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Bureaucrats, Bureaucracy and Utility Maximization: Empirical Evidence From Taiwan.

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BUREAUCRATS, BUREAUCRACY AND UTILITY MAXIMIZATION: EMPIRICAL EVIDENCE FROM TAIWAN

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ABSTRACT

An important issue in public finance is concerned with finding an appropriate choice-theoretic model for explaining state and local government fiscal behavior. Economists have traditionally viewed state and local expenditure and tax decision-making processes "as if" they were the results of utility maximization subject to a budget constraint. This approach provides a convenient device for applying the neoclassical demand theory to state and local public sector fiscal behavior. The appropriateness of making such an assumption has, however, not been directly addressed in the literature.

This research fills the gap by empirically testing whether the assumption of utility maximization holds in local public sector by using data drawn from Taiwan for the 1986-94 period. Taiwan's local public sector employment and spending data reflects weaker voter constraints on local bureaucracies, thus providing a unique opportunity for definitive direct tests of whether or not one can model bureaucratic behaviors as an "as if" constrained optimization outcome. Both parametric and nonparametric test procedures are performed. For parametric tests, a translog utility function is specified. For nonparametric tests, a method that is based on the theory of revealed preference is applied.

Additional tests are also performed. The sensitivity analysis allows this dissertation study to test the robustness of the results from nonparametric tests. The probit analysis of jurisdiction-specific factors determining consistency with the revealed preference axioms provides additional insight into local public sector fiscal behavior in Taiwan.

Overall results from this research provide a strong support for the assumption of bureaucratic utility maximizing behavior in Taiwan's local public sector. The empirical

evidence not only supports the hypothesis that the local bureaucracies have well-defined preferences over public sector employment and spending, but also indicates the intertemporal stability in the preference structures across individual local public bureaucracies in Taiwan.

This dissertation shows that the "as if" proposition in the public finance literature is justified. The results from this dissertation research therefore significantly provide the first definitive direct empirical support for this popular assumption in the literature.

CHAPTER 1

INTRODUCTION

One important issue in public finance concerns the appropriate choice-theoretic economic structural model of state and local government fiscal behavior. In an effort to explain interjurisdictional variations in public spending, economists have traditionally applied the neoclassical demand theory to state and local government fiscal behavior by either explicitly or implicitly assuming that the government fiscal choices reflect the utility maximization behavior of consumers/voters. Constrained optimization models, such as Barr and Davis (1966), Henderson (1968), Gramlich (1969a), and Inman (1971), and median voter models, such as Borcherding and Deacon (1972), Bergstrom and Goodman (1973), and Inman (1978), represent such an approach. A broader public choice approach, while rejecting the indifference curve analysis as being inappropriate, is not totally free of the utility maximizing agent assumption: instead of assuming utility maximization by voters/taxpayers, it often implicitly assumes utility maximization by bureaucrats or politicians, whether constrained by or interacting with voter/taxpayers preferences [e.g. Tullock (1972, 1974); Romer and Rosenthal (1978, 1979b, 1982); Denzau, Mackay, and Weaver (1979); Ott (1980); and Filimon, Romer and Rosenthal (1982)]. The bureaucratic models, especially those of Niskanen (1968, 1971, 1975), are representatives of this latter approach.

This dissertation research seeks to answer the question: do bureaucrats maximize anything? That is, does the public sector bureaucracy behave in a systematic fashion? Existing literature on state and local government fiscal behavior has at various stages

identified four utility-maximization groups of agents in local public finance: voters/taxpayers; public service recipients; politicians holding public office; and public sector bureaucrats. Each group has an interest in, and varying degree of capacity to affect, the outcome of local public sector decision-making process. Various combinations of the interaction among these four groups of agents generate different economic behavioral models of local government spending. The common feature of all these models is the role of voter/taxpayers as constraints on politicians and bureaucrats.

Regardless of their methodological differences in modeling local government fiscal behavior, these models typically view the process of state and local public expenditures and tax decisions "as if" it were the result of utility maximization subject to a budget constraint. Attempts to evaluate the median voter hypothesis implicitly test the utility maximization and the preference aggregation assumptions embodied in the hypothesis [Inman (1978), McEachern (1978), Pommerehne (1978), Holcombe (1980), Gramlich and Rubinfeld (1982), Romer and Rosenthal (1979a, 1979b, 1982), Deno and Mehay (1987), Wyckoff (1988), Turnbull and Djoundourian (1994), and Means and Mehay (1995)]. The empirical evidence, however, is mixed, depending on data set used and the empirical specification. Direct tests of optimization behavior are almost non-existing, with the two exceptions of Grosskopf and Hayes (1983) and DeBoer (1986). Overall, all these above-cited studies fail to provide a definitive answer to the fundamental questions concerned with how reasonable the assumption of utility maximization really is or even whose utility it is that is being maximized. Herein lies the motivation for this dissertation research: to directly test the utility maximization hypothesis in local public expenditure models.

There are two ways to empirically test whether or not the assumption of utility maximization holds. The first, and also the most frequently used, method is to perform parametric test procedures on a set of observed public sector spending data by estimating an explicit utility function and testing the parametric restrictions. The second is to perform nonstatistical nonparametric tests based on the theory of revealed preference. This dissertation research uses both methods. For the parametric tests, a translog utility function as in Christensen, Jorgenson and Lau (1975) will be specified to test the utility maximization hypothesis. One of the major advantages of a translog utility specification is its flexible functional form, thus avoiding making additional unnecessary *a priori* assumptions about the underlying preferences of the model that are to be tested. For the nonparametric tests, the Generalized Axiom of Revealed Preference (GARP) as in Varian (1982, 1983) will be used. A more detailed description of these two types of test procedures, as well as their relative strengths and weaknesses, will be discussed in Chapter 3.

This research uses the local public sector spending data drawn from Taiwan's publicly released sources from 1986 to 1994. Taiwan, though not an independent country *de jure*, has been a *de facto* nation since 1949.[1] It is a country undergoing a series of rapid political transformations during the past decade. Despite the development of democratic institutions in recent years, the political-budgeting process during the period from which

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[1]See, for example, Copper (1990) for the post-World War II history of Taiwan's legal status and its political culture, tradition and system. These factors provide the rationale for choosing a bureaucratic model, rather than one based on consumer choice theory, for this dissertation research.

the data set is drawn is very different from that of the United States or of other western democratic societies. One can safely assert that the public sector bureaucracy in Taiwan is less constrained by voters/taxpayers than the bureaucracy in the typical western representative democracy, although the situation is rapidly changing in recent years. To a large extent, Taiwan's local politicians and public bureaucracy depend on intergovernmental grants and aids to meet their annual budget.[2] Lower-level governments, other than the national government, do not have the constitutional or legal power to impose taxes, revise tax rates, or hold referenda on tax issues.[3] By way of contrast, take the fiscal institutions of the United States as an example. The fiscal structure of the United States reflects the federalist spirit that is deeply embedded in its constitution, under which not only the federal government is empowered to conduct fiscal transactions, but also the state governments have sovereign rights in taxing and spending powers, although with certain restrictions. Local governments, though do not have sovereign powers of their own, also have fiscal powers that are granted by the states.[4]

The fiscal arrangements of Taiwan, unlike those of the United States, have always been centralized. As such, Taiwan's public sector spending data provides a unique

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[2]See, for example, Lin and Lee (1989, pp. 5-20). It is reported that, among the sixteen Hsiens and five Municipalities, seven of these local governments received inter-governmental grants and aids that accounted for an average of fifty-four percent of their annual budget in the 1982-86 period. For all local governments at this administrative level, the average is forty-one percent in the same period.

[3]See Huang (1989, pp. 3-22) for a detailed description of Taiwan's institutional arrangements with regard to its central-local government fiscal responsibilities.

[4]For a more detailed account of the fiscal arrangements in the United States, see, for example, Musgrave and Musgrave (1984, pp. 27-46).

opportunity to test theories of bureaucratic behavior. Taiwan's data, reflecting weaker voter/taxpayer constraints on public sector bureaucrats and politicians, presents the opportunity for definitive tests of whether or not one can model bureaucratic behaviors as an "as if" constrained optimization outcome. A more detailed explanation of the data set will also be given in Chapter 3.

This dissertation is organized as follows: Chapter 2 reviews extant literature on models of state and local government fiscal behavior. Chapter 3 describes the empirical models and the parametric and nonparametric test procedures, as well as the data set drawn from Taiwan's publicly released sources. Additional test procedures and empirical statistical results from this research will be reported in Chapter 4. The last chapter, which concludes this dissertation, will provide discussions of the empirical results as well as possible avenues for further research.

CHAPTER 2

MODELS OF LOCAL GOVERNMENT FISCAL BEHAVIOR

2.1 Introduction

This chapter reviews extant literature on models of state and local government fiscal behavior. Based on the methodological development of these models, they are broadly divided into three categories: ad hoc expenditure determinants models, constrained maximization models, and public choice models.

The median voter models and the bureaucratic models that will be reviewed below are merely subsets of the more encompassing models known as the public choice models. Constrained maximization models, median voter models and the latter's variants all are applications of standard consumer choice theory. The public choice approach to state and local government expenditures, however, distinguishes from the consumer choice theory-based approach in that the former explicitly rejects the indifference curve analysis in favor of modeling the unit based on the actual political process within which public decisions on expenditures and taxation are made [see, for example, Bahl, Johnson and Wasylenko (1980)].

According to Mueller (1976, p. 395), the public choice approach to public finance "can be defined as the economic study of nonmarket decision-making, or, simply the application of economics to political science." The median voter models follow the public choice approach to the extent that they introduce an explicit political decision-making process. Because it reduces the political process to a representative constrained

maximization problem, however, the median voter model approach is viewed as inappropriate from the broader public choice perspective.

The following evaluates critically each of these approaches.

2.2 Ad Hoc Spending Determinants Models

How is the size of the local public sector determined? And, what are the determinants of state and local government expenditures? Questions such as these are the principal subject of a growing body of literature beginning with Solomon Fabricant's (1952) seminal NBER book on government spending [Bahl (1968, 1969); Fredland (1974)]. In his chapter on interstate differences in government activity, Fabricant uses a single-equation multiple regression analysis on cross-sectional per capita state and local government expenditures in 1942 and finds that personal income, degree of urbanization and population density together account for about 72 percent of the variation in state per capita total expenditures. Of these three factors, personal income is found to be the most important variable. Fisher (1961, 1964) extends Fabricant's analysis to find that both the absolute level and distribution of income are important determinants of government spending.

After Fabricant and Fisher, there has been a proliferation of expenditure determinants studies that seek to identify new variables explaining the growth or differences in state and local government expenditures. For example, Hirsch (1960) studies the public education expenditures of school districts in St. Louis county and concludes that per pupil assessed property value is the most important determinant of local expenditures on public education. Kurnow (1963) uses a multiplicative regression model rather than the

additive models in either the Fabricant or Fisher study. In addition to the above-mentioned three basic factors, Kurnow adds federal grants and a measure of the quality of public services to his regression equation. Sack and Harris (1964) compare the results from Fabricant (1952) and Fisher (1961) with those derived from their study with federal and state aid as additional explanatory variables. Bahl and Saunders (1966), however, question the use of federal aid as a determinant of state and local public spending on the ground that the direction of causality between expenditures and grants is not clear. In addition, their semi-log equation results do not support Kurnow's non-additive variant of the basic regression model. They also conclude that state and local government spending should be analyzed by specific category or function rather than aggregated general expenditures.

