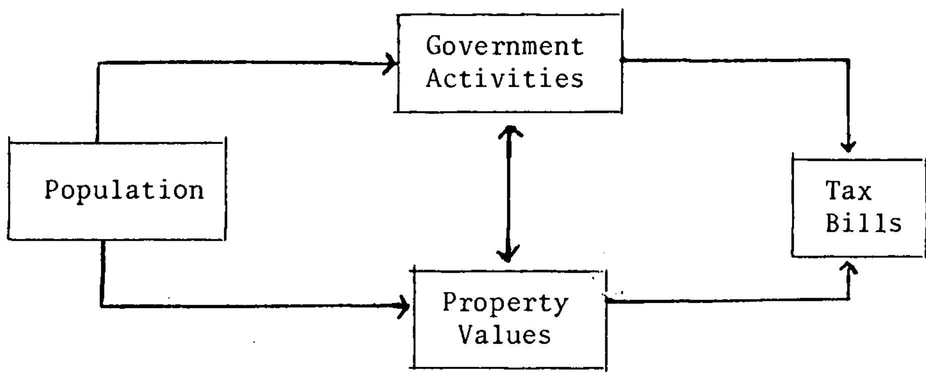

Figure 1-1. A Simple Population-Tax Bill Model.

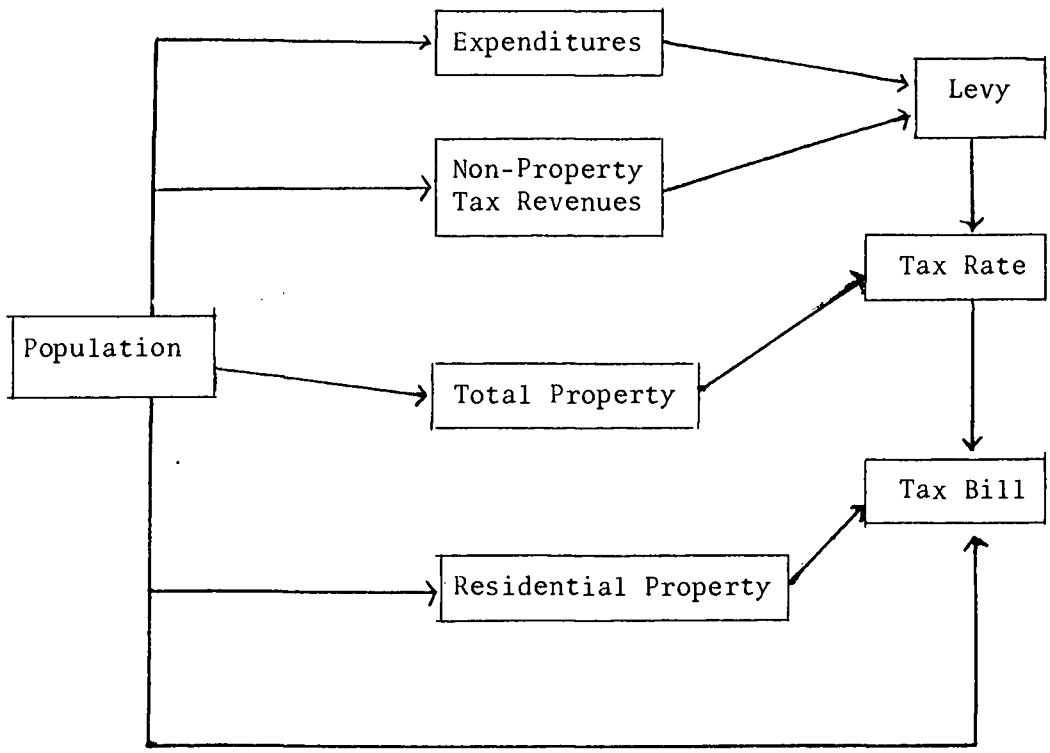

Figure 1-2. A Flow Chart Detailing the Population-Tax Bill Relationship.

tax bills is determined by its effect on the intervening variables.

Mathematically, the model is complete.

$$LEVY = TEXP - NTR$$

$$RATE = LEVY/TCV$$

$$TAX = RATE \times VRES$$

where

LEVY = property taxes levied by taxing unit

TEXP = total budgeted expenditures of taxing unit

NTR = total non-property tax revenues expected to be collected

RATE = tax rate

TCV = total true cash value assessed in taxing unit's jurisdiction

TAX = individual property tax bill

VRES = average value of assessed residential property

POP = population.

Since the question is:

$$TAX \stackrel{?}{=} f(POP)$$

by substitution

$$\frac{(TEXP - NTR)}{TCV} \cdot VRES \stackrel{?}{=} f(POP)$$

leading to the following possible relationships:

$$TEXP \overset{?}{=} f_1(POP)$$

$$NTR \overset{?}{=} f_2(POP)$$

$$TCV \overset{?}{=} f_3(POP)$$

$$VRES \overset{?}{=} f_4(POP)$$

Naturally, it is not assumed that the relationships are simple bivariate relations: certainly other factors affect the variables. We are interested primarily in the question of population effects, however and so concentrate on them. These simple equations are the basis of the analysis. Recognizing the presence of the intermediate government and property blocks the first relationship to analyze is the direct tax-population relation. Having determined the nature of that relationship the next step is to analyze what intermediate factors give rise to the final relationship; for example, if population growth increases taxes is it because local governments expenditures increase faster or because residential property values are increasing more rapidly than nonresidential property values? In the seemingly simple equation for TAX, there are several possibilities for increasing TAX. TEXP or VRES could increase. TCV or NTR could decrease. Or TEXP could increase faster than NTR. Or TCV could increase but not as fast as VRES. Clearly, though, the effect of population on the four intervening variables, TEXP, NTR, TCV, and VRES determines the effect of population on TAX.

Certain simplifying assumptions have been made in this study. Each of the four main variables -- TEXP, NTR, TCV, and VRES -- is assumed to be independent of the others. In certain cases this assumption may not be altogether realistic. In Chapter II for example the effect of NTR on TEXP is discussed and recognized especially with regard to the LEVY.

A great deal of work has been done in relating _per capita_ local government expenditures and taxes to residential property values. This work springs from the Tiebout hypothesis (Tiebout, 1956). As interpreted by Oates (1969), the hypothesis is that residential property values are not independent of community expenditures and taxes. The tax rate would tend to negatively affect residential property values, while _per capita_ expenditures would be positively associated with residential property values. In an empirical study of the New York Metropolitan area Oates found evidence to support the hypothesis.

In a study of North Carolina local governments Hyman and Pasour (1973) refuted the Tiebout-Oates hypothesis. Their contention was that first, the variation in the tax rate in North Carolina was small due to large amounts of state aid. Second, due to a more elastic supply of land and structures, property taxes would not likely be capitalized in the form of lower rents (actual or imputed). Finally, citizen-voters most of whom are not employed in a concentrated metropolitan area must usually live near their work with somewhat less choice than is available to the urban dweller. Their results confirmed their belief.

It is argued _a priori_ that Oregon more nearly represents the North Carolina situation than it does the New York Metro area. There is a large amount of state aid to local governments. While growing ever more crowded, Oregon still has land available for urban and residential expansion. Finally, Oregon, like North Carolina, has a more dispersed population which does not gravitate around a central urban area. Therefore it is argued that property values, tax levies (or rates), and local government expenditures are independent.

There is another important simplificationof the study, namely that the regression equations have only population terms as explanatory variables. Most are simple single explanatory variable equations although some include two population terms as explanatory variables. The major reason for making multiple as opposed to simple regression estimates is that the inclusion of control variables is supposed to improve the accuracy of the estimated coefficient on the variable of interest. Theil (1955) showed that by omitting a theoretically important variable from an estimating equation one induces a bias on the remaining variable(s)' estimated coefficient. It can be shown that for a two explanatory variable model the bias of an estimated coefficient resulting from the omission of the other variable is:

$$\text{Bias } (\hat{b}_1) = E(\hat{b}_1) - b_1 = r_{12}b_2$$

where the bias of $\hat{b}_1$ (the estimated regression coefficient) is by definition the difference between its expected value and the "true" value, and r_{12} is the correlation coefficient between the two explanatory variables and b_2 is the "true" value of the omitted coefficient. Note that if the signs of both r_{12} and b_2 are known the sign of the bias is merely their product. A positive (negative) bias means that the expected value of the regression coefficient over (under) estimates the "true" value of the coefficient. If the two explanatory variables are independent implying $r_{12} = 0$, then no bias results from omitting one variable or the other. The formula is used to assess the direction of bias in some of the simple estimates of this study.

Some of the concern with specification bias may be unwarranted, however. An example can best show why. Let us say that property values are determined by only two factors -- the local population and income. Assume both are positively related to property values and that both are positively correlated: incomes are higher in more populous areas. If one then estimates property values as a function of population alone the resulting coefficient will include some of the effect of income (as the bias equation shows) while, the "true" effect of population would be somewhat less. But remember the question we are asking. How are taxes (in the example, property values) related to population. The biased estimate actually gives us a better idea. Let's say the population increases substantially over the years. In predicting a property value for the city we would not want to compare it with a city of different size but the same income; that is, we don't want to hold income constant. What we really want is to include the effect of the higher incomes in the larger city in the prediction -- and that is what the simple equation does. As long as some direct and logical association is implied between the retained and omitted variables there is justification for using the simple estimating equation. In our example, incomes go up as population goes up, hence population increases are directly associated with income increases. It is only when the retained and omitted variable are only coincidentally correlated that the simple equation could be misleading. One instance in which this happens, county NTR, is discussed more thoroughly at a later time.

Therefore, in the interest of interpretive simplicity the bulk of the analysis turns on simple estimating equation. Some discussion of the direction of the bias is included at times so that in applying the results to a specific area of which there is some knowledge of the omitted variable one could adjust the estimate accordingly.

The following is a list of variable names and explanations.

Variable Codes

Variable	Explanation
TEXP	Total expenditures of a unit of government in dollars.
NTR	Total non-property tax revenues received by a unit of government in dollars.
LEVY	Total property tax levy of a unit of government in dollars.
TCV	Total true cash value of property in taxing district in dollars.
RATE	District property tax rate in dollars per thousand dollars of assessed value.
VRES	Value of a residential property in a taxing district in dollars.
TAX	Residential property tax bill in dollars.
POP	Population of taxing district.
CTEXP	Change in total expenditures of a unit of government in dollars.
CNTR	Change in total non-property tax revenues received by a unit of government in dollars.
CLEVY	Change in total property tax levy of a unit of government in dollars.

Variable	Explanation
CTCV	Change in true cash value of all property in a district in dollars.
CRATE	Change in property tax rate in a district in dollars per thousand.
CVRES	Change in value of a residential property in a district in dollars.
CTAX	Change in a residential property tax bill in a district in dollars.
CPOP	Change in population of a district.
PCPOP	Percent change in a population of a district.
PTEXP	Per capita (or per ADM) total expenditures of a unit of government in dollars.
PNTR	Per capita (or per ADM) total non-property tax revenues received by a unit of government in dollars.
PLEVY	Per capita (or per ADM) total property tax levied by a unit of government in dollars.
PTCV	Per capita (or per ADM) true cash value of property in a district in dollars.
CPTEXP	Change in per capita (or per ADM) total expenditures of a unit of government in dollars.

Variable	Explanation
CPNTR	Change in per capita (or per ADM) total non-property tax revenues received by a unit of government in dollars.
CPLEVY	Change in per capita (or per ADM) property tax levy by a unit of government in dollars.
CPTCV	Change in per capita (or per ADM) true cash value of property in a district in dollars.
INC	Per capita income in a district in dollars.
T	Time variable indicating the time period.
D	Dummy = 1 if county is an O & C county. Dummy = 0 if county is west of Cascades
POPSQ	Square of population in districts.
ADM	Average daily membership in school district.
BSSF	Total basic school support funds received by a school district in dollars.
N	Number of residential properties in a county.
TOTRES	Total value of residential property in county in thousands.
U_i	Error term to account for unexplained variation in the dependent variable of the i^{th} equation.
η	The Greek letter η is used in this paper to mean "the elasticity [of some variable] with respect to population".

Variable	Explanation
L	An L preceding a variable name indicates the natural log of the variable.
P	A P preceding a variable name is read as "per capita" or "per ADM".
C	A C preceding a variable name is read "Change in".
A	A subscript "A" on a variable indicates the variable is the aggregated county-wide variable, e.g.,, $TEXP_A$.
K	A subscript "K" on a variable indicates the variable is the county variable, e.g., NTR_K
S	A subscript "S" on a variable indicates the variable is the school district variable, e.g., $LEVY_S$.
C	A subscript "C" on a variable indicates the variable is the city variable, e.g., TCV_C.

CHAPTER II

A MODEL OF RESIDENTIAL PROPERTY TAX BILLS

Model Introduction

The equation for computing an average residential property tax bill (TAX) suggests two separate blocks: a government block and a property block. The former block includes a district's total expenditures (TEXP), its other non-property tax revenues (NTR) and the difference between the two, the property tax levy (LEVY). Ignoring special tax districts, the total tax bill paid by a residential property owner is the sum of the tax bills paid to each of the three basic units of local government: counties, schools, and cities. Although each unit of government has separate responsibilities they all share the basic function of providing public goods and services.

In order to understand the relationship between TAX and population some understanding of the relationship between population and the intermediate variables is necessary. Past studies have examined expenditure determinants to the point of exhaustion. Property value determinants have also been extensively studied. The effects of non-property tax revenues, mainly grants from state and Federal governments have been researched although far less has been done in the area of predicting these NTRs. But little, if any, work has been done to relate population to residential property tax bills.

In this chapter a complete, but simple, model is set forth from which testable hypotheses are generated to facilitate an understanding of the TAX-population relation. Each variable in the TAX formula is discussed separately with respect to population. Also, in the government block a discussion of each variable is presented for each unit of government. Where appropriate, property values are discussed in relation to the units of local government.

For each variable there are three basic equations derived. First are the simple equations where POP is the only explanatory variable. Then, first difference or change equations are derived to look at how a given variable changes with a change in population (CPOP). Then, quadratic equations are posited with the addition of a squared population term (POPSQ). These final equations may allow not only better predictions, but also a test of whether a given variable increases at an increasing rate with respect to population (i.e., an increasing marginal function) or increases at a decreasing rate with respect to population (i.e., a decreasing marginal function).

Then from the theoretical discussion heading the sections on each variable the "true" specifications of each variable are presented to allow assessments of the direction of bias on the estimated regression coefficients.

Finally, parallel equations for TEXP, NTR, LEVY, TCV and VRES are proposed for RATE and TAX. These latter equations are a result of combining the government and property value blocks.

In order to compare the effects of population on the separate parts of the model, some standard of measurement must be chosen. For this, the population elasticity is used. The advantages of using elasticities are many. They are easy to compute and, just as importantly, easy to interpret.

In this study, the Cobb-Douglas function is used to estimate constant elasticities. This is a log-linear equation of the form:

$$Y = AX^{\alpha}$$

where the exponent α can be shown to be the elasticity of Y with respect to X.[1/]

An added advantage of the log-linear form is in its interpretation. First, the elasticity is equal to the degree of homogeneity of the equation or α. By definition of homogeneity, if X is increased by n percent then Y is increased by (αn percent). Thus, the elasticity measures changes in the dependent variable associated with changes in the explanatory variable which in the model is population. Because the elasticity is unitless, the population elasticities of different variables may be compared.

The purpose of this chapter is to set forth a theoretical framework which will allow an empirical examination of its hypotheses. After these hypotheses are derived and discussed, the following chapter contains most of the quantitative results with a cursory analysis and interpretation. In Chapter IV, the remaining results appear along with more complete interpretations.

Local Government Expenditures

One might argue that local government expenditures is the most important variable in the TAX equation to understand because without

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1/ By definition the elasticity of Y with respect to X is:

$$\frac{dY}{dX} \cdot \frac{X}{Y} \quad \text{or} \quad \alpha AX^{\alpha-1} \cdot \frac{X}{AX^{\alpha}} = \frac{\alpha AX^{\alpha}}{AX^{\alpha}} = \alpha$$

expenditures there would be no taxes. To support that argument, one need only observe the explosion of expenditure determinants studies which appeared in the 1960's. Everyone, it seemed, had a new variable with which to explain local expenditures. Yet despite all the activity, most models retained the familiar look of previous models which had their genesis with Fabricant (1952). The bulk of the work in the area was labeled by Johnson (1976) as pragmatic empirical, a self-descriptive phrase. The main feature of these models is their attempt to estimate the effects of a host of explanatory variables on local government expenditures using multiple regression, which is precisely the goal of this study with the variable of interest being population. While other models and methodologies have been developed in the study of local government expenditures, the present study leans heavily on the so-called pragmatic empirical studies. For a superb treatment and review of expenditure determinant studies, please see Inman (1977).

Because of the separate and unequal responsibilities of the three units of government examined in this study, it will be useful to analyze each unit separately. How population (POP) affects a district's average residential property tax bill (TAX) depends in part on how it affects the district's expenditures (TEXP). This leads to the formulation of a general equation:

(1) $TEXP = f(POP)$

Since other variables may also explain TEXP, a second equation may be posited:

(2) $TEXP = g(POP; X_1, X_2, \ldots, X_n)$

where X_1, X_2, . . ., X_n represent other, as yet unspecified, explanatory variables. Primarily, the interest of this study is in (1) which estimates what might be called the gross effect of POP on TEXP. If, for example, the "true" TEXP equation had income (INC) as an explanatory variable and if INC were correlated with POP, then the estimated coefficient on POP in (1) would include some of the effect of INC. Were equation (2) to be estimated, assuming it were correctly specified and the basic Ordinary Least Squares (OLS) assumptions met, then the resulting coefficient on POP would be a measure of the effect on TEXP attributable solely to POP.

Before examining each unit of government, there are some general observations to be made based on past research which apply to all local governments in general and make possible a smooth, logical development of an expenditure model.

While most expenditure studies have examined _per capita_ expenditures, the interest of this study is in total expenditures. For example, one might specify an equation of the form:

$$(3) \quad \frac{TEXP}{POP} = a_0 + a_1 POP$$

where

$\frac{TEXP}{POP}$ = per capita expenditures

POP = population

a_0, a_1 = structural parameters.

Because the concern of this research is total expenditures, it is necessary to multiply both sides of equation (3) by POP to give:

(4) $TEXP = a_0POP + a_1POPSQ$

where now

TEXP = total expenditures

POP = population

POPSQ = population squared.

This procedure is followed throughout in developing the basis for examining expenditure determinants in the present study.

Essentially there have been three classes of variables proposed to explain expenditures. One class includes population-related variables such as total population, population change, and population density. The second class of variables measures wealth and includes income and average property values. Finally, there are variables measuring aid from other governments; that is, grants and other intragovernmental revenue transfers.

This last group corresponds to a subset of non-property tax revenues. The idea of other non-property tax revenues as a stimulus for local government spending is appealing. Often, government grants, CETA for example, are designed to stimulate expenditures which would not have been made in the absence of a grant. Too, it seems reasonable that a budget committee first assesses the amount of non-property tax revenues expected to be received before deciding on an expenditure proposal. This argument is made in the section on property tax levies later in this chapter.

Although it is easy to argue that NTRs have an impact on TEXP, they are omitted from the remainder of this section because the inclusion of NTR in (2) would effectively result in regressing TEXP on part of itself. A high correlation between the two variables would be neither surprising nor enlightening.[2/] A discussion of the effect of NTR on TEXP is reserved for the section on levies.

The other two classes of variable do merit discussion, however. Public goods and services are assumed to be normal goods; that is, income is positively related to the quantity demanded. Ceteris Paribus an increase in income shifts the demand curve for public services to the right. Given a fixed, positively sloped supply surve, a shift to the right of the demand curve results in a new equilibrium with both quantity and price at a higher level.

The empirical evidence strongly indicates that public services are normal goods. Of the studies reviewed, only Oates (1975) found a negative correlation between income and expenditures, but the coefficient was not statistically significant. That result appears to be an anomoly because every other study that included income (ACIR, 1968; Masten and Quindry, 1970; Gabler, 1971; Fabricant, 1952; and Henderson, 1968) found a positive relation between income and expenditures. Most of them had statistically significant coefficients.

These results are hardly surprising of course. Income reflects not only willingness but also ability to pay for public services. The wealth of a community is reflected by its residents' income: obviously a wealthy community has more resources to support the provision of public services. Furthermore, if demand for public services is income elastic, then greater incomes will mean proportionally greater quantities of public

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2/ In fact for cities the correlation coefficient between NTR and TEXP is .99 and .99 for NTR and POP. This suggests that regression results would not tell us much about whether NTR or POP is the main determinant of the level of expenditures.

services demanded, hence higher expenditures.

Masten and Quindry also used per capita property values (PTCV) as an index of wealth. By itself, PTCV is probably a justifiable explanatory variable if wealth is indeed a factor determining the level of expenditures. But when used in conjunction with income, it seems redundant. Because of the high correlation presumed between INC and property values (see section on property values) the inclusion of PTCV would unnecessarily add to multicollinearity problems. One measure of wealth would appear to be sufficient.

The class of population-oriented variables is the most extensive. A commonly examined variable has been change in population (CPOP) and percent change in population (PCPOP). There are arguments for both positive and negative signs on the coefficient of CPOP (or PCPOP). One argument (Hamilton and Reid, 1976) is that in-migration requires costly new facilities. If community resources are fixed, the increased demand for services resulting from a swelled population make the provision of these services a costly affair. On the other hand, by the same logic, if resources are fixed, causing the provision of public services to remain unchanged, the per capita cost of providing the services may decline. The studies which have included these variables have had mixed results reflecting the uncertainty. The ACIR, Oates, and Brazer (1959) studies found a negative, but generally non-significant coefficient. Both Fisher (1964) and Spangler (1963) found positive signs. Gabler found evidence of both signs, depending on the state and service functions examined.

This variable seems to be misplaced. While the current level of expenditure by a local government may depend in part on the past rate of growth in the population, it would seem more plausible to argue that the wealth of a community and its size are more important in determining the level of expenditures. As will be demonstrated below, the change in population would theoretically be a better predictor of change in expenditures (CTEXP) than of the absolute level of expenditures.

Gabler, Brazer, Masten and Quindry, and the ACIR have all examined total population as a variable to explain per capita local government expenditures. All found a positive relationship although not always a statistically significant relationship. Following Brazer, it is argued that the size of a district's population will bear a positive relation to its per capita expenditures. There are a couple of reasons for so arguing. One is that the long-run supply curve for public services is assumed to be positively sloped, the more services to be supplied the more costly they will be. There is nothing new about this argument. As more services are provided, more resources must be freed from other competing uses. If, for example, more engineers are needed it may take an offer of higher salaries (which must simultaneously be paid to those currently employed as well) to lure them away from their present positions.

Another reason why size of population may positively affect per capita expenditures is that only in larger communities does the provision of certain public services become feasible. A public museum or arts center, for example, might impose an excessive burden on taxpayers in a community of 400 people yet be a desirable expenditure in a city of 40,000. The expense of a computer operating system could be prohibitive for a county of 2,500 yet hardly noticed by a county of 250,000. If there is a negative relation between POP and per capita expenditure it would probably occur only a low levels of population where certain economies of scale might occur.

The goal of the remainder of this section is to refine equations (1) and (2) for the three units of government. Although equations corresponding to (2) will not actually be estimated, the theory developed will allow us to make inferences about the direction of the bias on the POP coefficient in (1).

Schools

Schools are the most homogeneous of the three units of local government. They provide one product: the education of students, which, if not identical, is at least similar whether the school is in Portland or in Philomath. There is no reason to believe that there is a wide difference in productivity among school districts, nor is there reason to believe that the costs of provision -- teachers' salaries, physical plant and equipment costs and so forth -- would vary widely across school districts. This leads to the first estimating equation corresponding to (1).

$$(5) \quad \frac{TEXP_S}{ADM} = a_1 + u_5$$

where

ADM is the number of pupils in a district

a_1 is some constant

u_5 is the unknown disturbance term.

Equation (5) implies that per pupil expenditures PTEXP are constant. Multiplying through by ADM yields:

$$(6) \quad TEXP_S = a_1 ADM + a_0 + u_6$$

where a_1 will be a positive parameter approximately equal to the marginal and average expenditures per pupil and a_0 is the intercept term by hypothesis equal to zero.

It is possible that there is some trend in expenditures over time not measured by ADM. Also, it is of interest whether short-run changes in expenditures conform to the long-run behavior measured by (6). If the structural relationship described by (6) holds over time such that only shifts up or down in $TEXP_S$ take place which are exogenous to the model and independent of population then by introducing a time variable to account for those shifts and rewriting (6) for a specific year gives:

$$(7) \quad TEXP_{St} = a_1 ADM_t + a_0 + a_2(T) + u_7$$

where T is time. In time period (t-1) the equation would be:

$$(8) \quad TEXP_{St-1} = a_1 ADM_{t-1} + a_0 + a_2(T-1) + u_8$$

The change between the two years is the difference between (7) and (8). Subtracting (8) from (7) gives:

$$(9) \quad TEXP_{St} - TEXP_{St-1} = a_1 ADM_t - a_1 ADM_{t-1} + a_0 - a_0 + a_2(T) - a_2(T-1) + u_7 - u_8$$

or

$$(10) \quad CTEXP_S = a_1 CADM + a_2(1) + u_{10}$$

Here a_1 should equal a_1 in (7) and (8), if the short-run relation between expenditures and population is identical to the long-run behavior.

If not, then a_1 in (10) will not equal a_1 in (6). Even if the parameter a_1 in (10) is different it will be an estimate of the change in $TEXP_S$ associated with a change in ADM. The parameter a_2, the intercept is a trend of CTEXP over the time interval which is not accounted for by CADM. It is argued that it is in this context that the change in population variable, in this case CADM, is appropriate, not in the $TEXP_S$ equation. Dividing (10) by ADM would give the change in PTEXP as a function of rate of change in ADM.

It may be that per student expenditures are higher in larger school districts, following the same logic outlined in the general discussion earlier in this section. This would be due to an increasing ability of larger school districts to support activities unavailable to smaller schools; for example, various electronic teaching aids including computer systems, special education teachers, and more extensive athletic programs. This hypothesis is also testable in the context of examining the relationship between total expenditures and student population. Thus:

$$(11) \quad \frac{TEXP_S}{ADM} = a_0 + a_1 ADM + u_{11}$$

implies per student expenditures are higher in larger districts. Multiplying (11) by ADM gives the quadratic:

$$(12) \quad TEXP_S = a_0 ADM + a_1 ADMSQ + u_{12}$$

This equation is also testable. A positive sign on a_1 would imply that $TEXP_S$ increases at an increasing rate with respect to ADM.

Because education is, like any public good, assumed to be a normal good, *ceteris paribus* higher incomes should be associated with larger expenditures on education. If so, and assuming a linear relation with ADM, then the "true" specification of (2) for schools would be:

$$(13) \quad TEXP_s = a_0 + a_1 ADM + a_2 INC + u_{13}$$

where a_0 should equal zero and a_1 and a_2 are positive. Note that (13) implies that given two districts with equal number of students, the wealthier district would have higher school expenditures. Since only those equations having population variables on the right side will actually be estimated, what can we say about the bias of the coefficient on ADM if INC is omitted? From Theil via the introduction, we know that if (6) is estimated then the bias of $\hat{a}_1$, the estimated regression coefficient on ADM would equal:

$$\text{Bias } (\hat{a}_1) = E(\hat{a}_1) - a_1 = r_{12}a_2$$

where r_{12} is the correlation coefficient between ADM and INC, and a_2 is the true coefficient on INC (from equation (13)).

The coefficient r_{12} is assumed to be positive: larger districts are, generally, expected to be wealthier districts (Baumol, 1974) and by hypothesis a_2 is positive. Hence the bias of $\hat{a}_1$ is expected to be positive. In other words, the expected value of $\hat{a}_1$ is its true value <u>plus</u> some unknown positive quantity equal to $r_{12}a_2$. So its expected value is an overestimation of the "true" effect of ADM on $TEXP_s$.

Counties and Cities

In contrast to schools, the city and county governments are more heterogeneous local governments.

The relationship between population and expenditures is first expressed linearly, although because of the heterogeneous nature of the cities and counties the fit may not be as good as with school districts. The appropriate equations to be estimated are:

(14) $TEXP_k = a_0 + a_1 POP_k + u_{14}$

(15) $TEXP_c = b_0 + b_1 POP_c + u_{15}$

with a_0 and b_0 close to zero and a_1 and b_1 approximating the average $PTEXP_k$ and $PTEXP_c$, respectively.

As with the school equations, the introduction of a time variable, t, in (14) and (15) will allow estimation of the change in expenditures over some interval of time. Repeating the same process carried out in equations (7) through (10) results in the two estimating equations:

(16) $CTEXP_k = a_1 CPOP_k + a_2 + u_{16}$

(17) $CTEXP_c = b_1 CPOP_c + b_2 + u_{17}$

The intercept terms, a_2 and b_2 are estimates of the exogenous trend in $CTEXP_k$ and $CTEXP_c$ between the two time periods t and (t-1). Also a_1 and b_1 measure the marginal expenditure associated with a change in POP of one unit. If the intercept terms a_0 and b_0 in (14) and (15) equal zero, then the marginal and average expenditures are equivalent.

Again, following the logic of the first part of this section, it can be reasonably hypothesized that $TEXP_k$ and $TEXP_c$ are increasing marginal functions of POP_k. This would lead to the addition of the polynomial $POPSQ_k$ to the equations thus:

(18) $TEXP_k = a_0 + a_1 POP + a_2 POPSQ_k + u_{18}$

(19) $TEXP_c = b_0 + b_1 POP_c + b_2 POPSQ_c + u_{19}$

As before a_2 and b_2 are expected to be positive. If negative, the implication would be that total expenditures increase with population but at a decreasing rate.

The remaining variable to be included in the "true" model is income. The specifications for $TEXP_k$ and $TEXP_c$ are:

$$(20) \quad TEXP_k = a_0 + a_1 POP_k + a_2 INC_k + u_{20}$$

$$(21) \quad TEXP_c = b_0 + b_1 POP_c + b_2 INC_c + u_{21}$$

Implicit in each equation is the assumption that the relationship between TEXP and POP is linear. Like the school equation the expectation is that the bias on the POP coefficient will be positive owing to the positive correlation coefficient between POP and INC and the expected positive sign on the INC coefficient in (20) and (21). Therefore, the expected values of $\hat{a}_1$ and $\hat{b}_1$ from (14) and (15) would overstate the true coefficients.

Summary

The statistical tests of the estimated coefficients in any model depend, of course, on the hypotheses about the coefficients. Throughout this study, whether the focus is on TEXP, NTR, or any other variable, the relationships between the dependent variables and population is presumed to be linear. But, at the same time, is expected that in many instances the relation will not be linear, hence the inclusion of higher order polynomial terms for population. If, indeed, there is a curvilinear relation between a dependent variable and population, the empirical results will, hopefully, demonstrate it. If none exists, then the results should demonstrate that too. As a result, the proper test of the squared populalation variable is whether its coefficient differs significantly from zero. Further, as an added check, since POPSQ and POP may be highly correlated thus inflating the variance of their coefficients, the increase in R^2 values resulting from the addition of the squared term should be a guide as to whether any real improvement in explanatory power has occurred.

In contrast, the most important test of the coefficients on POP in the simple regression equations is not whether they differ significantly from zero. Indeed, it would be astonishing if they did not. A more interesting test is whether the coefficients equal the average expenditure (the null hypothesis) or are greater or less than the average (the alternative hypothesis).

Determining the proper test in the change equations is not as easy. If the districts do, in fact, move along the regression curves estimated in the TEXP (or NTR or TCV) equations, then the regression coefficient in the change equation will equal the slope coefficient in the total equations. Hence, the proper test would be whether the two coefficients (on CPOP and on POP) are equal.

But, if in the short-run, say one or two years, the change in the dependent variable is a consequence of either random variation or some unspecified variable, then CPOP would not explain the variation in the change in the dependent variable. If only one interval of time is to be examined, this latter instance is a real possibility implying that the proper test is whether the coefficient on CPOP is significantly different from zero. Consequently, the CPOP coefficients in all instances will be compared both to the POP coefficients and to zero.

To briefly recap the expenditure section: Following a set of general remarks about local government expenditures, total expenditures of each unit of government are posited as linear functions of population. From the simple equations plus a variable for time, change equations are developed to allow examination of the relationship between changes in population and changes in expenditures. Then, the addition of a squared population term is made to test whether expenditures increase at an increasing or a decreasing rate with respect to population.

From the true models, all of which have income as the second explanatory variable, it is deduced that the bias on the POP coefficient in the simple equations is positive.

Local Government Non-Property Tax Revenues

Non-property tax revenues (NTR) are the most difficult block to model due to the wide variety of revenues included in the category. The problem is compounded by the lack of prior research on the subject, either theoretical or empirical. Not only is there a variety of revenues included in NTR, but the NTR's available to the three units of government differ markedly. For the purpose of developing a theoretical base for the NTR block it will be useful, as with the expenditure block, to analyze each unit of government separately. Consequently, three basic structural forms of the dependent variable, NTR, will emerge: each corresponding to a unit of government.

As an introduction, the variable NTR may be characterized as having a dual role in the model. Primarily it is one of the components of the tax bill (TAX). How population (POP) affects TAX depends, in part, on how it affects NTR. It follows that NTR may be posited as a function of population.

(22) NTR = f(POP)

Other variables may, of course, explain variation in NTR, leading to a second equation:

(23) NTR = f(POP; $X_1 \ldots X_n$)

where $X_1 \ldots X_n$ represent other explanatory variables either endogenous or exogenous to the model. Our interest is in equation (22) which includes the effects of population on NTR as well as the correlative effects of population and the other variables on NTR; that is, if, for example part of the effect of POP on NTR operates through (an)other variable(s) such as income (INC), then equation (22) would measure the total effect of population on NTR, not simply the direct effect of POP.

Equation (23) has its advantages as well. Given that it includes other variables it would be a better predictive equation. Further, if it were specified correctly and if the basic econometric assumptions were met, then (23) would estimate the separate effect of POP on NTR.

In addition to its place as a determinant variable in the TAX equation, NTR may also play a part in determining the level of expenditures.

(24) TEXP = f(NTR; $X_1 \ldots X_n$)

Non-property tax revenues, especially grants from other governments, as determinants of expenditure have been extensively researched, and are discussed briefly in the sections on expenditures and the LEVY in this chapter.

The goal of the remainder of this section is to refine equations (22) and (23) for the three units of government. Each sub-section will deal with important non-property tax revenues available to the unit of government followed by the development of equations in the general form of equations (22) and (23). Much of the information used to assess NTR is from the Bureau of Governmental Research (1975).

Schools

In 1975-1976, 44 percent of the revenues of Oregon's schools was from non-property tax revenues. Of that, 71 percent was from the state with the remainder coming from the federal government (3 percent) and miscellaneous sources including county school funds (26 percent) (OSU Extension, 1978).

Several types of state aid are made available to school districts including the Basic School Support Fund (BSSF), the Common School Funds (CSF) and grants for special education. The latter program involves states grants to school districts to support special education programs, for example programs for slow learners. The CSF is a fund of monies collected from rents on state-owned lands, apportioned to school districts on a per pupil basis.

By far the most important non-property tax revenue is the BSSF (Oregon Department of Education, 1977a). The total apportionment is the sum of apportionments for transportation, equalization, flat grants, and for growth or decline. The flat grants (73 percent of total) are apportioned solely on a per pupil basis. Growth and decline payments (one percent) are also on a per pupil basis and are for the purpose of compensating school districts for the additional costs expected to be incurred as a result of growth or decline.

The apportionment for transportation is distributed according to each school district's transportation costs which vary as the number of pupils and distances travelled vary.

Finally, the apportionment for equalization (19 percent) is intended to compensate the less wealthy districts. Briefly, district equalization is equal to the "basic program" (a set expenditure per pupil times number of pupils) minus the "local contribution correction" (the sum of the districts receipts from Federal Forest Fees and the CSF) minus flat grants minus the product of the local contribution rate per TCV (the rate which will distribute all the money available for equalization) times the TCV (Oregon Department of Education, 1975a). Some federal grants are available for specific programs, for example, the hot-lunch program.

Finally, the counties make some monies available to schools through county school funds. The county school funds derive money from Forest Service timber sales. Also there are Intermediate Education Districts (IED's) in most counties which are in a sense non-property tax revenue sources for schools. The IED levies are county-wide levies which are apportioned in a manner intended to compensate poorer districts with monies from the wealthier districts. While appearing in school accounts as NTR, the IED levy is a special property tax.

It is readily apparent from the above discussion that two variables influence the amount of NTR available to any given district. Most important, of course, is the number of pupils in the district measured by ADM. Virtually all monies received are distributed on a per pupil basis with some variation according to the districts wealth as measured by its relative True Cash Value. Those districts with higher per pupil TCV (PTCV) are considered wealthier than those with lower PTCV.

As with expenditure determinants, equation (22) needs only the substitution of ADM for POP. Estimation of (22) with ADM may then be used to make inferences about the population/NTR relation from information that may be available about the ADM/population relation.

The new equation is:

(25) $NTR_s = a_0 + a_1 ADM + u_{25}$

One would expect the intercept term a_0 to nearly equal zero while the coefficient on ADM, a_1, should be positive and significant. Further, a_1 should approximate the average per pupil NTR (PNTR) which should be nearly constant. Dividing (4) by ADM yields:

(26) $PNTR_s = \frac{a_0}{ADM} + a_1 + u_{26}$

where $\frac{a_0}{ADM}$ should equal zero and a_1 equals average PNTR.

The amount of outside monies available to schools may of course vary over time. The BSSF apportionment is changed by each session of the legislature, for example, resulting in different amounts available in different years. The estimation of such exogenous shifts and the examination of a short-run change in NTR's can be done in the same manner in which the TEXP equations were done. Through the same process one can derive:

(27) $CNTR_s = a_1 CADM + a_2(1) + u_{27}$

where $CNTR_s$ equals change in NTR's and CADM equals change in ADM.

If our hypotheses about a_0, a_1, and a_2 are correct then the following should be true. The coefficient a_1 in (5) should represent the <u>average</u> PNTR as stated. Further, it should represent the <u>marginal</u> PNTR equal to the average if one time period is examined (t = 0) or if all time observations are pooled. Equation (27) is an estimate of how NTR changes from one time period to the next according to changes in ADM. The parameter a_1 then measures the marginal PNTR. If the short-run behavior is identical to long-run behavior it should be equal to or perhaps slightly greater than the coefficient on ADM in (25). It may be greater due to the BSSF apportionment for growth. The coefficient a_2 is a measure of the (exogenous) trend in NTR; that is, the change in NTR taking place over time independent of CADM.

Further refinement is possible with the introduction of wealth. Wealth is measured by the state according to per pupil TCV (PTCV). The inclusion of wealth yields:

$$(28) \quad NTR_s = b_0 + b_1 ADM - b_2 PTCV_s + u_{28}$$

Here the expectations on b_0 and b_1 are the same as for a_0 and a_1. The coefficient, b_2, however, should have a negative sign indicating the inverse relation between wealth and available state and IED aid.

The simple correlation coefficient between ADM and PTCV is positive by hypothesis.[3/] The bias of $\hat{b}_1$ as a result of dropping PTCV is equal to:

$$\text{Bias} = E(\hat{b}_1) - b_1 = r_{12} b_2$$

Since r_{12} is positive by hypothesis and b_2 is negative by assumption the right-hand side is negative implying that the bias is negative; that is, the OLS estimate $\hat{b}_1$ will understate the "true" coefficient b_1 if the assumptions about PTCV are true. As a result $\hat{b}_1$ will estimate an effect of ADM on NTR which is less than the "true" effect on NTR attributable solely to ADM.

Cities

About 70 percent of revenues for cities are derived from non-property tax revenue sources, of which about 13 percent are received from the

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3/ See section on property values.

state, 23 percent from the federal government, and 61 percent from charges, fees, and miscellaneous sources at the local level.

Revenues from the state in descending order of magnitude include highway revenue, liquor revenue, cigarette tax revenue, and sewer system grants. Highway and liquor revenue are the bulk of state aid to cities.

Revenues from the federal government are dominated by revenue sharing funds. These funds are apportioned on the basis of population times tax effort (taxes collected divided by aggregate personal income) times relative income factor (per capita county income divided by per capita income) (U.S. Department of the Treasury, 1977).

Other federal revenues include grants-in-aid for sewer and water systems, manpower programs, and law enforcement programs, as well as several miscellaneous programs.

Local non-property tax revenue derive from a variety of sources. Tax revenues (other than property tax revenues) include franchise and business taxes. Other revenues are from sewer user changes, fees, and charges for parking, recreation, and land use and construction fees. There are also revenues from fines and forfeitures, interest earnings, and rental and sale of real property.

Most of the variation in NTR for cities should be explained by population, NTR varying directly with the magnitude of population. Development of NTR equations for cities parallels the development for schools.

$$(29) \quad NTR_c = a_0 + a_1 POP_c + u_{29}$$

The intercept term should approximately equal zero, but in any case has little meaning for the model. The coefficient a_1 obviously should be positive. If there is a direct correspondence between population and NTR on a (near) constant basis then a_1 would be a measure of both marginal and average NTR_c per capita, since dividing (29) by POP yields:

$$(30) \quad \frac{NTR_c}{POP_c} = \frac{a_0}{POP_c} + a_1(1) + u_{30}$$

At least at the limit, whatever the value of a_0, the term $(\frac{a_0}{POP_c}) \to 0$ as $POP_c \to \infty$. This leaves a_1 as the average NTR_c per person. From (29) a_1 can be interpreted as the variable or marginal NTR_c.

If there are exogenous structural changes over time or to examine short-run change, one can estimate:

$$(31) \quad CNTR_c = a_1 CPOP_c + a_2(1) + u_{31}$$

This equation estimates the change in NTR_c over some period of time according to changes in population (estimated by a_1) and structural trends (estimated by a_2). If no trend exists then a_2 should not differ significantly from zero.

As it stands, equation (29) may be incomplete. According to Baumol (1967) there is reason to believe that the effect of population is not linear, but is proportional to its square. With respect to the non-property tax revenues of cities this could be especially true. For example, state and federal grants are block grants designed to initiate or sustain projects such as sewage treatment plants, street lighting and improvements, manpower programs, and police and fire training facilities. Project such as these become feasible only at certain levels of population.[4/] Additionally, revenues from fees and fines may increase more than

4/ See expenditure theory in the previous section.

proportionally with larger populations. The incidence of crime,[5/] for example, is positively related to the size of population (FBI, 1973), implying that fines increase at an increasing rate as population increases. As a result, although the basic hypothesis of a simple linear relationship between NTR_c and POP_c remains, there is reason to suspect that non-property tax revenues would show a slight tendency to increase at an increasing rate as population increases. This implies the addition of $POPSQ_c$ to (29) to give:

$$(32) \quad NTR_c = a_0 + a_1 POP_c + a_2 POPSQ_c + u_{32}$$

where a_2 is expected to be positive.

Because of revenue sharing and other intergovernmental programs, several components of NTR are inversely related to income. Expanding (23) for cities results in:

$$(33) \quad NTR_c = b_0 + b_1 POP_c - b_2 INC_c + u_{33}$$

where b_0 and b_1 retain the same interpretation. The coefficient b_2 has a negative sign indicating the expected inverse relation between INC and NTR.

If equation (33) is the correct specification, then estimating (29) (or 33)) without INC will result in a bias on $\hat{b}_1$, the estimate of b_1 the coefficient on POP. From Theil:

$$\text{Bias } (\hat{b}_1) = E(\hat{b}_1) - b_1 = r_{12} b_2$$

Where b_2 is by hypothesis negative, and r_{12}, the correlation between

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5/ Defined as number of crimes per unit of population.

INC and POP, is positive by assumption.[6/] If indeed the true b_2 is negative then the bias of $\hat{b}_1$ is negative; that is, $\hat{b}_1$ would probably underestimate the "true" b_1.

County NTR Theory

About 82 percent of the revenues available to county governments derive from non-property tax sources. Easily the largest portion of NTR_k is from timber sales on federal land. Eighteen Oregon counties receive monies from O & C timber sales (U.S. Department of the Interior, 1977). This source is a result of the inability of local governments to tax federal government for its holdings of land. In lieu of taxes on the lands the federal government reimburses the counties a certain percentage of revenues collected from sales on O & C timber.

Similarly, revenues are derived from sales of timber on National Forest Service (FS) lands with thirty-one counties receiving payments from the Forest Service. Twenty-five percent of FS receipts are placed in the county school and county road funds.

Health department contributions are the only other major federal source of funds.

The major state sources are in decreasing order of importance, the Highway Fund Apportionment, cigarette tax funds, and liquor revenue allocations. There are also numerous, small apportionments.

The remaining NTR's derive principally from fees and fines, hospital receipts, land sale and rental, and interest on invested funds (Revenue Sources of Oregon Counties, 1976).

Of the many NTR sources only two are of major importance: revenues

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6/ As a city's population increases, so will its *per capita* income.

from timber sales (both O & C and FS) and highway fund receipts. The highway funds are apportioned according to the number of vehicle registrations in the county which is expected to be roughly proportional to POP_k. Hence, those counties with large population receive more highway funds.

The funds received from timber sales are more difficult to predict. Timber cuts vary over time as timber needs vary. Revenues would be expected to change as timber prices change and, obviously, as the amount of timber changes.

Although highway revenues and timber sale revenue are the two largest single sources of revenues, the bulk of county NTR derives from miscellaneous fees, fines, and intergovernmental grants including revenue sharing. Many of these funds are directly related to population. More people in a county would mean more fees and fines collected, also more total intergovernmental revenue received. Population ought to explain a large amount of variation in NTR_k, with a positive, highly significant coefficient on POP_k.

As a first approximation of the effect of population on NTR_k the following should do well:

$$(34) \quad NTR_k = a_0 + a_1 POP_k + u_{34}$$

The intercept term should be non-negative, but its value is of no real interest. The coefficient on POP_k, a_1, should be positive, significant, and an approximation of the average per capita NTR_k.

As with other governments, a change equation is easily developed:

$$(35) \quad CNTR_k = a_1 CPOP_k + a_2(1) = u_{35}$$

This equation is an estimate of how NTR_k changes from one time period to the next according to changes in population. The constant term as usual measures the trend and the parameter, a_1 may be seen as an estimate of the marginal NTR_k per person.

By the same logic of the section on cities' non-property tax revenues, the inclusion of a polynomial term, $POPSQ_k$, appears to be warranted. If per capita non-property tax revenues are higher in more populous counties, as expected, then the addition of $POPSQ_k$ ought to increase the explanatory power of the equation. Equation (36) follows:

$$(36) \quad NTR_k = a_0 + a_1 POP_k + a_2 POPSQ_k + u_{36}$$

where a_2 is expected to have a positive sign.

Without developing an extensive sub-model of the forest industry replete with timber yields and prices, the best alternative for specifying a county NTR equation corresponding to (23) would simply be the inclusion of a dummy variable, OC, equal to 1.0 if a county is an O & C county and 0 if not. The new equation is:

$$(37) \quad NTR_k = a_0 + a_1 POP_k + a_2 OC + u_{37}$$

where a_2 is expected to indicate the (positive) amount of revenues, on the average, accruing to counties eligible to receive O & C funds.

Again, from Theil, the bias of $\hat{b}_1$ occurring as a result of dropping OC from the estimated equation will be:

$$\text{Bias } (\hat{b}_1) = E(\hat{b}_1) - b_1 = r_{12} b_2$$

By hypothesis b_2 is positive, and, since the O & C counties are all in Western Oregon and so are generally more populous than the non O & C counties, r_{12} is assumed to be positive. The bias of $\hat{b}_1$ is expected, as a result, to be positive; that is $\hat{b}_1$ will over-estimate the true effect of POP_k on NTR_k.

Local Government Property Tax Levies

In the model, the LEVY is the identity: TEXP - NTR = LEVY. If both the TEXP and NTR equations include the same explanatory variables, the LEVY equation may be determined by subtracting NTR from TEXP. Obviously, if TEXP and NTR increase (or decrease) by the same absolute amount, the LEVY will remain unchanged. Should the absolute effect of population on both TEXP and NTR be equal then LEVY will be constant. That possibility seems unlikely because it implies that, for example, all cities regardless of size (yet alike in other factors) would have the same tax levy.

The relative effect of population on TEXP and NTR is also of interest. Note that since NTR $\leq$ TEXP, if both are increased by the same factor, the difference will be increased by the same factor. If the relative effect of population is different for each variable, however, then the relative effect on LEVY will be different.

A reason for treating LEVY as a variable with a life of its own was touched on briefly in the expenditure discussion and concerns the budget committee. It is here that the Oregon so-called six percent limitation takes on importance. Assume that local government budget makers determine that some amount of expenditures is desirable for the coming year. From that figure is subtracted the NTR expected to be received in the forthcoming year. The result is the tax levy; that is, the amount of money necessary to balance the budget to be raised through property taxes. If the budget levy is within the six percent limitation, it becomes the basis for the tax rate. If, however, the tax levy is beyond the six percent limitation, voter approval is required, giving an incentive to the budget committee to minimize the difference between expenditures and non-property tax revenues. Hence, if NTR is expected to be large, a higher level of expenditures may be budgeted while maintaining a levy within the six percent limitation. It is assumed that local government officials prefer to stay within the six percent limit because the viability of a levy beyond that limit is uncertain. In 1970, for example, over a third of Oregon's cities needed voter approval for levies outside the six percent limitation with many failing to receive approval. About 96 percent of Oregon's schools needed voter approval with some requiring as many as five elections (OSU, Extension, 1977).

The hypothesis is that the levy would be more tied to population than are TEXP and NTR since budget makers would, in this scenario, attempt to keep it at a level which would both support and be supported by the population. So, if costs (i.e., expenditures) increase with increases in population as hypothesized, and if the same level of services is desired then the levy would either have to be a constant proportion of the population or increase at an increasing rate with respect to population. Testing the proposition requires estimation of goodness of fit to population (R^2) as well as estimates of standard errors. So, the effect of population on LEVY is a question of interest beyond the mere mathematics of determining TAX.

As a result, the same equations developed for NTR and TEXP are used to predict LEVY at each level of local government. The same interpretations of the coefficients holds. The equations are:

(38) $LEVY = a_0 + a_1POP = u_{38}$

(39) $CLEVY = a_1CPOP + a_2 + u_{39}$

(40) $LEVY = a_0 + a_1POP + a_2POPSQ + u_{40}$

In addition, we need a fourth equation to estimate the elasticity of LEVY with respect to population.

A unitary LEVY elasticity implies that the proportion between LEVY and POP is constant. If POP increases by n percent, then LEVY increases by n percent. If the same happened to TCV, the RATE would remain constant. If LEVY were population elastic, it would increase at a rate greater than the rate of increase in POP. An increase of n percent in POP would lead to an increase of greater than n percent in LEVY; and conversely if the elasticity is less than one. Also, the LEVY elasticity may be compared with the elasticities of TCV and VRES. If the LEVY elasticity is greater than the TCV elasticity, then increases in POP will increase the tax rate which may increase residential property tax bills depending on the VRES elasticity. These relationships are discussed further in the remainder of the chapter.

An easy way to compute a constant elasticity is in log-linear form.

(41) $LEVY = a_0POP^{\alpha_1}e^{u_{41}}$

where a_0 is a constant parameter and a_1 is the elasticity of LEVY with respect to population. The nyll hypothesis is that LEVY is a constant proportion of POP. Thus,

(42) $LEVY = k\ POP$

which by substitution in (41) and solving for α_1 leads to the null hypothesis[7/]

(I) Ho: $\alpha_1 = 1.0$

versus the alternative

Ha: $\alpha_1 \neq 1.0$.

Considering LEVY as a separate entity, its importance to the model lies in its relationship to TCV. This relationship is examined further in the short section on RATE.

Property Values

Studies of property value determinants may be broadly classified into two groups according to their objective. The first group is comprised of "site-specific" studies; that is, a theory or methodology is proposed for estimating the value of a specific site. Such studies are useful for tax assessors, realtors, and speculators. A typical model would predict a property's market value on the basis of such variables as number of rooms, amount of frontage, the age of the house, and other related variables. While the models are primarily for predicting specific property values their general form may be extended to predict average values over a large area when data is available. For example, with neighborhood averages a model may help predict average housing values over a county-wide area. "Site-specific" models are characterized by an em-

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7/ The hypothesis concerning the relative effects of population on the dependent variables used for comparison with other dependent variables are numbered consecutively with Roman numerals to emphasize their importance in determining the ultimate tax-population relationship.

phasis on prediction at the expense of analytical value.[8/]

The other broad category of model types may be called "variable-specific" models. These are also predictive but are developed to test hypotheses about the influences of specific variables on property values. For example, Norse (1967) and Ridker and Henning (1967) have examined the effects of air pollution on residential property values.

It is the second category of study which is of interest here because the nature of this inquiry is variable-specific, namely what effect does population have on property values? In order to assess the impact of population on property tax bills one must understand and estimate the relationship between population and property values.

It should be noted that some previous work has been done relating population change to residential property values. Ruttan (1961) has done a study of local population pressure on farm real estate values in which he found population to have a highly significant positive impact on land prices. Witte (1977 and 1975) whose work is discussed in this section has examined residential site costs with respect to population. Other studies[9/] have examined urban and suburban sprawl but they tend to be site-specific and relate only to population growth within a particular sector in an urban area. Thus, it is necessary to deal with the available literature and glean what we can from it vis-a-vis the effect of population on property values.

Following a discussion of some general theoretical issues relating to property values the study proceeds along the line of developing a value

8/ Examples of these include models developed by Wood (1976) and Clonts (1970).

9/ See, for example, Harvey and Clark (1965) and Rancich (1970).

determinant model through the inclusion of first population then the only other exogenous variable, income. The sub-model for determining property values is proposed based on the discussion and is combined in a later section with the other sub-models to form the complete model which will, hopefully, allow us to make inferences about the effects of population on tax bills.

A question may arise about the difference between assessed and market values. Obviously, only changes in assessed values will be reflected in tax bill changes. On the other hand, changes in population would be expected to affect market values. Is there a relation between assessed and market values? Fortunately (for research purposes at least) Oregon law stipulates that assessed value must be 100 percent of market value. Assuming that assessed values do reflect market values then they should also reflect the effects of population on property values. And that should be a good assumption. The ACIR (1977) study showed that Oregon ranked first in the nation in 1971 in ability to assess at market value.

The Property Block Sub-Model

Recall the formula for computing a residential property tax bill.

$$TAX = \frac{LEVY}{TCV} \cdot VRES$$

Clearly, there are two different property variable with opposite effects on TAX. Assuming a constant LEVY, if both VRES and TCV change at the same rate, i.e.,

$$\frac{\frac{\Delta VRES}{VRES}}{\frac{\Delta TCV}{TCV}} = 1$$

then changes in property values do not affect property tax bills.

If VRES increases at a faster rate than TCV average property tax bills increase, while if TCV increases faster average property tax bills decline. This result makes possible inferences about whether the property value block influences changes in average property tax bills.

The major exogenous determinant of residential property values besides population, is income. Income should have a strong impact on the demand for residential property. In the studies which have examined it as an explanatory variable, income has been found to be significant and positively related to residential property values (Oates, 1969; Hyman and Pasour, 1973; Ottensman, 1977; and Heinberg and Oates, 1970).

Property is assumed to be a normal good. Therefore, income should have a positive impact on property values; that is, an increase in income by shifting the demand curve for property to the right will result in higher prices paid for property.

Surprisingly little research has been done on the effect of population on property values. Property value determinant studies have included total population and population change as explanatory variables but seldom are either of those variables the focus of the study. Despite that testable hypotheses may be generated from a common sense theory of property value determination.

Turning first to the supply side, how can we picture the shape of the supply curve for residential housing? Land, the essential element for supply of housing, is in the limit fixed, of course. But even in the most crowded city there are vacant lots and there is almost always room for urban expansion or land can be converted to more productive uses. Land for residential purposes is even less fixed. Zoning law changes, for example, may be used to create more residential land. To the extent that it is possible to free land for residential purposes, the supply curve for residential land will deviate from the vertical. This suggests that the more crowded an area, the more competition there will be for the available residential land. It is commonly assumed (Witte, 1977; Ottensman, 1977) that the supply curve for residential land is steep, becoming more inelastic in its upper portion. Hence, it is expected that population should be positively related to residential land values and so to residential property.

The studies examined for this paper include population only as a control variable. Both Ottensman and Hyman and Pasour found a significant positive relation between population and housing values. This is not too surprising. One would expect that in more populated areas there is a higher degree of competition for property, both residential and non-residential. Similarly, one would suppose that more populated areas are more popular areas -- that's why they are more populated -- and so prospective residents would be willing to pay a higher price for housing than they would in less populated areas. Certainly that could be true in Oregon. A greater population usually means a greater variety of services, both public and private, available to a resident.

By the same logic, population growth ought to affect residential property values positively. Population growth, means an effective increase in the demand for the relatively scarce resource of residential property. Given a fairly inelastic supply of residential housing, especially over a short-run period of a couple of years, everything else equal, those areas undergoing more rapid growth would be expected to simultaneously be undergoing more rapid increases in property values.

Ottensman (1977), in an interesting twist, hypothesized that population change has a supply effect. His reasoning was that landowners attempt to perceive not only current benefits from holding land but also a stream of future benefits which they may discount back to the present. If future net benefits are expected to be high more land will be withheld from the market in anticipation of higher future prices. The result, a decrease in supply (a left-hand shift in the supply curve), would be higher land values in the current time period. Population growth, Ottensman argued, is the best indicator for landowners trying to anticipate future development; those areas undergoing rapid growth may be expected to have more intensive development, thus more valuable land in the future than those areas not growing as quickly. In fact, Ottensman did find a significant positive relation between rate of growth and land values. Apparently both the demand and supply effects of population growth exert upward pressure on property values.

An important point of discussion is the distinction between all property and residential property. Recall that True Cash Value of all real property in a district (TCV) is the total valuation of all real property in the district. Residential property (VRES) is the value of single family dwellings, a subset of TCV. Also recall that if VRES and TCV change at the same rate, the changes do not affect tax bills (TAX). This suggests that while it is necessary to estimate the effects of population on VRES and TCV, it is also necessary to determine whether population has a more pronounced effect on one variable than on the other.

The proponents of growth have traditionally argued that as a result of growth the amount of taxable property in a district will increase enabling the district to decrease the tax rate. If, however, growth also increases residential values the total residential tax bill could go up despite the decline in tax rate. Just how the two variables change with growth is an empirical question examined in the next chapter. Nothing found in the literature offers a theoretical basis for examining the nature of the relationship.

Residential property is assessed at market value. Although individual properties are not assessed annually, assessors are charged with maintaining some semblance of true cash value on all property. Oregon law stipulates that property be re-assessed at least every six years. For the intervening years an indexing system is used. Using this method the appraiser compares a property with similar properties in the area that have been recently sold. A price index of housing costs so developed may then be applied to any property not physically appraised.

Commercial and industrial property, however, is appraised by an income method. The capitalization of net income a property will produce in the form of rent is the basis for estimating the market value of most non-residential property.

The different appraisal methods suggest that different factors influence the market value of different types of property, which means that population pressure may affect each differently.

It is, however, not possible to state _a priori_ at what rate each type of property will be affected by population. Total property includes both residential _and_ commercial and industrial property. Also, the relative shifts in the supply and demand curves depend on a variety of variables including the relative elasticities of each. It _is_ possible in light of the above discussion to specify equations which ought to result in an empirical estimate of the relative change in each type of property as a result of population growth. Estimation in log-linear form allows us to interpret the coefficients on population variables as elasticities.

Expressing TCV as a function of population yields:

$$(43)\quad TCV = a_0 POP^{\alpha_2} e^{u_{43}}$$

where a_0 is an unknown parameter and α_2, also unknown, is the elasticity of TCV with respect to POP.

In (43) note that α_2 may be greater than, equal to, or less than 1.0. If α_2 is greater (less) than 1.0, then TCV is an increasing (decreasing) function of POP. A one percent rise in POP would lead to a greater (less) than one percent increase in TCV. An elasticity of one ($\alpha_2 = 1.0$) implies that TCV will change at the same rate as POP. If the levy elasticity equals 1.0, the null hypothesis from the previous section, then a population's effect on the tax rate operates through TCV. If TCV is population elastic, the rate will decline, if inelastic the rate will go up. If TCV is unitary elastic there will be no change in the rate attributable to population. The second null hypothesis to be tested, then, concerns the TCV elasticity value:

$$(II)\quad Ho:\ \eta_{TCV} = \alpha_2 = 1.0$$

versus the alternative:

$$Ha:\ \eta_{TCV} = \alpha_2 \neq 1.0.$$

Although the alternative is two sided, one would expect the elasticity to be greater than one. Other studies (Maisel, 1964; Ottensman, Ruttan) have estimated <u>per capita</u> property values as linear functions of a variety of explanatory variables, including population. Each found the coefficient on population to be positive and significant.

The simplest estimation of the relation between TCV and POP is:

$$(44) \quad TCV = a_0 + a_1 POP + u_{44}$$

where a_1 should be significantly greater than zero and a_0 is the constant term. Dividing (44) on both sides by POP gives:

$$(45) \quad \frac{TCV}{POP} = PTCV = \frac{a_0}{POP} + a_1 + u_{45}$$

As POP increases the term $\frac{a_0}{POP}$ goes to zero and may be ignored. Then a_1 is an estimate of the average, per capita value of TCV.

But if PTCV is a positive function of POP as just proposed, then the following equation is obtained:

$$(46) \quad PTCV = \frac{TCV}{POP} = a_0 + a_1 POP + u_{46}$$

or multiplying through by POP:

$$(47) \quad TCV = a_0 POP + a_1 POPSQ + u_{47}$$

By hypothesis, a_1 is positive implying that TCV is a positive and increasing marginal function of POP; that is, the curve generated by (47) should get steeper as POP increases. If so, then the elasticity of α_2 in (43), should be greater than one.

Ottensman noted that population has a supply effect. Those districts which have relatively scarcer land should have higher per capita property values and more elastic responses to population pressure. Thus it would not be unreasonable to expect per capita property values and TCV elasticities to be higher for cities than for counties.

The value of all residential property in a district (TOTRES) is a subset of TCV. If the response of residential property to population pressure is the same as the TCV response, whatever it is, then residential property owners as a group will maintain a steady share of the property tax burden. Thus the null hypothesis:

(III) Ho: $\eta_{TOTRES} = b_1 = 1.0$

versus the alternative:

Ha: $\eta_{TOTRES} = b_1 \neq 1.0$.

As with TCV, the elasticity of TOTRES could be estimated from:

(48) $TOTRES = b_0 POP^{b_1} e^{u_{48}}$

where b_1 is the elasticity of TOTRES with respect to POP. If α_2 equals b_1 then the class of residential property owners will maintain a constant share of the property tax load. If α_2 is greater (less) than b_1 residential property owners would pay a declining (increasing) share of the property tax burden as a result of responses to population pressure. This gives another testable hypothesis:

(IV) Ho: $\eta_{TCV} = \alpha_2 = b_1 = \eta_{TOTRES}$

versus

Ha: $\eta_{TCV} = \alpha_2 \neq b_1 = \eta_{TOTRES}$

The average value of a residential property, VRES, as previously discussed is also a positive function of population. Expressed linearly it is:

(49) $VRES = C_0 + C_1 POP + u_{49}$

But VRES is the identity:

(50) $\quad VRES = \frac{TOTRES}{N}$

where N is the number of residential properties. If the number of properties is a constant proportion of population:

(51) $\quad N = KPOP$

then by substitution:

(52) $\quad TOTRES = (KPOP)(VRES)$

and substituting into (48):

(53) $\quad VRES(KPOP) = b_0 POP^{b_1} e^{u_{53}}$

or

(54) $\quad VRES = (\frac{b_0}{K}) POP^{b_1 - 1} e^{u_{54}}$

or

(55) $\quad VRES = C_0 POP^{\alpha_3} e^{u_{55}}$

where

$$C = \frac{b_0}{K} \quad \text{and} \quad \alpha_3 = b_1 - 1$$

Hence, if b_1 equals 1.0, the null hypothesis, then α_3 equals zero, an equivalent hypothesis if N is a constant proportion of POP. So hypothesis III may be modified by substituting $(\alpha_3 + 1)$ for b_1 and reducing to:

(III)' Ho: $\eta_{VRES} = \alpha_3 = 0$

Ha: $\eta_{VRES} = \alpha_3 \neq 0.$

Then substituting $b_1 = \alpha_3 + 1$ into III and rearranging one obtains:

(IV)' Ho: $\alpha_2 - 1 = \alpha_3$

versus

Ha: $\alpha_2 - 1 \neq \alpha_3$

Hypotheses II and III allow inferences about residential property as a whole. Inferences about the average residential property, VRES, from the results of the hypothesis tests are valid only if the assumption stated in (51) holds. Hypothese III'and IV', however allow a direct test of average residential property elasticities.

If there is some trend over time not captured by POP or to estimate short-run changes in VRES the familiar change equation is:

$$(56) \quad CVRES = C_1(CPOP) + C_2(1) + u_{56}$$

The intercept term in (56) is the trend indicators while C_1 measures the difference in CVRES associated with a difference in CPOP and if short-run and long-run behavior are identical will equal the coefficient on POP in equation (49). The change equation (56) allows estimation of short-run changes in residential property values resulting from changes in population.

By a similar process one can arrive at:

$$(57) \quad CTCV = a_1(CPOP) + a_2 + u_{57}$$

which allows estimation of short-run changes in TCV resulting from changes in population.

Assuming the relationship between TCV and POP is linear, the correct specification of (44) is:

$$(58) \quad TCV = a_0 + a_1 POP + a_2 INC + u_{58}$$

developed in the discussion earlier in this section. It is assumed that property, being a normal good, would have value positively related to the income of its owners or prospective buyers. As was mentioned, this is indeed the case according to past research. If so, the coefficient on INC, α_2, would have a positive value. Also, it is expected that POP and INC would be positively related, since per capita incomes are normally higher in larger cities. Again, following Theil, the sign of the bias on the POP coefficient resulting from the omission of INC in a regression estimate would be the sign of the product of the correlation coefficient between POP and INC and the coefficient on INC. Since the signs of each are expected to be positive, the bias of the POP coefficient is expected to be positive. If so, then the regression estimate, $\hat{a}_1$ from (58), will overstate the "true" coefficient by some unknown amount.

Similarly, VRES is also correctly specified as a function of INC as well as POP. Accordingly, equation (49) may be written as:

$$(59) \quad VRES = C_0 + C_1 POP + C_2 INC + u_{59}$$

By the same reasoning outlined above the regression coefficient, $\hat{C}_1$, estimated using equation (49) will have a positive bias, implying an overestimation of the "true" POP coefficient.

To summarize the property value block, both TCV and VRES are first posited as functions of the single variable POP. Linear estimation of each with POP gives estimates of the increase in each variable associated with unit increases in POP. Log-linear estimation of each may be used to generate the elasticities of each with respect to population. The elasticity of TCV with respect to population, α_2, reveals the effect of population on the tax rate as it operates through TCV. Then comparison of the TCV elasticity with the elasticities of TOTRES and VRES shows first whether population has an equivalent impact on residential property as on all property, then how average residential property values respond to population.

The quadratic estimating equation appears to be warranted by past researchers' results with the expectation that the estimated equation would show TCV to be an increasing marginal function of population.

Next, short-run estimating equations of change in TCV and VRES can be derived which are expected to conform with the pooled equations.

Finally, the bias on the POP coefficient in simple linear estimations of TCV and VRES are expected to be positive, implying that the estimated coefficients may overstate the "true" relationship between population and property values.

Property Tax Rates and Property Tax Bills

Just as the LEVY is a mathematical identity, so are the RATE and the TAX. The RATE for any taxing district is its LEVY divided by its TCV. The average residential property tax bill (TAX) in the district is the RATE multiplied by the average value of a residential property (VRES).

In light of the foregoing discussion of the government and property blocks what can be said *a priori* about the relationship between population and RATE and TAX?

Recall the basic null hypotheses developed for TCV and LEVY. Both are assumed to have population elasticities equal to 1.0; that is, they are homogeneous of degree one. If both are of unitary elasticity, then the equations relating each of them to population would be rays emanating from the origin. Under this assumption, the linear estimating equations would also be rays emanating from the origin.[10/]

Now, if both TCV and LEVY are homogeneous equations of degree one, then RATE expressed as a function of population will be an equation of degree zero. In other words, its population elasticity will equal zero. This is easy to demonstrate.

(60) Let $LEVY = a_0 POP^{\alpha_1} e^{u}$

and let

(61) $TCV = b_0 POP^{\alpha_2} e^{u_{61}}$

Then

(62) $$RATE = \frac{LEVY}{TCV} = \frac{a_0 POP^{\alpha_1} e^{u_{60}}}{b_0 POP^{\alpha_2} e^{u_{61}}} = \frac{a_0}{b_0} POP^{\alpha_1 - \alpha_2} e^{u_{62}} = C_0 POP^{\alpha_4} e^{u_{62}}$$

where $C_0 = \frac{a_0}{b_0}$ and $\alpha_4 = \alpha_1 - \alpha_2$.