Sharkansky (1967) separates state government spending from that of local government and includes in his analysis lagged expenditures as an important determinant. He argues that previous expenditures have profound statistical and theoretical relevance for current-period expenditures. That is, previous expenditures serve as a base in the determination of current-period expenditures in the techniques of incremental budgeting. Gramlich (1969b) distinguishes different types of federal grants (unconditional vs. matching) and their effects of state and local government spending and concludes that earlier empirical studies on this subject are confusing and inadequate. Weicher (1970) extends the usual determinants analysis by taking account of tastes and service conditions as additional factors in explaining local public spending. Racial and ethnic composition of the population, educational level of the adult population and age distribution of the population are used as measures of "tastes", whereas population density, the existence of

slums, the age of the housing unit, and the existence of crowding within a dwelling unit are employed as measures of the "service conditions".

According to Bahl (1969), there have been more than 75 determinants studies up to 1969. And in Bahl, Johnson and Wasylenko (1980), more than 150 determinants studies are cited for review. Despite the large number of these early determinants studies, they provide no definitive answers to the question of why state and local government fiscal behavior differs among jurisdictions [Bahl (1968, 1969); Bahl, Johnson and Wasylenko (1980); Inman (1979)]. Failure of the early determinants studies to produce satisfactory explanations can generally be summarized by the following criticisms of the methodologies used in those studies on both conceptual and empirical grounds. First, and the most serious problem of all, the early determinants studies are based on nothing more than an ad hoc model that includes variables that seem to work empirically. Fabricant himself admits that "[t]racing relationships between government activity and the factors affecting it *involves a good deal of speculation*" [1952, p. 122, italics added]. Lack of a generally acceptable theoretical framework may cause relevant variables to be omitted from, and irrelevant variables to be included in, the model specifications, resulting in possibly biased parameter estimates.

Second, the determinants studies typically use aggregated data of state and local government spending, while disaggregated data is arguably more appropriate for jurisdiction-level policy analysis. Bahl (1968), Morss (1966), and Inman (1979) point out that the aggregation bias in estimates may be large, thus providing little information about the factors that affect the expenditure decisions of a particular government unit.

Third, the comparability of expenditure data across governmental units poses another serious problem because of interjurisdictional differences in the nature of functional responsibilities as well as the externality effects of jurisdictional spending. Thus failure to distinguish expenditures, say, in the city area from those by the city government will generally yield erroneous empirical results [Bahl (1968)].

Fourth, the inclusion of intergovernmental aid as an exogenous variable in the regression equation explaining expenditures introduces an element of circularity since total expenditures are equal to the sum of expenditures from own sources and expenditures from intergovernmental sources. Therefore, the strong correlation of grants with expenditures contributes little to our understanding of the pattern of interjurisdictional spending differences. Also, for certain types of grants the direction of causality is actually reversed, that is, the level of grants is determined by the level of expenditures [Bahl (1968, 1969); Fisher (1964); Gramlich (1969b); Morss (1966); Bahl and Saunders (1966)]. And finally, improper specifications of the grants variable (i.e. matching vs. non-matching) may lead to inconsistent estimates of the effect of total aid, since lump-sum aid as a pure budget transfer has a different effect on expenditure decisions from matching aid as a price reduction for the aided services [Gramlich (1969b); Inman (1979)].

It is in response to these shortcomings of the early determinants models that later structural empirical models based on constrained maximization models or median voter models were developed.

2.3 Constrained Maximization Models

Modeling state and local government fiscal behavior within a framework of utility maximization represents a major attempt by public finance economists to provide a theoretical basis upon which to build and interpret empirical analyses.

Barr and Davis (1966) use the traditional tools of economic analysis to develop a "political" theory of local government expenditures. In their theoretical model, each individual (consumer/voter) maximizes his or her utility, which is a function of privately consumed goods and the expenditure of the local government, subject to a budget constraint, which is just the sum of private expenditures plus his tax burden. Politicians are motivated to remain in office and therefore make their expenditure and taxation decisions in such a way that results in a mix of expenditures and taxes that appeal to a dominant coalition of voters. Henderson (1968) uses a community welfare function rather than an individual's utility function. A community's welfare is defined as a function of the community's per capita personal income, per capita aid received from federal and state governments, population, per capita private and public expenditures. Politicians, as in Barr and Davis (1966), make expenditure and taxation decisions on behalf of the residents of the community. The resultant public expenditure and tax levels are the outcome of community welfare maximization subject to community budget constraints.

Wilde (1968) also uses consumer choice theory approach to analyzing expenditure effects of grants. A public utility function, with public goods and community resources as its arguments, is maximized by local decision makers subject to resources constraints. This public utility function in Wilde's model, however, is not a social welfare function or part

of it, and he is vague in specifying whom or which groups the utility function actually represents. According to Wilde, local governments do not reflect perfectly the true preferences of their citizens, owing to limitations of representative democracy and the existence of inter-community spillover effects. The public utility function in his model therefore merely represents a set of preferences for community goods and services that are consistent with standard indifference curves. Gramlich (1969a) specifically models state and local utility functions that are assumed to be maximized. His utility function includes the usual public and private good arguments, but also includes a built-in statutory constraint against borrowing. The state and local budgetary process is employed to derive structural equations for expenditures and revenues. Like Wilde, Gramlich is mute about whose utility that is being maximized. To get around the difficult and often unmanageable issues surrounding the social welfare function or the social indifference map, both Wilde and Gramlich simply assume the existence of it without further deliberations.

Inman (1971. p. 701) similarly "characterizes the local government decision-making process by the optimization of a 'leadership preference function,' subject to a budget constraint." Inman's leadership preference function is fundamentally similar to Wilde's and Gramlich's state and local government utility functions, but with more complicated public good variables as arguments. In addition to locally provided public goods, a variable representing gross additions to the local public capital stock, which captures the investment aspect of local public investment decision, is also included in the preference function. Here Inman is explicit about whose utility that is being maximized,

although the actual political and budgetary processes that form the basis of the "leadership preference function" are intentionally left undefined in his model.

Inman (1979) argues that the fundamental innovation of Barr and Davis (1966), Henderson (1968), Gramlich (1969a) and others like Wilde (1968) and Inman (1971) is their view of the process of state and local fiscal behavior as an "as if" proposition: state and local expenditure and tax decisions are analyzed "as if" they were the result of utility maximization subject to a budget constraint. This constrained maximization approach represents a major improvement over the ad hoc approach of earlier determinants studies. Federal and state government policy variables can be systematically specified and empirically testable hypotheses regarding their effects on local budgetary choices can be derived and tested.

The constrained maximization approach of the 1960's served as an important stepping-stone to later studies of state and local government expenditures leading to the representative voter and median voter models of the 1970's. Variants of these constrained utility maximization models have since been used to study a variety of public finance issues. For instance, Gordon (1983) employs constrained community welfare optimization technique to study issues of fiscal federalism, and Holsey (1993) uses the constrained utility maximization of the decisive voter to derive tax price and income illusions.

The constrained optimization approach, though providing a more coherent conceptual framework for studies of state and local government expenditures, is not without drawbacks. Inman (1971) and Bahl, Johnson and Wasylenko (1980) criticize the characterization of the political process as if it were identical to individual decision-making

as naive and not directly testable. In addition, they contend that the heuristic assumption of the existence of a community utility function as if the Arrow impossibility theorem could be conveniently rejected for a group choice process is contrary to the tenants of a positive analysis, and that the question of how individuals are aggregated to produce a community welfare function had not been resolved.

These arguments against the constrained maximization approach, though legitimate then, are, however, mitigated by later developments in the median voter approach and in the nonparametric test procedures based on the theory of revealed preference. These later developments will be discussed in turn in the following literature review and in Chapter 3.

2.4 Median Voter Models

The median voter approach postulates that in a direct or representative democracy with simple majority rule the level of public expenditures will correspond to the preferences of the median voter with median income. A median voter model based on this hypothesis represents a method of preference aggregation to derive public demand for local public goods and services. The median voter method addresses the political-budgetary question by providing a mechanism by which individual preferences are aggregated to community level.

Like the constrained maximization models, the median voter models also apply standard consumer choice theory to the public decision-making process. Unlike the constrained maximization models in which individuals as a group are making all the fiscal decisions in response to changes in income, tax prices and tastes, however, the median

voter method introduces the political process into analysis. In this latter approach, local fiscal decisions are made by politicians who choose the mix of expenditure and tax decisions that reflect the preferences of the median voter in order to attract a winning coalition of voters at election. In essence, therefore, the median voter models reduce the complexity of the community utility function to the simplicity of the median voter's preferences if the conditions of simple majority rule within a democracy and single-peakedness of voters' preferences hold [Bahl, Johnson and Wasylenko (1980); Inman (1979)].

The median voter models of state and local fiscal behavior have their tradition from the theory of spatial competition developed by Hotelling (1929), refined by Bowen (1943), Black (1948), and Downs (1957). Barr and Davis (1966) argue for the relevance of median position in election outcome, and use the median assessed value of taxable property as an explanatory variable in their empirical tests, even though the term of "median voter" is not explicitly used. Borcherding and Deacon (1972) are among the first to formally develop an empirical median voter model of local public spending. By assuming a Cobb-Douglas technology in the production of public goods, and by assuming a specific functional form of the median voter's demand schedule for public goods and services, they derive a local public demand equation (in logarithmic form) expressed as a function of wage rate, population and the median voter's income in the jurisdiction under consideration. Bergstrom and Goodman (1973) develop five conditions that are sufficient for local public expenditures to correspond to the preferences of the median-income voter. These five conditions together require that income distribution in a jurisdiction is constant and

proportional across jurisdictions, and that public goods and services are normal goods. These conditions in effect assume the existence of a homothetic utility function for all individuals in a jurisdiction. Bergstrom and Goodman do not derive their own public expenditure demand equation, but use, in their empirical study, a multiple regression equation similar to that derived by Borcherding and Deacon (1972). In addition to the now standard explanatory variables (that is, the population or number of households, tax share of the median-income voter, and the median voter's income) in the equation, they also include an array of several socio-economic variables pertinent to a particular community, including nonwhite as a percentage of population, population density, senior citizens as a percentage of population, percentage change in population, the percentage of houses occupied by owners, the employment-residential ratio, etc.

Despite the innovative approach of median voter models to state and local public expenditures and taxation behavior, the usefulness and validity of these models in describing and interpreting local public sector depend to a large extent on their empirical relevance. How well does the median voter model explain actual demand for public goods and services?

As cited above, Borcherding and Deacon (1972) specify an exact functional form (i.e. a CES-type log-linear form in marginal tax price and income) of the median voter's demand schedule for public goods and services, and from which they derive a local public demand equation in logarithmic form as:

(1) $$\ln E = \ln A + \alpha_1 \ln W^{\beta} + \alpha_2 \ln Y + \alpha_3 \ln N$$

where A is the constant term, E the per capita expenditure on a particular public good, W

the average wage rate, Y the median voter's income and N the population in the jurisdiction under consideration. Note that α_i's are elasticities of the respective variables and β is the labor's share. Also note that the tax price elasticity, η, is embedded in their expenditure equation as $\eta = (\alpha_1 - 1)$. In addition to the population variable in equation (1), population density and total land area of the jurisdiction are also included, somewhat arbitrarily, to form a number of variants of equation (1). Their estimates of equation (1) and its variants on various local public functions for forty-four states show that the median voter hypothesis is in general a useful working assumption.

Bergstrom and Goodman (1973) use a variant of equation (1) as the following:

(2) $$\ln E = \ln A + \alpha_1 \ln S + \alpha_2 \ln Y + \alpha_3 \ln N + \Sigma_i \beta_i X_i$$

where S is an explicit tax share term for the median voter that replaces the wage rate variable in equation (1), and X_i's are a number of descriptive socio-economic variables. They estimate the equation on various typical local services for 826 municipalities in ten states and conclude that their empirical results support the median voter hypothesis.

Equations (1) and (2) have since become *the* standard median voter models, with their various variants being used by numerous researchers. Inman (1978) uses equation (2) as a basis to conduct an empirical study on fifty-eight Long Island school districts and finds that the median voter hypothesis can be rejected by no more than a quarter of his sample districts, and that even in these districts the predictive bias of the model based on the median voter hypothesis never exceeds 20%.

McEachern (1978) employs the median voter hypothesis in specifying voters' preference concerning local debt level under different collective decision rules in debt

issues (i.e. simple majority vs. great-than-majority referendum or no referendum required, and provision of statutory debt limit vs. no debt limit, etc.) and uses an ad hoc linear function with per capita outstanding local debt as the endogenous variable. His empirical results from all fifty states support the hypothesis under either direct or representative democracy.

Pommerehne (1978), like Bergstrom and Goodman (1973), also applies the standard equation (2) to 110 Swiss municipalities and finds that the median voter approach to local public expenditures has a great explanatory power in general, especially for localities with referendum requirements. He concludes that for representative democracies with no provisions for referendum, the local bureaucracy's influence on expenditure and tax issues may be so strong as to render the median voter hypothesis inoperative. It is worth noting that this particular point of Pommerehne's conclusion is contrary to that of McEachern (1978), and will be used as part of the conceptual foundation for this dissertation research.

Holcombe (1980) develops a framework in which the median voter demand and constant marginal cost curves intersect to give rise to the equilibrium quantity and tax price. He uses the 1973 referenda data from 257 Michigan school districts to estimate the "Bowen" equilibrium (i.e. the outcome most preferred by the median voter) level of expenditures in each school district and compares these estimates with the actual level. His test results show that, on average, the actual level of expenditures is less than 3% away from the estimated Bowen equilibrium, thus providing support for the median voter hypothesis.

Gramlich and Rubinfeld (1982) test, among other things, the median voter hypothesis by utilizing the standard utility-maximization procedures to derive a typical individual's public spending demand function which, though more sophisticated, is both conceptually and configuratively similarly to equations (1) and (2). Using the 1977 macro data for the 83 counties in Michigan and the 1978 micro survey responses on demands for public spending from 2001 households in Michigan to estimate the demand functions separately, they find the median income approach provides a better fit than mean income and therefore conclude that their empirical results support the hypothesis that the median voter is decisive in setting spending levels.

Deno and Mehay (1987) employ the median voter framework to derive a variant of equation (2) to determine whether or not expenditure behavior differs across municipalities with different management structures (i.e. city manager vs. elected mayor-council). Using data from 73 Michigan and Ohio cities, they find no statistically significant differences between the two types of governmental forms, thus supporting the median voter hypothesis.

Although the above-cited studies all find empirical evidence to support the hypothesis upon which the median voter model is based, Romer and Rosenthal (1979a, 1979b, 1982) fail to find supporting evidence. Romer and Rosenthal (1979a) review the empirical results by leading median voter economists such as those cited above, but conclude that (pp. 161-2, italics added):

> "[t]he various studies we have reviewed *have not provided strong, broadly based support for the median voter hypothesis*. We found methodological problems that made tests of the hypothesis inherently difficult; and we found that the median voter models were inadequately tested against competing models. An implication of our finding is that,..., [political] *institutions matter*."

Romer and Rosenthal (1979b, 1982) present a monopoly model in which they, like Niskanen (1971), assume that bureaucrats are budget maximizers and that bureaucrats have the power to control the agenda. Their "setter-reversion" bureaucratic model shows that when the reversion point is below the spending level most preferred by the median voter, the lower the reversion level, the higher the actual expenditure. Their empirical results from Oregon school district expenditure data in 1971 provide evidence for their bureaucratic model, but against the median voter outcome. A more detailed treatment of the Romer-Rosenthal model will be given in the next section in which the bureaucratic models will be reviewed.

Wyckoff (1988) also assumes budget-maximizing bureaucrats in his specification of the public spending demand equation, which, again, is some variant of equation (2) with additional explanatory variables like revenue-sharing aid received by the median voter, percentage of population age 65 and over, and percentage of population that is nonwhite, etc. Using the 1977 Census data from 115 Michigan cities, he finds that current expenditures appear to be better explained by the median voter model, while the bureaucratic model has a greater explanatory power for capital expenditures. One possible explanation of this discrepancy in the predictive power of different models could be that non-recurrent capital expenditures, unlike current expenditures that have to be approved annually, are subject to less scrutiny by voters/taxpayers, so that the bureaucrats have greater control over these types of spending.

Turnbull and Djoundourian (1994) apply the standard median voter specifications to their public expenditure demand equation and test the model on public spending data

from 139 municipalities in five upper Midwestern states (Illinois, Indiana, Michigan, Ohio and Wisconsin). They find evidence to support the hypothesis on the aggregate level, but not on the individual separate functions of local governments.

Overall, as shown by the above review, the empirical evidence does appear to support the claim that the median voter is decisive.[1] And because of its popularity, the median voter model itself has become the subject of study.[2] As a practical matter, even when the median voter model is accepted as the appropriate theoretical model for aggregating individual preferences to the community level, other problems arise from the wide variety of empirical model specifications and conflicting interpretations of the parameter estimates. For example, Turnbull (1985) demonstrates that the estimated tax share elasticity derived from one of the most popular version of the reduced form demand equation is not necessarily the same as the estimate of the tax price elasticity in the structural model used in the empirical literature. Also, Turnbull (1995a) shows that the minor differences in demand equation specifications frequently leads to wide swings in tax price elasticity estimates. And, though conceptually clear, the actual identity of the median voter is ambiguous in empirical studies [Turnbull and Mitias (1995)].[3]

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[1]For a concise summary of the median voter framework and its empirical relevance, see Turnbull (1995b, pp. 501).

[2]See Holcombe (1989) for a review of the role of the median voter model in public choice theory.

[3]Turnbull and Mitias (1995) specifically address the question: Is the median voter the individual with median household income or with median family income? They show that key parameter estimates are sensitive to how the median voter is defined.

On a more fundamental level, the median voter approach to local public spending is also burdened with some conceptual difficulties [Bahl, Johnson and Wasylenko (1980)]. As mentioned above, the condition of single-peakedness of voters' preferences is crucial to the validity of the "as if" proposition of the median voter model. Even if this condition holds, there is another problem. If the issues to be voted on are multi-dimensional, vote-trading or logrolling may be present and as a consequence there may not be a unique voting equilibrium. Plott (1967), on the one hand, shows that in a multi-dimensional issues setting it is possible to have a majority equilibrium if it is a maximum utility state for one, and only one, individual and the remaining individuals can be divided into pairs whose preferences are diametrically opposed in each direction in the issue space. Bernholz (1973, 1974), on the other hand, shows that when voter preference intensities on each issue are not the same and when issues are decided in pairs, logrolling may arise, leading to cycling or intransitive group preferences. At any rate, if the voting equilibrium is not stable, the resultant expenditure and tax levels then would not correspond to the preferences of the median voter. Furthermore, as Romer and Rosenthal (1978, 1979b, 1982) have shown, the equilibrium expenditure and taxation mix would depart from those derived from the median voter model if politicians have the power to set the agenda, as explained in the next section.[4]

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[4]Banks (1993) shows, however, that the ability of the agenda-setter to deviate from the median voter's most preferred outcome is hampered by the same information asymmetries that give rise to the agenda-setter's ability to affect the voting process in the first place. Contrast this with the results in Section 2.5.2.

2.5 Bureaucratic Models

2.5.1 The Niskanen Model

Instead of modeling local government budgetary process using standard consumer choice theory from the demand side, bureaucratic models assume budget maximization by bureaucrats. The most well known economic model of bureaucracy is the one developed by Niskanen, who suggests that his 1971 book on "Bureaucracy and Representative Government" be alternatively titled "The Supply of Public Services" [Niskanen, (1971), p. 9], from which we can infer that emphasis is placed on the supply of, rather than the demand for, public goods and services. The bureaucratic approach or the budget-maximization approach to modeling local public sector behavior is based on two critical characteristics of bureaus: (1) Bureaucrats maximize the total budget of their bureaus, given demand and cost conditions, subject to the constraint that the budget must be equal to or greater than the minimum total costs of supplying the output expected by the bureau's sponsor, and (2) Bureaus exchange a specific output for a specific budget [Niskanen, (1968, 1971, 1975)]. The second characteristic distinguishes a bureau from a firm in the marketplace. To quote Niskanen (1971, p. 25, italics original):

> "*A bureau offers a promised set of activities and the expected output(s) of these activities for a budget.* The primary difference between the exchange relation of a bureau and that of a market organization is that a bureau offers a total output in exchange for a budget, whereas a market organization offers units of output at a price."

Oates (1979), in his examination of the price effects of intergovernmental grants, presents a somewhat different characterization of a bureau. Oates' bureaucratic model postulates that bureaucrats are output maximizers who set output at the highest level

consistent with that most preferred by the median voter in exchange of voters' tax-price that is necessary to provide the proposed level of public output. If the proposed budget is rejected, then the budget is reversed back to a reduced level of expenditure. The presence of intergovernmental grants allows the local bureaucracy to provide a given level of output at a lower tax-price, not the true cost, to the voters. Note that Oates's characterization of the budgetary process is analogous to those of Romer and Rosenthal (1978, 1979b, 1982).

In Niskanen's bureaucratic model, the implication of this characteristic of a bureau is that the "all-or-nothing" choice gives a bureau the same type of market power as a price discriminating monopoly. On the other hand, the bureau's sponsor (the budget-reviewing committee) usually depends on the bureau for the supply of a specific service. Lack of a significant alternative and its unwillingness to forego the services supplied by the bureau make the sponsor a passive player in this bureau-sponsor relationship. Furthermore, a bureaucrat will know, through past budget-output experience, relatively more about the factor costs and production processes for the bureau's services than will the officers of the sponsoring organization. A bureaucrat also has a stronger incentive to obtain information relevant to his position. These relative incentives and available information give the bureau the overwhelmingly dominant monopoly power.

According to Niskanen's formulation, a bureaucrat's utility is a function of salary, perquisites of the office, public reputation, power, patronage, output of the bureau, ease of managing the bureau, and ease of making exchanges. Since all of these variables are a positive monotonic function of the total budget of the bureau, budget maximization is therefore an adequate proxy for maximization of a bureaucrat's utility.

With the assumptions of a passive sponsor and a dominant monopoly bureau, Niskanen formulates the basic system of his bureaucratic model as follows: there is a cost-output function represented by:

(3) $TC = cQ + dQ^2,\ 0 \leq Q$

and there is a budget-output function as:

(4) $B = aQ - bQ^2,\ 0 \leq Q < a/2b$

where

TC = minimum total cost to a bureau;

B = total potential budget of a bureau; and

Q = output of a bureau.

The constraint is that the budget must be equal to or greater than the minimum total cost such that:

(5) $B \geq TC$

The first derivative of equation (3) and (4) yields, respectively:

(6) $C = c + 2dQ$

(7) $V = a - 2bQ$

where

C = minimum marginal cost to a bureau; and

V = marginal valuation function (demand function).