Since the population elasticities of each are the exponents then the RATE elasticity is α_4 or $\alpha_1 - \alpha_2$. If both α_1 and α_2 equal 1.0, then α_4 will equal zero. If the LEVYis more elastic than TCV ($\alpha_1 > \alpha_2$) then the RATE elasticity will be positive ($\alpha_4 > 0$). If TCV is more elastic than LEVY, then the RATE elasticity will be negative ($\alpha_4 < 0$).

In the second case ($\alpha_4 > 0$) the interpretation of the elasticity is that a one percent increase in population will lead to some positive increase in the RATE. Conversely in the latter case. More generally, interpreting the log-linear (on simple linear) equations (1), (2), and (3) as comparisons among districts of different sizes without assuming

10/ Recall that in the simple linear equations, the expected value of the intercept is zero.

any dynamism, a positive (negative) exponent in (3) would imply that larger (smaller) districts have higher tax rates.

For consistency with the other variables, RATE is also estimated as a linear function of POP. Also, the change in the RATE, CRATE, is regressed on CPOP and the percent change in population, PCPOP. Finally, quadratic equations are also to be examined. These results, together with the elasticity estimates, are presented in the next two chapters.

Because the null hypotheses developed earlier are that both TCV and LEVY are of unitary population elasticity, logic demands that the null hypothesis for RATE is:

(V) Ho: $\eta RATE = \alpha_4 = 0$

versus the alternative

Ha: $\eta RATE = \alpha_4 \neq 0$

Each of the alternative hypotheses developed so far has been two sided. The reason for using a two-sided alternative is to minimize the probability of making a Type I error; that is, to minimize the probability of rejecting a true null hypothesis. Nevertheless, it was speculated that both TCV and LEVY might have population elasticities greater than 1.0. It would be nice to speculate logically about the RATE elasticity also but in the absence of any reason to suspect that α_1 or α_2 are not equal it is not possible to guess logically whether α_4 would be positive or negative.

This last point is at the heart of the growth-no growth controversy. Proponents of growth argue that by increasing TCV the RATE will decline. The other side argues that the rate of increase in the LEVY will offset and TCV increase and tax rates will rise. The relative effects of population on TCV and LEVY hence on RATE may be compared by comparing their elasticities in what is essentially a modified version of Hypothesis V. With this substitute one can inspect the underlying relationships which result in either rejection or failure to reject Hypothesis V. The new hypothesis is:

(V^1) Ho: $\alpha_1 = \alpha_2$

Ha: $\alpha_1 \neq \alpha_2$

For property tax payers as a group, the relationship between population and RATE is a key question. For any one class of property tax payers, residential property owners for instance, the focus on the RATE may be slightly misplaced. Also, to be considered are their own properties' assessed valuations. Even if the RATE remains unchanged, if VRES is positively related to population, then the average residential property owner will pay higher tax bills as the district's population increases.11/

Given the preceding null hypotheses, the hypothesis for TAX is that its population elasticity is zero. If:

(63) $RATE = C_0 POP^{\alpha_4} e^{u_{63}}$

and if

(64) $VRES = d_0 POP^{\alpha_4} d^{u_{64}}$

then

(65) $TAX = (RATE)(VRES) = c_0 d_0 POP^{\alpha_3 + \alpha_4} e^{u_{65}} = k_0 POP^{\alpha_5} e^{u_{65}}$

11/ Obviously, if the property's market value increases, the resultant increase in the owner's wealth may offset his tax increase.

where $k_0 = (c_0)(d_0)$ and $\alpha_5 = \alpha_3 + \alpha_4$.

If $\alpha_3 = \alpha_4 = 0$, then $\alpha_5 = 0$. If both are positive (negative) then the TAX elasticity (α_5) will be positive (negative). Thus, a percent increase in population would be associated with some positive increase in TAX. If the signs of α_3 and α_4 differ, their relative magnitudes will determine whether TAX has a positive or negative elasticity.

For TAX then, the null hypothesis is:

(VI) Ho: $\eta TAX = \alpha_5 = 0$

versus the alternative

Ha: $\eta TAX = \alpha_5 \neq 0$.

As with RATE, other TAX equations will also be estimated to be consistent with the other variables' results. Simple linear, change, and quadratic equations are included in this group; the change equations also include percent change in population as an explanatory variable. These results are presented in the next two chapters.

Is it possible to hazard speculation about the TAX elasticity? Since the RATE elasticity must be assumed to equal zero, attention must be given to the VRES elasticity. The expectation of α_4, VRES elasticity, is that it probably is positive: average residential values rise as districts' populations rise. If that happens, and α_3 does indeed equal zero, then TAX would be positively related to population. As a district grows, the average residential property tax bills will also grow. TAX will be higher in more populous districts. It remains to be seen whether the data bears this out.

Model Summary

This chapter has been an attempt to trace out the hypothesized relation between population and residential tax bills. The formula for computing the average residential tax bill was used to divide the model into two separate parts: the government block and the property block.

The government block consists of expenditures and non-property tax revenues and, by subtraction, the property tax levy. With help from the literature, a relationship between population and the expenditures of each of the three units of local government was hypothesized. Both TEXP and NTR are hypothesized to have good linear fits to population such that as districts' populations increase so do both TEXP and NTR. Basically, three types of equations are developed. First, to estimate the gross effect of population, TEXP and NTR are each posited as functions of the single variable POP. Then, using these simple specifications change equations are developed to estimate the relationships between changes in TEXP and NTR and changes in population. Depending on both the accuracy of the first type of equation and the similarity between the short- and long-run relationships, the change equations may predict behavior conformable to the simple pooled equations.

Because of the possibility of NTR and TEXP increasing with POP at an increasing rate, the inclusion of a squared population term, POPSQ, is suggested to test the possibility. Also, the second explanatory variable should increase the goodness of fit. In all cases, when POPSQ is included in an equation's specification, it is expected to have a positive sign.

Additionally, the "true" equations for NTR and TEXP are hypothesized and presented. The "true" equations include an additional variable, income, which in the case of expenditures is expected to have a positive sign, and with non-property tax revenues a negative sign. Although the multi-explanatory variable equations will not actually be estimated, the model allows a logical deduction as to the sign of the bias on the estimated regression coefficient in the simple equations. Thus, it is possible to arrive at some idea of whether the estimated POP coefficient under- or over-estimates the "true" coefficient.

From the discussions of TEXP and NTR, the estimating equations for LEVY are developed. These equations exactly parallel those for TEXP and NTR. While any LEVY equation may be calculated as the difference between the corresponding TEXP and NTR equations, they will also be estimated from the data. Because there is reason to believe that the LEVY is not merely a mathematical identity but has a "life of its own" it would be interesting to examine the standard errors and R^2 (goodness of fit) values for the levy-population relationship. Also, in order to compare the effect of population on LEVY to the other variables in the model, an estimate of the LEVY population elasticity will be calculated. The null hypothesis to be tested is whether the LEVY elasticity (α_1) equals unity.

The property value block consists of the two variables TCV and VRES, respectively, the value of all property in a district and the average value of a residential property in the district. The relationship between population and TCV and VRES is developed in a manner similar to the development of the government block. The three types of equations, simple, change, and quadratic, are discussed and the "true" specifications are presented which also include an income term. The presence of income in the "true" equation leads to the deduction that the estimated coefficient on POP will be biased upward in both the TCV and the VRES equations.

The population elasticity of both TCV (α_2) and VRES (α_3) is also included in the discussion so that the effect of population on all the relevant variables may be compared. For TCV, the null hypothesis is that its elasticity will equal 1.0, while for VRES, the hypothesis is that it will equal zero.

Finally, the two blocks are fitted together to form the RATE and the TAX. Estimating equations for these variables are also presented exactly parallelling the equations for the other variables. From the preceding arguments it happens that the null hypotheses to be tested for these variables are equivalent, that their population elasticities equal zero.

The major null hypotheses to be tested may be briefly summarized:

(I) LEVY elasticity = α_1 = 1.0

(II) TCV elasticity = α_2 = 1.0

(III) TOTRES elasticity = b_1 = 1.0

(III^1) VRES elasticity = α_3 = 0

(IV) TOTRES elasticity = b_1 = α_2 = TCV elasticity

(IV^1) TCV elasticity = 1.0 = $\alpha_2 - 1 = \alpha_3$ = VRES elasticity

(V) RATE elasticity = α_4 = 0

(V^1) LEVY elasticity = α_1 = α_2 = TCV elasticity

(VI) TAX elasticity = α_5 = 0

In each case, the alternative hypothesis replaces the equals sign with a not equals sign.

In conclusion, there may or may not be a significant relationship between population and residential property tax bills. If there is, it is due to some relationship between population and the other variables in the model which on balance results in the TAX-population relation. If no significant relation exists it may be due to either to (1) no significant relation between population and the models variables or, more likely, (2) a cancelling effect within the model, for example, $\alpha_3 = 0$ and $\alpha_1 = \alpha_2$ such that α_4, the RATE elasticity hence equals zero.

In the next two chapters, the empirical results are presented and analyzed with a view toward a more complete understanding of the whole of the TAX-population relation.

CHAPTER III

RESULTS BY UNIT OF GOVERNMENT

The Data

In the preceding chapter a theoretical framework was set forth from which empirically testable hypotheses have emerged. In this chapter, empirical results are presented.

The bulk of the data was obtained from the Oregon Department of Education and the Oregon Department of Revenue. The most recent fiscal year for which complete data was available was 1976-1977. Local budget summaries have been available only since 1973-1974. Hence there was little latitude in selecting data for this study. The main criterion for selecting data was to get the most recent data available. Also it was felt that because one year is too short of an interval to examine change, and that at the local level three years is longer than the normal planning horizon, the optimum years to examine were 1974-1975 and 1976-1977.

For each of the three units of local government data on TEXP, NTR, and LEVY were obtained from the local budget summary sheets of the Oregon Department of Revenue for 1974 and 1976. Also from the Department of Revenue were data on VRES, TOTRES and N in the property classification sheets for each of the two years. The only information on residential property values was at the county level. Therefore, in the computation of tax bills for each of the units of government it was assumed that the VRES for any district was equal to the VRES of the county in which the district was located. Because there was no information on VRES available for Yamhill County it was excluded from the data set entirely.

Data on income (INC) was obtained from the U.S. Department of the

Treasury, General Revenue Sharing Data Elements Listing for 1974 and 1976. INC is available only for cities and counties. School district INC is assumed to be equal to INC of the nearest city. Incomes are all *per capita* incomes.

Population (POP) figures were obtained from the Oregon Center for Population Research and Census, Population Estimates for Counties and Incorporated Cities of Oregon for 1974 and 1976. Because no population figures are available for school districts the Average Daily Membership (ADM) of each school district was used instead. This information came from the Oregon Department of Education, "Estimated Per Pupil Current Expenditure" summaries for 1974 and 1976. The statewide average population/student ratio of 5.2 is used to compare ADM to POP when appropriate.

True Cash Value (TCV) figures were obtained from the Department of Revenue, Oregon Property Tax Statistics for 1974 and 1976.

For each district RATE and TAX were computed by the identities RATE = LEVY ÷ TCV and TAX = RATE x VRES.

At the county level there were 35 observations for each year since Yamhill was excluded from the data set.

Of the 240 incorporated cities in Oregon, 156 were included in the data set. Those that were excluded were cities with populations of less than 500, none of which had complete information, the six Yamhill County cities, and those few cities over 500 in population but with incomplete data.

Of the 333 Oregon school districts, 299 appear in the data set. The nine Yamhill school districts were not included. Eight districts were excluded because of errors in the published figures, and 14 more were excluded because of incomplete data. Three districts were excluded because their total expenditures for new schools appeared in one year's expenditure figures.

All figures are the actual figures reported except that all are in 1976 dollars. To remove the effects of inflation, the 1974 figures were multiplied by 1.155 representing the increase in the Portland Consumer Price Index over the two-year period. Property values were inflated by 1.176 based on the housing price figures.

Two sets of data were constructed for each level of government. One set, the pooled data set, includes two observations on each district, city or county, one for each of the two years. The other set, the change data set, is composed of the values of the change in each variable over the two-year period.

The pooled data set for schools is used to test hypotheses about long-run relationships of the key variables and population. It is from this set of data that elasticities and predictive equations for the key variables are generated.

The pooled data set is also used to estimate predictive equations for each of the key variables in order to gain insight into the relation between absolute levels of population and each of the endogenous variables. It is assumed, for example, that all school districts (and to a much lesser extent counties and cities) behave the same way; that all school districts provide one and only one product, educated students and that a school district of a certain size will behave the same way as a school district of larger size when it, the first district, reaches that size. In general, given a regression curve relating population to any of the key variables, say total expenditures (TEXP), a growing district will tend to follow the curve as it grows. This implies, of course, more than a statistical relationship between TEXP and POP. It implies a behavioral relation which is measured by the regression curve obtained with the pooled data.

The change data set ought to provide a reasonable indicator of the short-run changes in the variables with respect to changes in population. As it turns out it will also shed light on the legitimacy of using estimates derived from cross-sectional data for making inferences about behavior in the short-run. More discussion of this subject is in the next chapter, but readers are invited to make their own comparisons of the results presented in this chapter.

In addition to the three units of government, each of the two sets of data are augmented at the county level by aggregated data. In each county the total expenditure, non-property tax revenues and property tax levies for all school districts and cities in the county were summed and added to the county figures. The result is the total expenditures by all units of government in the county ($TEXP_A$), total non-property tax revenues received by all units of government in the county (NTR_A), and the total of all property tax levies of each unit of government in the county ($LEVY_A$). As always, $TEXP_A - NTR_A = LEVY_A$. The summation was done over 34 counties. Yamhill was excluded for reasons previously mentioned, and Morrow was excluded for inconsistencies in the data, namely a negative figure for NTR_A.

The result of the aggregation is an estimate of the expected total tax bill paid by residential property owners by county. Also the county-wide aggregation can give insight into the total relationship between population and tax bills by allowing estimation of the effect of population on the activities of all three units of local government simultaneously; e.g., how the total property tax rate faced by a residential property owner is related to population.

A Caveat

In the analysis of residential property tax bills one should, ideally, have information on each residential property in the state, but such information would be extremely cumbersome and prohibitively expensive. The best reasonable approximation appears to be information about each major unit of government. The reader should be aware, however, of the limitations of calculations computed at the unit of government level. This can best be illustrated by an example. Suppose we are interested in finding the expected county tax bill ($E(TAX_K)$) for an Oregon residential property owner chosen at random. The computational formula is:

$$E(TAX_K) = \frac{1}{n} \sum_{i=1}^{n} TAX_{Ki}$$

where TAX_{Ki} denotes the county tax paid by the i^{th} residential property owner in the state.

The routine used for computations of county tax bills differs from the above formula. Here, the counties' average tax bills are summed and divided by 35.[1/] The formula is:

$$E(TAX_K) = \frac{1}{35} \sum_{j=1}^{35} TAX_{Kj}$$

where TAX_{Kj} denotes the average county tax bill in the j^{th} county.

This formula actually gives us the expected value of a county residential tax not the expected value of a residential property owner's county tax bill. Notice that this procedure gives equal weight to all counties whereas a "true" average would weight each county according to

1/ Remember, Yamhill County is excluded from all calculations.

its population. The difference is usually not large for school districts, somewhat larger for cities, and largest for counties. Those averages which are directly related to population tend to be biased low with this method.

Figures and Tables

Figures 3-1, 3-4, 3-7, and 3-10 contain the mean values and standard deviations of the population and of the variables in the tax equation for each unit of government. In addition the simple regression coefficients and their standard errors plus the R^2 values are shown on the connecting branch from POP (or ADM) to the relevant variable. Figures 3-2, 3-5, 3-8, and 3-11 contain the same information for the change in the variables.

Figures 3-3, 3-6, 3-9, and 3-12 depict the (constant) elasticities of each variable with respect to population and their standard errors.

The simple regression equations estimated with the pooled data are summarized in Tables 3-1, 3-3, 3-5, and 3-7. Those equations estimated with the change data set are summarized in Tables 3-2, 3-4, 3-5, and 3-8. Finally, the mean values for each variable in each year, the mean values of their change and their percent change are summarized in Table 3-9 for quick reference.

All confidence intervals are 95 percent confidence intervals. Also, the standard for significance tests is the five percent level of significance, where five percent denotes the probability of rejecting a true null hypothesis.

Aggregated County-Wide Governments

The average total residential property tax bill paid over the two-year period was $410.16 (see Table 3-9). The change over the two-year period was $41.24 or 10.6 percent over the 1974 average of $389.54. During the same period, population increased at a rate of 3.12 percent. Increases in expenditures were not to blame for the tax jump, however, as $TEXP_A$ declined by $89.828 (1.14 percent). The decline in NTR_A was twice the decline in $TEXP_A$. The average NTR_A went down $1,633,513 (3.44 percent). The net effect was an increase in the $LEVY_A$ from $24,523,635 to $25,337,320, up $813,685 (3.32 percent). The rate of increase in the LEVY was more than offset by the increase in TCV_A. The average change in TCV_A was $75,351,008, an 8.06 percent increase.

The average value of residential property during the two-year period increased by 10.9 percent. As a result, although $RATE_A$ went down 1.41 percent; residential property owners saw their tax bills increase 10.6 percent.

Thus aggregated local government expenditures declined although not as much as non-property tax revenue receipts did. The increase in levies was offset by the rising value of property resulting in a declining tax rate. Residential property owners were one class of property owners whose tax bills increased because of rapid increase in their property's assessed values.

Now that we know how tax bills and the components of tax bills behaved over the two-year period, it is time to examine the nature of the relationship between the tax variables and population. Regression estimates of the equations developed in Chapter II have been computed from the aggregated data to yield statistical estimates of the relation of population to the key variables.

Equations 3-1-1 to 3-1-7 (see Table 3-1) were estimated with the county-wide aggregated data. Equation (3-1-7) indicates a significant positive relationship between population and the average residential total tax bill. One half of the variation in TAX_A is explained by POP_A. The coefficient on POP_A, significantly different from zero at the one percent level indicates that every thousand people in a county is associated with a ($1.23 $\pm$ .30) increase in TAX_A; i.e., the larger the county the larger the total average tax bill on residential property.

Closer examination reveals that each variable, simple and composite, in the TAX_A equation is positive related to POP_A. Each variable in the government block is highly correlated with POP_A. The simple correlation coefficients between POP_A and the variables $TEXP_A$, NTR_A, and $LEVY_A$ are .99, .97, and .99 respectively, so the linear fits of POP_A to the variables are very good as one might expect. POP_A explains 98.5 percent of the variation in $LEVY_A$ with each additional person in a county associated with a ($413.80 $\pm$ 6.40) increase in $LEVY_A$. This compares to the average $PLEVY_A$ of $376.10. The intercept term is negative and significantly different from zero at the one percent level. This result contradicts the hypothesis that the constant term equals zero. It also violates common sense because the levy cannot be less than zero. This could suggest a curvilinear fit, i.e., the $POPSQ_A$ term might be appropriate, implying that the marginal $LEVY_A$ with respect to population is not constant but increases as POP_A increases.

The $LEVY_A$ equation (3-1-3) is the difference between $TEXP_A$ and NTR_A (3-1-1 minus 3-1-2). As hypothesized, the constant terms do not differ significantly from zero at the five percent level. Equation 3-1-1 indicates that each additional person in a county is associated with ($1,174.40 $\pm$ 49.80) additional $TEXP_A$. The coefficient closely compares to the average $PTEXP_A$ of $1,080.60. The results of the NTR_A equation are similar where the increase in NTR_A associated with an additional person is ($761.80 $\pm$ 44.80). This also compares closely with the average $PNTR_A$ of $704.50. POP_A explains 97.1 percent of the variation in $TEXP_A$ and 95.0 percent of the variation in NTR_A.

As expected TCV_A and POP_A are highly correlated and, not surprisingly, the linear fit of POP_A to TCV_A is good; 98.9 percent of the variation in TCV_A is explained by POP_A (Equation 3-1-4). The intercept term while significantly different from the hypothesized value of zero at the five percent level is at least positive and small compared to the average TCV_A of $972,607,377. The coefficient indicates an increase in TCV_A of ($13,846.60 $\pm$ 181.80) is associated with each additional person in a county. This compares to the average $PTCV_A$ of $14,673.

If $LEVY_A$ and TCV_A are indeed linear functions of POP_A then there will be a "cancelling" effect[2/] such that $RATE_A$ would not be a linear function of POP_A.

Equation 3-1-5 indicates that $RATE_A$ <u>is</u> some function of POP_A; the coefficient on POP_A is significantly different from zero at the one percent level. The positive sign indicates that the more populous counties tend to have the higher average total property tax rates. Although the coefficient of (.0000231 $\pm$ .0000134) is statistically significant it is still rather trivial. Given two counties one of which has 10,000 more

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2/ See Chapter II.

people than the other, the associated difference in the total tax rates would be only 23 cents.[3/] Also, POP_A explains only 15.3 percent of the variation in $RATE_A$.

The final variable in the tax equation, $VRES_A$, is also positively related to POP_A. The coefficient indicates that each additional thousand people in a county is associated with an additional \$31.40 $\pm$ 1.08 in the average assessed valuation of a residential property. As with the coefficient on $RATE_A$, statistical significance does not imply economic significance. For example, at the mean $RATE_A$ of 22.365 a difference in assessed valuation of \$31.40 would be a difference of only 70 cents in TAX_A. POP_A is, however, an important explanatory variable, explaining over a third (34.1 percent) of the variation in $VRES_A$.

The examination of elasticities was suggested in the last chapter as a method of comparing the effect of population on the variables in the tax equation. Figure 3-2 depicts the elasticity of each variable with respect to population. All elasticities are constant elasticities computed with log-linear equations; i.e.,

$$Y = APOP^{\alpha}$$

or

$$\ln Y = \ln A + \alpha \ln POP$$

where

Y = the predicted variable

A = a constant term

α = coefficient on lnPOP = the elasticity of Y with respect to POP

[3/] One percent of average tax rate.

The notation of Chapter II is preserved here:

The elasticity of $LEVY_A = \alpha_1 = .92$

The elasticity of $TCV_A = \alpha_2 = .84$

The elasticity of $VRES_A = \alpha_3 = .18$

The elasticity of $RATE_A = \alpha_4 = .07$

The elasticity of $TAX_A = \alpha_5 = .27$

The TAX_A elasticity (α_5) is 0.27 $\pm$ .056 which is consistent with the positive sign on the coefficient on POP_A in equation 3-1-7. The elasticities are interpreted as implying that a one percent increase in population is associated with a α_i percent increase in the i^{th} dependent variable. So, a one percent increase in population would be associated with a 0.27 percent increase in TAX_A. It would appear that although residential property taxes do not change at the same rate as population changes, they do increase when population increases. If residents' property taxes do increase with increases in population the question is which component(s)[4/] of the tax equation cause(s) the increase.

The $LEVY_A$ elasticity (α_1) indicates that a one percent increase in POP_A would be associated with a 0.92 $\pm$ .046 increase in the levy, or a rate of increase in the levy just slightly less than the rate of increase in the population.

Because the LEVY elasticity is significantly different (and less) than 1.00, the null hypothesis from Chapter II is rejected in favor of the

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4/ The term "component of the tax equation" refers to any variable in the tax equation (e.g., TCV_A) or any combination of variables; e.g.,

$$\frac{LEVY_A}{TAX_A} = RATE_A$$

alternative. The TCV elasticity estimate is .84 $\pm$ .046 which is also significantly different (and less) than 1.00, causing a rejection of the null hypothesis II in Chapter II. The TCV_A is apparently not as elastic with respect to population as is $LEVY_A$, although such an assertion could be unwarranted. Since the question of which variable increases more with increases in population is at the heart of the growth-no growth controversy a more careful examination of the respective elasticities is called for. One of the null hypotheses proposed in Chapter II was:

(V^1) Ho: $\alpha_1 = \alpha_2$

versus

Ha: $\alpha_1 \neq \alpha_2$

The null hypothesis may be tested by examining the confidence intervals around each elasticity α_1 and α_2.[5/] For α_1 the 95 percent confidence interval (CI) is $.856 \leq \alpha_1 \leq .984$. The 95 percent confidence interval for α_2 is $.794 \leq \alpha_2 \leq .886$ which overlaps the CI for α_1. Therefore at the 95 percent level of confidence one cannot reject the null hypothesis $\alpha_1 = \alpha_2$.

The elasticity of $RATE_A$ itself can, of course, be computed. The computed estimate (α_4) is .07 $\pm$ .054. The 95 percent confidence interval is .016 to .124 which does not include zero, therefore the null hypothesis:

(V) Ho: $\alpha_4 = 0$

is rejected in favor of the alternative

5/ An equivalent test would be a "T" test of the difference $(\alpha_1 - \alpha_2)$ where Ho: $(\alpha_1 - \alpha_2) = 0$ is tested versus the Ha: $(\alpha_1 - \alpha_2) \neq 0$.

Ha: $\alpha_4 \neq 0$.

The result appears to be at odds with the previous result which implied that since $\alpha_1 = \alpha_2$ then $\alpha_1 - \alpha_2 = K = 0$. There is a dilemma about which result is "true". Perhaps an example would best illustrate the problem. Let us say we are interested in finding the average $RATE_A$. The method might be:

$$\overline{RATE_A} = \frac{\overline{LEVY_A}}{\overline{TCV_A}} = \frac{\frac{1}{n}\sum_{i=1}^{n} LEVY_{A_i}}{\frac{1}{n}\sum_{i=1}^{n} TCV_{A_i}} = \frac{\sum_{i=1}^{n} LEVY_{A_i}}{\sum_{i=1}^{n} TCV_{A_i}}$$

Alternatively, one could compute

$$\overline{RATE_A} = \frac{1}{n}\sum_{i=1}^{n} \frac{LEVY_{A_i}}{TCV_{A_i}}$$

which is not equal to the first computation. The problem with the elasticities is analogous to this example where the first method parallels the first null hypothesis ($\alpha_1 = \alpha_2$) and the latter method parallels the second null hypothesis ($\alpha_3 = 0$).

For the purpose of estimating the elasticity of $RATE_A$ with respect to population the latter method and null hypothesis have been chosen for two reasons. First, simply because at the 95 percent confidence the hypothesis $\alpha_1 = \alpha_2$ cannot be rejected does not mean that α_1 does equal α_2. Note that the total interval over which each confident interval extends is .794 to .984; the interval where each confidence overlaps is .856 to .886, which is only 15.8 percent of the total interval.[6/]

6/ Although not necessarily 15.8 percent of the area of the intersection of the probability density functions of each variable.

The second reason is because a direct estimate of α_4 is made with the individual observations of $RATE_A$ and POP_A rather than with the aggregated effects of $LEVY_A$ and TCV_A. It is more intuitively appealing to consider rate estimates computed with direct observations rather than from the more roundabout $LEVY_A/TCV_A$ method.

In spite of the shortcomings of the first method it is still useful. If the tax rate is significantly related to population, either positively or negatively, it is worthwhile for policy purposes to find out why the relationship is as it is. For example, although the null hypothesis $\alpha_1 = \alpha_2$ was not rejected, one might still be inclined to think that $\alpha_1 > \alpha_2$. As separate components of the tax rate, the levy and true cash value variables are interesting in their own right. The procedure followed here of estimating α_3 as the difference between α_1 and α_2, and estimating α_3 directly is followed throughout for each unit of government in order to gain insight into the nature of the relationship between population and the three variables LEVY, TCV, and RATE.

Another important hypotheses developed in Chapter II concerned the relative effect of population on the valuation all property (TCV_A) and on residential property (TOTRES). From 1974 to 1976 the county[7/] average total value of all residential property (TOTRES) increased by 13.9 percent compared to the TCV_K increase of 8.1 percent. As a percentage of TCV_K, TOTRES went from 34.8 percent in 1974 to 36.6 percent in 1976.

Recall hypothesis IV developed in Chapter II:

$$\text{(IV)} \quad \text{Ho:} \quad \eta_{TCV} = \alpha_2 = b_1 = \eta_{TOTRES}$$

versus

7/ The county variables cited here are equivalent to those of the aggregated data set except that they include Morrow County.

Ha: $\eta_{TCV} = \alpha_2 \neq b_1 = \eta_{TOTRES}$.

If the null hypothesis is true then the conclusion would be that the effect of POP_K on TCV_K is the same as on $TOTRES_K$. The modified hypotheses are:

(IV^1) Ho: $\alpha_2 - 1.0 = \alpha_3$

versus

Ha: $\alpha_2 - 1.0 \neq \alpha_3$

A true null would imply that the effect of population on TCV is[8/] matched by its effect on VRES so that the only net population effect on TAX would be through the government block.

The two confidence intervals for α_2 and b_1 are:

α_2 = .794 to .886

b_1 = 1.161 to 1.273

which do not overlap. Obviously the effect of population on TOTRES is greater than on TCV. The data showed that over the two-year period TOTRES became a larger portion of TCV which, given the estimated elasticities is at least partly a result of the effect of population pressures.

It is also interesting that the elasticity of TOTRES, 1.22, is very close to 1.0 more than the elasticity of VRES which equals 0.18. This is consistent with the proposition that the number of residences is a constant proportion of population. Also the correlation coefficient between N and POP is, .99+, implying that the proportion is constant

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[8/] The complete derivation of the hypotheses and their interpretation is contained in Chapter II.

across all counties regardless of economic or social characteristics.

Comparing TCV and VRES elasticities the confidence interals for α_2 and α_3 are:

α_2 = .794 to .886

α_3 = .110 to .250

α_2 - 1.0 = -.206 to -.114

Clearly the confidence intervals of α_3 and (α_2 - 1.0) do not overlap, so the null hypothesis is rejected in favor of the alternative. Had the statistically more powerful alternative hypothesis been:

Ha: $\alpha_2 - 1 < \alpha_3$

then the null hypothesis would still have been rejected, implying that, an increase in population while reducing the tax rate by increasing TCV, could increase residential property tax bills due to the elastic response of VRES to population.

The preceding discussion has been centered around estimates of partial coefficients and elasticities derived from pooled cross-sectional data from two time periods. The concepts of partials and elasticities imply the presence of some dynamic relationship. So by implication, cross-sectional studies assume that changes in expenditures or property values occur along the regression curve.

Pooled time series cross-sectional data is preferable, obviously, because there is a temporal element added, but even then it may be fallacious to put too faith in the notion that changes occur along the estimated curve. Indeed, in this study's set of differential relationships, the changes in the variables from 1974 to 1976, the estimated change equations do not generally conform to the pooled equations so far presented.

Figure 3-3 depicts the mean values and simple regression coefficients for the aggregated county-wide governments' change equations as well as their standard deviations and standard errors respectively. The regression equations in their entirety are contained in Table 3-2.

Recall the general form of the change equations derived in Chapter II.

$$\Delta Y = \alpha_1 \Delta X + \alpha_2$$

where

ΔY = the change in the dependent variable

ΔX = the change in the explanatory variable (in this case population)

α_1 = the coefficient explaining the relationship between ΔY and ΔX

α_2 = the intercept measuring any trend over time for ΔY.

In addition, the three variables $CRATE_A$, $CVRES_A$, and $CTAX_A$ are also estimated as functions of percent change in population. The reason for so doing is that for these variables the effect of a change in population would depend largely on the initial magnitude of population.

Equations 3-2-7 and 3-2-10 estimate $CTAX_A$ as functions of $CPOP_A$ and $PCPOP_A$ respectively. In both cases the intercept term, the trend indicator, is positive and significant at the five percent level. The intercept in 3-2-7 is 52.59 which is slightly larger than the mean change in TAX_A of \$41.24. The coefficient on $CPOP_A$ has a negative sign but not significantly different from zero. Its sign and the positive intercept indicate that there may be a slight general tendency for taxes to increase by a smaller amount in those counties experiencing larger absolute population changes. This result is at odds with the positive sign on TAX_A

in equation 3-1-7. The R^2 value indicates that the equation explains less than two percent of the variation in $CTAX_A$. The overall tendency seems to be for taxes to rise with the change in TAX apparently unrelated to change in population. Because of the large standard error of the $CPOP_A$ coefficient one cannot reject the null hypothesis that it equals the coefficient on POP_A in 3-1-7.

Equation 3-2-10 does a little better but still explains less than six percent of the variation. The intercept term is 84.887 again greater than the average change in TAX_A. The negative coefficient while not significant implies some tendency for those counties with higher rates of population growth to have smaller residential property tax increases.

The results for the remainder of the equations are similar, characterized by low R^2 values and nonsignificant coefficients. The intercept terms in equations 3-2-1 and 3-2-2 although negative, are not significant and do not approximate the average change in $TEXP_A$ and NTR_A. Further, the coefficients are negative, although not significant, another result differing from the results of equations 3-1-1 and 3-1-2.