The equilibrium level of output, Q, can be determined from the above system of equations. Budget maximization of B leads to Q = a/2b, which is the upper bound of the output level. The constraint that budget must be at least equal to total minimum cost leads to

$Q = (a-c)/(b+d)$, which is the lower bound of the output level derived by equating equation (3) to equation (4). These two levels of Q are equal at where $a = 2bc/(b-d)$. The Pareto-optimal level of output, however, is at where $Q = (a-c)/2(b+d)$, which can be derived by equating equation (6) to equation (7). Comparison of the output levels shows that the equilibrium output under a monopoly bureau is exactly twice as large as that under competitive conditions.

Figure 1 reproduces Niskanen's original diagram illustrating the above equilibrium levels of output of a monopoly bureau [Niskanen, (1971), p. 47]. For the lower demand condition represented by V_1, the equilibrium output is indicated by a level marked as $(a_1-c)/(b+d)$ on the Q-axis. At that level of output, total budget is represented by the area ea_1gh, which is equal to the total cost area *ecfh*. The Pareto-optimal level of output will be at where the marginal cost function, C, intersects the marginal valuation function, V_1. From the diagram, it is clear that the equilibrium level of output is higher than the Pareto-optimal level. At the equilibrium level of output, the marginal cost *fh* is higher than the marginal value to the sponsor *gh*. With the higher demand condition represented by V_2, the equilibrium output will be even higher, at where the marginal value of output is zero, whereas the marginal minimum cost is *ij*.

Niskanen's bureaucratic model, given its assumptions about the bureau and the sponsor, produces a large set of hypotheses concerning the level of bureau budgets, bureaus' production efficiency, the level of output of bureaus' services, etc. Specifically, five hypotheses stand out: (1) **The Overspending Hypothesis**: government budgets are larger than what is preferred by the median legislator, and in a representative government,

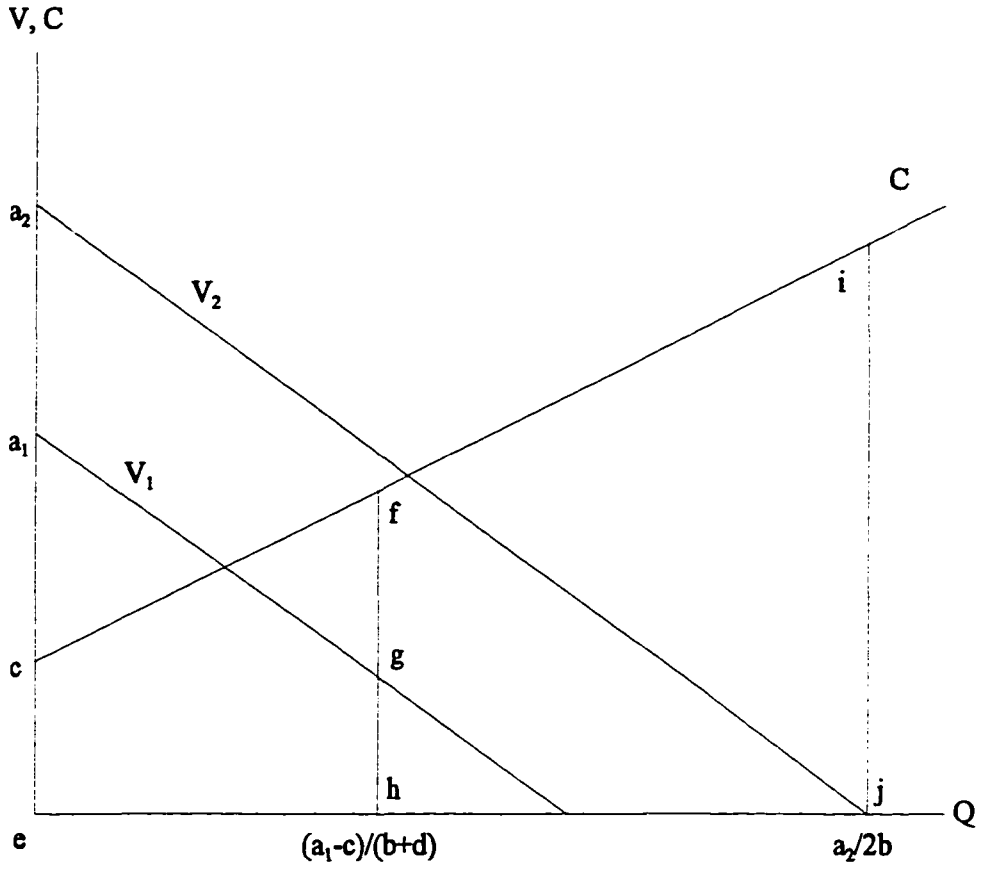

Figure 1. Equilibrium Output of a Bureau

Source: Reproduced from William A. Niskanen, Jr., *Bureaucracy and Representative Government*, Chicago: Aldine-Atherton, 1971, p. 47, Figure 5.1.

larger than what is preferred by the median voter. And the larger is the monopoly power of the government and the bureaus supplying the government services, the larger will be the amount of overspending; (2) **Production Inefficiency Hypothesis**: overspending by bureaus may take the form of inefficiency in producing a given set of outputs and/or a higher level of some output. The relative magnitude of inefficiency and higher output depends on the bureaucrat's preferences, the reward structures, and the characteristics of

the budget-reviewing process; (3) **The Oversupply Hypothesis**: a bureau will supply more of some output valued by the legislature than would be approved by the whole legislature if monitoring were costless; (4) **The Overcapitalization Hypothesis**: a bureau will use more capital-intensive production technology than would a private firm producing the same service; and (5) **The Bureaucratic Structure Hypothesis**: the consolidation of bureaus supplying competitive services would increase the monopoly power of the remaining bureaus, by increasing the costs to Congress of identifying the actual and potential costs of a service and by changing the incentives of bureaucrats from competing on an efficiency basis to promoting the total demand for the service [Niskanen, (1975)].

Perhaps the single most important conclusion from Niskanen's analysis is that budget size in a representative democracy generally tends to be too large and the level of public services too excessive, as compared with the outcome implied in the median voter models [Holcombe (1989)]. This conclusion contributed to the ongoing debate on the "proper" size of the public sector, which is at the core of the Leviathan hypothesis.[5] Borcherding (1977) is in general in agreement with Niskanen's analysis, and cites other studies that seem to substantiate Niskanen's various hypotheses. Staaf (1977a, 1977b) presents empirical evidence that support Niskanen's premise that a bureaucrat's salary, power, prestige and the size of the bureau's budget are positively related. Orzechowski (1977) in his empirical study of public colleges and universities finds evidence that support

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[5]See Brennan (1981) and Brennan and Buchanan (1977, 1978, 1980) for detailed discussions of the Leviathan hypothesis. While Oates (1985, 1989) and Forbes and Zampelli (1989) do not find empirical support for the hypothesis, Zax (1989) finds evidence supporting the Leviathan view.

Niskanen's Production Inefficiency hypothesis. In his review of Niskanen's work, Tullock (1972, 1974) extends the model to strengthen his own theoretical explanation for the growth of bureaucracy over time. Specifically, he rejects Niskanen's view that public services are superior goods and argues instead that the gradual expansion of bureaucracy is because civil servants have an incentive to vote for those congressmen who are interested in expanding bureaus. Once the Congress expands the bureaucracy in one period, there will be more bureaucrats, and hence their political weight in the next period.

Disagreement with Niskanen's analysis also generates several critical reviews. For example, in a review of Niskanen's 1971 book, Thompson (1973) questions Niskanen's assumption of a passive sponsor and dominant bureau. He argues that in the real world it is the trustees, e.g. the budget-reviewing committee, not the bureaucrats, that actually decide on the final budget of the bureaus. The trustees are in a superior bargaining position because they can replace the bureaucrat if he refuses to produce their desired level of output at their preferred price. The budget size in this context will depends on how successful the bureaucrat is in misrepresenting actual expected costs and output. But misrepresentation will normally not work because any striving underling who knows what is going on could raise his wage by informing the trustees of the true costs or promising to deliver lower outputs at the true costs. Since under these conditions the bureau's customer is a monopsonist, the bureau may underproduce rather than overproduce.

Margolis (1975) expresses his skepticism about the fruitfulness of Niskanen's methodology of a bilateral monopoly model, arguing that the division of government into just two groups is inappropriate. The division must at least contain the minimum set of

institutions such as: the executive, the legislature, the administration, the bureaucracy, and organizations of the citizenry such as parties and lobbies. Therefore the budget maximization hypothesis and the premise of utility-maximizing bureaucrats are seriously questioned. Margolis further argues that government is involved in the much more complex problems of social stability, nation building, etc. that affect its behavior and the form of its institutions. Thus consumers' satisfaction alone is not a sufficient objective to explain the behavior of government.

Breton and Wintrobe (1975), like Thompson (1973), also question Niskanen's assumption of a passive sponsor and dominant bureau. But unlike Thompson, they emphasize the disparity of information available to the sponsor. The bureau's "control" over its sponsor does not stem from its dominant position as a monopoly supplier of a given service, but rather from its control of information. They also elaborate on the sponsor's control processes to derive a conclusion that modifies that from Niskanen's model. Recall that one of the major conclusions of the Niskanen model is the oversupply hypothesis as the source of inefficiency in bureaucratic supply. Breton and Wintrobe argue that it is costlier for the sponsor to monitor X-inefficiency than to monitor oversupply, so the major source of inefficiency in bureaucratic supply is X-inefficiency rather than oversupply of output. Finally, also like Thompson (1975), Breton and Wintrobe (1975, p. 204) question the logic of budget maximization, arguing that:

> "...mobility among bureaus in governmental organization is large, and that heads of bureaus often improve their salaries and other amenities of office by moving from a position at the head of a relatively large bureau to one at the head of a smaller one, this would seem to indicate that a different objective function is being maximized."

Musgrave (1981), in his discussion of the Leviathan hypothesis, also raises objections to the assumption of budget maximization as being too simplistic to realistically describe the complexities of human motivation.

Despite the criticism, Niskanen's most significant contribution is in providing a systematic supply-side framework of bureaucratic behavior [Holcombe, (1989), pp. 116-7]. A number of extensions are made by others to examine the consequences of situations where bureaucrats are able to determine the agenda of issues on which voters are permitted to vote [see, for example, Romer and Rosenthal (1978, 1979b, 1982); Denzau, Mackay and Weaver (1979); Filimon, Romer and Rosenthal (1982); Ott (1980); and Wyckoff (1988)].[6] The next sub-section reviews Romer and Rosenthal's bureaucratic model.

2.5.2 The Romer-Rosenthal Model

The setter-reversion , or agenda-control, model of Romer and Rosenthal (1978, 1979b, 1982), which has already been noted earlier, is of particular interest here in the context of Niskanen's monopoly supply model. Their model extends Niskanen's notion of bureaucratic behaviors to the median voter model framework, and in the end significantly modifies the expenditure outcome predicted by the latter model.

In their monopoly model, bureaucrats are posited to have the power to control the agenda. Under full information, the bureaucrats' monopoly power is derived from lack of "competitive" substitutes to the proposed public services. Under imperfect information and uncertainty, voters do not have adequate information about the true cost of publicly provided services or about the fall-back or reversion expenditure and therefore the

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[6]Mackay and Weaver (1978) offer a detailed review of this line of literature.

bureaucrats can exercise agenda control. Like Niskanen (1971), Romer and Rosenthal also characterize bureaucrats as budget or expenditure maximizers. Because the agenda setter has monopoly power over the proposed budget to be put before the electorate, voters are forced to choose between the agenda-setter's proposed budget or some reduced level. That is, if the proposed budget is not accepted by voters, it will automatically be reversed back to a pre-specified level. The reversion level is determined legally or exogenously. How it is set is, however, not important to the analysis. What is interesting is their demonstration of the mechanism through which the actual public expenditure level depends on the reversion point or the status quo. They show that when the reversion point is below the spending level most preferred by the median voter, the lower the reversion level, the higher the actual expenditure.