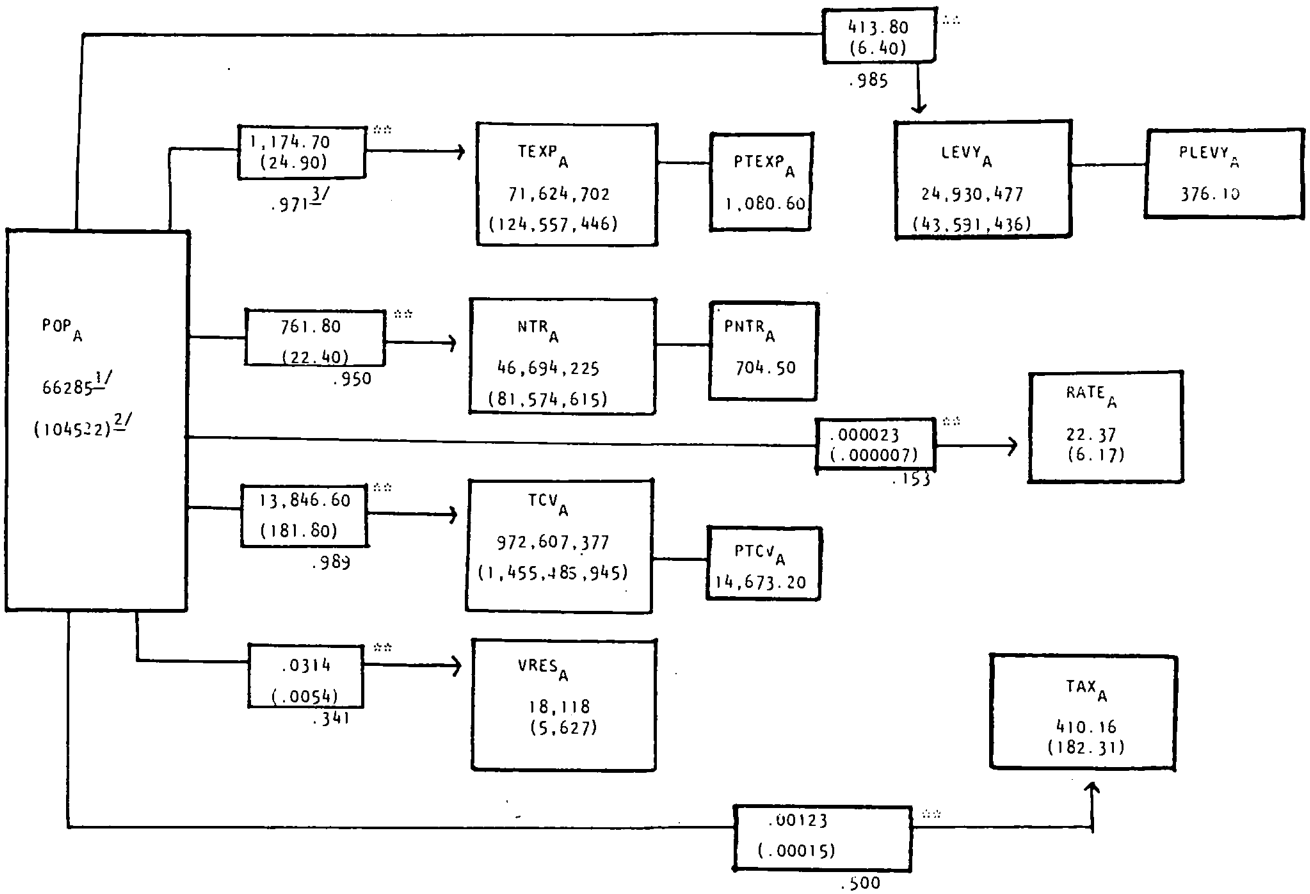
The equation for $CLEVY_A$ (3-2-3) is slightly better but still without significant coefficients. The intercept and coefficient on $CPOP_A$ are positive but not significant. The partial on $CPOP_A$ of 260.90 does approximate the coefficient of 413.80 in equation 3-1-3 but given that $CLEVY_A$ is merely ($CTEXP_A$ - $CNTR_A$) this appears to be a spurious result. The R^2 of .02 also indicates that even if the result is not spurious, $CPOP_A$ does a poor job of explaining variation in $CLEVY_A$.

Of all the change equations only 3-2-4 achieves a good fit. Nearly 73 percent of the variation in $CTCV_A$ is explained by the single variable $CPOP_A$. There was, apparently, no real trend in CTCV over the two-year period as evidenced by the intercept term. The coefficient on $CPOP_A$ is, however, highly significant. Its value of 36,600 $\pm$ 7,910 indicates that each additional person in a county is associated with an additional \$36,600 in TCV. This marginal change in much higher than the average per capita TCV_A of \$14,673.20.

Variation $CRATE_A$ is also poorly explained by $CPOP_A$ and $PCPOP_A$ although the latter variable does appear to explain $CRATE_A$ better. In neither case is the trend indicator significant nor even the same sign as the average $CRATE_A$. Although not significant in each equation, the population coefficients indicate a slight tendency for counties with either higher absolute or higher relative population growths to have smaller changes in property tax rates. Because of the large standard errors on $CPOP_A$ in equations 3-2-1, 3-2-2, 3-2-3, 3-2-5, and 3-2-6 it is not possible to reject the null hypothesis that the $CPOP_A$ coefficients equal the POP_A coefficients even though none of the $CPOP_A$ coefficients are significantly different from zero. Thus, the "true" $CPOP_A$ coefficient may in fact equal the POP_A coefficients. Only $CTCV_A$ has a significant $CPOP_A$ which is significantly different (and greater) than the corresponding POP_A coefficient.

Finally, equations 3-2-6 and 3-2-9 estimate change in residential property values as functions of $CPOP_A$ and $PCPOP_A$. Both have positive significant trend indicators which approximate the average CVRES of \$1,876. Both also have positive though nonsignificant coefficients on the explanatory variable. There may be a slight tendency for those counties with higher absolute or relative population increases to have greater increases in residential property values which, if true, is consistent with the results of equation 3-1-6. Both R^2 values are very low.

Figure 3-1. Means and Simple Regression Coefficients: Aggregated Local Governments.



= simple regression coefficient X = f(POP)

( ) = Standard error in parentheses.

** = coefficient significantly different from zero @ one percent level.

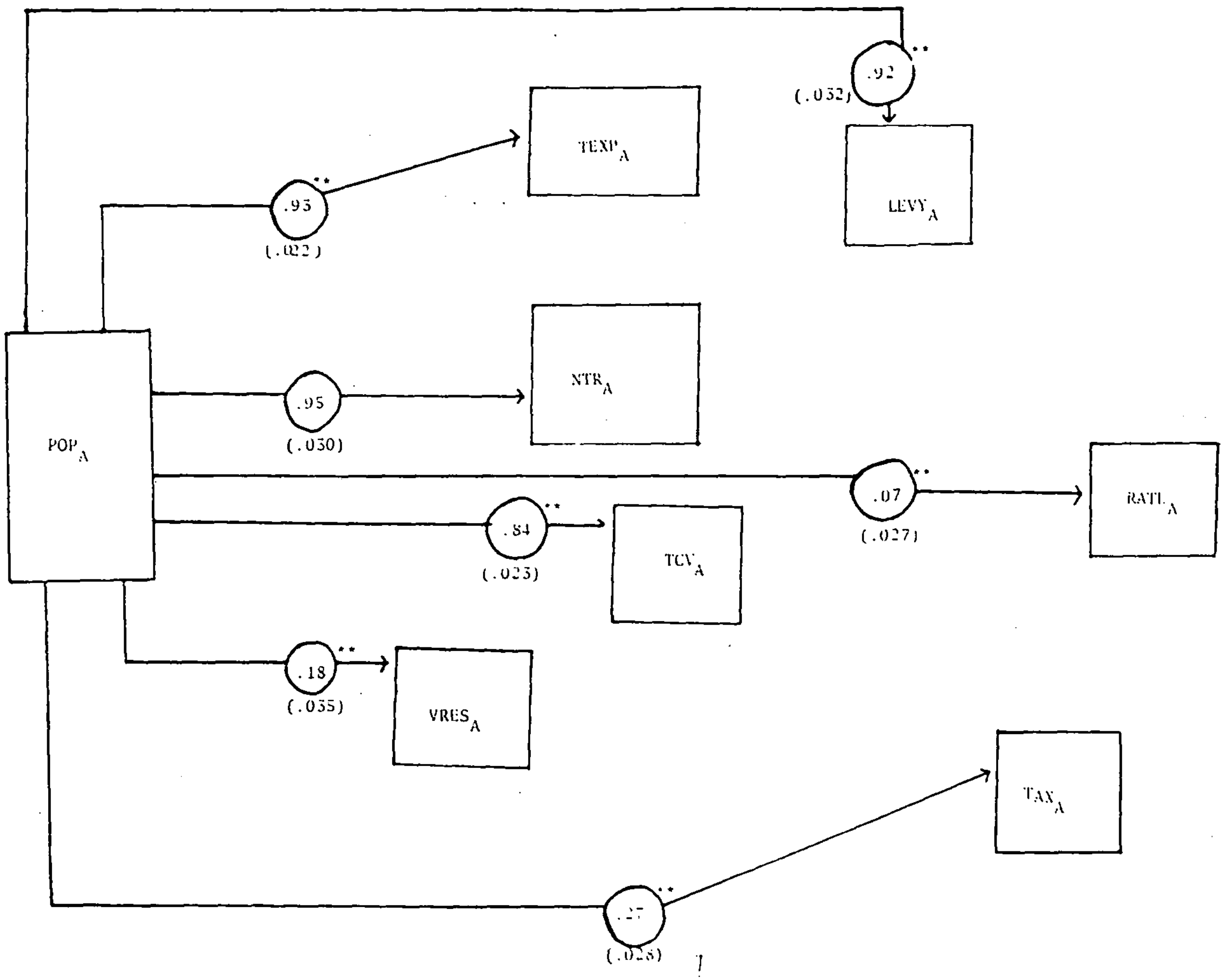
* = coefficient significantly different from zero @ five percent level.

1/ All figures given in single units.

2/ Standard deviation of variable shown under the mean.

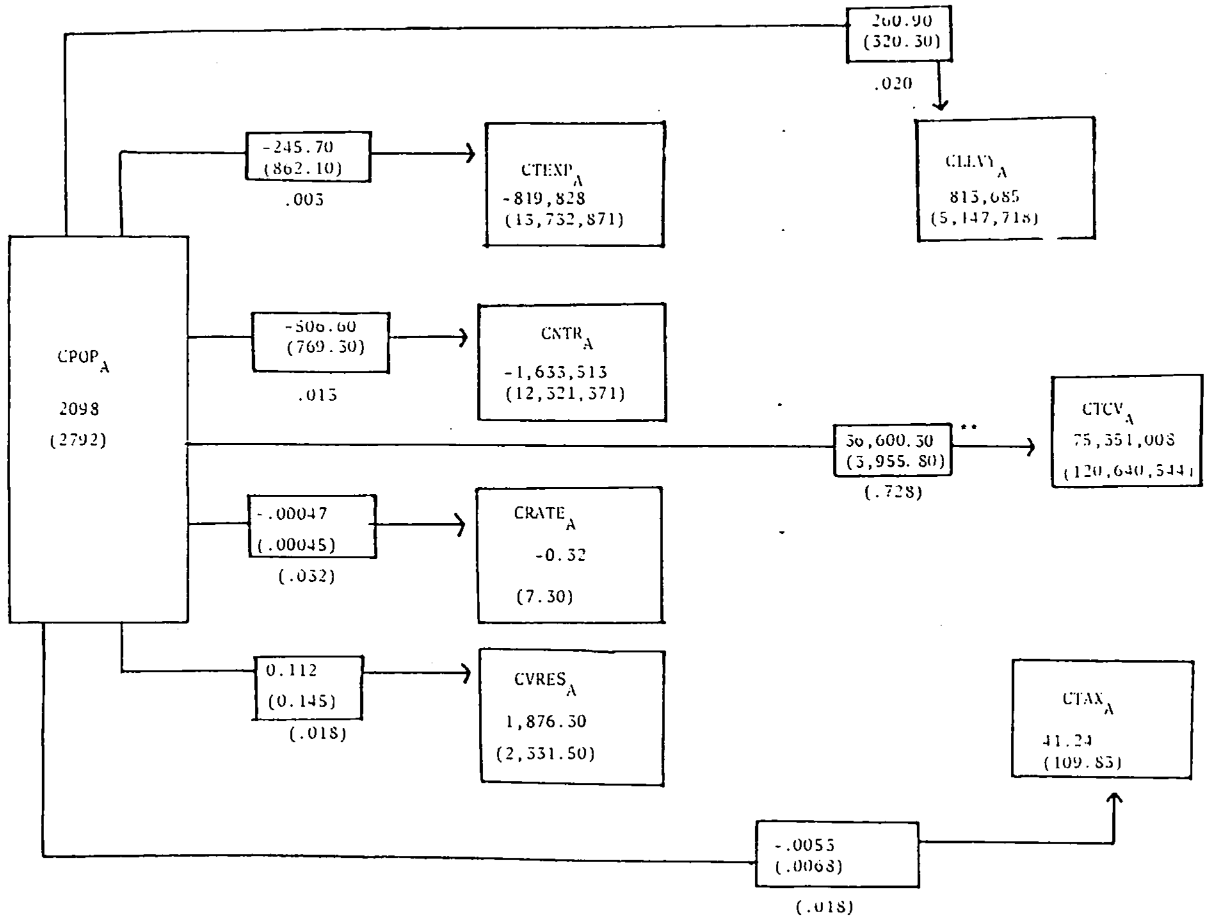
3/ R^2 of regression equation given below regression coefficient.

Figure 3-2. Constant Elasticities: Aggregated Governments.



= Elasticity with respect to population.
( ) = Standard error of elasticities in parentheses.
** = Significant at one percent level (see page 67 for null hypotheses).
* = Significant at five percent level (see page 67 for null hypotheses).

Figure 3-3. Means and Simple Regression Coefficients of Changes: Aggregated Governments.



→□→ = Simple regression; coefficient X = f(CPOP)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

Table 3-1. Regression Results. Pooled Simple Equations: Aggregated Local Governments.

Equation number	Dependent variable	Intercept	Pop	R^2	F
3-1-1	$TEXP_A$	-6,221,363.10	1,174.40 **	.971	2228.45
		(3,062,959.90)[1]	(24.90)		
3-1-2	NTR_A	-3,720,322.10	761.80 **	.950	1246.45
		(2,652,217.60)	(22.40)		
3-1-3	$LEVY_A$	-2,501,041.50 **	413.80 **	.985	4237.38
		(782,721.10)	(6.40)		
3-1-4	TCV_A	54,790,599 **	13,846.60 **	.989	5800.44
		(22,383,682)	(181.80)		
3-1-5	$RATE_A$	20.84 **	0.0000231 **	.153	11.89
		(0.82)	(0.000007)		
3-1-6	$VRES_A$	16,034.80 **	0.0314 **	.341	34.11
		(662.40)	(0.0054)		
3-1-7	TAX_A	328.45 **	0.00123 **	.500	65.87
		(18.70)	(0.00015)		

[1]Standard errors are in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

Table 3-2. Regression Results. First Difference Equations: Aggregated Local Governments.

Equation number	Dependent variable	Intercept	CPOP	PCPOP	R^2	F
3-2-1	$CTEXP_A$	-293,480	-245.70		.003	0.08
		(3,019,600)	(862.10)			
3-2-2	$CNTR_A$	-548,060	-506.60		.013	0.43
		(2,694,439)	(769.00)			
3-2-3	$CLEVY_A$	254,580	260.90		.020	0.66
		(112,173)	(320.30)			
3-2-4	$CTCV_A$	-3,069,053	36,600 **		.728	85.60
		(13,852,244)	(3,955)			
3-2-5	$CRATE_A$	0.68	-0.00047		.032	1.07
		(1.58)	(0.00045)			
3-2-6	$CVRES_A$	1,635.50 **	0.112		.018	0.60
		(508.50)	(0.145)			
3-2-7	$CTAX_A$	52.59 *	-0.0053		.018	0.60
		(23.96)	(0.0068)			
3-2-8	$CRATE_A$	3.02		-0.92	.077	2.67
		(2.38)		(0.57)		
3-2-9	$CVRES_A$	1,717.30 *		44.00	.002	0.05
		(790.90)		(187.80)		
3-2-10	$CTAX_A$	84.89 *		-12.07	.058	1.97
		(36.19)		(8.59		

[1]Standard errors in parentheses.
**Indicates coefficient significant at 1% level.
*Indicates coefficient significant at 5% level.

With the exception of $CTCV_A$ neither $CPOP_A$ or $PCPOP_A$ by themselves explain more than eight percent of the variation in any of the dependent variables. Nor do the point estimates of the coefficients bear any resemblance to those in the equations in Table 3-1. At least for the two-year period one would be hard-pressed to argue that population change significantly affected changes in residential property tax bills or its components (except TCV).

County Governments

Over the two-year period the sum total of the average residential property tax bills paid to the three units of government was \$398.36[9/] (Table 3-9). The average county tax bills was \$38.20 or 9.6 percent of the total tax bill. Over the two-year period the average county tax bill went up from \$36.12 to \$40.28 a \$4.16 or 11.53 percent increase. The average county population during the same period increased only 3.31 percent. The trend of the variables making up the tax equation was similar to the trends of the aggregated variables. Total expenditures ($TEXP_K$) declined by about two percent. Non-property tax revenues (NTR_K) declined at a greater rate (3.6 percent), resulting in a net increase in the average county levy ($LEVY_K$) of 6.9 percent. As happened with the aggregated units, TCV_K increased an average of \$75,768,640 per county or 8.4 percent. The result was a decline in the tax rate ($RATE_K$) of \$0.09 per thousand, about four percent less.

During the two-year period the value of residential property became

[9/] Because of the slightly different data sets used in the computations this does not quite add up to the average aggregate tax bill of \$410.16 (See Table 3-9).

a larger portion of TCV_K, increasing by 12 percent.[10/] So, despite the lower tax rate, county residential property tax bills increased 11.5 percent.

The regression estimates of the relation between population and the tax equation variables are presented in Table 3-3. Additionally, the mean values of the variables and the simple regression coefficients are contained in Figure 3-4. Equation 3-3-7 indicates a statistically significant positive relation between the average residential county tax bill and population. Approximately one-fourth of the variation in TAX_K is explained by the single variable POP_K. The coefficient on POP_K, significantly different from zero at the one percent level suggests that every thousand people in a county is associated with a \$0.10 $\pm$ .04 increase in TAX_K; that is, larger counties have larger county residential property tax bills than smaller counties. While statistically significant the coefficient is almost trivial economically. The equation predicts that two counties differing by 10,000 people (15.5 percent of the mean county population) would have average county tax bills differing by only \$1.00.

What is the relation of the other key variables to population? Each variable in the government block is highly and directly correlated with POP_K. The linear fits of POP_K to the county government variables, while not as tight as with the aggregated units, are nonetheless quite good.

POP_K explains 81.5 percent of the variation in $LEVY_K$ (equation 3-2-3 and Figure 3-4). The coefficient, significant at the one percent level indicates that each additional person in the county is associated with an additional \$51.20 $\pm$ 5.80 in the levy. This is significantly greater than

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10/ The behavior of county property values for counties is nearly identical to that of the aggregated units because the data sets are identical except that the county set includes Morrow County and the aggregated set does not.

the average $PLEVY_K$ of \$34.60. As happened with the aggregated data the intercept term is negative and significant, again suggesting the inclusion of a POPSQ term.

$LEVY_K$ is the difference between $TEXP_K$ and NTR_K. As hypothesized, neither constant term differs significantly from zero (equations 3-3-1 and 3-3-2). POP_K explains 86.6 percent of the variation in $TEXP_K$ and 78.4 percent of the variation in NTR_K. The coefficient on POP_K suggests that each additional person in a county would be associated with \$197.00 $\pm$ 18.60 additional expenditures. That figure is not significantly different from the average $PTEXP_K$ of \$207.10. The results of equation 3-3-2 are similar where the increase in NTR_K associated with an additional person is \$145.80 $\pm$ 18.40. This is not significantly different from the average $PNTR_K$ of \$172.50.

The results of the TCV_K predictive equation (3-3-4) are virtually identical to those of the aggregated data set. To summarize briefly, 98.9 percent of the variation in TCV_K is explained by POP_K while the coefficient, significant at the one percent level implies an increase in TCV_K of \$13.839.30 $\pm$ 178.40 is associated with each additional person in a county. The average $PTCV_K$ is \$14,646.40 which is not significantly different from the value of the coefficient.

Due to the tendency of TCV_K to have a cancelling effect on $LEVY_K$ when both are linear functions of POP_K there appears to be no significant linear relation between $RATE_K$ and POP_K. The coefficient on POP_K does not differ significantly from zero and virtually none of the variation in $RATE_K$ is explained by POP_K. There is reason to believe that more populous counties do not have higher tax rates than smaller counties.

The $VRES_K$ equation (3-3-6), like the TCV_K equation is nearly identical to the aggregated equation (3-1-6). About 31 percent of the variation in $VRES_K$ is explained by POP_K. Also, an additional average residential value of \$32.30 $\pm$ 5.80 is associated with each additional thousand people in a county.

Following the procedure of the previous section, the elasticities of each variable with respect to population are examined (see Figure 3-5). The same notation and subscripts are preserved.

The TAX_K elasticity is -.0056 which does not differ significantly from zero. This is somewhat surprising given the high significance of equation 3-3-7. Given that the estimated coefficient in equation 3-3-7 is so small, however, it is not surprising that the elasticity of TAX_K is also small.

Note that the elasticity of $RATE_K$ (α_4) is negative (-.16 $\pm$ .07) and highly significant. Its value suggests that a one percent increase in POP_K would be associated with a 0.16 percent decrease in the $RATE_K$. For county governments, then, population growth may reduce the tax rate.

A likely reason is that the $LEVY_K$ does not appear to be as responsive to POP_K as TCV_K does. The TCV_K elasticity α_2 is .84 $\pm$ .09 while that of the $LEVY_K$, α_1, is .63 $\pm$ .23 both significantly less than 1.00. The same type of result has occurred here as occurred with the aggregated governments: the confidence intervals of α_1 and α_2 overlap so we cannot reject the null hypothesis that $\alpha_1 = \alpha_2$. Yet α_4 is significant. For the same reason described in the previous section the null hypothesis $\alpha_4 = 0$ is rejected in favor of the alternative $\alpha_4 \neq 0$. Therefore, for the county data set, TCV_K must have a greater elasticity than $LEVY_K$.

The $VRES_K$ elasticity remains the same, .18 $\pm$ .07 because the data is identical. So while $RATE_K$ appears to decline with increased population, VRES increases with population. Because $\alpha_5 = \alpha_3 + \alpha_4$ there is the by now familiar cancelling effect [note that the absolute values of the confidence intervals overlap, $.11 \leq | \alpha_3 | \leq .25$ and $.09 \leq | \alpha_4 | \leq .23$]. A one percent increase in POP_K appears to decrease $RATE_K$ at nearly the same rate as it increases $VRES_K$. Although there was an increase in county tax bills paid by residential property owners, population growth does not appear to have been a cause of the increase.

The same conclusion would have to be reached after examining the predictive change equations. Equations 3-4-7 and 3-4-10 (see Table 3-4) estimate $CTAX_K$ as a function of $CPOP_K$ and $PCPOP_K$ respectively. Neither has a significant coefficient on the population variable. $CPOP_K$ explains less than two percent of the variation in TAX_K while $PCPOP_K$ explains only about four percent of the variation.

As with the aggregated county-wide governments, the change equations do not correspond well to the original pooled predictive equations, adding to the skepticism about using the cross-sectional data to make short-run inferences. Generally, the equations have low R^2 values and nonsignificant coefficients.

Neither of the intercepts (trend indicators) in equations 3-4-1 and 3-4-2 are significantly different from zero, nor are the coefficients. Although the coefficient on $CPOP_K$ in the $CTEXP_K$ equation (176.40) is close to the estimated partial of equation 3-3-1 (197.00) the results is probably spurious. The variable $CPOP_K$ explains only about two percent of the variation in $CTEXP_K$, and the standard error of the estimated coefficient is large (220.20). $CPOP_K$ does even worse explaining variation in $CNTR_K$, accounting for only 0.5 percent of the variation.

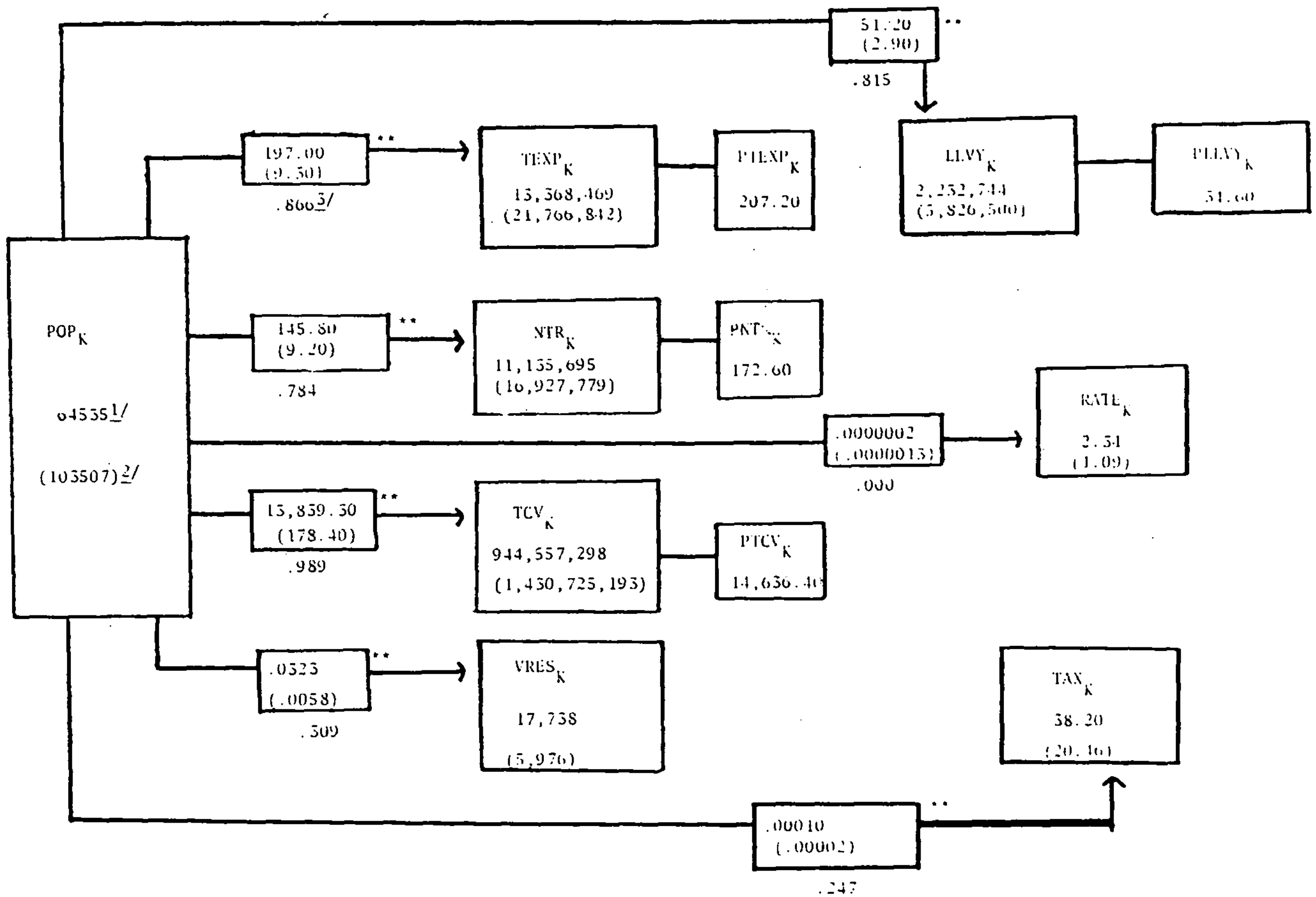
Surprisingly the coefficient on $CPOP_K$ in the $LEVY_K$ equation 3-4-3 is significant at the one percent level -- surprising because the results are so poor for the components of $LEVY_K$, ($TEXP_K$ and NTR_K). The intercept term is not significant indicating no apparent trend in $LEVY_K$ beyond that which is estimated by $CPOP_K$. The coefficient of 88.60 $\pm$ 45.80 suggests that a change in a county's population of one person is associated with a change in the $LEVY_K$ of \$88.60. The point estimate exceeds both the estimate of equation 3-3-3 (\$51.20 per person and the average $PLEVY_K$ of \$34.60). Hence there is a possibility that the marginal $LEVY_K$ with respect to POP_K exceeds the average $LEVY_K$ per capita. $CPOP_K$ explains nearly one-third (31.2 percent) of the variation in $LEVY_K$.

The CTCV and CVRES equations are nearly identical to those in Table 3-2. Some of the point estimates differ slightly but the conclusions are the same. The reader is referred to the text of the previous section for a discussion of these equations.

Of the two equations for $CRATE_K$ only $PCPOP_K$ has a significant coefficient. Equation 3-4-5 has little explanatory power and relatively large standard errors on the coefficeints. In contrast, $PCPOP_K$ explains nearly 31 percent of the variation in $CRATE_K$. Although highly significant its value of (-.122) is not large. There also appears to be a trend in CRATE measured by the intercept value of 0.38. The difference in signs between intercept and coefficient suggests that counties that grew at an average rate or less experienced increases in tax rates, while those that grew at a faster rate than average had declining tax rates. A county that grew at the rate of six percent for example (twice the average rate of about three percent) would be predicted to have a decline in the RATE of \$0.35.

The county change equations for TEXP, NTR, RATE, VRES, and TAX, like those of the aggregated governments equations, have large standard

Figure 3-4. Means and Simple Regression Coefficients: County Governments.



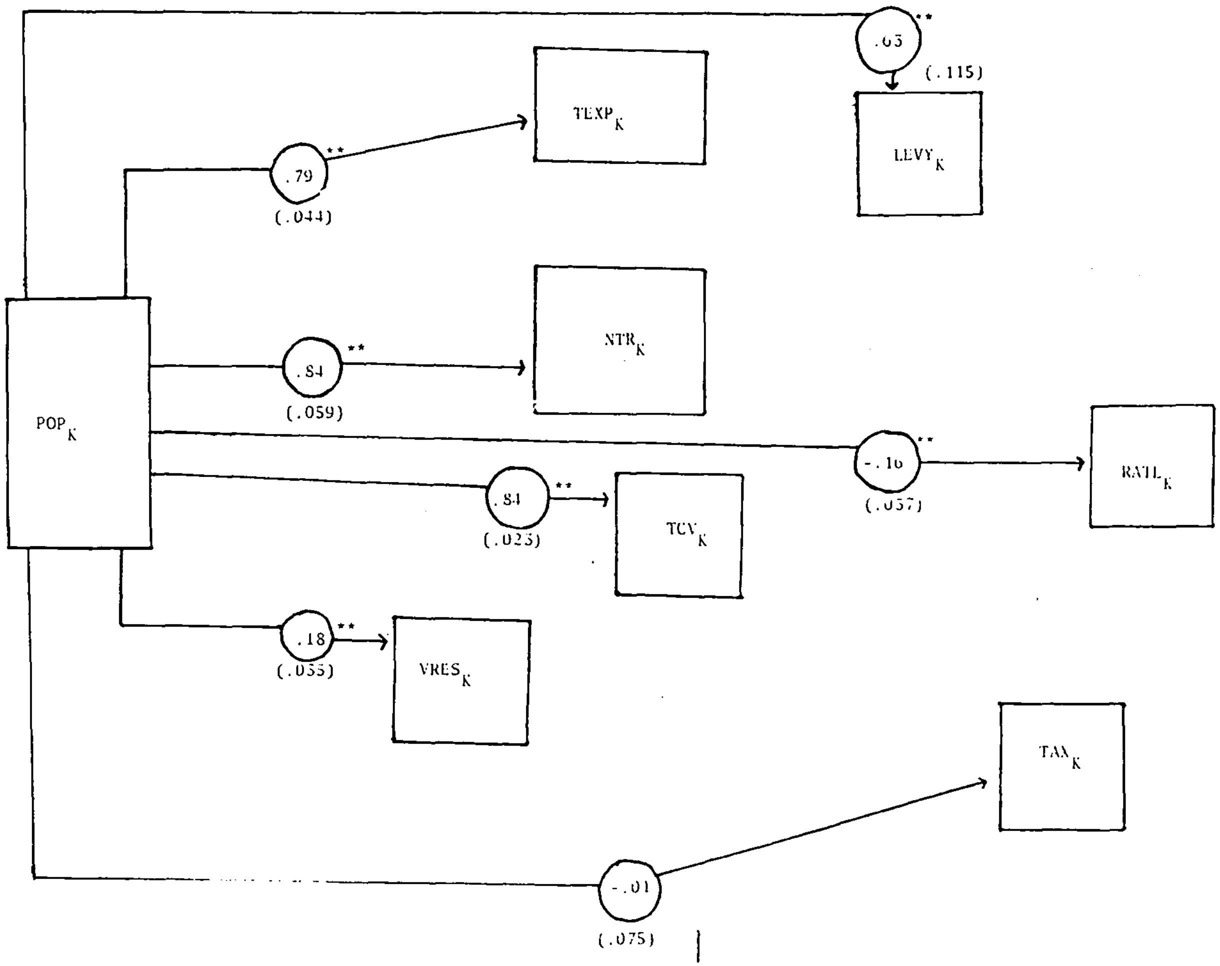
= Simple regression; coefficient X = f(POP)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

1/ All figures given in single units.

2/ Standard deviation of variable shown under the mean.

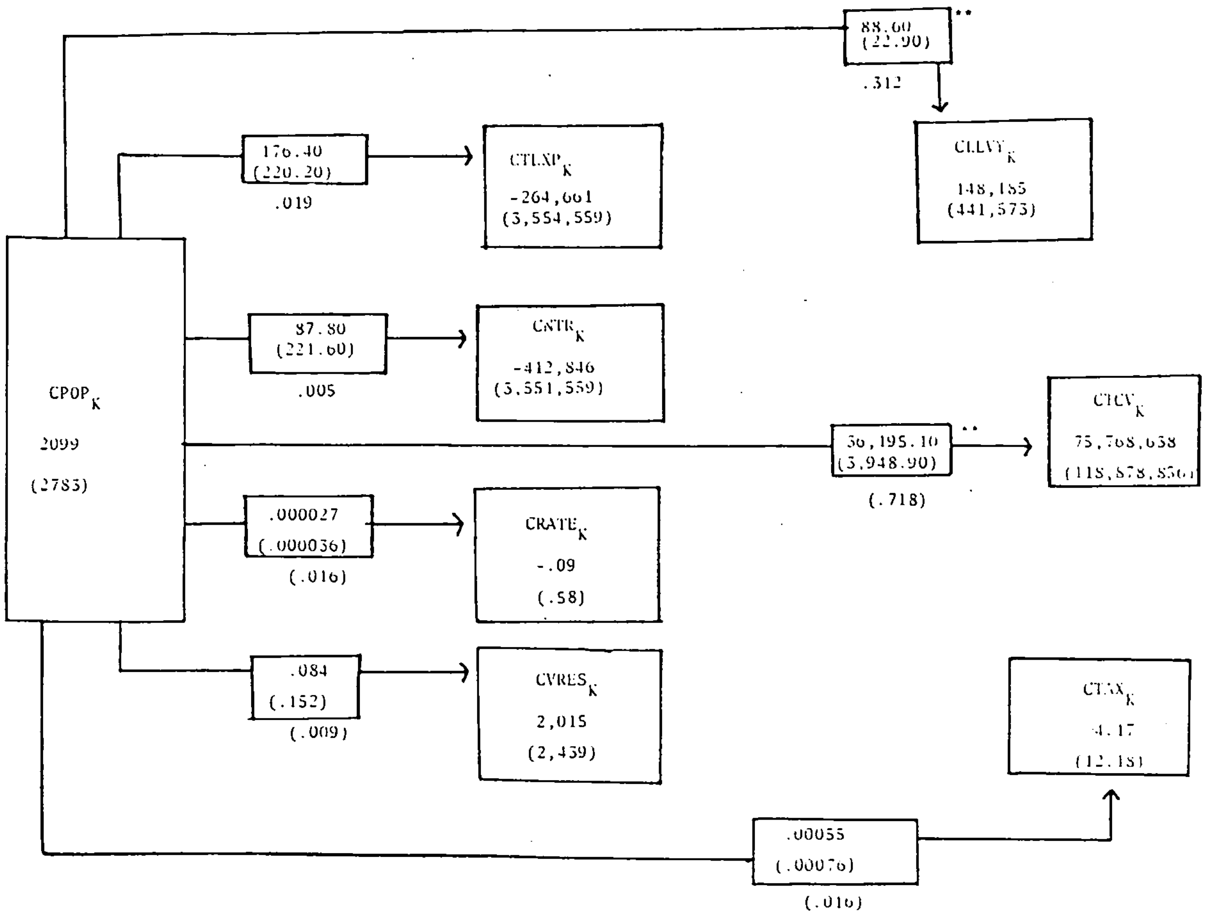
3/ R^2 of regression equation given below regression coefficient.

Figure 3-5. Constant Elasticities: County Government.



= Elasticity with respect to population.
( ) = Standard error of elasticities in parentheses.
** = Significant at one percent level (see page 67 for null hypotheses).
* = Significant at five percent level (see page 67 for null hypotheses).

Figure 3-6. Means and Simple Regression Coefficients of Changes: County Governments.



—▭→ = Simple regression; coefficient X = f(CPOP)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

Table 3-3. Regression Results. Pooled Simple Equations: County Governments.

Equation number	Dependent variable	Intercept	POP	R^2	F
3-3-1	$TEXP_K$	712,091.60	197.00 **	.866	444.08
		(1,127,447.60)	(9.30)		
3-3-2	NTR_K	1,767,300.20	145.80 **	.784	250.61
		(1,110,918.70)	(9.20)		
3-3-3	$LEVY_K$	-1,055,208.60 **	51.20 **	.815	304.48
		(353,725.90)	(2.90)		
3-3-4	TCV_K	55,442,013 **	13,839.30 **	.989	6020.79
		(21,510,419)	(178.40)		
3-3-5	$RATE_K$	2.33 **	0.0000002	.000	0.03
		(0.16)	(0.0000013)		
3-3-6	$VRES_K$	15,663.60 **	0.032 **	.309	30.80
		(701.90)	(0.006)		
3-3-7	TAX_K	31.82 **	0.00010 **	.247	22.97
		(2.49)	(0.00002)		

[1]Standard errors in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

Table 3-4. Regression Results. First Difference Equations: County Governments.

Equation number	Dependent variable	Intercept	CPOP	PCPOP	R^2	F
3-4-1	$CTEXP_K$	-634,900	176.40		.019	0.64
		(760,530)[1]	(220.20)			
3-4-2	$CNTR_K$	-597,060	87.80		.005	0.16
		(765,420)	(221.60)			
3-4-3	$CLEVY_K$	-37,830	88.60 **		.312	14.97
		(79,120)	(22.90)			
3-4-4	$CTCV_K$	-189,420	36,195.10 **		.718	84.01
		(13,638,130)	(3,948.90)			
3-4-5	$CRATE_K$	-0.15	0.000027		.016	0.55
		(0.12)	(0.000036)			
3-4-6	$CVRES_K$	1,840 **	0.084		.009	0.30
		(52)	(0.152)			
3-4-7	$CTAX_K$	2.89	0.00055		.016	0.55
		(2.55)	(0.00075)			
3-4-8	$CRATE_K$	0.38 *		-0.12 **	.309	14.73
		(0.15)		(0.03)		
3-4-9	$CVRES_K$	1,210		208.10	.051	1.77
		(730)		(156.40)		
3-4-10	$CTAX_K$	7.82 *		-0.97	.044	1.58
		(3.60)		(0.77)		

[1]Standard errors in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

errors on the $CPOP_K$ coefficients. Therefore, one cannot reject either the null hypothesis that the coefficients equal zero, nor the hypothesis that they equal the POP_K coefficients of Table 3-3. One cannot assert that short-run changes in population have a significant effect on short-run changes in the dependent variables. Nor can one assert that short-run changes do not correspond to long-run changes. One can say that there is little correlation between short-run changes in population and short-run changes in the dependent variables. The large variance of the estimated $CPOP_K$ coefficients preclude precise interpretations about the short-run relationship between the dependent variables and population.

School Districts

The average school district residential property tax bill was $243.91, 62.1 percent of the total tax bill of $398.36 (Table 3-9). The average school tax bill went up $32.52 (14.3 percent) over the two-year period, from $227.65 in 1974 to $260.17 in 1976. During the same period the average school district "population" (ADM) increased by only four students, from 1,449 to 1,453 (0.3 percent). The average total school district expenditure ($TEXP_S$) increased 6.6 percent from $3,004,912 to $3,204,007. Non-property tax revenues (NTR_S) failed to keep pace with $TEXP_S$, however, increasing at an average rate of 5.1 percent from $1,375,292 per district to $1,444,853. As a result the average $LEVY_S$ went up 7.9 percent from $1,629,621 to $1,759,154, an average increase of $129,533 per school district.

The average school district's TCV went up 8.4 percent from $116.474,320 per district to $126,247,600 and the average school district tax rate

($RATE_S$) went up from \$11.59 to \$11.90, a 2.7 percent rise.[11/]

Information on residential property values is not available at the school district or city level and so VRES is not discussed in this or the next section. Instead, for computing average tax bills, the average residential values of the counties in which the school districts or cities are located are used.

The regression estimates of the relation between population (hereinafter referred to as ADM, the average student population) and the other variables are presented in Table 3-5. Also, the mean values of the variables and the simple regression coefficients are depicted in Figure 3-7.

Only seven percent of the variation in TAX_S is explained by ADM, despite the highly significant regression coefficient (Equation 3-5-6). The estimated coefficient is (.00977 $\pm$ .00292). Each additional 100 students are associated with an additional \$0.98 in the average tax bill. Given one school district of average size (1,451 students) and another district which is 100 students, or 6.9 percent, larger, the two tax bills would be predicted to differ by only \$0.97 or 0.4 percent. While statistically significant, the coefficient, at least from an economic standpoint, is almost trivial, just as it was the county TAX_K equation. Still, there is a positive relationship between TAX_S and ADM so it appears to be disadvantageous for the residential property tax payer to live in a larger

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11/ The apparently contradictory result of the average TCV_S increasing at a greater rate than the average $LEVY_S$ while the average $RATE_S$ also increased is a direct consequence of the methods of calculating mean values as discussed in the section on aggregated county-wide governments. Recall, the average rate is:

$$\frac{1}{n}\sum_{i=1}^{n}\frac{LEVY_i}{TCV_i} \quad \text{not} \quad \frac{\frac{1}{n}\sum_{i=1}^{n} LEVY_i}{\frac{1}{n}\sum_{i=1}^{n} TCV_i}$$

school district.[12/]

Each of the other variables in the tax equation is also positively related to ADM, and all are significant at the one percent level. Almost 98 percent of the variation in $TEXP_S$ is explained by the single variable ADM. The coefficient predicts a difference in total expenditures between school districts of \$2,221 $\pm$ 14 per student. This is just over the average $PTEXP_S$ of \$2,139. The close fit between $TEXP_S$ and ADM is mildly surprising because TEXP includes both current and capital costs of operating the school district. Such a close fit for current expenditures would be less surprising.[13/]

The NTR_S equation (3-5-2) also shows a close fit, where 90 percent of the variation in NTR_S is explained by ADM. The estimated coefficient of (929.40 $\pm$ 25.40) compares to the average $PNTR_S$ of \$971.70 and implies that school districts differing by 100 students would have a predicted difference of \$92,940 in non-property tax revenues. The intercept term is not significantly different from zero.

The difference between equations 3-5-1 and 3-5-2 is given by equation 3-5-3, the $LEVY_S$ equation. ADM explaines 98 percent of the variation in $LEVY_S$. The value of the coefficient is close to the average $PLEVY_S$ of \$1,168.

TCV_S is also directly related to ADM, as equation 3-5-4 demonstrates. Just over 94 percent of the TCV_S variation is accounted for by ADM. The

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12/ Of course there may be other advantages of larger school districts not discussed here.

13/ In fact regressing total current expenditures ($TCEXP_S$) on ADM does produce a closer fit, with ADM explaining 99.3 percent of the variation in $TCEXP_S$, a near perfect fit. The regression coefficient is \$1,685 compared to the average per student current expenditure of \$1,662.36.

average $PTCV_S$ is \$83,640 which is just below the estimated value of \$91,103 $\pm$ 1,834 per student as measured by the regression coefficient on ADM.

Despite the highly linear nature of the relationship between both TCV_S and $LEVY_S$ and ADM, there is also an apparent relationship between $RATE_S$ and ADM, although only five percent of the variation in $RATE_S$ is explained by ADM. The significance of the regression coefficient, however, is more apparent than real. Two districts differing by 100 students would be predicted to have only a three cent difference in tax rate. For the homeowners in each district with property assessed at \$25,000 that would translate as a difference in tax bills of 75 cents.

As in the previous sections, the elasticities of each variable with respect to population are examined (see Figure 3-8). The same notations and subscripts are preserved.

The TAX_S elasticity, α_5, is 0.25 $\pm$ .04, significant at the one percent level. Of the three units of local government, the school tax elasticity is the highest. Each four percent increase in ADM would be expected to be associated with a one percent increase in TAX_S. Although this figure appears to be high, relative to other units of government, it should be remembered that, on the average, ADM increased by only 0.26 percent over the two-year period. Given that, it does not seem likely that much of the 14.3 percent increase in tax bills from 1974 to 1976 can be attributed to ADM increases. On the other hand, the magnitude of the elasticity may be an indication that residential property owners in those districts that <u>do</u> grow fast have rapidly increasing property tax bills.

What about the principal components of the tax bill? The $LEVY_S$ elasticity (α_1) indicates that a one percent increase in ADM would be associated with a (1.00 $\pm$ .02) percent increase in the levy; the levy rising at the same rate as ADM. Thus, the null hypothesis that $\alpha_1 = 1.00$ cannot be rejected.

The TCV_S elasticity (α_2), however, is significantly less than 1.00. Its value is .81 $\pm$ .02. As a result, the elasticity of the $RATE_S$ (α_4) is also highly significant with a value of .19 $\pm$ .03. Quite obviously, these results show that for school districts increased population as measured by ADM leads to increased property tax rates. At the 99 percent level of confidence one would reject the null hypothesis:

(V^1) Ho: $\alpha_1 = \alpha_2$

in favor of the alternative:

Ha: $\alpha_1 \neq \alpha_2$

Or in a slightly different form, the null hypothesis:

(V) Ho: $\alpha_4 = 0$

is rejected in favor of the alternative:

Ha: $\alpha_4 \neq 0$.

Moreover, had the more powerful alternative hypotheses been $\alpha_1 > \alpha_2$ or $\alpha_4 > 0$, the null hypotheses would still have been rejected.

The average school district $VRES_S$ elasticity may also be computed for illustrative purposes. As shown in figure 3-8 the value of α_3 = .06 $\pm$ .01. It is this estimate which has been implicitly used by the statistical package to compute the tax elasticities. (Each school district's VRES is assumed to be equal to the corresponding county VRES, and each school district is an observation in computing the TAX_S variable.) Had the county VRES elasticity been considered, the estimated TAX_S elasticity, $\alpha_5 \div \alpha_3 + \alpha_4$ would have been .19 + .18 = .37, half again as large as the estimate of α_5 presented here.

The by-now questionable validity of short-run predictions drawn from the pooled data estimates is once again underscored by the set of change equation regression estimates (Table 3-6).

In neither of the two estimated $CTAX_S$ equations (one with CADM and the other with PCADM) is the regression coefficient significant. Nor can either variable explain as much as one percent of the variation in CTAX. The intercept terms in equations 3-6-6 and 3-6-8 are both highly significant, and are both plausible estimates of the exogenous trend in $CTAX_S$. The former estimate is \$32.47 $\pm$ 8.06, the latter \$32.74 $\pm$ 8.13. Both are nearly identical to the average $CTAX_S$ of \$32.52.

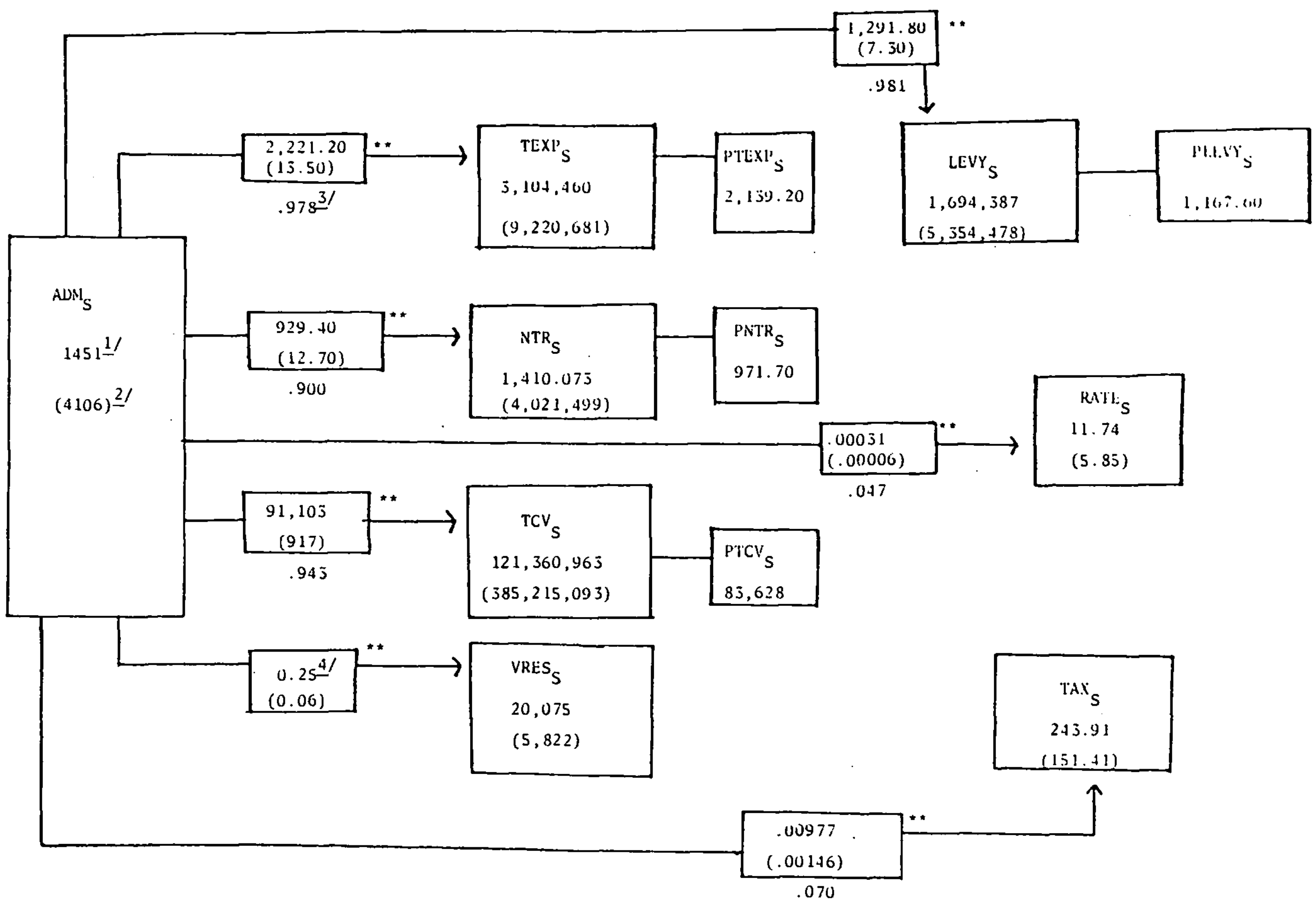
In the government block equations, CADM does a lot better as an explanatory variable. Although only four percent of the variation in $CTEXP_S$ is explained by CADM, the regression coefficient is highly significant. Its value of 1,167.40 $\pm$ 688.00 implies an associated change of \$1,167.40 in total expenditures per unit change in ADM. This estimate is less than the estimated coefficient of 2,221,20 in equation 3-5-1. It is, however, closer to, although still less than, the average per student <u>current</u> expenditure of \$1,662.36. The value of the trend indicator the intercept, is \$194,610, significant at the five percent level, and quite close to the average $CTEXP_S$ of \$199,090.

As equation 3-6-2 shows, CADM explains over ten percent of the variation in $CNTR_S$, the best fit of any of the school change equations. The trend indicator of \$63,120 while not significantly different from zero nevertheless is an accurate estimate of the average $CNTR_S$ of \$69,561. The regression coefficient is significant at the one percent level. Its value of 1,678.10 $\pm$ 573 suggests a change of \$1,678.10 in total non-property tax revenues per unit change in ADM. This value is well above the average $PNTR_S$ of \$972.70. That result is difficult to explain as there should not be any reason why the marginal NTR_S should be so much higher than the average NTR_S. Although the BSSF apportions larger funds to rapidly growing school districts, that apportionment is only one percent of the total funds made available. The confidence interval on the coefficient extends down to 1,105.10 which is in the range of the expected value.

The result of subtracting equation 3-6-2 from 3-6-1 is the $CLEVY_S$ equation. Slightly over four percent of the variation in $CLEVY_S$ is explained by CADM. The coefficient is significant at the one percent level and <u>negative</u>, a surprising result. Its value of (-510.60 $\pm$ 278) indicates a decline in the $LEVY_S$ of \$510.60 per unit increase in ADM. This result is a direct consequence of the result in equation 3-6-2. Although the negative coefficient implies that in the short-run, increases in ADM may reduce the $LEVY_S$ it is unlikely to be a good long-run strategy to encourage growth as the pooled equation (3-5-3) shows. The trend indicator is highly significant and equal to \$131,494 per district, virtually identical to the average $CLEVY_S$ of \$129,533.

$CTCV_S$ (equation 3-6-4) does not appear to be a function of CADM. The regression coefficient is not significantly different from zero, and the explanatory variable, CADM, explains less than one percent of the variation in $CTCV_S$. Only the trend indicator is significant. Its value of \$9,757,408 almost exactly equals the average $CTCV_S$ of \$9,773,280.

Figure 3-7. Means and Simple Regression Coefficients: School Districts.



= Simple regression; coefficient X = f(ADM)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

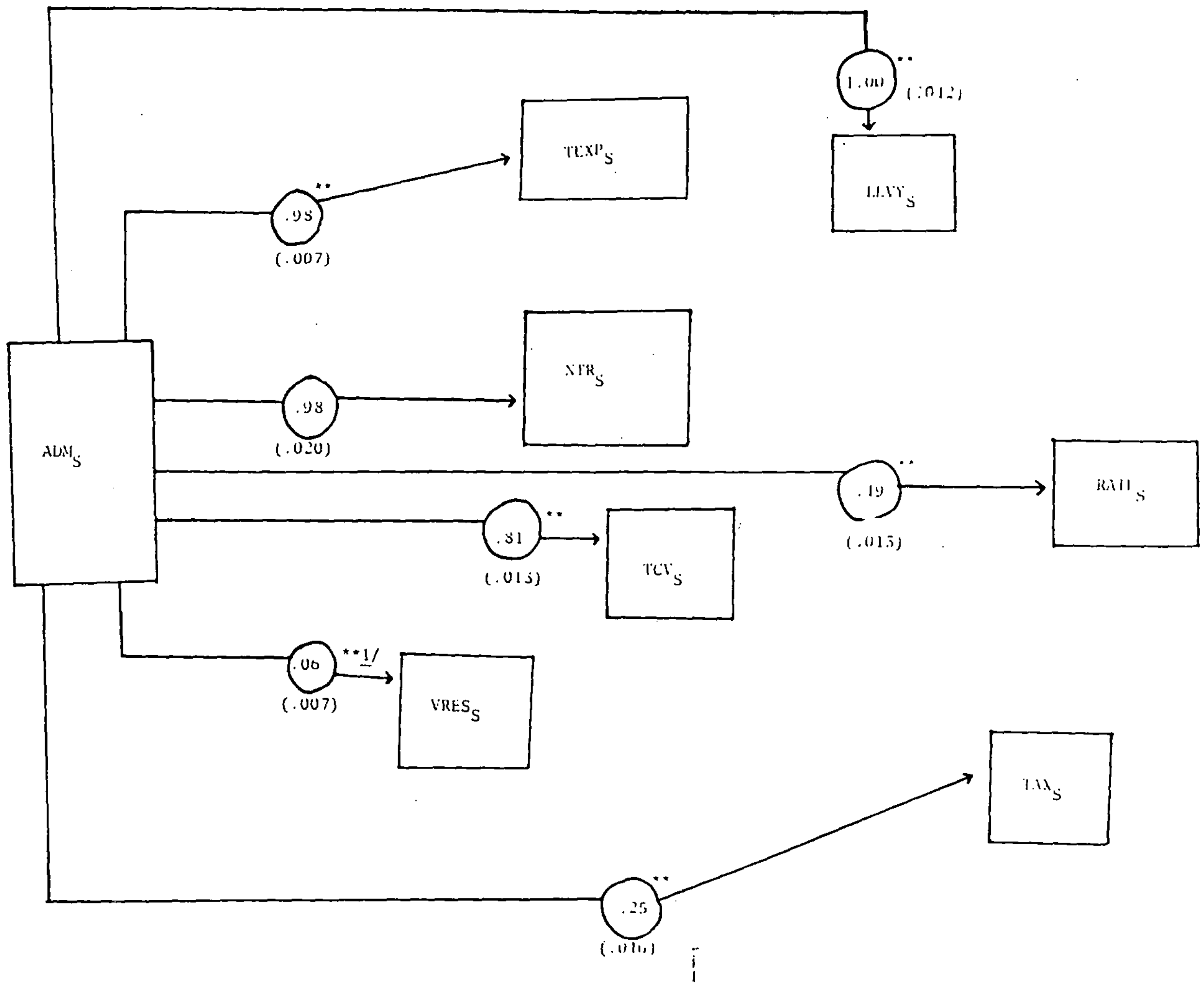
1/ All figures given in single units.

2/ Standard deviation of variable shown under the mean.

3/ R^2 of regression equation given below regression coefficient.

4/ VRES$_S$ regression coefficient shown for illustrative purposes only.

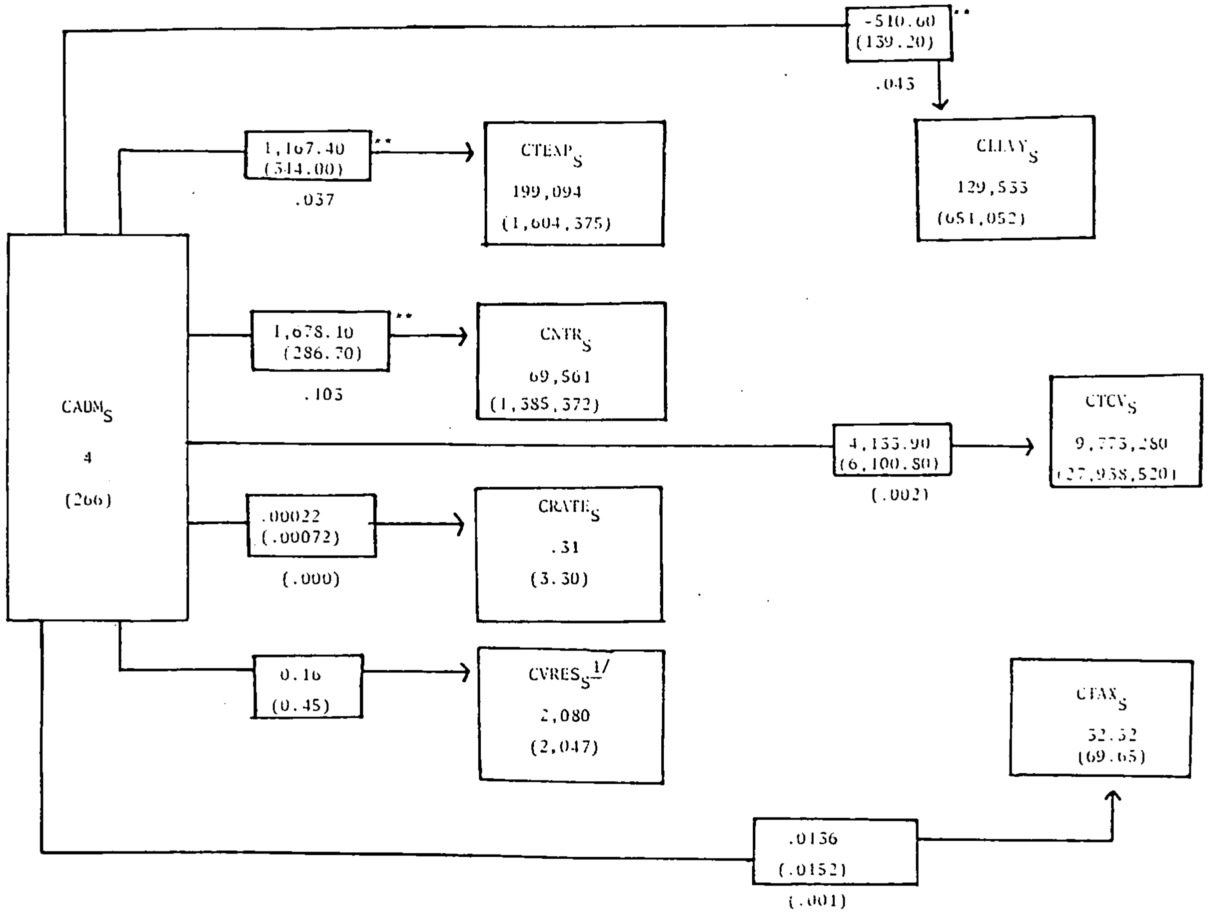
Figure 5-8. Constant Elasticities: School Districts.



◯ = Elasticity with respect to schools.
( ) = Standard error of elasticities in parentheses.
** = Significant at one percent level (see page 67 for null hypotheses).
* = Significant at five percent level (see page 67 for null hypotheses).

1/ VRES$_S$ elasticity shown for illustrative purposes.

Figure 3-9. Means and Simple Regression Coefficients of Changes: School Districts.



= Simple regression; coefficient X = f(CADM)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

1/ $CVRES_S$ regression coefficient shown for illustrative purposes.

Table 3-5. Regression Results. Pooled Simple Equations: School Districts.

Equation number	Dependent variable	Intercept	ADM	R^2	F
3-5-1	$TEXP_S$	-118,901.80 *	2,221.20 **	.978	26,990.96
		(58,836.46)[1]	(13.50)		
3-5-2	NTR_S	61,378.10	929.40 **	.900	5,392.69
		(55,075.30)	(12.70)		
3-5-3	$LEVY_S$	-180,280.00 **	1,291.80 **	.981	31,410.05
		(31,720.20)	(7.30)		
3-5-4	TCV_S	10,846,172 **	91,102.00 **	.943	9,865.72
		(3,991,503)	(917.20)		
3-5-5	$RATE_S$	11.29 **	0.00031 **	.047	29.12
		(0.25)	(0.00006)		
3-5-6	TAX_S	229.73 **	0.00977 **	.070	45.02
		(6.34)	(0.00146)		

[1]Standard errors in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

Table 3-6. Regression Results. First Difference Equations: School Districts.

Equation number	Dependent variable	Intercept	CADM	PCADM	R^2	F
3-6-1	$CTEXP_S$	194,612 *	1,167.40 **		.037	11.52
		(91,198)[1]	(344.00)			
3-6-2	$CNTR_S$	63,118	1,678.10 **		.103	34.52
		(75,997)	(286.70)			
3-6-3	$CLEVY_S$	131,494 **	-510.60 **		.043	13.47
		(36,892)	(139.20)			
3-6-4	$CTCV_S$	9,757,408 **	4,133.90		.002	0.46
		(1,617,364)	(6,100.80)			
3-6-5	$CRATE_S$	0.31	0.00022		.000	0.09
		(0.19)	(0.00072)			
3-6-6	$CTAX_S$	32.47 **	0.014		.003	0.79
		(4.03)	(0.015)			
3-6-7	$CRATE_S$	0.36		-0.02 *	.013	3.88
		(0.19)		(0.01)		
3-6-8	$CTAX_S$	32.74 **		-0.096	.001	0.18
		(4.07)		(0.225)		

[1]Standard errors in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

Finally, none of the variation in $CRATE_S$ is explained by CADM nor is the trend indicator statistically significant. PCADM is a far better explanatory variable, although it explains less than two percent of the variation in $CRATE_S$. The regression coefficient, however, is significant at the five percent level. Its value of -.021 ± .020 suggests that each one percent increase in ADM is associated with a two cent decline in the tax rate. While statistically significant, a two cent change in the tax rate is trivial. There was no apparent trend in $CRATE_S$ as measured by the intercept.

The regression coefficients on CADM in equations 3-6-1 through 3-6-4 are significantly different than the corresponding coefficients on ADM in equations 3-5-1 through 3-5-4. For those variables one must reject the null hypothesis that short-run and long-run behavior are identical. CADM is significantly related to $CTEXP_S$, $CNTR_S$ and $CLEVY_S$ but that short-run relationship is not equivalent to the long-run population relationship.

Because of the large standard errors on the CADM coefficient in equations 3-6-5 and 3-6-6 one cannot reject the null hypothesis that the short-run relation between CADM and either $CRATE_S$ or $CTAX_S$ is similar to the long-run relationship of ADM and $RATE_S$ and TAX_S.

City Governments

The average tax bill paid to the final unit of local government, cities, was \$116.25, 29.2 percent of the total property tax bill paid to the three units of government (Table 3-9). Over the 1974 to 1976 period the average city tax bill increased \$16.46 (15.2 percent) from \$108.02 to \$124.48. The average city population increased only four percent during the same period.

Average city expenditures ($TEXP_C$) went from \$4,520,872 in 1974 to \$4,644,820 in 1976, a 2.7 percent rise. Non-property tax revenues increased at a slower pace (1.8 percent) going from \$3,862,421 per city to \$3,930,704. As a result the average city's property tax levy ($LEVY_C$) went from \$658,452 to \$714,117 a rise of 8.5 percent.

On the average, the true cash value of all property in cities (TCV_C) increased ten percent, from \$93,868,878 to \$103,221,190. The average tax rate for cities ($RATE_C$), however, went up to \$6.09, a 4.1 percent increase over the 1974 average rate of \$5.85.[14/] The rise in $RATE_C$, combined with the state-wide increase in VRES resulted in the large TAX_C increase.

The regression estimates of the relation between population and the tax variables are presented in Table 3-7. In addition, the mean values of the variables and the simple regression coefficients are exhibited.

Equation 3-7-6 estimates TAX_C as a function of city population, POP_C. The regression coefficient is positive and significant at the five percent level although it explains only 1.3 percent of the variation in TAX_C. Further, the value of the coefficient is not large (.000344 $\pm$ .000340). Two cities differing in size by 1,000 would be predicted to have average tax bills differing by only 34 cents.

14/ Recall that the average rate is:

$$\frac{1}{n}\sum_{i=1}^{n}\frac{LEVY_i}{TCV_i} \quad \text{not} \quad \frac{\sum_{i=1}^{n} LEVY_i}{\sum_{i=1}^{n} TCV_i} .$$

This may imply that in the smaller cities (on which there are more observations) levies are increasing more rapidly than TCV whereas in larger cities TCV is increasing more rapidly.

With the exception of $RATE_C$, POP_C does a far better job with the other variables that compose the tax bill explaining 99 percent of the variation in $TEXP_C$, NTR_C, $LEVY_C$, and TCV_C. The regression coefficients in each of those equations (3-7-1 through 3-7-4) are positive and significant at the one percent level.

One mildly disturbing result is the recurring problem of negative intercept terms in the four equations that are highly significant. This result appears to be due to the curvilinear relation between POP_C and the four variables $TEXP_C$, NTR_C, $LEVY_C$, and TCV_C. That is, the slope of the regression line becomes steeper as city size increases. Consequently, the predicted values of the dependent variables are underestimated for small cities (such as a near-zero population city) and large cities, and over-estimated for medium-sized cities. This result is not unexpected from the theory outlined in Chapter II.[15/]

Equation 3-7-1 predicts that two cities with populations differing by 1,000 people would have total expenditures differing by $702,800 $\pm$ 7,800, or $702.80 per person. The average per capita total expenditure for all cities was $431.80 $\pm$ 36.00, significantly less than the coefficient's value.

Similarly, the value of the regression coefficient in equation 3-7-2 is larger than the average per capita NTR_C ($PNTR_C$). The equation predicts that the same two cities in the above example would have non-property tax revenue receipts differing by $587,100 $\pm$ 7,200, or $587.10 per person. The average $PNTR_C$ was $380.30 $\pm$ 36.00.

15/ For more on this the reader is referred to the Appendix where regression estimates for three size classes of cities are presented.

Because of the behavior of $TEXP_C$ and NTR_C, the $LEVY_C$ equation follows a similar pattern. The same two cities would be predicted to have levies differing by \$115,700, or \$115.70 per person compared to the average PLEVY of \$51.50 ± 4.00.

Finally, equation 3-7-4 predicts that the two cities would have TCV_C differing by \$14,173,900 ± 127,600, a \$14,173.90 per person difference. By comparison the average $PTCV_C$ is only \$9,796 ± 584.

The regression coefficients are often interpreted as marginal expenditures or revenues. It is for that reason that the values of the coefficients are compared here to the average per capita values of the respective variables. While the comparisons are illustrative, however, they may or may not have much meaning. If the intercept term in a linear equation is negative, for instance, the marginal value of the dependent variable with respect to the explanatory variable will always be greater than the average value of the quotient of the two variables. Further, if a curvilinear fit is always steeper for increasing values of the explanatory variable then, by definition, the marginal value of the dependent variable with respect to the explanatory variable is always increasing. When the marginal value is increasing it always exceeds the average value. If indeed, the true relationship is curvilinear then the conclusion of increasing marginal values may be warranted.[16/]

Because of the previously discussed cancelling effect of TCV on LEVY when both have a linear relationship with POP, it is no surprise that pratically none of the variation in $RATE_C$ is explained by POP_C, nor that the regression coefficient does not differ significantly from zero. The correlation coefficient between POP_C and $RATE_C$ is .05 which indicates a

16/ Even then, one must still assume that the cities will tend to move along the regression curve as they grow.

very slight positive relationship between the two variables. It would appear then, that the reason residential property tax bills are higher in larger cities is the effect of larger population not on expenditures or other revenues, but on the value of residential property.

The elasticities of each variable with respect to population are shown in Figure 3-11. For cities the TAX_C elasticity, α_5, is .19 $\pm$ .09. Hence a five percent increase in POP_C would be predicted to lead to a nearly one percent increase in TAX_C. This elasticity while positive and significant at the one percent level does not appear to account for the average city residential property tax bill increase from 1974 to 1976. Recall that tax bills increased by over 15 percent while population increased by only four percent. Still, the positive elasticity, consistent with the school and aggregated government results, is evidence that growth and taxes may be directly related.