To illustrate the agenda-control model, consider Figure 2 in which the median voter's preferences over the private and public goods are represented by the indifference curves U_i's. Expenditures on public goods are measured on the horizontal axis labeled as G, and private consumption is represented by the vertical axis X. The line MM represents the budget constraint facing the median voter.[7] The median voter's most preferred level of public expenditures would be the one that maximizes his utility given this budget constraint. As shown in the diagram, G^M is the equilibrium level of public sector spending that maximizes the median voter's utility, at U^1.

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[7]For simplicity, all forms of intergovernmental aid are assumed to be non-existent so that they do not enter the voter's budget set. The omission of this variable would not affect the analysis in any significant way.

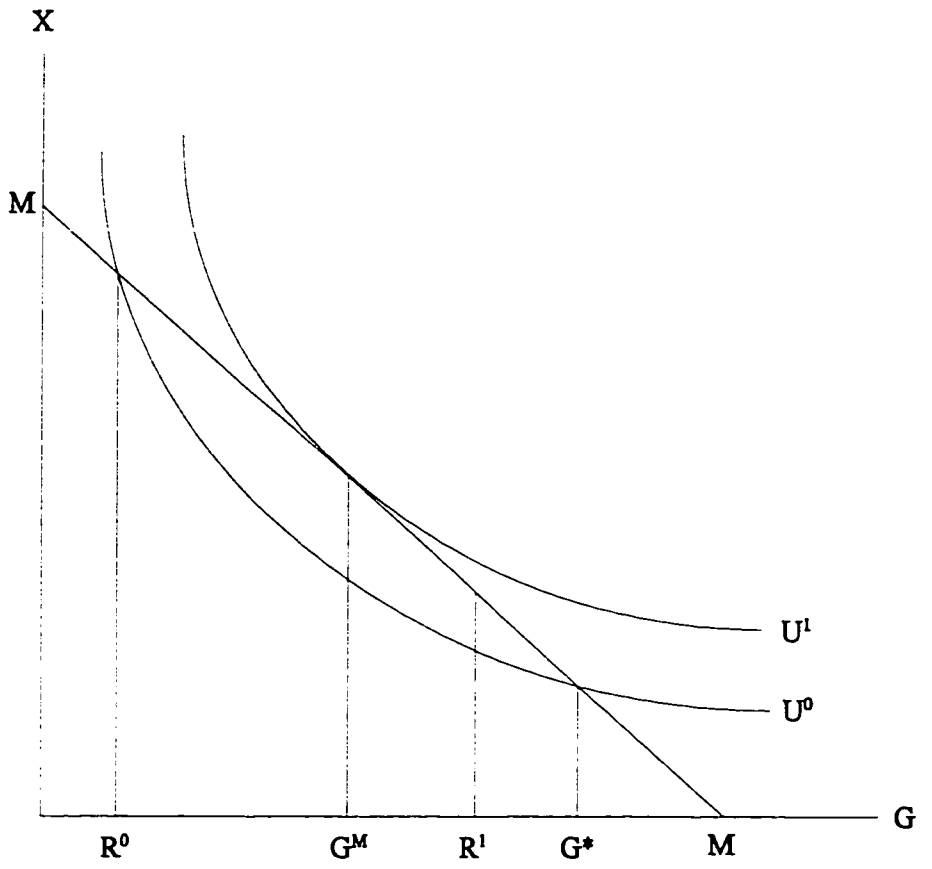


Figure 2. The Romer-Rosenthal Agenda-Control Model

Legends: G: Public expenditure;
X: Private consumption;
MM: The median voter's budget constraint;
U^i: Indifference curves;
R^i: Reversion levels;
G^M: The median voter's most preferred public sector expenditures;
G^*: The maximum budget the setter can propose, given R^0.

If the spending authority, or the agenda-setter, has the monopoly power to control the agenda, he could propose a budget for public services that deviates from the most preferred state of the median voter. Voters are confronted with a "take-it-or-leave-it" binary choice. If the reversion or fall-back position, say R^0, is such that $R^0 < G^M$, the median voter's utility level would be lowered, to U^0, if the proposed budget is voted down by voters. Since the median voter is indifferent between R^0 and G^*, he and all of the above-median voters would vote for any proposed budget between R^0 and G^*. If the only alternative to the proposed budget is the reversion level R^0 and if the setter has complete information about the median voter's preferences, the maximum budget the agenda-setter can propose is G^*.

According the median voter hypothesis already reviewed in the previous section, the level of public expenditures most preferred by the median voter, G^M in the diagram, would be the level actually chosen by voters under a simple majority rule. The Romer-Rosenthal agenda-control model, however, shows a totally different outcome. Any proposed budget level between G^M and G^*, such as R^1, that is greater than G^M, would actually be chosen by voters, since the median and the above-median voters would be better off with this greater-than-median public sector budget.

If the reversion level of public expenditures, say R^1, is such that $R^1 > G^M$, then the agenda-setter needs only propose a budget greater than R^1 to ensure that the reversion level will win in the election. The result again is that the actual public sector budget accepted will be greater than the median voter's most preferred choice. Only when the reversion

level is exactly equal to the median voter's most preferred state would the median voter's preferences be realized.

It is clear from the agenda-setter model that the actual level of public sector expenditures depends on the reversion or fall-back position. The lower the reversion level is, the higher would be the budget accepted by voters. Obviously, the best situation, from the bureaucrats' perspective, is Niskanen's "all-or-nothing" choice where the reversion level is zero. An example would be voters' choice between a fire department budget that is considered excessive and no fire department at all. When the budget is subject to reversion, how the voters would choose is therefore intuitively clear. The key here is the availability of viable alternatives.

2.5.3 Comparison of the Romer-Rosenthal Model with the Niskanen Model

What parallels Romer and Rosenthal's (1978, 1979b, 1982) setter-reversion model with the bureaucratic model of Niskanen is in their characterization of bureaucratic behaviors and in their implied outcome concerning the equilibrium level of public expenditures. Both describe the same type of asymmetric information possessed by bureaucrats and their constituents. Both predict an expenditure outcome that deviates from the median voter result. In particular, both models lead to the same conclusion about the output expansion effect in the public sector. Another common feature of these two models is that, although both characterize bureaucrats as budget-maximizers, neither is definitive about the underlying utility function for the bureaucrats. This lack of explicit treatment of bureaucratic utility functions, which is common to most bureaucratic models, has important implications as to the usefulness of these models, as discussed further below.

Aside from the similarities of these two models, there are fundamental differences as well. First, Niskanen's bureaucratic model emphasizes the supply side aspect of the publicly provided goods and services, while the Romer-Rosenthal model extends the standard median voter model by introducing into the analysis the interactions between monopolistic bureaucrats and hapless voters. Second, whereas Niskanen's monopoly model leads to an "all-or-nothing" binary choice facing the budget-reviewing committee, Romer and Rosenthal's model leads to a "take-it-or-leave-it" binary choice facing voters. In fact, Niskanen's "all-or-nothing" choice can be viewed as a special case of the Romer-Rosenthal model in which the reversion level is zero expenditure. Third, the bureaucrats' monopoly power in Niskanen's model comes from the "all-or-nothing" choice and lack of significant alternatives, while in Romer and Rosenthal's model the source of monopoly power is derived either from lack of competitive substitutes (under certainty) or from voters' insufficient information (under uncertainty) concerning the fall-back or reversion expenditures. Finally, the political-budgetary processes described in the models are different. The Niskanen model is formulated in the Congressional legislative context, while the Romer-Rosenthal model is formulated under direct democracy and referenda situations.

2.6 Relevance of the Bureaucratic Models to This Study

In this chapter, models of state and local government fiscal behavior are reviewed. The public choice approach, especially Niskanen's bureaucratic model, is of particular relevance to this dissertation research. As noted earlier, Pommerehne (1978, pp. 270-7) contends that the median voter approach is inadequate for representative democracies with

no provisions for referendum. The influence of bureaucracy, central or local, and interest groups on public expenditures may be so strong that other politico-economic models rather than the median voter approach are needed to adequately model equilibrium outcomes.

As noted in the introduction chapter in this dissertation, the political culture, tradition and system in Taiwan are different from those of the western democracies. For a country such as Taiwan, where the opposition parties to the ruling Koumintang (KMT) party did not exist technically prior to 1989, the political-budgetary process of which is certainly different from that of the United States. Since in Taiwan the collective choice mechanism has long been dominated by a single party, unqualified applications of voter/taxpayer choice theory-based models, which assume that local public sector expenditures reflect the preferences of the median voter, are clearly not suitable for studies of Taiwan's local fiscal behavior; a bureaucratic approach along the line of Niskanen's model may therefore be more appropriate to serve as the theoretical framework upon which this dissertation is based.

Although the bureaucratic models of Niskanen and Romer and Rosenthal provide an alternative framework for studies of local fiscal behavior under different institutional settings, neither approach explicitly address the question: Regardless how the public sector budget is determined, what do bureaucrats do with it once the budget is approved? Do they spend the money in a systematic fashion? Can the observed public expenditure data be viewed as the constrained optimization outcome? Although he alluded to this kind of question in his treatment of budget-maximizing bureaucrats, Niskanen (1968, 1971, 1975) only implies that budget maximization is an adequate proxy for maximization of a

bureaucrat's utility. Romer and Rosenthal (1978, 1979b, 1982) never even ask the question.

Also as indicated earlier, Taiwan's local governments have to depend on intergovernmental grants and aids to meet their annual budgets. Given the central government's prominent role in the local public spending process and given the important role of local bureaucracy in extracting spending budgets from the central authority, to what extent does the behavior of the local public bureaucracy and politicians reflect that of a utility-maximizing bureaucrat? Or to what extent does local bureaucracy's spending pattern reflect that of a utility-maximizing central government? Regardless how the question is posed, the central issue is whether or not one can view the local public sector expenditures in Taiwan as constrained optimization outcomes. This is a question answered by neither Niskanen, nor Romer and Rosenthal, nor others.

The task of this study is, therefore, to empirically test the "as if" proposition central to public sector economics. To perform this task, a bureaucratic model along Niskanen's notion of budget-maximizing bureaucrats is implicitly assumed in this dissertation. The bureaucrats are also assumed to maximize their utility subject to the public sector budget constraint. Using local public sector spending and employment data drawn from Taiwan, the assumption of utility maximization is then tested empirically. The following chapter describes the test procedures.

CHAPTER 3

METHODOLOGY

3.1 Empirical Models

Under the implicit framework of a bureaucratic model in which bureaucrats maximize their utility subject to a public sector budget constraint, the task of this dissertation research is to find an appropriate statistical procedure to empirically test whether the assumption of constrained optimization holds.

There are two approaches to test whether or not the observed data set conforms to the assumption of utility maximization in the literature. The most frequently used approach is to assume either a specific functional form of the underlying utility (preference) relations among a set of economic and socio-economic variables from which the demand curves are derived, or a specific functional form for the demand curves directly with an implicit assumption about the underlying utility (preference). Parameters such as price and income elasticities are then estimated empirically and evaluated for their consistency with the known theoretical properties from consumer choice theory. For example, Barr and Davis (1966), Henderson (1968), Wilde (1968), Gramlich (1969a), and Inman (1971) all proceed from the constrained utility maximization framework to derive the demand equations, whereas Ohls and Wales (1972), Borcherding and Deacon (1972), Bergstrom and Goodman (1973), Deacon (1978), and other researchers working on the median voter models assume a set of demand functions which they then estimate.

The alternative approach uses the nonparametric revealed preference theory to test the data, and does not assume a specific functional form of either the utility function or the

demand functions. As the term "nonparametric" implies, no estimation of parameters are involved in this test procedure. What follows is a more detailed description of these two alternative approaches to testing utility-maximization with a given set of observed data.

3.1.1 Parametric Tests

To apply the neoclassical consumer choice theory to public sector decision-making, it is necessary to specify a variety of functional forms of utility and/or demand functions to derive the estimating equations. The functional form so specified can be any of the following: the standard Cobb-Douglass utility function, the constant elasticity of substitution (CES) utility function, the Stone-Geary Homothetic utility function, the addilog utility function, the translog utility function, the Rotterdam model of systems of demand equations, or the Almost Ideal Demand System (AIDS) [see, for example, Theil (1980, chapters 2 and 13); Deaton and Muellbauer (1980); and Silberberg (1990, pp. 405-411)].

The choice of functional form for the utility function determines the set of restrictions on the structure of the underlying utility (preference) as well as the resultant behavior functions. For example, it is well-known that the demand equations derived from neoclassical utility maximization subject to a budget constraint must satisfy the following three properties:

(a) negativity of the Hicksian own price effect;

(b) symmetry of the Hicksian cross-price effects; and

(c) The resultant Mashallian demand function is homogeneous of degree zero in income and prices.

What follows is a demonstration of the actual parametric test procedure used for this dissertation research. The translog utility function as developed in Christensen, Jorgenson and Lau (1975) is known for its flexibility. For the purpose of this research, it is chosen for the parametric tests of utility maximization hypothesis. The objective then is to:

$$(8) \qquad Max \quad lnU_i = \alpha_0 + \Sigma_i \alpha_i \, lnX_i + \tfrac{1}{2} \Sigma_i \Sigma_j \beta_{ij} \, lnX_j$$

$$\text{Subject to} \quad \Sigma_i P_i X_i = M, \quad i, j = 1, 2, \ldots, m$$

Where U is the utility of local (or central) bureaucracy, M the total local public budget, X_i the output or service level of the i^{th} local public function, P_i the price of the i^{th} public good, and *m* the number of local public goods and services. The budget or expenditure share for each category of public services can be derived from the above constrained maximization problem, and is expressed as following:

$$(9) \qquad \frac{P_i X_i}{M} = \frac{\alpha_i + \Sigma_j \beta_{ij} \, lnX_j}{\Sigma_k \alpha_k + \Sigma_j \Sigma_k \beta_{kj} \, lnX_j}$$

where β_{ij} are parameters of the cross-partial derivatives and $\Sigma_k \alpha_k = -1$, $k = 1, 2, \ldots, m$.

The budget share equations must satisfy the three properties of a well-behaved demand function derived from a constrained utility maximization problem. In empirical testing of the utility maximization hypothesis, these properties translate into the following two restrictions [Christensen, Jorgenson and Lau (1975), p. 371]:

(a) Symmetry: $\beta_{ij} = \beta_{ji}$, $i \neq j$, $i, j = 1, 2, \ldots, m$; and

(b) Equality: $\Sigma_k \beta_{kj}$ (appearing in the denominator) must be the same for each budget share equation.

To perform the estimation procedures, two additional assumptions are needed: (a) stochastic specification of the theoretical models of the budget share equations is assumed, so that disturbances from i = 1, 2, ..., m of the budget share equations sum to zero. Given the disturbances in any (m - 1) equations, the disturbance of the remaining equation can be determined. Thus only (m - 1) estimating equations are required; and (b) disturbances are assumed to be independent of the X_i's.

The total number of parameters to be estimated for the econometric demand equations without the restrictions is [5 + (m - 2)*2]*(m - 1). For the restricted model, there will be (½)*m*(m - 1) symmetry restrictions, and m*(m - 2) equality restrictions. If there are only three categories of public services under study (i.e. m = 3), the whole system of demand equations will comprise of *three* budget share or expenditure equations, and we only have to estimate any two, such as the following:

(10) $$\frac{P_1 X_1}{M} = \frac{\alpha_1 + \beta_{11} lnX_1 + \beta_{12} lnX_2 + \beta_{13} lnX_3}{(-1 + \beta_{k1} lnX_1 + \beta_{k2} lnx_2 + \beta_{k3} lnX_3)}$$

(11) $$\frac{P_2 X_2}{M} = \frac{\alpha_2 + \beta_{21} lnX_1 + \beta_{22} lnX_2 + \beta_{23} lnX_3}{(-1 + \beta_{k1} lnX_1 + \beta_{k2} lnx_2 + \beta_{k3} lnX_3)}$$

Where P_iX_i = total public expenditure in service category *i*, *i* =1, 2;

X_i = output or service level in service category *i*, *i* = 1, 2, 3;

$\beta_{k1} = \beta_{11} + \beta_{21} + \beta_{31}$;

$\beta_{k2} = \beta_{12} + \beta_{22} + \beta_{32}$;

$\beta_{k3} = \beta_{13} + \beta_{23} + \beta_{33}$;

Note that for the unrestricted form (i.e. no assumption is made about utility maximization), the denominators in equations (10) and (11) will have to be estimated separately. For the restricted form (i.e. when the utility maximization restrictions are imposed), only one set of the denominator needs be estimated. The hypothesis testing procedure is as follows: The maintained hypothesis is that the restricted form is not statistically different from the unrestricted form. To test this hypothesis, a likelihood ratio test procedure as described in Christensen, Jorgenson and Lau (1975, pp. 378-9) or in Judge, Hill, Griffiths, Lütkephol and Lee (1988, p.105) can be performed to determine whether or not the hypothesis of utility maximization can be rejected at a certain pre-determined significance level. Specifically, the likelihood ratio λ is:

(12) $$\lambda = l(\omega) / l(\Omega)$$

where $l(\omega)$ is the maximum value of the likelihood function for the restricted model, and $l(\Omega)$ the maximum value of the likelihood function for the unrestricted model. The test statistic LR is:

(13) $$LR = 2 [L(\Theta^*) - L(\Theta_0)]$$

where $L(\Theta^*)$ is the maximum likelihood estimator of the unrestricted log-likelihood function, and $L(\Theta_0)$ the maximum likelihood estimator of the restricted log-likelihood function. Under the maintained hypothesis, LR is asymptotically distributed as a χ^2 random variable with degrees of freedom equal to the number of restrictions (i.e. the number of maintained hypotheses) to be tested. Once the models are estimated, LR can be calculated and compared with the critical value to determine if the null hypothesis can be rejected. Failure to reject the null hypothesis implies that the assumption of utility maximization holds.

For separability under utility maximization, the following restrictions (for a system of three equations) can be separately imposed:

(a) $\beta_{13}/\alpha_1 = \beta_{23}/\alpha_2$ (separability of X_1 and X_2 from X_3); or

(b) $\beta_{12}/\alpha_1 = \beta_{32}/\alpha_3$ (separability of X_1 and X_3 from X_2); or

(c) $\beta_{21}/\alpha_2 = \beta_{31}/\alpha_3$ (separability of X_2 and X_3 from X_1).

A similar likelihood ratio test can be performed for each of these separability restrictions to determine whether of not the maintained specific separability hypothesis can be rejected. Failure to reject the null hypothesis implies that the assumption of separability holds for the specific group of service categories from other service category. For example, if the test results show that restriction (a) cannot be rejected while restrictions (b) and (c) are rejected at the pre-specified significance level, then we can conclude that public services X_1 and X_2 as a group is separable from public service X_3.

3.1.2 Nonparametric Tests

Instead of testing whether or not the observed public sector expenditure data conforms to the particular functional form of the bureaucracy's utility function, a nonparametric approach simply tests whether or not the observed data is consistent with the axioms of revealed preferences. In this approach, no parameters need be estimated, nor is it necessary to assume *a priori* a particular functional form of the utility function. This nonparametric test procedure is based on the theoretical concepts first developed by Samuelson (1938) and Houthakkar (1950) and later made empirically operational by Afriat (1967, 1976) and Varian (1982, 1983, 1985).

The weak axiom of revealed preference (WARP) states that a bundle of goods $\mathbf{X}^i$ is revealed preferred to a bundle of goods $\mathbf{X}^j$ if given the price vector $\mathbf{P}^i$ and total expenditures $\mathbf{P}^i\mathbf{X}^i$, the goods bundle $\mathbf{X}^i$ is purchased when the goods bundle $\mathbf{X}^j$ is also available. The goods bundle $\mathbf{X}^j$ *could have been chosen*, but was not, at prices $\mathbf{P}^i$, it then must be inferior to goods bundle $\mathbf{X}^i$ and will never be revealed preferred to $\mathbf{X}^i$. Thus WARP can be written in mathematical form as:

(14) $\quad$ If $\mathbf{P}^i\mathbf{X}^i \geq \mathbf{P}^i\mathbf{X}^j$, $\quad$ then $\quad \mathbf{P}^j\mathbf{X}^j < \mathbf{P}^j\mathbf{X}^i$

In the context of this dissertation research, $\mathbf{P}^i\mathbf{X}^i = \sum_k^i p_k^i x_k^i$ (k = 1, ..., m, the number of public goods and services) represents total local public expenditures on all publicly provided goods and services by jurisdiction *i* in the cross-section data set, or for year *i* by a jurisdiction in the time-series data set. $\mathbf{P}^i\mathbf{X}^j = \sum_k^j p_k^i x_k^j$ represents total public expenditures for jurisdiction *j* evaluated at jurisdiction *i's* prices in cross-section analysis, or for year *j* at year *i*'s prices in time-series analysis.

The strong axiom of revealed preference (SARP) states that if given the price vector $\mathbf{P}^i$ and total expenditure $\mathbf{P}^i\mathbf{X}^i$, the goods bundle $\mathbf{X}^i$ is revealed preferred to the goods bundle $\mathbf{X}^j$, and given the price vector $\mathbf{P}^j$ and total expenditure $\mathbf{P}^j\mathbf{X}^j$, the goods bundle $\mathbf{X}^j$ is revealed preferred to $\mathbf{X}^k$, then the goods bundle $\mathbf{X}^i$ is revealed preferred to the goods bundle $\mathbf{X}^k$ through transitivity, and the goods bundle $\mathbf{X}^k$ cannot be also revealed preferred to the goods bundle $\mathbf{X}^i$. In mathematical terms, SARP can be expressed as:

(15) $\quad$ If $\quad \mathbf{P}^1\mathbf{X}^1 \geq \mathbf{P}^1\mathbf{X}^2$, $\mathbf{P}^2\mathbf{X}^2 \geq \mathbf{P}^2\mathbf{X}^3, \ldots, \mathbf{P}^{k-1}\mathbf{X}^{k-1} \geq \mathbf{P}^{k-1}\mathbf{X}^k$,

$\quad$ then $\quad \mathbf{X}^1 \, R \, \mathbf{X}^k$, $\quad$ and $\quad \mathbf{P}^k\mathbf{X}^k < \mathbf{P}^k\mathbf{X}^1$

where "R" describes the transitive relationship.