Reviewing the remaining elasticity estimates, α_1, the $LEVY_C$ elasticity is estimated to be 1.24 $\pm$ .08; that is, a one percent change in population would be associated with a 1.24 percent change in $LEVY_C$. If this estimate is accurate then tax levies appear to increase faster than population. An elasticity greater than 1.00 also implies an increasing marginal $LEVY_C$ with respect to population, a result consistent with those of the simple linear regression estimates.

The estimated elasticity of TCV_C, α_2, is 1.13 $\pm$ .04 also consistent with the previous results. Here a one percent increase in POP_C would be associated with a 1.13 percent increase in TCV_C, again significantly greater than 1.00.

Apparently TCV_C does not respond to POP_C as strongly as does $LEVY_C$. One cannot, however, reject the null hypothesis:

(V^1) Ho: $\alpha_1 = \alpha_2$

in favor of the alternative:

Ha: $\alpha_1 \neq \alpha_2$

because the confidence intervals around each α_1 overlap.[17/] Nevertheless, by the reasoning in the preceding sections one can directly examine the $RATE_C$ elasticity (α_4). The estimate value of α_4 is .08 $\pm$ .06 implying that a one percent increase in POP_C is associated with a .08 percent increase in $RATE_C$. The null hypothesis:

(V) Ho: $\alpha_4 = 0$

is rejected in favor of the alternative:

Ha: $\alpha_4 \neq 0$.

Again, while the estimate of the elasticity is statistically significant, its value is small. It would take over a 12 percent increase in POP_C to increase $RATE_C$ just one percent.

Of all the predictive change equations, those for the cities are the best, at least as far as having regression coefficients approaching the values of the pooled estimates. $CTAX_C$ is estimated as a function of $CPOP_C$ and $PCPOP_C$ (equations 3-8-6 and 3-8-8). Neither variable explains even one percent of the variation in $CTAX_C$ nor do they have significant regression coefficients. The trend indicator is significant in equation 3-8-8 and nearly so in equation 3-8-6. Both are close to the average $CTAX_C$ of \$16.45.

[17/] One could, however, reject the null in favor of the more powerful alternative: Ha: $\alpha_1 > \alpha_2$.

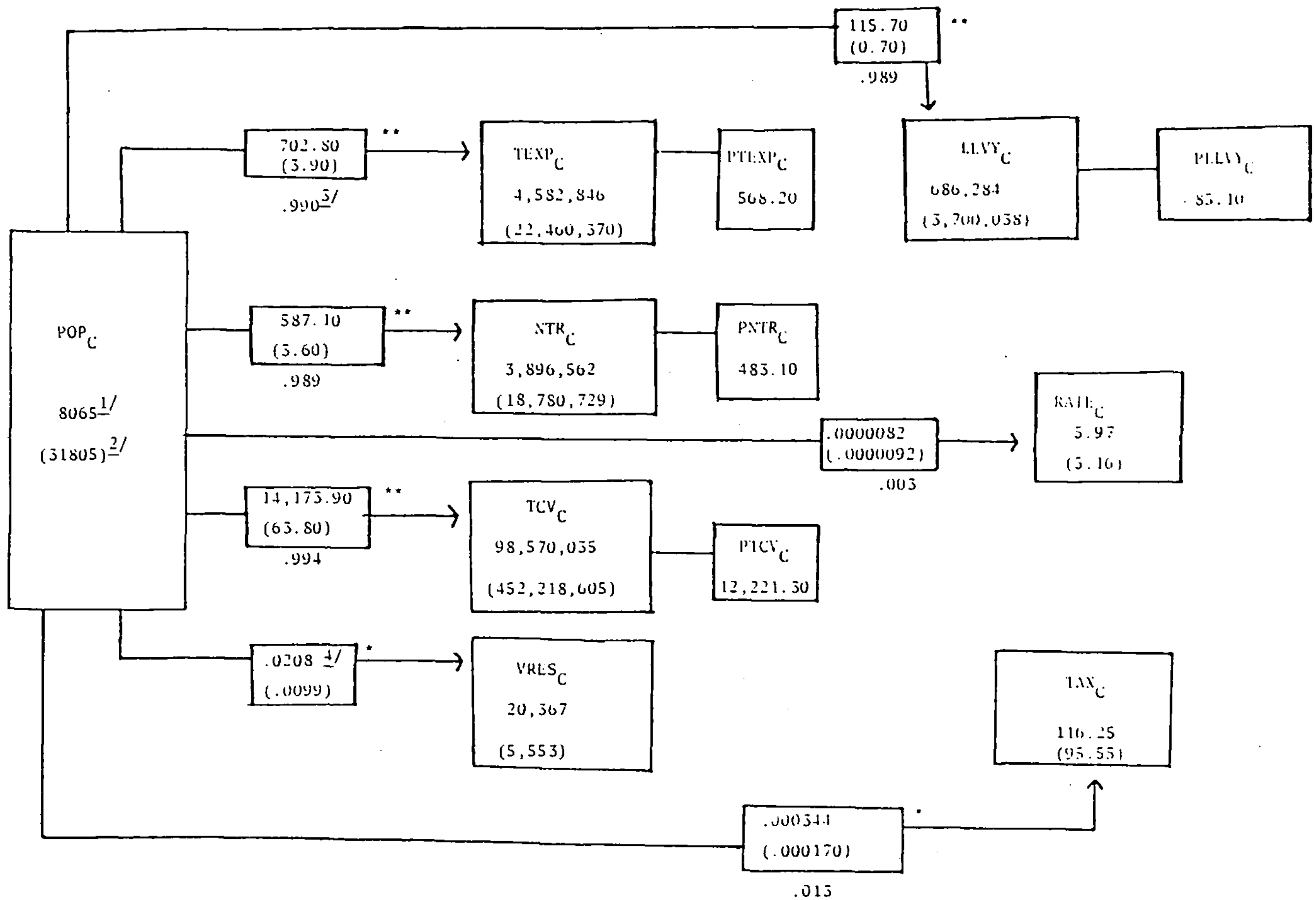
With the exception of the $CRATE_C$ equations (3-8-5 and 3-8-7) the changes in the variables composing TAX_C are significantly related to $CPOP_C$. $CPOP_C$ explains about 13 percent of the variation in $CTEXP_C$ and has a coefficient significant at the one percent level. Its value of 741.40 $\pm$ 310.00 indicates a change in average total city expenditures of $741.40 per unit change in population. This marginal expenditure is slightly higher (although not statistically different) than the estimated coefficient of 702.80 of equation 3-7-1. The inference that marginal expenditures equal average expenditures is supported by this result. The trend indicator of this equation, and of equations 3-8-2 and 3-8-3, is not significantly different from zero.

Nine percent of the variation in $CNTR_C$ is explained by $CPOP_C$. The point estimate of the regression coefficient is highly significant and just greater than the corresponding coefficient of equation 3-7-2. Its value is 596.00 $\pm$ 306.20 suggesting that non-property tax revenues change $596.00 per unit change in population.

Both the CTEXP and CNTR equations imply that short-run and long-run changes in these variables with respect to population are identical. This may be because cities translate population increases into expenditures and other revenues with little delay. Other governmental units may take more time to adjust.

Nearly 35 percent of the variation in $LEVY_C$ is explained by $CPOP_C$. The estimated coefficient is 145.40 $\pm$ 32.40; a confidence interval that just barely includes the estimated coefficient of 115.70 $\pm$ 1.40 in equation 3-7-3. Although we cannot say with 95 percent certainty that the coefficients differ, had the alternative hypothesis been that the coefficient in equation 3-8-3 is greater than that of 3-7-3 we could re-

Figure 3-10. Means and Simple Regression Coefficients: City Governments.



→☐→ = Simple regression; coefficient X = f(POP)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

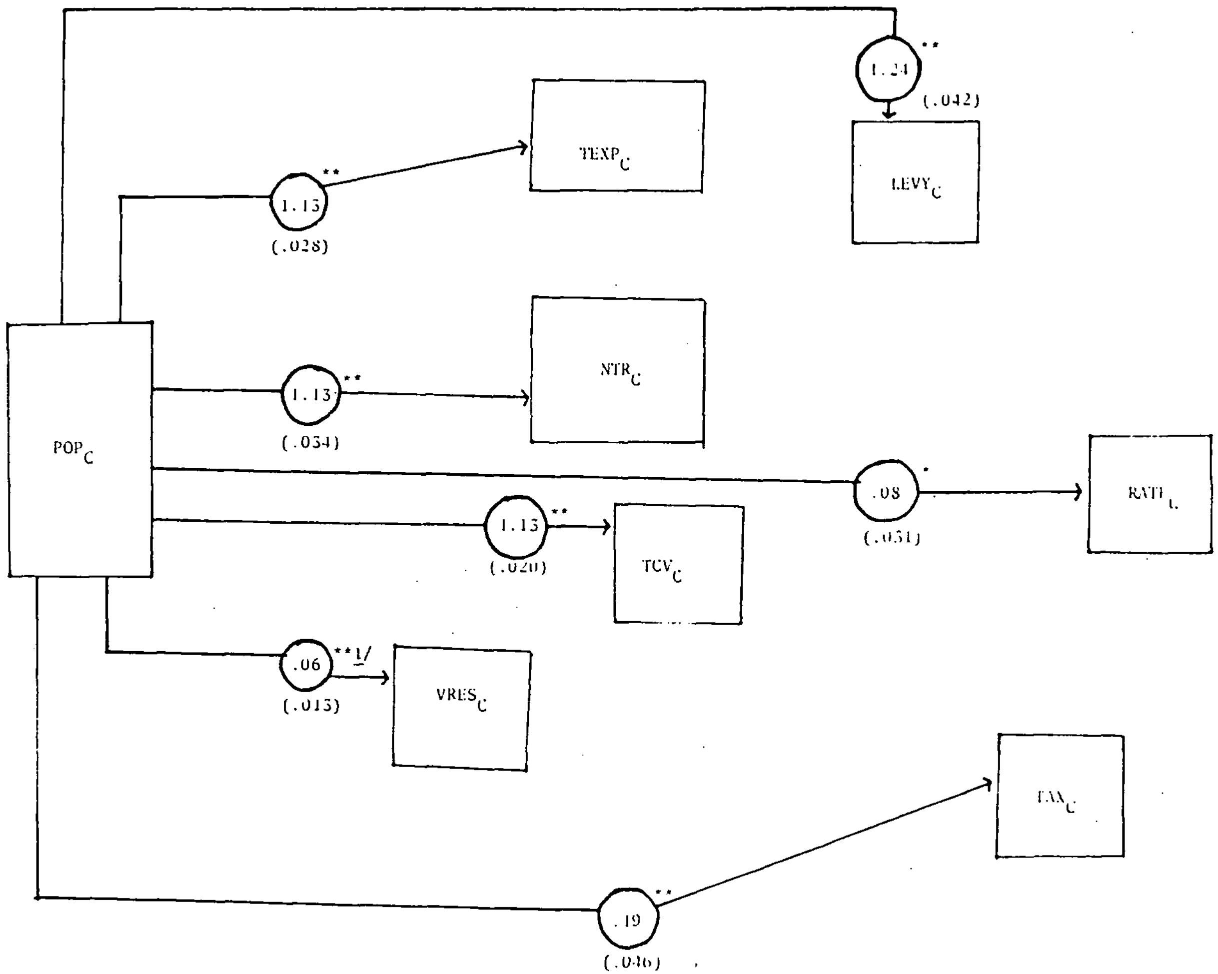
1/ All figures given in single units.

2/ Standard deviation of variable shown under the mean.

3/ R^2 of regression equation given below regression coefficient.

4/ $VRES_C$ equation shown for illustrative purposes only.

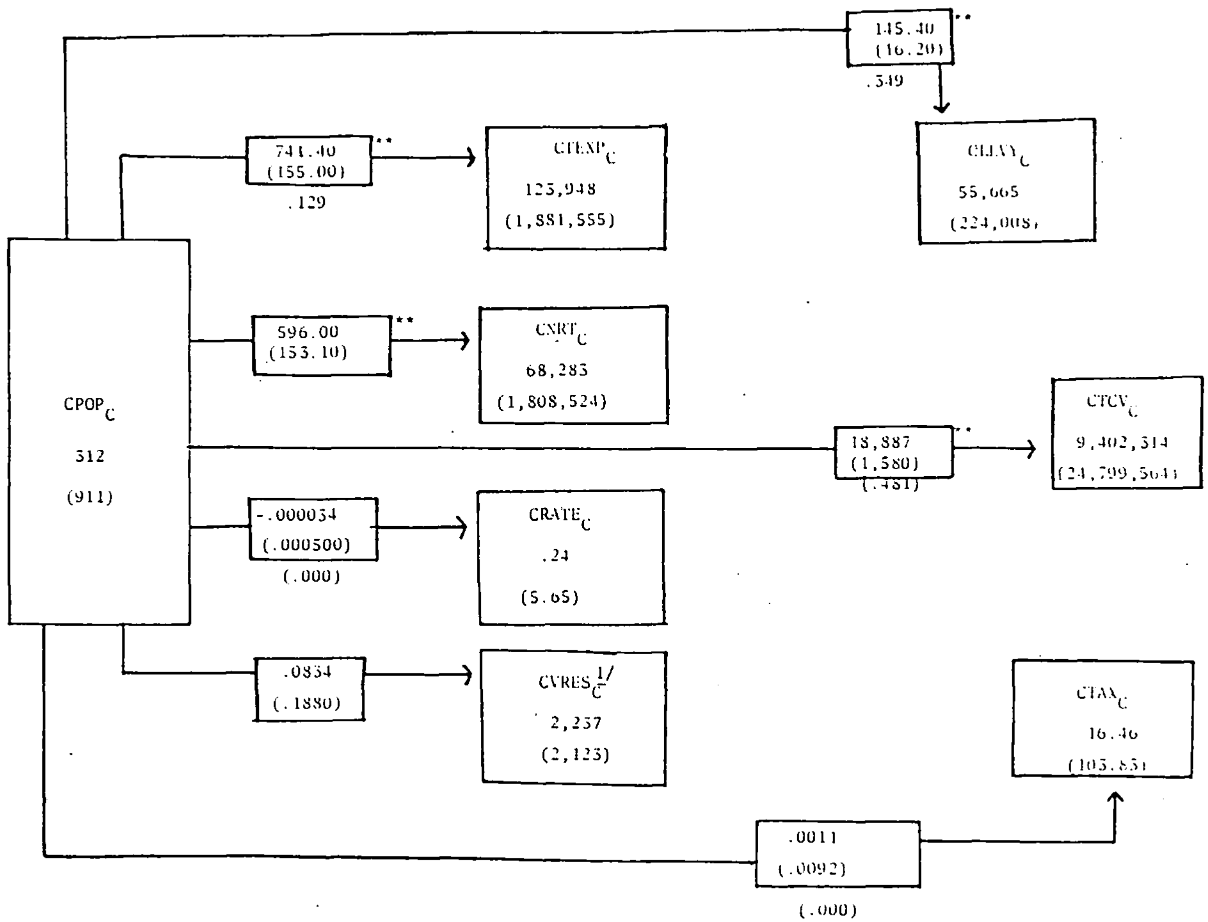
Figure 5-11. Constant Elasticities: City Governments.



—○— = Elasticity with respect to population.
( ) = Standard error of elasticities in parentheses.
** = Significant at one percent level (see page 67 for null hypotheses).
* = Significant at five percent level (see page 67 for null hypotheses).

1/ VRES$_C$ elasticity shown for illustrative purposes.

Figure 5-12. Means and Simple Regression Coefficients of Changes: City Governments.



= Simple regression; coefficient X = f(CPOP)
( ) = Standard error in parentheses.
** = Coefficient significantly different from zero @ one percent level.
* = Coefficient significantly different from zero @ five percent level.

1/ CVRES_C regression coefficient shown for illustrative purposes.

Table 3-7. Regression Results. Pooled Simple Equations: City Governments.

Equation number	Dependent variable	Intercept	POP	R^2	F
3-7-1	$TEXP_C$	-1,085,551 **	702.80 **	.990	32,097.45
		(128,520)[1]	(3.90)		
3-7-2	NTR_C	-838,890	587.10 **	.989	26,972.63
		(117,125)	(3.60)		
3-7-3	$LEVY_C$	-246,661 **	115.70 **	.989	26,980.87
		(23,072)	(0.70)		
3-7-4	TCV_C	-15,748,800 **	-14,173.90 **	.994	49,301.02
		(2,091,412)	(63.80)		
3-7-5	$RATE_C$	5.91 **	0.000008	.003	0.80
		(0.30)	(0.000009)		
3-7-6	TAX_C	113.48 **	0.000344 **	.013	4.11
		(5.55)	(0.000170)		

[1]Standard errors in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

Table 3-8. Regression Results. First Difference Equations: City Governments.

Equation number	Dependent variable	Intercept	CPOP	PCPOP	R^2	F
3-8-1	$CTEXP_C$	-107,610	741.40 **		.129	22.77
		(149,200)[1]	(155.00)			
3-8-2	$CNTR_C$	-117,870	596.00 **		.090	15.25
		(146,500)	(153.10)			
3-8-3	$CLEVY_C$	10,260	145.40 **		.349	82.73
		(15,350)	(16.20)			
3-8-4	$CTCV_C$	3,503,360 *	18,887 **		.481	142.80
		(1,517,350)	(1,580)			
3-8-5	$CRATE_C$	0.25	-0.000034		.000	0.00
		(0.48)	(0.000500)			
3-8-6	$CTAX_C$	16.10	0.001		.000	0.02
		(8.82)	(0.009)			
3-8-7	$CRATE_C$	0.49		-0.04	.007	1.10
		(0.51)		(0.03)		
3-8-8	$CTAX_C$	20.36 *		-0.548	.005	0.78
		(9.42)		(0.619)		

[1]Standard errors in parentheses.
**Indicates coefficient is significantly different from zero at the 1% level of significance.
*Indicates coefficient is significantly different from zero at the 5% level of significance.

Table 3-9. Mean Values of Local Government Variables.

Variable	1974 Mean	Two year mean	1976 Mean	Change 1974-1976	Percent change
$TEXP_A$	72,034,616	71,624,702	71,214,788	-819,828	-1.14
NTR_A	47,510,982	46,694,225	45,877,469	-1,633,513	-3.44
$LEVY_A$	24,523,635	24,930,477	25,337,320	813,685	3.32
TCV_A	934,931,870	972,607,377	1,010,282,900	75,351,008	8.06
$RATE_A$	22.52	22.37	22.21	-0.32	-1.41
$VRES_A$	17,180	18,118	19,056	1,876	10.92
TAX_A	389.54	410.16	430.78	41.24	10.59
POP_A	65,236	66,285	67,334	2,098	3.12
$TEXP_K$	13,500,800	13,368,469	13,236,139	-264,661	-1.96
NTR_K	11,342,118	11,135,695	10,929,272	-412,846	-3.64
$LEVY_K$	2,158,682	2,232,774	2,306,867	148,185	6.86
TCV_K	906,672,980	944,557,298	982,441,620	75,768,638	8.36
$RATE_K$	2.39	2.34	2.29	-0.09	-3.87
$VRES_K$	16,731	17,738	18,746	2,015	12.04
TAX_K	36.12	38.20	40.28	4.16	11.53
POP_K	63,486	64,535	65,584	2,099	3.31

Table 3-9 continued. Mean Values of Local Government Variables.

Variable	1974 Mean	Two year mean	1976 Mean	Change 1974-1976	Percent change
$TEXP_S$	3,004,912	3,104,460	3,204,007	199,094	6.63
NTR_S	1,375,292	1,410,073	1,444,853	69,561	5.10
$LEVY_S$	1,629,621	1,694,387	1,759,154	129,533	7.95
TCV_S	116,474,320	121,360,963	126,247,600	9,773,280	8.39
$RATE_S$	11.59	11.74	11.90	0.31	2.67
TAX_S	227.65	243.91	260.17	32.52	14.28
ADM	1,449	1,451	1,453	4	0.26
$TEXP_C$	4,520,872	4,582,846	4,644,820	123,948	2.74
NTR_C	3,862,421	3,896,562	3,930,704	68,283	1.77
$LEVY_C$	658,452	686,284	714,117	55,665	8.45
TCV_C	93,868,878	98,570,035	103,271,190	9,402,314	10.02
$RATE_C$	5.85	5.97	6.09	0.24	4.08
TAX_C	108.02	116.25	124.48	16.46	15.23
POP_C	7,909	8,065	8,222	312	3.95

ject at the 95 percent level of confidence the null hypothesis that the two were equal. In any case, there is some evidence that the marginal $LEVY_C$ exceeds the average $LEVY_C$ with respect to population. The $LEVY_C$ would be predicted to change by \$145.40 per unit change in population.

About half (48 percent) of the variation in $CTCV_C$ is explained by $CPOP_C$. The predicted trends in $CTCV_C$ exogenous of $CPOP_C$ is \$3,503,360 per city, significant at five percent, which is significantly less than the average $CTCV_C$ of \$9,402,312. The value of the regression coefficient is 18,887 $\pm$ 3,160 significant at one percent. The implication is a predicted change in TCV_C of \$18,887 per unit of change in population. This value is significantly different, and higher, than the value of the coefficient of equation 3-7-4 (14,173.90). It would appear that the marginal TCV_C exceeds the average TCV_C with respect to population.

The two results of the $CLEVY_C$ and $CTCV_C$ equation appear to support both the contention that population growth leads to higher-than-average tax levies, and that growth also leads to higher-than-average total property values. As it turns out, the net effect on $CRATE_C$ is about zero. Neither $CPOP_C$ nor $PCPOP_C$ explains even one percent of the variation in $CRATE_C$. Not surprisingly, neither regression coefficient differs significantly from zero. Further, as estimated by the trend intercepts, there is no apparent exogenous trend in $CRATE_C$.

Summary

The simple pooled equations presented in this chapter show a close fit between POP and the government block variables as well as TCV for each unit of government. In every case, for every variable, for each unit of government, the relation to population was positive and, with the exception of $RATE_K$ and $RATE_C$, significant. The positive relationship between TAX and POP appears to be mainly a result of residential property values becoming a larger portion of TCV which in turn is due at least in part to the more elastic response of TOTRES, hence VRES, to population as compared to the TCV population elasticity. This result may support the argument that property tax relief should be aimed primarily at home owners.

Another reason for the positive association between TAX and POP is because of the positive association between RATE and POP. This latter association appears to have its roots in the more elastic response of LEVY to POP than of TCV to POP. Tax districts appear to have increasingly higher levies compared to TCV when their populations are greater.

The change equations do not show much correlation between changes in the variables and changes in population. While population is ostensibly a good long-run predictor, the short-run changes have no apparent relation to changes in population. Either the changes over the two-year interval are random, or they are caused by something other than population changes. This is discussed at greater length in the following chapter. Now that the simple relationships have been presented the study turns to a more in-depth analysis and interpretation of the data.

CHAPTER IV

RESULTS BY VARIABLE

Introduction

The simple pooled and first difference regression equations presented in the last chapter have provided some useful insights into the tax-population relationship. Each unit of local government was analyzed separately to provide a first look at the relation between population and the variables which compose TAX. Some questions remain unanswered, however, and still others have emerged. In this chapter the analysis of the tax-population relation continues. Instead of analyzing the relationships by unit of government, the format returns to that of the theory chapter. The two main blocks of the model, governmental activities and property values, are re-examined and broken down by their sub-groups: expenditures, non-property tax revenues, the levies, and total and residential property values. Further regression results are presented in an attempt to clarify some of the confused or contradictory relationships that emerged from the last chapter.

Paramount among these issues is the lack of similarity between the pooled results and the first difference results. While the theory developed in Chapter II would have one believe that the results in either instance would be comparable, clearly comparability was the exception, not the rule.

Several explanations suggest themselves depending upon the variable and the unit of government in question. Most obviously, the "lumpiness" induced by capital expenditures is likely to introduce variation in the dependent variable which will not be explained by the change in population over the same period of time. For example, a capital expenditure in time t may be a direct result of population growth up to time (t - 1), yet entirely independent of growth between the two most recent time periods. The model, however, estimates changes in the dependent variable vis-à-vis changes in population during the same period. Certainly a lagged relationship could easily exist yet never be demonstrated by the model.1/ Had the data been available it would, of course, have been preferable to include more observations over time as well as the lagged relationships between population growth and the dependent variables. For policy purposes it would naturally be useful to have information on the expected change in some future time period given a (known) change in the current period's population.2/

Before beginning a closer examination of the several dependent variables and their relationship with population a general discussion of the change versus pooled regression estimates is appropriate. It was noted in the previous chapter that the first difference regression equations bore little resemblance to the pooled equations. Furthermore, the coefficients tended to be non-significant and R^2 values low.

1/ One justification of the model which circumvents this flaw is an assumption about the relationship between population growth in different time periods. If, over some period of time, say a decade, growth is relatively constant then growth in any time period within the decade is highly correlated with growth in any other time period in the decade. If so, then the use of growth in the current time period would be equivalent (or nearly so) to using the lagged variable which would have been the "true" explanatory variable.

2/ Recall, however, that this is not the object of this study. The purpose here is to determine how (or whether) population is related to current residential property tax bills. As such, this study is only a partial and first-run assessment of the larger question of how population is related to both present and future residential property tax bills.

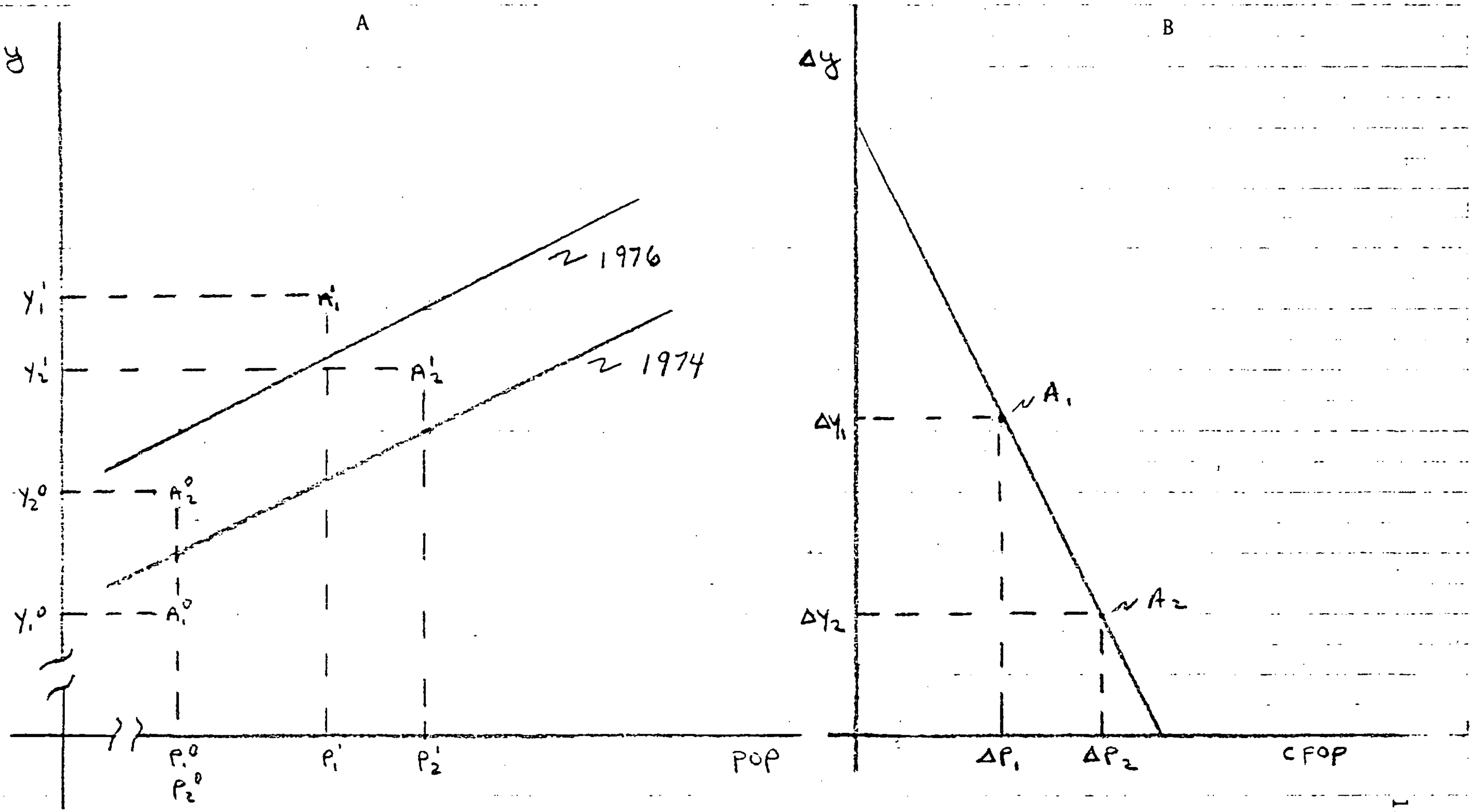
To examine the possibility that some structural change took place over the two-year interval which was not captured by either POP or CPOP, equations were estimated for each year with the cross-sectional data for each unit of government, with the same general results for each variable. Two typical regression equations for the two years are shown in Figure 4-1A. The Y axis represents any of the dependent variables estimated and the X axis represents population. For illustrative purposes, the graph measures only a small portion of the regression lines. Points A_1^0 and A_2^0 represent two local governments, A_1 and A_2, in 1974 both with population $P_1^0 = P_2^0 = P^0$. The Y value for government A_1 is Y_1^0, the value for A_2 is Y_2^0. There are, of course, other points (observations) from which the regression line for 1974 is estimated which are not shown, but which are near the regression line as evidenced by the high R^2 values for these regression equations (see Tables 4-10 through 4-17).

The two hypothetical local government have grown by 1976. District A_1 now has the values (P_1^1, Y_1^1) and A_2 has the values (P_2^1, Y_2^1). Again, the remaining unseen observations result in a new regression line for 1976 which is parallel to and slightly above the estimated line for 1974.[3/]

Note that in each time period both districts are about the same small distance from the regression lines, so the two regression equations fit the data equally well in either time period, i.e., in either year a district's population and the dependent variable are highly correlated. Throughout the range of population values the observations (districts) lie near the estimated regression lines suggesting that despite whatever

3/ For some variables the 1976 line was parallel to and slightly below the 1974 line. The argument in either instance is the same.

Figure 4-1. Comparison of Pooled vs. Change Equations: An Illustration.



differences there may be between tax districts of different sizes, the tax districts appear to respond to population in similar fashions. While one could not say assuredly that local governments move along the regression curve as they grow, it does appear that in fact they have the tendency to so do. Even with exogenous shifts up (or down) in the curve it can be shown that a movement from any point on one curve to any point on the other curve follows the form of the general change equation. To repeat, briefly:

(1) $Y_{t+1} = b_0 + b_1 POP_{t+1} + b_2(t+1)$

(2) $Y_t = b_0 + b_1 POP_t + b_2$

(3) $\Delta Y = b_1 \Delta POP + b_2(1)$

Where equation (3) is merely equation (2) subtracted from equation (1). The parameter b_2 in equation (3) is the intercept of the equation representing the exogenous trend in Y over the interval of time, or the vertical distance between the two separate regression estimates. The parameter b_1 is the (same) slope of the regression line. Hence, one would expect the coefficient on CPOP to equal that which is on POP. The results in Chapter III demonstrate that that occurrence was rare, despite the high R^2 values for equations (1) and (2). Further, the coefficient on CPOP was generally non-significant and R^2 values approached zero. Why?

To help see why refer back to the figure. Note that the district A_1 was below the 1974 regression line but above the 1976 regression line. Conversely A_2 was above for 1974, below for 1976. In panel B the change in population is plotted on the abscissa and the change in Y is plotted on the ordinant. Had these been the only observations available on change the regression line would pass through the two points as indicated.

Clearly, the slope and intercept of the new equation are not what would be expected from the pooled equations.

Extending the analysis to include all observations, it is not hard to imagine similar behavior by other local governments; that is, a general tendency for the observations to lie on or near the regression line for the first year (1974), then after growth has occurred there is a general tendency for the observations to be clustered about the new regression line (1976). Note, however, that because the lines are so close to one another that very little change need take place in the 1974 value of the dependent variable for its new (1976) value to lie near the 1976 regression line. The summary statistics presented in the previous chapter make it clear that for most units of government the values of the dependent variables did not change much over the two-year interval.[4/] As such, the two regression lines are statistically inseparable although they are drawn separately for purposes of illustration. If, indeed, they are not separable then the change in the dependent variable is analogous to the residual, that is, unexplained, variation in the dependent variable. Looking at it this way, it is obvious that population is not going to explain the residual variation in the dependent variable since the residual is what is left unexplained by population in the first place.

A general interpretation of the effects of the two data types is helpful in assessing the usefulness of the two types of equations which have been estimated. As Willis points out, "the sort of behavior measured by cross-sectional data is likely to be long-run in nature, while time series data typically reveals short-run behavior" (p. 19). The data used for this study seems to support that statement. Over the long-run, districts

[4/] In no instance did a statistical test of the difference between two means of any of the variables in each year prove significant.

do appear to generally follow the estimated pooled regression lines. Between two periods of time (the short-run) there is some variation around the line which is not explained by population or more precisely change in population. One would have to conclude that the estimates derived from the data are useful for long-run assessments of the effects of population, but fare poorly in explaining an immediate, i.e., short-run effect of a change in population. Further, one would also have to conclude that short-run and long-run responses to population growth do not appear to be the same.

The interested reader is referred to Tables 4-16 through 4-23 for a tabular summary of the separate regression results for each year. In no instance does any significant change in the slope of the regression line occur between the two years, implying that there was little, if any, change in the behavioral relationship between the dependent variable and population over the two-year interval. Only the intercept terms change by any magnitude and even then the differences are not statistically significant.

Until now, all of the results presented have been simple, single explanatory variable equations. The rationale for examining only bivariate relationships, i.e., excluding other explanatory variables, was discussed in Chapter I, and the argument remains in force here. There are reasons, however, for desiring slightly more complex estimating equations yet retaining the same bivariate relations. To do so, one need only employ polynomials of degree greater than one. Rather than having only simple linear relationships, the inclusion of polynomials of the same explanatory variable, population, allows curvilinear fits to the sample data, which, hopefully, would more closely approximate the "true" underlying relationships of the entire population. The polynomials that have been examined in this study are of degree one (POP) and degree two (POPSQ or population-squared) which gives the familiar quadratic form. There are both theoretical and statistical reasons for including a population-squared term.