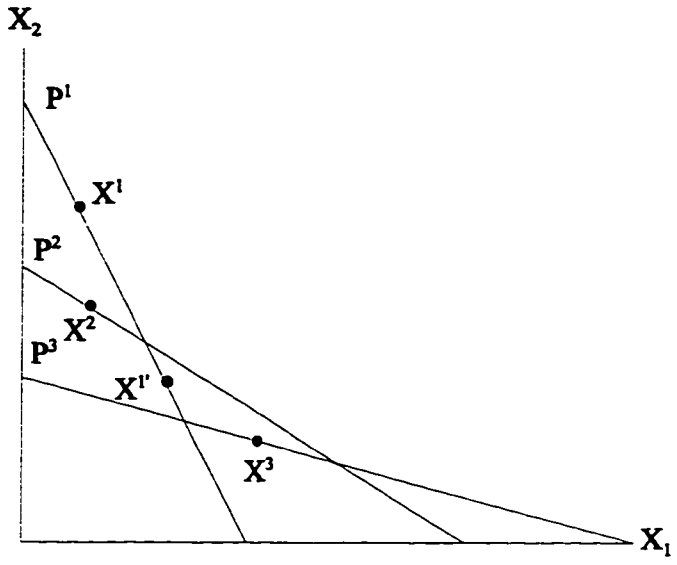
SARP implies Varian's (1982) Generalized Axiom of Revealed Preference (GARP), which states that if $\mathbf{X}^i$ is revealed preferred to $\mathbf{X}^k$ through transitivity, then $\mathbf{X}^k$ cannot be *directly strictly* revealed preferred to $\mathbf{X}^i$. A goods bundle $\mathbf{X}^k$ is defined as *directly strictly* revealed preferred to $\mathbf{X}^i$ if $\mathbf{P}^k\mathbf{X}^k > \mathbf{P}^k\mathbf{X}^i$. Therefore GARP can be expressed as:

(16) If $\mathbf{P}^1\mathbf{X}^1 \geq \mathbf{P}^1\mathbf{X}^2$, $\mathbf{P}^2\mathbf{X}^2 \geq \mathbf{P}^2\mathbf{X}^3, \ldots, \mathbf{P}^{k-1}\mathbf{X}^{k-1} \geq \mathbf{P}^{k-1}\mathbf{X}^k$,

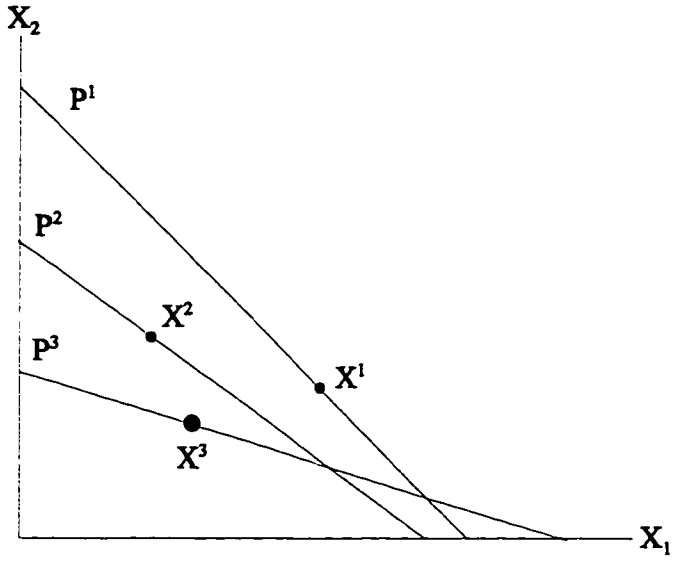
then $\mathbf{X}^1 \, R \, \mathbf{X}^k$, and $\mathbf{P}^k\mathbf{X}^k \leq \mathbf{P}^k\mathbf{X}^1$

Note that WARP is a necessary, but not sufficient, condition for the data set to be consistent with SARP or GARP, and that SARP requires the demand relations to be single-valued while GARP is compatible with multi-valued solutions, so that although SARP implies GARP, the reverse is not true. That is, GARP allows for flat areas on the indifference curves in standard consumer theory. The transitivity relations described above is what is called by Varian as the "transitive closure" in GARP.

Figure 3 is used to illustrate the relations among WARP, SARP and GARP. As shown in Panel A of the diagram, the goods bundle $\mathbf{X}^2$ lies inside the budget line represented by $\mathbf{P}^1\mathbf{X}^1$, and $\mathbf{X}^3$, though inside the budget line represented by $\mathbf{P}^2\mathbf{X}^2$, is outside the budget line $\mathbf{P}^1\mathbf{X}^1$. What the diagram means is that at prices $\mathbf{P}^1$ the goods bundle $\mathbf{X}^1$ is chosen, indicating that $\mathbf{X}^2$ could have been purchased, but was not, at prices $\mathbf{P}^1$, therefore $\mathbf{X}^1$ is revealed preferred to $\mathbf{X}^2$. At prices $\mathbf{P}^1$, goods bundle $\mathbf{X}^3$ is more expensive than goods bundle $\mathbf{X}^1$, indicating that it is not available at $\mathbf{P}^1$. Therefore $\mathbf{X}^1$ and $\mathbf{X}^3$ are not comparable by direct comparison. The goods bundle $\mathbf{X}^2$ is chosen at prices $\mathbf{P}^2$ when $\mathbf{X}^3$ is also available, therefore $\mathbf{X}^2$ is revealed preferred to $\mathbf{X}^3$. The paired bundles ($\mathbf{X}^1$, $\mathbf{X}^2$) and ($\mathbf{X}^2$, $\mathbf{X}^3$) are consistent with WARP.



(Panel A)



(Panel B)

Figure 3. The Weak, Strong and Generalized Axiom of Revealed Preference

A comparison of goods bundles $\mathbf{X}^{1'}$ and $\mathbf{X}^2$, however, shows a violation of WARP. At prices $\mathbf{P}^2$, the goods bundle $\mathbf{X}^{1'}$ could have been chosen, but was not. Therefore $\mathbf{X}^2$ is revealed preferred to goods bundle $\mathbf{X}^{1'}$. At prices $\mathbf{P}^1$, however, the goods bundle $\mathbf{X}^{1'}$ is also revealed preferred to the goods bundle $\mathbf{X}^2$. This clearly violates WARP.

Although $\mathbf{X}^1$ and $\mathbf{X}^3$ are not comparable by WARP as in Panel A, since $\mathbf{X}^1$ is revealed preferred to $\mathbf{X}^2$, and $\mathbf{X}^2$ to $\mathbf{X}^3$, then $\mathbf{X}^1$ is revealed preferred to $\mathbf{X}^3$ through the transitive closure. Note that the implied relationship $\mathbf{P}^3\mathbf{X}^3 \leq \mathbf{P}^3\mathbf{X}^1$ is fulfilled. The paired bundle $(\mathbf{X}^1, \mathbf{X}^3)$ is therefore consistent with both SARP and GARP. By the same token, in Panel B of the diagram, the paired bundles $(\mathbf{X}^1, \mathbf{X}^2)$, $(\mathbf{X}^1, \mathbf{X}^3)$, and $(\mathbf{X}^2, \mathbf{X}^3)$ are all consistent with WARP, and $(\mathbf{X}^1, \mathbf{X}^3)$ is also consistent with both SARP and GARP.

If a data set satisfies GARP, then, according to Afriat's Theorem (1967, 1976), "*there exists a nonsatiated, continuous, concave, monotonic utility function that rationalizes the data*" [Varian (1982), p. 946, Italics original]. Therefore, it is possible to work backward to demonstrate the existence of a well-behaved (i.e. quasi-concave) utility function from a data set that does not violate GARP, which in turn guarantees the simultaneous satisfaction of the three properties of a demand function [Silberberg (1990), p. 381].

As described by DeBoer (1986), there are two possible types of GARP violations. The first is a "direct" violation that occurs when a goods bundle $\mathbf{X}^i$ is revealed preferred or indifferent to another goods bundle $\mathbf{X}^j$, but $\mathbf{X}^j$ is also revealed preferred to $\mathbf{X}^i$. This type of violation is in essence a violation of WARP described above. A second type of violation is the "transitive" violation, which occurs when $\mathbf{X}^i$ is revealed preferred to $\mathbf{X}^j$ through the

transitive closure, but $\mathbf{X}^j$ is also revealed preferred to $\mathbf{X}^i$ through direct comparison. "If GARP is satisfied, the data may be characterized as the result of constrained utility maximization. If the data set contains a violation of GARP, it cannot be described as the result of constrained maximization." [DeBoer (1986), p. 90]

In order to ascertain whether or not the local public bureacrats have well-behaved preferences defined over the public sector budget, the nonparametric test techniques according to the concept of GARP can be carried out to check the consistency condition of the oberserved data set. In the first stage of the procedures, the task is to calculate $\mathbf{P}^i\mathbf{X}^i$ and $\mathbf{P}^i\mathbf{X}^j$ across all jurisdictions i and j in any given year in the cross-section analysis, or for all years i and j in any given jurisdiction in the time-series analysis. In the second stage, these total public expenditure results will be compared pairwise with all other cross-price expenditure results to check if there exist any violations of WARP. In the final step, a pairwise comparison through the transitive closure will be performed to check whether GARP is violated. Failure to find GARP violations would imply that the public expenditure data from Taiwan can be viewed as constrained optimization outcome. In other words, if the data satisfy GARP, then the local (or central) bureaucracies have well-defined bureaucratic utility functions and they behave "as if" they maximize public spending.

3.1.3 Comparison of Parametric and Nonparametric Tests

As made clear by the above description of these two alternative test approaches, the nonparametric approach appears superior to the parametric procedure.

As DeBoer (1986, p. 89) puts it, rejection of utility maximization, using a particular functional form, may mean either one of two possibilities: (1) the data set cannot be rationalized by constrained maximization; or (2) the data set can be rationalized by constrained maximization, but not by the chosen parametric form of the utility or demand function. The second possibility is perhaps the most likely cause for rejection of utility maximization, and hence consumer choice theory, because the parametric test results are conditional on the functional form's being correct. Christensen, Jorgenson and Lau (1975) reject demand theory using direct and indirect translog utility functions. Deaton (1986), however, contends that functional form is not likely to be the source of the failure of demand theory because there have been a variety of studies using different functional forms. Nevertheless, numerous researchers, such as Varian (1982, 1983, 1985), DeBoer (1986), Chavas and Cox (1988), Chalfant and Alston (1988), Swofford and Whitney (1987, 1994), and Swofford (1995), have cited this disadvantage of parametric tests. The fundamental shortcoming in this regard is that the parametric test is really a joint test of the structure of the underlying utility and the choice of particular functional form. When the observed data set fails to accept the assumption of utility maximization, hence the validity of demand theory, there is no way of knowing whether the failure is due to data inconsistency or to the choice of an inappropriate functional form of preference [see, for example, Famulari (1995), p.372].

Another disadvantage of parametric tests is that they require more observations than the number of parameters to be estimated, as pointed out by Swofford and Whitney (1994) and Swofford (1995). In the translog utility example described in Section 3.1.1 above, there

are at least fourteen parameters to be estimated for the unrestricted models for a system of three budget share equations, with any two service categories being estimated. The number of parameters to be estimated increases to twenty-seven for a system of four budget share equations, with any three service categories being estimated. It is well-known in econometrics that the number of observations has to be *at least equal* to the number of parameters to be estimated, and in this case the degrees of freedom will be too small as to render the statistical results unacceptable. Thus the number of observations available to the researcher performing the parametric test often becomes a source of problem itself.