Theoretically there are sound reasons for including POPSQ which were discussed in Chapter II, and need not be discussed here. Despite the generally high R^2 values of the simple equations so far presented there are also statistical reasons for inclusion of POPSQ, which are not unrelated to the theoretical bases for polynomial estimation.

In the previous chapter, it was hypothesized that the prevalence of negative intercepts suggested a curvilinear fit to the data. If the "true" population regression line does get steeper as POP increases, then fitting a straight line to the data could easily result in a negative intercept. In such a case, the inclusion of a polynomial term (POPSQ) should, by allowing a curved fit, result in a more accurate fit to the data.

In a similar vein, the addition of the polynomial term POPSQ could improve the accuracy of the equations' predictions. It is known, of course, that additional explanatory variables, unless completely uncorrelated with the dependent variable, will always improve R^2 values. This may seem like unnecessary effort for equations with R^2 values approaching 1.00. Note, however, that R^2 may be defined (Johnston, p. 35) as follows:

$$(4) \quad R^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2}$$

which by rearranging is:

$$(5)\quad \frac{\sum_{i=1}^{n} (y_i - \hat{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2} = 1 - R^2$$

which is equivalent to:

$$(6)\quad \frac{\sqrt{\sum_{i=1}^{n} (y_i - \hat{y})^2 / n}}{\sqrt{\sum_{i=1}^{n} (y_i - \bar{y})^2 / n}} = \sqrt{1 - R^2}$$

If R = .99, then the right side of (6) equals:

$$\sqrt{1 - R^2} = \sqrt{.01} = .1$$

implying that the numerator on the left side is one-tenth the size of the denominator. If the estimated standard deviation of the dependent variable (the denominator) is large, then the standard error of the regression equation (the numerator) while only one-tenth as large may still be fairly big. Since the sum of squares of deviation of the y_i about the mean, $\bar{y}$, remains constant, any improvement in R^2 will reduce the standard error of the regression estimate. The standard error of the estimate may be interpreted intuitively as the average absolute value of the distance between an observation and the regression curve, which is another measure of the accuracy of the regression equation. Although prediction is not the main goal of this study, certainly the model would be more helpful to policymakers the better it predicts.

With these general thoughts in mind, it is now time to examine the endogenous variables and their relation to population.

Local Government Expenditures

In this section the relation between local government expenditures and population is examined in more detail. The discussion includes a comparison of the relation among the three units of local governments, the presentation and interpretation of the quadratic regression results, and an assessment of the accuracy of the TEXP equations. Following this section there is a similar discussion of the association between NTR and population.

The R^2 values indicate that POP does a better job explaining variation in city expenditures (99 percent) than the expenditures of any other unit of government, although the school relationship is nearly as close with 98 percent of the variation explained. Also, the 95 percent confidence interval around the regression coefficient is extremely narrow for the city equation, extending over a range of only about 15 dollars (see Table 4-4).

The state-wide average population/student ratio is 5.2. If the school regression coefficient of 2,221.20 is divided by 5.2 the result (427.20) is a rough approximation of the association between school expenditures and the population of a district which makes possible comparisons of the relative effect of POP on the expenditures of the three units of government. The sum total of the three regression coefficients is 1,327.00. If one assumes that each person is thus associated with $1,327.00 in local government expenditures it is clear that the major share of the expenditures is attributable to city governments. Of the $1,327.00, $702.80 or 53 percent are at the city level, $427.20 or 32 percent are at the school level, and the remaining $197.00 or 15 percent are at the county level.

The estimates of the regression coefficients on POP in the previous chapter may be biased. A variable which is theoretically related to TEXP is income (INC). The simple correlations between INC and POP_K, POP_S, and POP_C are, respectively, 0.46, 0.23, and 0.15, all positive values. Assuming the "true" coefficients on INC in the expenditure equations are positive then the direction of the bias on the estimated coefficient is in each case positive. In the case of expenditures the bias is not too serious because whether the true cause of the level of expenditure is the size of population or the district's income is immaterial. It is the association between expenditures and population that is of concern in this study. Given that objective the only real advantage there would have been in including income would be a possible improvement in the predictive power.

There is some improvement in the $TEXP_K$ equation when $POPSQ_K$ is included but not much (Table 4-1). Only about seven percent of the residual sum of squares from the simple equation (3-3-1) is explained by $POPSQ_K$. There is also a correspondingly small reduction in the standard error of the estimate demonstrated by the coefficient of variation (C.V.) which goes from 60.1 percent to 57.5 percent.

For $TEXP_S$ the reduction in unexplained variation is even smaller upon including the squared term ADMSQ (Table 4-2). ADMSQ accounts for only 4.5 percent of the residual sum of squares in $TEXP_S$. The C.V. goes down to 43.2 percent from 43.7 percent, a negligible difference.

Twenty percent of the residual sum of squares in $TEXP_C$ is explained by $POPSQ_C$ (Table 4-3), although that translates into an increase in R^2 of only .002. And the C.V. is slightly reduced from 48.0 percent to 44.2 percent.

Despite the absence of significant statistical gains the quadratic equations are nonetheless interesting. For all three units of government the coefficient on the squared term is positive and significantly different from zero implying that across the board the expenditures of local governments appear to be increasing marginal functions of population. This phenomenon could be a result of either the increase in demand for public goods and services as districts get larger or because of the nature of the supply curve for public goods and services or for both reasons. The model is not fine enough to answer why spending patterns are such, only that they are.

Whether one judges the expenditure equations to be accurate depends on ones point of view. The R^2 values are certainly high which means that expenditures and population are highly correlated. Also the standard errors of the regression coefficients are very small resulting in narrow confidence intervals around the coefficients (see Table 4-4).

On the other hand it was shown in this chapter's introduction that high R^2 values do not necessarily imply accurate predictive abilities. One indicator of predictive ability is the coefficient of variation (C.V.) which, expressed as a percentage, is the ratio of the standard error of the estimating equation to the mean value of the dependent variable. Table 4-4 shows that none of the TEXP equations had C.V.'s of less than 40 percent. The school equations had the lowest C.V., the counties the highest.

Another test of predictive ability is to test the equations with actual examples. Ideally one would use available observations which had not been included in the data set from which the equations were estimated. Unfortunately, all available data was used in this study. The best alternative is to use observations chosen on some basis and comparing their actual and predicted values. Although this procedure has one evaluating predictions with the same data used to estimate the equations used to generate the predictions, the large number of observations on each unit of government tends to mitigate the bias.

Three examples are chosen for illustrative purposes on the basis of covering the geographic areas of the state and the range of populations among schools, cities, and counties. One city is Corvallis chosen as a fairly large Willamette Valley city. The second city is Grants Pass chosen because it is in the mid-range of populations and is a western Oregon city not in the Willamette Valley. The last city is Burns, chosen because of its relatively small population and because of its Eastern Oregon location which is said to be God's country. In addition the main school districts for each city are examined (Corvallis 509J, Grants Pass 7, and Burns 1) and finally the counties in which the cities are located are examined (Benton, Josephine, and Harney).

The predicted and actual values for each of the nine expenditure variables are presented in Table 4-5. All are generated from the equations of Table 4-1 through 4-3. Also the percentage difference between the predicted and actual values are listed with the actual value as the point of reference.

For the three areas chosen the $TEXP_S$ appear to be predicted reasonably well. The Grants Pass prediction is off by only 2.4 percent. The $TEXP_C$ equations do the next best job although the most accurate prediction is nearly nine percent from the true value. The $TEXP_K$ equations are the poorest predictors for the three examples. The percentage deviations range from 17 percent to 63 percent.

Table 4-1. Regression Results. Pooled Quadratic Equations: County Governments.

Equation number	Dependent variable	Intercept	POP	POPSQ	R^2	F
4-1-1	$TEXP_K$	2,590,270	142.70 **	0.000117*	.875	227.58
		(1,383,238)[1]	(25.00)	(0.000050)		
4-1-2	NTR_K	1,727,694	150.40 **	-0.0000106	.785	117.03
		(1,416,862)	(25.70)	(0.0000516)		
4-1-3	$LEVY_K$	862,575 **	-7.70 **	0.000128**	.988	2,793.95
		(112,755)	(2.00)	(0.000004)		
4-1-4	TCV_K	72,766,495 **	13,309.70 **	0.001162	.989	2,918.38
		(27,005,462)	(489.10)	(0.000983)		
4-1-5	$RATE_K$	2.87**	-0.000017**	0.0000000000367**	.418	23.32
		(0.15)	(0.000003)	(0.0000000000054)		
4-1-6	$VRES_K$	13,886 **	0.0956 **	-0.000000139**	.567	42.57
		(655)	(0.0119)	(0.000000024)		
4-1-7	TAX_K	40.04**	-0.00012 **	0.000000000463**	.464	28.18
		(2.48)	(0.00005)	(0.000000000094)		

[1]Standard errors in parentheses.
**Indicates coefficient significant at 1% level.
*Indicates coefficient significant at 5% level.

Table 4-2. Regression Results. Pooled Quadratic Equations: School Districts.

Equation number	Dependent variable	Intercept	ADM	ADMSQ	R^2	F
4-2-1	$TEXP_S$	-25,000	2,124.80 **	0.0024**	.979	13,762
		(63,435)[1]	(28.60)	(0.0006)		
4-2-2	NTR_S	48,788	942.40 **	-0.0003	.901	2,684
		(60,088)	(27.10)	(0.0006)		
4-2-3	$LEVY_S$	-73,788*	1,182.40 **	0.0027**	.983	17,514
		(32,728)	(14.80)	0.0003)		
4-2-4	TCV_S	20,951,319**	58,434.10 **	0.8143**	.977	12,646
		(2,762,192)	(1,247.10)	(0.0275)		
4-2-5	$RATE_S$	10.54**	0.0011**	-0.000000020**	.133	45
		(0.26)	(0.0001)	(0.000000003)		
4-2-6	TAX_S	208.07**	0.0322)**	-0.00000056**	.174	62
		(6.52)	(0.0029)	(0.00000006)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at the 1% level.
*Indicates coefficient is significant at the 5% level.

Table 4-3. Regression Results. Pooled Quadratic Equations: City Governments.

Equation number	Dependent variable	Intercept	POP	POPSQ	R^2	F
4-3-1	$TEXP_C$	-645,570 **	613.60 **	0.000260**	.992	18,995.00
		(131,730)[1]	(12.30)	(0.000034)		
4-3-2	NTR_C	-524,560 **	523.40 **	0.000186**	.990	14,890.00
		(124,270)	(11.60)	(0.000032)		
4-3-3	$LEVY_C$	-121,010 **	90.20 **	0.000744**	.993	22,369.00
		(20,010)	(1.90)	(0.000052)		
4-3-4	TCV_C	-3,428,985 *	11,675.90 **	0.00729 **	.997	45,929.00
		(1,709,685)	(159.90)	(0.00045)		
4-3-5	$RATE_C$	5.82**	0.000026	-0.000[2]...0	.004	0.58
		(0.37)	(0.000031)			
4-3-6	TAX_C	109.03**	0.0012*	-0.000[2]...0	.022	3.40
		(6.17)	(0.0006)			

[1]Standard errors in parentheses.

[2]Coefficient extends to ten digits beyond decimal point, is negative and not significant.

**Indicates coefficient is significant at 1% level.

*Indicates coefficient is significant at 5% level.

Table 4-4. Comparisons of Simple Regression Coefficients and Standard Errors of Estimating Equations for Local Government: Total Expenditures.

Unit of Government	Simple pooled coefficient on POP or ADM	95% Confidence interval	Standard Error[1] of estimate	Coefficient[1] of variation	Standard Error[2] of estimate	Coefficient[2] of variation
COUNTY						
Coefficient	197.00	178.40 to 215.60	8,039,926	60.1	7,943,286	57.5
Standard Error	9.30					
R^2	.87					
SCHOOL						
Coefficient	2,221.20	2,194.20 to 2,248.20	1,356,433	43.7	1,343,494	43.2
Standard Error	13.50					
R^2	.98					
CITY						
Coefficient	702.80	695.00 to 710.60	2,200,245	48.0	2,023,981	44.2
Standard Error	3.90					
R^2	.99					

[1]Computed from pooled simple equations.
[2]Computed from pooled quadratic equations.

Table 4-5. Comparison of Predicted Versus Actual Values for Selected Tax Districts: Total Expenditures.

Variable	District[1]	Predicted Value	Actual Value	Percentage Difference[2] predicted from actual
$TEXP_K$	Benton (65,600)	12,454,883	8,663,642	+43.7
$TEXP_K$	Josephine (47,000)	9,555,623	15,587,452	-38.7
$TEXP_K$	Harney (7500)	3,667,101	4,289,268	-14.5
$TEXP_S$	Corvallis 509J (7046)	15,065,491	16,938,282	-11.1
$TEXP_S$	Grants Pass 7 (4040)	8,598,364	8,808,814	- 2.4
$TEXP_S$	Burns 1 (681)	3,667,101	4,289,268	-14.5
$TEXP_C$	Corvallis (40,180)	24,428,630	22,265,762	+ 9.7
$TEXP_C$	Grants Pass (13,570)	7,728,860	5,281,017	+46.3
$TEXP_C$	Burns (3600)	1,566,760	1,040,664	+50.6

[1]Population of district in parentheses.

[2]Computed by: $\left(\frac{\text{Predicted - Actual}}{\text{Actual}}\right) \text{ X } 100\%$.

In comparing the three areas there seems to be no pattern to the predictive abilities. Grants Pass school expenditures achieve the closest prediction but Josephine County has the worst.

All of the equations make it clear that while the association between local government expenditures and population is strong the equations are not especially good predictors. Over the long-run the expenditure-population relation appears to be stable, an inference based on the similar behavior of large and small districts. But for any specific district more information about local characteristics needs to be incorporated into any predictive analysis. Even with as much as 99 percent of the variation explained by population, the variance of TEXP is so large that the remaining one percent is still substantial.

How the expenditure-population relation influences the size of property tax levies depends on the simultaneous relationship of non-property tax revenues and population. The next section covers that relation.

Local Government Non-Property Tax Revenues

The counterpart of TEXP in the government block is NTR, the non-property tax revenues received by a unit of local government. In this section, a more complete analysis of the relationship between population and NTR is presented. Following the procedure of the expenditures section, a comparison of the relationship is made among the units of local government after which the quadratic regression results are presented and interpreted, and finally an assessment of the accuracy of the NTR equations is offered. In the next section there is a similar discussion of the association between LEVY and population.

It was pointed out in Chapter III that population did a poorer job explaining variation in county NTR than in any of the three units of local government studied, as indicated by the R^2 values. In light of the discussion of Chapter II on county non-property tax revenues this result is not surprising. A major portion of the NTR received by counties are from Forest Service and BLM timber sales with the amount received depending on current timber demands and prices, not on population. Josephine County, for example received almost $13 million in O & C payments in 197 (U.S. Department of Interior, 1977). Its total NTR received in 1976 was about $15.5 million, most of which, obviously, was obtained from O & C payments. The 1976 NTR was well above the state-wide average county of $10.9 million even though the 1976 county population of 47,000 was below the state average of 65,584. This example, although admittedly extreme, does cause one to wonder how POP_K was able to account for 78 percent of the variation in NTR_K, and why its coefficient has such a small standard error.

Although O & C payments are very important to those counties that receive them, the distribution is hardly even. Only 18 of the 36 counties are O & C counties (17 of the 35 in the data set) and of those, over two-third of the monies go to four counties (Douglas, Jackson, Josephine, and Lane), which, excepting Josephine, have populations well above the state county average. The dummy variable, OC, excluded from equation 3-3-2 is equal to 1.0 if a county is an O & C county, and zero if not. But because OC is not independent of POP_K (their correlation coefficient is .49), its exclusion imparts a bias on the coefficient of POP_K: POP_K accounts for some of the effect of OC.

Not surprisingly, the school NTR equation does quite well with ADM as an explanatory variable. ADM explains 90 percent of the variation in NTR_S. It was noted in the last chapter that the coefficient on ADM was below the average $PNTR_S$ of 971.70. The "true" coefficient, however, may be higher in light of the theoretical discussion on school NTR_S. Dropping $PTCV_S$ from the estimating equation for NTR_S (equation 3-5-2) has the usual effect of biasing the estimated coefficient on ADM. The correlation coefficient between ADM and $PTCV_S$ is -0.14. Under the assumption that NTR_S is inversely related to $PTCV_S$, the bias of the ADM coefficient is positive; that is, it over-estimates the true coefficient. This is a mildly surprising result as the bias was expected to be negative.

Not much can be said about the relationship between population (as opposed to ADM) and NTR_S in the absence of information about school district populations. A first-run approximation can be made, however, by dividing the regression coefficient by 5.2, the average statewide population/student ratio. The result of that division is 178.70, which would be the average increase in a school district's NTR associated with a population increase of one. If, over the long-run there is information about the population/student ratio, especially of incoming residents, the expected addition to NTR from increases in population may be adjusted accordingly, above or below the $178.70 figure.

POP_C does exceptionally well explaining variation in NTR_C with an R^2 of .99 in equation 3-7-2. Judging by the regression coefficient, NTR_C on a *per capita* basis is higher than for the other two units of government combined.

In the case of NTR_C the omitted variable was INC, the *per capita* income of the city. Because the correlation coefficient between POP_C

and INC is positive (0.15) the bias on the POP_C coefficient is assumed to be negative because of the assumption that the "true" coefficient on INC, is negative. This assumption may be weak, however, due to the possibility that wealthier communities with more ability to sustain more extensive public services such as parks and recreation facilities, libraries, health facilities, and businesses and industries, all of which may generate fees, may actually have higher NTR values than similar sized but poorer communities. If so, that is, if NTR_C and INC are positively related, then the bias on the POP_C coefficient would be positive, indicating that it over-estimates the "true" coefficient.

The quadratic NTR equations for the three units of government are disappointing in that the POPSQ and ADMSQ terms explain little of the residual variation in NTR after fitting POP and ADM (Tables 4-1 through 4-3). In only one case -- city NTR -- is POPSQ statistically significant and of the predicted sign. As expected, it is positive implying that NTR_C is an increasing marginal function of POP_C. Unfortunately, the negative and significant intercept of equation 3-7-2 remains, although it has been reduced. Also, the increase to R^2 due to $POPSQ_C$ is imperceptible.

In both other NTR equations the coefficients on POPSQ and ADMSQ are negative and non-significant, and in both cases the increase in R^2 from the addition of POPSQ and ADMSQ is negligible.

The accuracy of the NTR equations corresponds to the accuracy of the TEXP equations. The standard errors of the regression coefficients are roughly equivalent to the TEXP coefficients although the ratios of the standard errors to the regression coefficients are a bit larger. Narrow confidence intervals for the coefficients prevail, however (see Table 4-6).

Table 4-6. Comparisons of Simple Regression Coefficients and Standard Errors of Estimating Equations for Local Governments: Nonproperty-Tax Revenue.

Unit of Government	Simple Pooled Coefficient on POP or ADM	95% Confidence Interval	Standard Error[1] of estimate	Coefficient[1] of variation	Standard Error[2] of estimate	Coefficient[2] of variation
COUNTY						
Coefficient	145.80	127.40 to 164.20	8,205,621	71.1	8,136,375	70.5
Standard Error	9.20					
R^2	.78					
SCHOOL						
Coefficient	929.40	904.00 to 954.80	1,269,724	90.0	1,262,598	89.5
Standard Error	12.70					
R^2	.90					
CITY						
Coefficient	587.10	579.90 to 594.30	2,005,167	51.5	1,909,366	49.6
Standard Error	3.60					
R^2	.99					

[1]Computed from pooled simple equations.

[2]Computed from pooled quadratic equations.

Table 4-7. Comparison of Predicted Versus Actual Values for Selected Tax Districts: Nonproperty-tax Revenues.

Variable	District[1]	Predicted Value	Actual Value	Percentage Difference[2] predicted from actual
NTR_K	Benton (65,600)	11,548,318	6,465,991	+78.6
NTR_K	Josephine (47,000)	8,773,079	15,587,452	-43.7
NTR_K	Harney (7500)	2,855,098	3,810,022	-25.1
NTR_S	Corvallis 509J (7046)	6,674,044	5,707,272	+16.9
NTR_S	Grants Pass 7 (4040)	3,851,188	4,441,155	-13.3
NTR_S	Burns 1 (681)	1,362,091	1,266,984	+ 7.5
NTR_C	Corvallis (40,180)	20,805,936	20,665,926	+ .7
NTR_C	Grants Pass (13,570)	6,612,229	3,899,579	+69.6
NTR_C	Burns (3600)	690,423	908,588	-24.1

[1] Population of district in parentheses.

[2] Computed by: $\left(\dfrac{\text{Predicted} - \text{Actual}}{\text{Actual}}\right) \times 100\%$.

The C.V.'s tend to be rather large for both the simple and polynomial equations, ranging from 49 percent to 90 percent. These figures do not bode well for the predictive accuracy of the NTR equations.

The three example areas bear out that claim (Table 4-7). As with the TEXP equations the predictions tend to be better with school districts, deviating from 7.0 percent to 15.3 percent from the true values. And, again, the county equations are the worst with as much as 77.7 percent inaccuracy. That 77.7 percent figure is from Josephine County whose extraordinary NTR figures have already been discussed. The inaccuracy demonstrates the danger of putting too much faith in the estimated association between NTR_k and POP, especially when some causality is implied.

The city NTR equations fare poorly with the exception of Corvallis which has a relative inaccuracy of less than one percent.

The difference between TEXP and NTR is the LEVY. In the next section the LEVY-population relationship is examined.

Local Government Property Tax Levies

In almost every instance population explains a higher proportion of the variation in LEVY than in either TEXP or NTR. This supports the notion that budget committees adjust the levies according to the size of the population served by the district and paying the property taxes.

The bulk of the property tax levies associated with each member of the population goes to school districts. Dividing the regression coefficient on ADM by the population/ADM ratio of 5.2 gives a figure of 248.40. Then, summing the regression coefficients for each unit of government the result is 415.30. Of that, 60 percent goes to the schools, 28 percent to cities, and 12 percent to counties.

Unlike the TEXP and NTR equations, the addition of the squared population terms adds significantly to the explanatory power of the equations (Tables 4-1 through 4-3). At the city level, 36 percent of the unexplained sum of squares are explained by $POPSQ_C$. About 11 percent of the residual in the school equation is explained by ADMSQ. And a whopping 94 percent of the unexplained sum of squares in the simple county LEVY equation is accounted for by $POPSQ_K$.

This latter result is, to say the least, a surprise. It coincides with a reduction in the C.V. from 113.0 percent to a respectable 28.3 percent. The reason for such a significant increase in explanatory power may be behind the negative sign on POP_K in the quadratic equation. Since the intercept has a positive sign, and the $POPSQ_K$ coefficient has a positive sign, a graph of the equation would reveal a U-shaped curve. It makes sense that the smaller counties would have larger levies than some of the mid-size counties because none of the smaller counties receive O & C funds. The mid-size counties such as Josephine, Columbia, Coos, Curry, Klamath, and Polk all receive substantial O & C payments. Although the POP_K and $POPSQ_K$ explain most of variation in $LEVY_K$ the result must be due to the importance of the O & C payments. While population and the omitted dummy variable in the NTR equation are correlated, there is no causality implied from population to O & C payments. The correlation is coincidental; no matter how big the eastern counties grow they will never obtain revenues from the O & C timber sales. So, because the bias on POP_K in the NTR_K equation was positive it is negative in the $LEVY_K$ equation since the $LEVY_K$ equation is $TEXP_K$ - NTR_K. The expected value of the estimated POP_K coefficient (and the estimated $POPSQ_K$ coefficient) is less than the "true" value of the POP_K (and $POPSQ_K$) co-

Table 4-8. Comparisons of Simple Regression Coefficients and Standard Errors of Estimating Equations for Local Governments: Property Tax Levies.

Unit of Government	Simple Pooled Coefficient on POP or ADM	95% Confidence Interval	Standard Error[1] of Estimate	Coefficient[1] of Variation	Standard Error[2] of Estimate	Coefficient[2] of Variation
COUNTY						
Coefficient	51.20	45.40 to 57.00	2,522,450	113.0	647,498	28.3
Standard Error	2.90					
R^2	.82					
SCHOOL						
Coefficient	1,291.80	1,277.20 to 1,306.40	731,288	43.2	693,147	40.8
Standard Error	7.30					
R^2	.98					
CITY						
Coefficient	115.70	114.30 to 117.10	394,983	57.6	307,433	44.8
Standard Error	0.70					
R^2	.99					

[1] Computed from pooled simple equations.

[2] Computed from pooled quadratic equations.

Table 4-9. Comparison of Predicted Versus Actual Values for Selected Tax Districts: Property Tax Levies.

Variable	District[1]	Predicted Value	Actual Value	Percentage Difference[2] predicted from actual
$LEVY_K$	Benton (65,600)	906,565	2,197,651	-58.8
$LEVY_K$	Josephine (47,000)	781,547	0	-[3]
$LEVY_K$	Harney (7500)	811,725	479,246	+69.3
$LEVY_S$	Corvallis 509J (7046)	8,391,446	11,231,010	-16.4
$LEVY_S$	Grants Pass 7 (4040)	4,747,176	4,367,659	+ 8.7
$LEVY_S$	Burns 1 (681)	732,679	257,631	+184.8
$LEVY_C$	Corvallis (40,180)	3,622,694	1,599,836	+126.5
$LEVY_C$	Grants Pass (13,570)	1,116,631	1,381,438	-19.2
$LEVY_C$	Burns (3600)	876,336	132,076	+563.6

[1]Population of district in parentheses.

[2]Computed by: $\left(\frac{\text{Predicted - Actual}}{\text{Actual}}\right)$ X 100%

[3]Value is not defined.

efficient. Each person in a county would be associated with a higher value of $LEVY_K$ in a "true" model.

The $LEVY_C$ and $LEVY_S$ equations are both increasing functions of population reflecting the increasing TEXP equations and the inability of NTR to increase at a rate sufficient to offset the increased expenditures.

The LEVY equations appear to be highly accurate; at least, the R^2 values are high in the simple equations, and even more so in the quadratic equations. The confidence intervals around the simple coefficients are extremely narrow (see Table 4-8). The standard error of the estimates, however, follow a pattern similar to the TEXP and NTR equations. And so do the coefficients of variation. About the only difference is that the county C.V. is lower than either the school or city C.V.'s.

As to predictive accuracy the LEVY equations do about the same job with the three example areas as the TEXP and NTR equations.

In Josephine County the percentage error is undefined because there was no county LEVY in 1976, again, because the O & C payments create substantial errors. Also, Benton County's prediction was way off, missing by 142 percent. The remaining predictions range in quality from fair (eight percent on Grants Pass school levy) to poor (84.5 percent on Burns city levy).

In short, the LEVY equations show a strong, tight fit between local government levies and population. Unfortunately, the strong fit is not indicative of accurate predictions, at least judging by the C.V.'s and the three chosen examples.

Property Values

In light of the discussion at the outset of this chapter, it would seem appropriate to extend the analysis of property values beyond the basic results derived in the previous chapter. Consequently, this section is devoted to the analysis of the relationship between property values and population. Comparisons of the relationship among types of local governments is made, quadratic regression results are presented and interpreted with comparisons to the elasticity estimates and an evaluation of the accuracy of the estimates is made complete with predictions from the three example cities chosen in the previous section. Following the analysis of the property block, the two major blocks are discussed as a whole; that is, the workings, implications, and results for the complete model are proffered.

The discussion of elasticities in the last chapter implied that the effect of population is stronger on residential property than on other classes of property as a whole, at least at the county level. Had the comparisons been made at the city level, given information on VRES, the results would not necessarily have been the same.

For example, TCV_C elasticity with respect to population is $1.13 \pm .04$, which is significantly greater than one. If the VRES elasticity for cities were the same as for counties (.18) then the net property block influence on tax bills would be slight. Perhaps, though, it would be more likely that the VRES elasticity would also be higher in the cities corresponding to the higher TCV elasticity.

Of the three units of government, only the cities have an estimated TCV elasticity of greater than one. The TCV_S elasticity (.81) corresponds closely to the TCV_K elasticity (.84). Assuming a constant population-to-student ratio then the effect of population on school district property is virtually identical to the effect on county property -- not a very surprising result since it is the same property in either case with different boundaries defining the districts,

Estimating TCV as a linear function of population the regression coefficients of the city equations may be compared to those of the county equations. At the county level the estimate of POP_K coefficient is 13,839.30 ± 356,80. This confidence interval overlaps the confidence interval around the regression coefficient in the city equation which is 14,173.90 ± 127.60, although the point estimate of the coefficient on POP_C is greater than the corresponding coefficient on POP_K. While one could not conclude that the coefficients differ, one might expect that because the city's point estimate is higher, had city property been excluded from the county data set, the two coefficients would have been significantly different.

The coefficient on ADM in the TCV_S equation is 91,103.00. Dividing by 5.2, the average population/student ratio, the value is 17,519.80. This is higher than the estimates of either the city or county equations. Why this occurs is not clear. Perhaps families with school-age children tend to locate in the more wealthy districts. It is also entirely possible that had the true POP/ADM ratios been known for each district and that information incorporated into the estimates that the resulting regression coefficients would have been no different than the one on POP_K.

The TCV estimating equations that include the POPSQ and ADMSQ term are also all fairly similar (Tables 4-1 through 4-3). As expected,[3/] the sign of the coefficients on POP (or ADM) and POPSQ (or ADMSQ) are positive in all cases. The implication is that the marginal TCV is an increasing marginal function of population; that is plotting TCV as the dependent

3/ See Chapter III.

(Y) variable, the curve gets steeper as population increases. For cities this is a neat result. The estimated population elasticity of TCV was 1.12 which implies an ever steeper TCV regression curve.

Such is not the case with either schools or counties both of which had estimated TCV elasticities of less than one. An elasticity of less than one corresponds to a TCV curve which increases at a decreasing rate -- it flattens out at higher levels of POP (or ADM). Why the two results differ is not clear. Possibly the apparent contradiction is a result of the mathematics of OLS regression which minimizes the sum of squares $[(Y - \hat{Y})^2]$. The quadratic regressions use the actual values for each observation giving a proportionally greater weight to the observations with TCV and POP values differing greatly from the mean. The elasticity estimates are computed using natural logs which transform the data in a manner which gives relatively less weight to those observations at the extreme ends of the range than does the former procedure. Note, for example, that the two numbers 10 and 100 differ in absolute magnitude by a factor of ten, but their natural logs differ only by a factor of two. The contradictory results could be the result of the difference between the two estimating procedures. In the range of values encompassed by about 80 percent of the observations, however, the two estimating equations are nearly equal.

Whatever the explanation, it is at least implied by the quadratic equations that the relationship between TCV and POP (or ADM) remains similar regardless of the unit of government under examination.

One other comment on the quadratic equations is appropriate here. At the county level the $POPSQ_K$ coefficient is not statistically significant. Whether this result is because the equation is mis-specified by the inclusion of $POPSQ_K$ or because of collinearity with POP_K is not clear. The simple correlation coefficient between POP_K and $POPSQ_K$ is .93 a fairly high correlation. It is well known (Johnston) that the effect of multicollinearity is to inflate the variance of the coefficient. For a two-explanatory variable model the simple correlation coefficient can be used to estimate how much the variance is actually inflated (Brown, 1978). The procedure is to invert the matrix of simple correlation coefficients, where the inverse of the determinants of the correlation matrix is the variance inflative factor (VIF). In the case where r_{12} equals .93, the VIF is 7.40 implying that the standard error of the coefficient is inflated by 2.72, more than enough to result in a t-test which fails to reject the null hypothesis that the coefficient equals zero. The VIF's for schools (4.43) and cities (10.26) were apparently offset by the large number of observations in each set which reduced the estimated standard error of the $POPSQ_C$ and ADMSQ coefficients.

Finally the R^2 values of the quadratic equations are generally a great improvement over the simple equations. The already high (.989) R^2 value for TCV_K (equation 3-3-4) is unchanged with the addition of $POPSQ_K$ (Table 4-1). But almost 60 percent of the unexplained variation in TCV_S (equation 3-5-4) is explained with the addition of ADMSQ, as the R^2 value goes from .943 to .977. Similarly, half of the residual variation in TCV_C (equation 3-7-4) is explained by $POPSQ_C$, R^2 going from .994 to .997. The increase in R^2 for VRES is also notable as the R^2 value nearly doubles from .309 in equation 3-3-6 to .567 in equation 4-1-6.

What about the accuracy of the estimating equations? It was demonstrated earlier in this chapter that the estimated R^2 value is not always a reliable indicator of the predictive ability of a regression equation.

But in assessing the accuracy of the equations there is more to consider than predictive ability. It is just as important, if not more important, to know how accurate the estimated coefficients are. This study addresses the relationship between certain variables and population, and that relationship is estimated by the regression coefficient. Policy makers will no doubt want accurate predictions as well, however.

Following the procedure of the government block section, one can examine the coefficients of variation (see Table 4-10). At the county level, the C.V. is 16.0 percent, the best of the three units of government. In light of the tremendous variation in TCV_K this is a reasonably good figure. The addition of $POPSQ_K$ does little to improve the accuracy of the equation, reducing the C.V. to 15.9 percent.

As measured by the C.V. the school district equations are the least accurate with the standard error of the estimate equal to 75.8 percent of the mean TCV_S value. The addition of ADMSQ results in a reduction of the C.V. to a more respectable 48.2 percent.

Between the two aforementioned coefficients is the city C.V. of 36.3 percent, so that the standard error of the estimates is approximately one-third of the mean TCV_C. The standard error is reduced considerably with the inclusion of $POSPQ_C$ resulting in a C.V. of 26.6 percent.

The remarkably small standard errors of the simple regression coefficients were noted previously. The narrow confidence intervals about the estimates provide tight, high probability estimates of the "true" coefficients, or, in other words, of the linear relationship between TCV and population. The coefficients of variation for the estimated regression coefficients at the county, school, and city levels are, respectively, 1.3 percent, 1.0 percent, and 0.5 percent, all of which are acceptably low.

Table 4-10. Comparisons of Simple Regression Coefficients and Standard Errors of Estimating Equations for Local Governments: Property Values.

Unit of Government	Simple Pooled Coefficient on POP or ADM	95% Confidence Interval	Standard Error[1] of Estimate	Coefficient[1] of Variation	Standard Error[2] of Estimate	Coefficient[2] of Variation
COUNTY						
Coefficient	13,839.30	13,482.50 to 14,196.10	151,129,170	16.0	150,182,611	15.9
Standard Error	178.40					
R^2	.99					
SCHOOL						
Coefficient	91,103.00	89,268.60 to 92,937.40	92,021,412	75.8	58,500,230	48.2
Standard Error	917.20					
R^2	.94					
CITY						
Coefficient	14,173.90	14,046.30 to 14,301.50	35,804,508	36.3	26,268,788	26.[illegible]
Standard Error	63.80					
R^2	.99					
COUNTY VRES						
Coefficient	.0323	.0207 to .0439	5,006	28.2	3,759	20.7
Standard Error	.0058					
R^2	.31					

[1]Computed from pooled simple equations.

[2]Computed from pooled quadratic equations.

Table 4-11. Comparison of Predicted Versus Actual Values for Selected Tax Districts: Property Values.

Variable	District[1]	Predicted Value	Actual Value	Percentage Difference[2] predicted from actual
TCV_K	Benton (65,600)	950,833,320	711,606,031	+33.6
TCV_K	Josephine (47,000)	700,889,250	594,535,042	+17.9
TCV_K	Harney (7500)	172,654,610	113,649,214	+51.9
TCV_S	Corvallis 509J (7046)	473,104,820	505,771,264	- 6.5
TCV_S	Grants Pass 7 (4040)	270,315,760	270,343,452	0
TCV_S	Burns 1 (681)	61,122,582	42,806,397	+42.8
TCV_C	Corvallis (40,180)	477,477,890	357,259,000	+33.7
TCV_C	Grants Pass (13,570)	156,355,390	184,817,000	-15.4
TCV_C	Burns (3600)	38,698,733	25,313,000	+52.9
VRES	Benton (65,600)	19,559	28,630	-31.7
VRES	Josephine (47,000)	18,072	19,323	- 6.5
VRES	Harney	14,595	14,023	+ 4.1

[1]Population of district in parentheses. [2]Computed by: $\left(\frac{\text{Predicted - Actual}}{\text{Actual}}\right)$ X 100%.

The accuracy of the equations with respect to the three examples of the previous sections is presented next (see Table 4-11).

The equations generally predict best for the Grants Pass area, not a surprising result because its population and ADM values are near their respective mean values. The prediction for TCV_S in Grants Pass District 7 is almost perfect. Other predictions vary from good (VRES in Harney and Josephine Counties) to poor (TCV in Burns). As a group, and as predictors the equations would have to be considered disappointing. On the other hand, the equations were not developed as predictors per se or they would have included more explanatory variables, most notably income. Also, the VRES equations even with low R^2 values are not bad as predictors, missing by only 6.5 percent in Josephine County and 4.1 percent in Harney County. So, there is hope that with additional information on VRES and better specification, a good predictive equation is not far away.

Property Tax Rates

Not surprisingly, the simple RATE equations showed a generally low correlation between RATE and POP (or ADM). The estimated coefficients were all positive although significant only for schools. Even there, though, ADM explained only five percent of the variation in $RATE_S$ and the coefficient was very small. It predicts a difference in $RATE_S$ of only three cents for each difference of 100 students. That translates as a difference of three cents for every difference of 520 people in a school district using the state-wide population/student ratio. Population explained practically none of the variation in $RATE_K$ or $RATE_C$.

The addition of the squared population term changes things considerably for $RATE_K$ and $RATE_S$ but not for $RATE_C$. In the latter case, neither term has a significant coefficient and the equation explains less than one percent of the variation in $RATE_C$.

POP_K and $POPSQ_K$ together explain nearly 42 percent of the variation in $RATE_K$. Both variables have coefficients significant at the one percent level. Interestingly, the $RATE_K$ equation (4-1-5) is a U-shaped curve as was the $LEVY_K$ equation (4-1-3). Since TCV_K was an increasing marginal function of population, the $RATE_K$ result must stem from the nature of the LEVY-population relation. Undoubtedly, the lower levies for mid-size counties resulting from their large NTR_S, most notably O & C funds, are the direct cause of tax rates being lowest at a medium value of population. Actually, solving the equation for the value of population which minimizes the rate yields the value of roughly 225,000 which would be a large Oregon county. Beyond that size, the equation predicts rapidly rising tax rates.

As with the $LEVY_K$ equation (4-1-3), and for the same reasons, it would be dangerous to presume too much of a causal relationship between population and county tax rates.

The $RATE_S$ equation is also improved with the addition of ADMSQ. The equation (4-2-5) explains about 13 percent of the variation in $RATE_S$. And the coefficients are significant at the one percent level. In the case of schools, however, with respect to ADM the rate appears to increase at a decreasing rate. Apparently, at some point the increase in TCV_S associated with population would be sufficient to offset the increase in $LEVY_S$.

Despite the low R^2 values of the RATE equations, the standard errors of the estimates are not much worse than those of the better fitting equations as indicated by the coefficients of the variation (Table 4-12). The C.V.'s range from a low of 36.5 percent for counties to 86.5 percent

Table 4-12. Comparisons of Simple Regression Coefficients and Standard Errors of Estimating Equations for Local Governments: Property Tax Rates.

Unit of Government	Simple Pooled Coefficient on POP or ADM	95% Confidence Interval	Standard Error[1] of Estimate	Coefficient[1] of Variation	Standard Error[2] of Estimate	Coefficient[2] of Variation
COUNTY						
Coefficient	.00000021	-.0000254 to .0000258	1.10	47.0	0.85	36.5
Standard Error	.00000128					
R^2	.00					
SCHOOL						
Coefficient	.000307	.000193 to .000421	5.71	48.7	5.46	46.4
Standard Error	.000057					
R^2	.05					
CITY						
Coefficient	.0000082	.0000102 to .0000266	5.17	86.5	5.17	86.5
Standard Error	.0000092					
R^2	.00					

[1] Computed from pooled simple equations.

[2] Computed from pooled quadratic equations.

Table 4-13. Comparison of Predicted Versus Actual Values for Selected Tax Districts: Property Tax Rates.

Variable	District[1]	Predicted Value	Actual Value	Percentage Difference[2] predicted from actual
$RATE_K$	Benton (65,600)	1.93	3.09	-37.5
$RATE_K$	Josephine (47,000)	2.17	0	-[3]
$RATE_K$	Harney (7500)	2.75	4.22	-34.8
$RATE_S$	Corvallis 509J (7046)	17.30	22.21	-22.1
$RATE_S$	Grants Pass 7 (4040)	14.66	16.16	- 9.3
$RATE_S$	Burns 1 (681)	11.28	16.03	-29.6
$RATE_C$	Corvallis (40,180)	6.86	4.48	+53.1
$RATE_C$	Grants Pass (13,570)	6.17	7.47	-17.4
$RATE_C$	Burns (3600)	5.91	5.21	+13.4

[1] Population of district in parentheses.

[2] Computed by: $\left(\frac{\text{Predicted} - \text{Actual}}{\text{Actual}}\right) \times 100\%$.

[3] Value is not defined.

for cities. Only the county C.V. is reduced by the addition of POPSQ. The other two governments' C.V.'s remain nearly the same.

As usual, the percentage differences between the predicted and actual values for the three example areas have a pattern similar to the results of previous variables (Table 4-13). The percentage error for Josephine County is undefined, since there was no levy; hence, no tax rate. The Corvallis city prediction is off by over 50 percent, the rest ranging from 9.3 percent off (Grants Pass School) to 37.5 percent off (Benton County). In most cases, the equation under-estimated the actual value of the RATE.

Except possibly for the schools, the relationship between RATE and population appears to be fairly tenuous. For cities, there is almost no correlation. For counties, the correlation appears to be coincidental. What about the TAX-population relation as a result?

Property Tax Bills

The simple linear equations and the elasticities presented in the last chapter show a positive significant relationship between TAX and population. The larger the tax district, the larger the tax bill one would expect to pay. This relationship was due in part to the positive relation between RATE and population but perhaps more so due to the VRES behavior with respect to population.

The improved results of the quadratic equations for RATE and VRES described in the previous two sections make one wonder how well TAX can be explained with the two variables POP and POPSQ (or ADM and ADMSQ). For the TAX equations, the results follow a pattern similar to the LEVY and RATE equations. The greatest improvement was for county TAX, then school TAX, and last but least, the city TAX.

Almost half of the variation in TAX_K can be explained by POP_K and $POPSQ_K$ (equation 4-1-7). The regression coefficients are both significant at the one percent level. Also, the by now familiar U-shaped curve obtains for TAX_K. Counties in the mid-range of population would be predicted to have a minimum tax. Solving equation 4-1-7 for the value of population which minimizes TAX_K gives a figure of about 125,000. To put that into perspective, only five counties have larger populations. Jackson County, at 113,000, is the closest. A county of 50,000 would be predicted to have a TAX_K of \$39.45, one of 250,000 a TAX_K of \$39.96. The minimum predicted TAX_K (at 125,000 population) would be 32.75. Clearly, even though the equation is statistically significant, over a wide range of population, TAX_K would not be predicted to vary significantly in an economic sense.

For the same reasons that applied in the NTR_K, $LEVY_K$ and $RATE_K$ equations, caution should be taken in interpreting the influence of POP_K on TAX_K. Since the estimated coefficients on the population term(s) had a negative bias in the LEVY equation, the same sign of the bias will also hold for the TAX_K equation. Probably, the regression coefficients underestimate the "true" effect of population on TAX_K. The influence of the O & C revenues which are not "caused" by population pressures are probably a factor determining the shape of the TAX_K curve.

The introduction of $POPSQ_K$ does reduce the standard error of the estimate by 17 percent, an appreciable reduction. The new C.V. is 37.7 percent, a good deal less than the previous (simple) C.V. of 46.8 percent (see Table 4-14).

The TAX_S equation is also improved by the addition of the squared population term ADMSQ, although not by as much as the TAX_K equation improved. The R^2 value more than doubles from .07 to .17. Its coefficients are both significant at the one percent level. Like $RATE_S$, equation 4-2-6 predicts that TAX_S will increase at a decreasing rate with respect to ADM. But solving the equation for the ADM value which would maximize TAX_S gives a result of nearly 29,000. Only one school district in the state (Portland) has as many students. The rest, if they follow expectations may expect to have higher average residential tax bills the larger they are. $LEVY_S$ increases at an increasing rate. And although TCV_S also increases at an increasing rate, it is not enough to offset the $LEVY_S$ increase until a size of about 27,000 ADM is reached, at which time $RATE_S$ is predicted to be a maximum. That alone could cause TAX_S to be a positive function of population but when coupled with increasing residential property values (which are increasing faster than TCV) there is little hope that some optimal size of school district will be reached insofar as residential property tax bills for schools are concerned.

For TAX_C there appears to be little to gain by including POPSQ. True, the R^2 doubles, but it only goes from .01 to .02. The coefficient on $POPSQ_C$ is not significantly different from zero at the five percent level, and the coefficient on POP_C is still barely significant at five percent. Except for that, there would appear to be little in the way of a relationship between population and city residential property tax bills. What relation there is is due to the relationship between VRES and population. The city tax rate and population are almost entirely uncorrelated (equation 4-3-5). Even though $LEVY_C$ is an increasing marginal function of population, TCV_C is also and appears to almost exactly offset the rise in $LEVY_C$. People living in larger cities might be expected to pay higher tax bills but, given the large confidence interval around the regression

Table 4-14. Comparisons of Simple Regression Coefficients and Standard Errors of Estimating Equations for Local Governments: Residential Property Tax Bills.

Unit of Government	Simple Pooled Coefficient on POP or ADM	95% Confidence Interval	Standard Error[1] of Estimate	Coefficient[1] of Variation	Standard Error[2] of Estimate	Coefficient[2] of Variation
COUNTY						
Coefficient	.0000996	.000058 to .0001412	17.88	46.8	14.83	37.7
Standard Error	.0000208					
R^2	.25					
SCHOOL						
Coefficient	.00977	.00685 to .01269	146.12	59.9	138.02	56.5
Standard Error	.00146					
R^2	.07					
CITY						
Coefficient	.000344	.000004 to .000684	95.08	81.8	94.82	81.6
Standard Error	.000170					
R^2	.01					

[1]Computed from pooled simple equations.

[2]Computed from pooled quadratic equations.

Table 4-15. Comparison of Predicted Versus Actual Values for Selected Tax Districts: Residential Property Tax Bills.

Variable	District[1]	Predicted Value	Actual Value	Percentage Difference[2] predicted from actual
TAX_K	Benton (65,600)	34.40	88.47	-61.1
TAX_K	Josephine (47,000)	35.59	0	-[3]
TAX_K	Harney (7500)	39.18	59.18	-33.8
TAX_S	Corvallis 509J (7046)	407.15	635.87	-36.0
TAX_S	Grants Pass 7 (4040)	329.02	312.26	+ 5.4
TAX_S	Burns 1 (681)	229.74	224.79	+ 2.2
TAX_C	Corvallis (40,180)	157.52	128.26	+22.8
TAX_S	Grants Pass (13,570)	125.58	144.34	-13.0
TAX_S	Burns (3600)	113.62	73.06	+55.5

[1] Population of district in parentheses.

[2] Computed by: $\left(\frac{\text{Predicted - Actual}}{\text{Actual}}\right)$ X 100%.

[3] Value is not defined.

coefficient (Table 4-14) and the large standard error of the estimate (the C.V. is 81.8 percent), this would be only a tendency. Since nearly 98 percent of the variation in TAX_C is unexplained by population, it appears that other factors are more important than population in influencing the TAX_C bills.

Despite the poor statistical results for the TAX_C equations, they don't fare too badly in predicting TAX_C values for the three example cities (Table 4-15). The prediction for Burns is off the mark, missing by 55.5 percent, but the Corvallis and Grants Pass predictions miss by only 22.8 percent and 13.0 percent respectively, not much different than the results of previously discussed variables.

The TAX_K equations do the worst of the three units of government although the inaccuracy of Josephine County is a result of its exceptionally high O & C revenues.

The TAX_S predictions are easily the best although the Corvallis figure is a third off the mark. Still, in Grants Pass and Burns figures are only 5.4 percent and 2.2 percent away from the actual values.

Summary

In this chapter the quadratic regression results were presented. The addition of POPSQ (or ADMSQ) resulted in improved explanatory power, and the coefficients on the variable were usually significant. The quadratic equations generally showed that most of the tax-component variables appear to be increasing marginal functions of population. The notable exceptions were $LEVY_K$, $RATE_K$, and each of the TAX variables.

Despite the high R^2 values in most equations, the equations do not predict well, at least judging by the coefficients of variation and the example predictions. The regression coefficients, however, appear to be highly accurate.

In the next chapter the major conclusions of this and the last chapter are summarized and suggestions for further research are presented.

Table 4-16. Regression Results. Pooled Simple Equations: Aggregated Local Governments, 1976.

Dependent Variable	Intercept	Population	R^2	F
$TEXP76_A$	-7,488,182	1,168.50 **	.962	804.75
	(5,134,590)[1]	(41.20)		
$NTR76_A$	-4,776,482	752.00 **	.931	433.34
	(4,503,444)	(36.10)		
$LEVY76_A$	-2,711,699 *	416.40 **	.986	2,205.64
	(1,105,340)	(8.90)		
$TCV76_A$	62,140,445	14,076.60 **	.990	3,169.17
	(31,170,703)	(250.00)		
$RATE76_A$	20.869 **	0.000020 *	.131	4.80
	(1.130)	(0.000009)		
$VRES76_A$	16,863 **	0.0326 **	.358	17.81
	(962)	(0.0077)		
$TAX76_A$	349.212 **	0.00121 **	.481	29.70
	(27.702)	(0.00022)		

[1]Standard Errors in parentheses.

**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-17. Regression Results. Pooled Simple Equations: Aggregated Local Governments, 1974.

Dependent Variable	Intercept	Population	R^2	F
$TEXP74_A$	-4,981,640	1,181.00 **	.982	1,703.71
	(3,477,978)	(28.60)		
$NTR74_A$	-2,692,917	769.80 **	.970	1,034.69
	(2,909,200)	(23.90)		
$LEVY74_A$	-2,288,722	411.10 **	.984	1,923.51
	(1,139,542)	(9.40)		
$TCV74_A$	47,934,977	13,601.50 **	.988	2,745.16
	(31,555,871)	(259.60)		
$RATE74_A$	20.800 **	0.000026 *	.176	6.86
	(1.227)	(0.000010)		
$VRES74_A$	15,219 **	0.0301 **	.339	16.44
	(901)	(0.0074)		
$TAX74_A$	307.92 **	0.00125 **	.530	36.04
	(25.34)	(0.00021)		

[1]Standard Errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-18. Regression Results. Pooled Simple Equations: County Governments, 1976.

Dependent Variable	Intercept	Population	R^2	F
$TEXP76_K$	502,529	195.70 **	.866	207.40
	(1,693,581)[1]	(13.60)		
$NTR76_K$	1,629,386	143.80 **	.779	112.88
	(1,686,946)	(13.50)		
$LEVY76_K$	-1,126,857 *	51.90 **	.823	148.57
	(530,508)	(4.30)		
$TCV76_K$	62,140,445	14,076.60 **	.990	3,169.17
	(31,170,703)	(250.00)		
$RATE76_K$	2.27 **	0.0000005	.003	0.08
	(0.22)	(0.0000018)		
$VRES76_K$	16,863 **	0.0326 **	.358	17.81
	(962)	(0.0077)		
$TAX76_K$	34.42 **	0.000106 **	.268	11.70
	(3.85)	(0.000031)		

[1]Standard Errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-19. Regression Results. Pooled Simple Equations: County Governments, 1974.

Dependent Variable	Intercept	Population	R^2	F
$TEXP_K$	1,040,914	198.30 **	.863	202.31
	(1,694,417)[1]	(13.90)		
$NTR74_K$	2,148,912	147.30 **	.787	118.26
	(1,646,883)	(13.50)		
$LEVY74_K$	-1,107,998 *	50.90 **	.810	136.18
	(530,516)	(4.40)		
$TCV74_K$	47,934,977	13,601.50 **	.988	2,745.16
	(31,555,871)	(259.60)		
$RATE74_K$	2.34 **	0.00000009	.000	0.00
	(0.24)	(0.00000194)		
$VRES74_K$	15,219 **	0.0301 **	.339	16.44
	(901)	(0.0074)		
$TAX74_K$	31.32 **	0.000090 **	.269	11.77
	(3.19)	(0.000026)		

[1]Standard Errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-20. Regression Results. Pooled Simple Equations: School Districts, 1976

Dependent Variable	Intercept	ADM76	R^2	F
$TEXP76_S$	-171,879 *	2,323.30 **	.984	18,224.99
	(73,808)[1]	(17.20)		
$NTR76_S$	61,149	952.20 **	.908	2,930.56
	(75,440)	(17.60)		
$LEVY76_S$	-233,028 **	1,371.00 **	.983	17,439.19
	(44,525)	(10.40)		
$TCV76_S$	11,367,678 *	94,704.40 **	.947	5,288.75
	(5,585,045)	(1,302.20)		
$RATE76_S$	11.48 **	0.000289 **	.038	11.62
	(0.36)	(0.000085)		
$TAX76_S$	245.72 **	0.0100 **	.064	20.43
	(9.44)	(0.0022)		

[1]Standard Errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-21. Regression Results. Pooled Simple Equations: School Districts, 1974.

Dependent Variable	Intercept	ADM74	R^2	F
$TEXP74_S$	-75,645	2,125.60 **	.977	12,349.19
	(84,428)[1]	(19.10)		
$NTR74_S$	59,432	908.00 **	.894	2,505.39
	(80,066)	(18.10)		
$LEVY74_S$	-135,077 **	1,217.70 **	.987	22,554.76
	(35,787)	(8.10)		
$TCV74_S$	-10,667,361	87,728.50 **	.942	4,830.70
	(5,571,339)	(1,262.20)		
$RATE74_S$	11.12 **	0.000324 **	.057	17.95
	(0.34)	(0.000077)		
$TAX74_S$	213.73 **	0.0096 **	.079	25.60
	(8.38)	(0.0019)		

[1] Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-22. Regression Results. Pooled Simple Equations: City Governments, 1976

Dependent Variable	Intercept	Population	R^2	F
$TEXP76_C$	-1,139,307 **	705.20 **	.991	17,172.61
	(177,036)[1]	(5.40)		
$NTR76_C$	-903,500 **	589.30 **	.989	14,040.02
	(163,612)	(5.00)		
$LEVY76_C$	-235,808 **	115.90 **	.991	16,419.30
	(29,758)	(0.90)		
$TCV76_C$	-13,428,399 **	14,226.70 **	.995	31,254.97
	(2,647,200)	(80.50)		
$RATE76_C$	5.92 **	0.0000083	.002	0.26
	(0.53)	(0.0000162)		
$TAX76_C$	119.51 **	0.00036	.010	1.51
	(9.67)	(0.00029)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table 4-23. Regression Results. Pooled Simple Equations: City Governments, 1974.

Dependent Variable	Intercept	Population	R^2	F
$TEXP74_C$	-1,005,128 **	700.00 **	.990	15,402.02
	(180,517)[1]	(5.60)		
$NTR74_C$	-754,481 **	584.70 **	.988	13,322.02
	(162,112)	(5.10)		
$LEVY74_C$	-250,646 **	115.40 **	.987	11,553.54
	(34,347)	(1.10)		
$TCV74_C$	-17,615,016 **	14,114.20 **	.992	20,747.94
	(3,135,793)	(98.00)		
$RATE74_C$	5.67 **	0.0000097	.008	1.26
	(0.28)	(0.0000086)		
$TAX74_C$	103.25 **	0.00035 *	.028	4.55
	(5.28)	(0.00017)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

CHAPTER V

SUMMARY AND CONCLUSIONS

The intent of this study was to explore the relationship between population and residential property tax bills. What can now be said about the relationship?

The relationship between population and TAX is positive and statistically significant for each unit of government; that is, the larger the taxing district the larger will be the expected tax bill on the district. For counties, the expectation is that tax bills will differ by \$0.10 for every difference in population of 1,000. School tax bills are expected to differ by \$9.77 for every difference in ADM of 1,000. City tax bills are expected to differ by \$0.34 for every difference of 1,000 in city population (based on estimated linear relationships).

Short-run (two-year) changes in tax bills appear to be uncorrelated with changes in population over the same period. Hence, by itself, change in population is not a good predictor of change in tax bills.

One reason behind the positive relation between population and residential property tax bills is that residential property value is directly related to population. The estimate of the elasticity of residential property values with respect to population is that a one percent increase in county population will lead to a 1.22 percent increase in the total value of county residential property (TOTRES) and a 0.18 percent in the <u>average</u> value of county residential property (VRES). In contrast the estimated elasticity of the value of <u>all</u> property in a county (TCV) with respect to population is 0.84 implying that population pressure causes residential property to increase in value faster than <u>all</u> property increases in value. Since the TOTRES and VRES elasticities are greater than 1.00 and 0 respectively, a population increase would be expected to result in residential property owners paying a larger proportion of the property taxes in a district.

Another reason leading to the positive TAX-population relationship is that the tax rates of all units of local government are positively related to levels of population when expressed as linear functions. However, in only one case, schools, is the linear relationship significant. The RATE elasticities are positive for schools and cities implying that increases in population would be predicted to result in increased tax rates. The county rate elasticity is negative but may be due to non-property tax revenues, specifically O & C timber revenues, being available to the mid-size and larger counties but not to small ones. The two largest tax rates on the average are $RATE_S$ and $RATE_C$ both of which are positively related to population, but increase at a decreasing rate with respect to population.

The reason tax rates are generally positively related to population is that, with the exception of the counties, the levies appear to be more elastic than property values with respect to population. The LEVY and TCV elasticities tend to be accurate only at the lower values of population but appear to be useful for comparative purposes.

Both $LEVY_S$ and $LEVY_C$ appear to increase at an increasing rate with respect to population. One would expect to find higher *per capita* values of LEVY in larger school districts and cities. $LEVY_K$ seems to decline as population increases and then, after a minimum value, to increase as population increases. This phenomenon is probably due more to the high correlation between size of county and the amount of O & C funds received than to the effect of population on the levies.

The reason $LEVY_S$ and $LEVY_C$ appear to increase at an increasing rate is because of the relationship between TEXP and NTR. Both appear to also be increasing at an increasing rate with respect to population. Larger school districts and cities probably supply more public goods and services _per capita_ than smaller schools and cities resulting in increased expenditure _per capita_. Non-property tax revenues, which are a linear function of ADM for schools and do not increase at an increasing rate, are not sufficient to offset the rising expenditures. City non-property tax revenues, though increasing at an increasing rate, increase relatively less than expenditures increase and, like school non-property tax revenues, are also unable to offset increases in expenditures. County non-property tax revenues increase at a _decreasing_ rate with respect to population. County expenditures, like those of cities and schools, increase at an increasing rate, and the relative association of each to population is such that the $LEVY_K$ seems to be larger for small and large counties, and a minimum for medium-sized counties. The relative effect of population appears to be coincidental with the amount of O & C funds received by a county.

The variables TEXP, NTR, LEVY, TCV, and VRES follow a pattern similar to TAX in relation to population. The terms POP and POPSQ (or ADM and ADMSQ) can explain up to 99 percent of the variation in the TEXP, NTR, LEVY, and TCV variables for any unit of government and up to 57 percent of the variation in the VRES; hence the long-run association between each variable and population is fairly clear since smaller districts appear to behave in the same predictable manner as the larger districts. Also, narrow confidence intervals about the estimated coefficients prevail.

Despite the high R^2 values of the pooled equations, the difference or change equations display a general lack of correlation between short-run (two-year) changes in the variables and changes in population over the same interval. The short-run changes appear to be either random variation or dependent upon some unknown variable(s).

While the high R^2 values of the quadratic equations demonstrate a considerably close fit of the government block and TCV variables to POP and POPSQ (or ADM and ADMSQ) prediction of a value of a variable given values of POP and POPSQ (or ADM and ADMSQ) is hazardous. The standard errors of the estimated equations are generally high considering the coefficients of variation that range from 15 percent to 113 percent.

Further Research

Within the framework of the present study what else might be done to increase our knowledge of the tax-population relation?

A finer breakdown of the data by size of district is one possibility. A closer examination of the population relationships within small cities for example might be a fruitful avenue of research given the large number of Oregon cities with populations of less than 2,500. Such a breakdown might allow detection of different behavior patterns in different sized cities or school districts. A rough beginning of that approach is presented in Appendix 1 where the simple pooled and change regressions are presented for small, medium, and large cities.

There is a plethora of cross-sectional data available at the local government level. If and when such data becomes available over time there are further possibilities for study. One might be estimating the same relationships studied here for each year. This was done for the two years examined and was alluded to in Chapter IV. Results for 1974 and 1976 are in Tables 4-16 through 4-23. Although there was no apparent change in the structural relationships that does not mean that some change was not taking place. Given enough time periods, a tracking of the estimated coefficients over time might reveal an ongoing pattern of change.

The methodology employed in the study allowed a simple first-round look at the relationships between population and tax-related variables for each of the three units of local government. Other procedures would, of course, be possible.

One obvious possibility is to add more complexity by specifying and estimating a more complete model. The relevant exogenous variables could be added, income for example, and the assumption of independence among the dependent variables could be relaxed to allow testing of the Tiebout-Oates hypothesis and the relation between expenditures and non-property tax revenues.

The present study deals with the expected value of a districts average tax bill. Alternatively, it would be of interest to know more about the expected value of an individual's tax bill; that is, choosing residential property owners at random,what can be expected to be true about their tax bills?

A possible procedure would be to collect data on individuals chosen state-wide on a sample basis and incorporate information about the districts in which they live with information about their own incomes, tastes, demographic characteristics, and property values. Or one could examine the relation on a case study basis with selected areas chosen on the basis of either size of population or rate of growth or both.

APPENDIX 1

Table A-1. Pooled Simple Regression Results: City Governments with Population Greater than 10,000.

Dependent Variable	Intercept	Population	R^2	F
$TEXP_C$	-4,351,276 **	720.70 **	.993	5,293.09
	(923,513)[1]	(9.90)		
NTR_C	-3,401,480 **	601.10 **	.991	4,128.93
	(872,030)	(9.40)		
$LEVY_C$	-949,796 **	119.70 **	.994	6,488.53
	(138,485)	(1.50)		
TCV_C	-63,860,272 **	14,433.10 **	.995	7,387.32
	(15,654,520)	(167.90)		
$RATE_C$	6.45 **	0.0000058	.044	1.64
	(0.42)	(0.0000045)		
TAX_C	138.74 **	0.00020 *	.106	4.25
	(9.20)	(0.00010)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table A-2. Pooled Simple Regression Results: City Governments with Populations of 2500 to 10,000.

Dependent Variable	Intercept	Population	R^2	F
$TEXP_C$	-1,015,913 **	604.00 **	.738	220.07
	(295,163)[1]	(40.70)		
NTR_C	-1,069,690 **	553.00 **	.678	164.15
	(312,880)	(43.20)		
$LEVY_C$	53,776	51.00 **	.386	49.08
	(52,824)	(7.30)		
TCV_C	-13,594,035 *	13,051.10 **	.791	295.59
	(5,502,972)	(759.10)		
$RATE_C$	9.28 **	-0.00039	.028	2.27
	(1.85)	(0.00026)		
TAX_C	157.31 **	-0.0037	.009	0.65
	(33.48)	(0.0046)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table A-3. Pooled Simple Regression Results: City Governments with Populations less than 2500.

Dependent Variable	Intercept	Population	R^2	F
$TEXP_C$	-88,183	488.70 **	.328	93.57
	(76,803)[1]	(50.50)		
NTR_C	-87,846	446.80 **	.296	80.85
	(75,543)	(49.70)		
$LEVY_C$	337	41.90 **	.383	119.35
	(5,828)	(3.80)		
TCV_C	-2,634,431 *	11,235.50 **	.502	193.43
	(1,228,134)	(807.80)		
$RATE_C$	6.44 **	-0.00072	.018	3.51
	(0.58)	(0.00038)		
TAX_C	102.15 **	0.00045	.000	0.00
	(11.16)	(0.00734)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table A-4. First Difference Regression Equations: City Governments with Population Greater than 10,000.

Dependent Variable	Intercept	CPOP	PCPOP	R^2	F
$CTEXP_C$	-747,480	914.30		.160	3.23
	(1,316,370)[1]	(508.40)			
$CNTR_C$	-894,710	801.80		.134	2.63
	(1,280,040)	(494.40)			
$CLEVY_C$	147,230	112.40 *		.238	5.30
	(126,470)	(48.80)			
$CTCV_C$	28,049,990 *	14,280.60 **		.360	9.55
	(11,961,660)	(4,619.90)			
$CRATE_C$	-0.27	0.000045		.007	0.12
	(0.34)	(0.000133)			
$CTAX_C$	8.67	0.00192		.030	0.52
	(6.90)	(0.00267)			
$CRATE_C$	-0.37		0.058	.021	0.36
	(0.39)		(0.097)		
$CTAX_C$	4.99		2.402	.085	1.59
	(7.59		(1.905)		

[1] Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table A-5. First Difference Regression Equations: City Governments with Population of 2500 to 10,000.

Dependent Variable	Intercept	CPOP	PCPOP	R^2	F
$CTEXP_C$	87,650	14.80		.000	0.00
	(139,380)[1]	(248.60)			
$CNTR_C$	126,980	-305.00		.036	1.42
	(143,660)	(256.20)			
$CLEVY_C$	-39,330	319.80 **		.626	63.58
	(22,490)	(40.10)			
$CTCV_C$	608,790	24,215.70 **		.581	52.62
	(1,871,760)	(3,338.20)			
$CRATE_C$	1.89	-0.00049		.000	0.02
	(2.04)	(0.00364)			
$CTAX_C$	47.41	-0.0035		.000	0.00
	(36.12)	(0.0644)			
$CRATE_C$	1.39		0.066	.001	0.02
	(2.68)		(0.424)		
$CTAX_C$	39.25		1.382	.001	0.03
	(47.41)		(7.502)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table A-6. First Difference Regression Equations: City Governments with Population Less than 2500.

Dependent Variable	Intercept	CPOP	PCPOP	R^2	F
$CTEXP_C$	32,870	399.00		.016	1.50
	(64,840)[1]	(325.40)			
$CNTR_C$	27,340	417.70		.017	1.68
	(64,290)	(322.60)			
$CLEVY_C$	5,520	-18.80		.017	1.66
	(2,900)	(14.60)			
$CTCV_C$	682,780	15,412.80 **		.301	40.97
	(479,800)	(2,407.80)			
$CRATE_C$	0.05	-0.0031		.031	3.07
	(0.35)	(0.0018)			
$CTAX_C$	11.96	-0.062		.029	2.82
	(7.36)	(0.037)			
$CRATE_C$	0.01		-0.033	.035	3.41
	(0.33)		(0.018)		
$CTAX_C$	9.48		-0.479	.017	1.63
	(7.05)		(0.375)		

[1]Standard errors in parentheses.
**Indicates coefficient is significant at 1% level.
*Indicates coefficient is significant at 5% level.

Table A-7. Table of Simple Correlation Coefficients Between Variables: City Governments

	POP	TEXP	NTR	LEVY	TCV	RATE	TAX	INC	POPSQ
POP	1.00								
TEXP	.99+	1.00							
NTR	.99+	.99+	1.00						
LEVY	.99+	.99+	.99+	1.00					
TCV	.99+	.99+	.99+	.99+	1.00				
RATE	.05	.05	.05	.06	.04	1.00			
TAX	.11	.11	.11	.12	.11	.94	1.00		
INC	.15	.14	.14	.14	.16	-.03	.03	1.00	
POPSQ	.96				.99	.04	.08		1.00

Table A-8. Table of Simple Correlation Coefficients Between Variables: County Governments

	POP	TEXP	NTR	LEVY	RATE	TCV	VRES	TAX	INC	POPSQ
POP	1.00									
TEXP	.93	1.00								
NTR	.89	.99	1.00							
LEVY	.90	.87	.78	1.00						
RATE	.02	-.01	-.11	.30	1.00					
TCV	.99	.94	.89	.91	.01	1.00				
VRES	.59	.46	.48	.34	-.46	.59	1.00			
TAX	.51	.42	.30	.68	.71	.51	.24	1.00		
INC	.36	.25	.21	.33	.06	.38	.34	.28	1.00	
POPSQ	.93	.90	.82	.99	.26	.93	.37	.64	.34	1.00

Table A-9. Table of Simple Correlation Coefficients Between Variables: School Districts

	ADM	TEXP	NTR	LEVY	TCV	RATE	TAX	PTCV	INC	ADMSQ
ADM	1.00									
TEXP	.99	1.00								
NTR	.95	.98	1.00							
LEVY	.99	.99	.93	1.00						
TCV	.97	.97	.92	.98	1.00					
RATE	.22	.21	.19	.21	.12	1.00				
TAX	.26	.26	.24	.27	.17	.88	1.00			
PTCV	-.14	-.13	-.14	-.12	-.08	-.55	-.51	1.00		
INC	.20	.20	.19	.20	.19	.03	.15	.10	1.00	
ADMSQ	.88	.88	.84	.90	.94	.05	.08	-.04	.10	1.00

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