The advantages of nonparametric tests are therefore clear: the method requires no ad hoc functional form specifications, and when only a small number of observations is available, the revealed preference approach is clearly to be preferred to parametric ones. But nonparametric tests are not without drawbacks: Nonparametric tests are capable of only showing whether or not the observed data set can be viewed as the result of constrained optimization. They offer no statistical criteria for evaluating functional relationships among key variables. And for public policy purposes, parametric tests are still necessary in order to obtain coefficient estimates of policy control variables (the explanatory variables) so that the effects of their changes on policy target variables (the dependent variable) can be approximated and studied. Nonparametric tests do not provide such policy-oriented guidance to researchers. Thus to get "the best of two worlds," nonparametric tests should be performed to check data consistency. Once the consistency characteristic is established, parametric tests that use flexible functional specifications for the underlying preferences can be undertaken for policy purposes.

3.2 Data: Taiwan's Hsien and Municipal Data

The data set utilized to perform both parametric and nonparametric tests is drawn from the public spending and employment data of Taiwan's current sixteen "Hsiens" and five provincially designated "Municipalities" from 1986 to 1994. A Hsien in Taiwan is comparable to a county in the United States. These Hsien and Municipal governments are administratively equal in rank in the hierarchical order of government structure under the provincial government of Taiwan: under a Hsien, there are smaller cities, townships and villages; under a provincially designated Municipality, there are districts. These Hsien and Municipal governments are all general-purpose local political administrative agencies, providing, under the aegis of the provincial government of Taiwan, a variety of public goods and services that include: general administration and civil affairs; primary and secondary education (henceforth public education); transportation/public road services and maintenance; social welfare including social insurance, social relief, employment services and public health; community development and environmental protection, public safety including both police and fire protection; grants and aids to lower-leveled administrative units, etc.

Of these public services, public education is the single most important function of the Hsien and Municipal governments, accounting for an average of more than 45 percent of total local current account expenditures. Public safety is the second most important local public function, accounting for about 15 percent of total local current account expenditures. Together these two functions account for as high as 72 percent of current account spending for some Hsiens and Municipalities, with an overall average of 61

percent for all localities during the 1986-94 period. Table 1 provides a summary of local public service to total current account expenditures ratios for public education and public safety by year during the 1986-94 period. In terms of employment, public education and public safety are also the two most important local government functions, with the former accounting for an average of more than 55 percent of local public employment. These two functions together account for approximately three-fourths of local public sector employment. Table 2 provides a summary of local public service to total public sector employment ratios.

Because of limited data availability, this research focuses on four public service categories: public education, public safety, public health, and environmental protection. Full-time employment data for each of the four public functions is used as a proxy for the quantity of public goods received by the citizenry and the average wage rate for each public service category is used as a proxy for the unit price of that public function.

In empirical studies, per capita expenditures are typically used to proxy service level under the assumption that the services are produced under constant returns technology. Alternatively, public sector employment and wages for each service category can be assumed to be equivalent to public output and prices. For this alternative approach to be valid, however, three conditions must hold: First, employment is proportional to output. This implies that public output varies directly with public employment. Second, the quality of labor input is the same across jurisdictions. This implies that output differences among jurisdictions can be explained by employment differences. And finally, the prices of nonlabor inputs do not vary across jurisdictions. This implies that the prices of public services vary directly with public sector wages. The public employment

Table 1. Maximum, Minimum and Mean Ratios of Local Service Current Account Expenses to Total Current Account Expenditures [a, b]

Year	Public Education Maximum Ratio	Public Education Minimum Ratio	(1) Public Education Mean Ratio[c]	Public Safety Maximum Ratio	Public Safety Minimum Ratio	(2) Public Safety Mean Ratio[c]	(3) = (1) + (2)
1986	.623 (Taipei H.)	.374 (Taichung M.)	.494 (.078)	.184 (Chiayi H.)	.114 (Taichung M.)	.148 (.017)	.642
1987	.610 (Taoyuan H.)	.362 (Penghu H.)	.487 (.072)	.189 (Hsinchu H.)	.115 (Taichung M.)	.150 (.022)	.637
1988	.585 (Taoyuan H.)	.381 (Keelung M.)	.486 (.064)	.184 (Hsinchu H.)	.122 (Taichung M.)	.147 (.019)	.633
1989	.579 (Taipei H.)	.217 (Taichung M.)	.443 (.088)	.241 (Penghu H.)	.073 (Taichung M.)	.144 (.036)	.587
1990	.573 (Taipei H.)	.326 (Penghu H.)	.453 (.072)	.255 (Penghu H.)	.108 (Nantou H.)	.147 (.034)	.600
1991	.567 (Taoyuan H.)	..344 (Penghu H.)	.464 (.060)	.271 (Penghu H.)	.043 (Chiayi M.)	.156 (.041)	.620
1992	.567 (Taoyuan H.)	.346 (Penghu H.)	.470 (.059)	.241 (Penghu H.)	.081 (Chiayi M.)	.151 (.032)	.621
1993	.540 (Changhwa H.)	.336 (Penghu H.)	.437 (.055)	.247 (Penghu H.)	.115 (Tainan H.)	.146 (.032)	.583
1994	.552 (Taipei H.)	.323 Penghu H.)	.455 (.058)	.269 (Penghu H.)	.114 (Tainan H.)	.157 (.037)	.602
Average			.465			.150	.614

a: "H" stands for Hsien, and "M" for Municipality. Jurisdictions in parentheses indicate where the respective maximum or minimum ratios take place.

b: Sources: These ratios are calculated from the expenditure data from various editions of the *Annual Report: Financial Statistics of Taiwan Province,* Department of Finance, Taiwan Provincial Government.

c: The numbers in parentheses in columns (1) and (2) are standard deviations.

Table 2. Maximum, Minimum and Mean Ratios of Local Service Employment to Total Public Sector Employment [a, b]

Year	Public Education Maximum Ratio	Public Education Minimum Ratio	(1) Public Education Mean Ratio[c]	Public Safety Maximum Ratio	Public Safety Minimum Ratio	(2) Public Safety Mean Ratio[c]	(3) = (1) + (2)
1986	.677 (Taoyuan H.)	.460 (Penghu H.)	.568 (.057)	.199 (Hsinchu H.)	.113 (Changhwa H.)	.152 (.026)	.720
1987	.672 (Taoyuan H.)	.447 (Penghu H.)	.567 (.060)	.202 (Hsinchu H.)	.116 (Changhwa H.)	.154 (.028)	.721
1988	.665 (Taoyuan H.)	.388 (Penghu H.)	.561 (.070)	.295 (Penghu H.)	.116 (Tainan H.)	.166 (.043)	.727
1989	.668 (Taoyuan H.)	.368 (Penghu H.)	.560 (.075)	.326 (Penghu H.)	.112 (Tainan H.)	.167 (.050)	.727
1990	.673 (Taoyuan H.)	.369 (Penghu H.)	.563 (.077)	.318 (Penghu H.)	.109 (Tainan H.)	.168 (.050)	.731
1991	.675 (Taichung M.)	.357 (Penghu H.)	.558 (.074)	.321 (Penghu H.)	.109 (Tainan H.)	.173 (.048)	.731
1992	.653 (Taoyuan H.)	.357 (Penghu H.)	.549 (.067)	.336 (Penghu H.)	.155 (Taichung H.)	.201 (.044)	.750
1993	.636 (Taoyuan H.)	.332 (Penghu H.)	.537 (.064)	.393 (Penghu H.)	.175 (Hsinchu H.)	.215 (.050)	.754
1994	.663 (Taoyuan H.)	.337 Penghu H.)	.559 (.072)	.395 (Penghu H.)	.155 (Taichung M.)	.205 (.054)	.764
Average			.558			.178	.736

a: See Table 1.

b: Sources: These ratios are calculated from the employment data from various editions of the *Statistical Abstract of Personnel Affairs in Taiwan Province*, Department of Personnel, Taiwan Provincial Government.

c: The numbers in parentheses in columns (1) and (2) are standard deviations.

approach to measuring public output also assumes that the public sector production uses a Leontief fixed-coefficient technology, which is identical across all jurisdictions [Bahl, Johnson and Wasylenko (1980, pp. 99-100); Grosskopf and Hayes (1983, p. 209); and DeBoer (1986, p. 91)].

The assumption of Leontief fixed-factor production technology precludes the possibility of labor-capital substitution. Note that the Cobb-Douglas constant return to scale production technology can also be shown to satisfy the three conditions described above. For example, Borcherding and Deacon (1972) use the Cobb-Douglas production function and assume that labor and capital are the only two types of factors of production. Since capital is typically assumed to be perfectly mobile, while labor is not, across all political units, the rental price per unit of capital is invariant for all jurisdictions. However, the Cobb-Douglas production function implies the possibility of considerable substitution among factors of production, which, it can be argued, may be questionable for certain types of public service production. For instance, Bahl, Johnson and Wasylenko (1980, p. 100) use the example of police to argue that a unit of police output requires a policeman plus certain amount of expenditures for his uniform, gun, club, patrol car, etc. Thus the public employment approach typically assumes a fixed-factor production technology in the public sector.

The justification for choosing a fixed-factor production technology over the constant returns technology does not necessarily mean that the public sector employment approach is superior to the per capita expenditures method in measuring public output. As Bahl, Johnson and Wasylenko (1980) point out, the equality of labor quality condition in

a cross-sectional analysis ignores geographical diversity, and in a time-series analysis this condition is equivalent to assuming that labor productivity does not vary over time. Because of the stringent conditions and obvious drawbacks, this public sector employment approach should be employed with care. Data availability typically dictates which approach is followed, as is the case in this study.

For this research, the use of public employment and wages is justified despite these drawbacks. First, local public sector services in Taiwan are provided with labor-intensive production technologies, with labor's share accounting for an average of about 75 percent of total noncapital expenses for all localities in each year during the 1986-94 period.[1] Second, population notwithstanding, Taiwan is a small political unit, about one-third the size of the State of Louisiana. The sixteen Hsiens and five Municipalities are contiguous sub-level political entities in which there are no legal or institutional restrictions to free labor mobility. Therefore, as far as Taiwan is concerned, the constant labor quality assumption is reasonably well justified in the cross-section analysis.

As noted above, the use of public employment and wages to proxy public output and prices assumes that public sector prices vary directly with public sector wages. It is well known in the spatial economics literature that even when labor is homogeneous and mobile, wages will vary across regions, depending upon the relative size of the urban areas contained in the regions [Brueckner (1987), p. 837]. Therefore, public sector wage

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[1]Please see Table 7 on p. 84 and Table 12 on p. 87 in Chapter 4 for avearge overall labor share at the local level.

differentials across jurisdictions in Taiwan are expected. The 1986-94 data set confirms this expectation.[2]

Data on current account expenditures by function and aggregated wages and salaries for each of the Hsien and Municipality are drawn from the *Annual Report: Financial Statistics of Taiwan Province*, various editions, published by the Department of Finance, Taiwan Provincial Government. Data on full-time employment by function for each Hsien and Municipality are drawn from the *Statistical Abstract of Personnel Affairs in Taiwan Province*, various editions, published by the Department of Personnel, Taiwan Provincial Government. GNP deflators, for adjusting for price changes over time, are from the *Quarterly National Economic Trends*, published in August 1995 by the Directorate-General of Accounting, Budget and Statistics, Executive Yuan, Taiwan, Republic of China.

For the probit analysis, additional data are collected. Data on population and population density for each Hsien and Municipality are from the *Annual Report of Interior of the Republic of China*, various editions, published by Department of Statistics, Ministry of Interior, Republic of China. Data on the number of eligible voters and voter turnouts, also at local level, for the 1985, 1989 and 1993 elections of magistrates and mayors are drawn from the *Statistical Abstract of Interior of the Republic of China*, the 1993 edition, also published by Department of Statistics, Ministry of Interior, Republic of China. Data on election results from the above-mentioned Hsien and Municipality elections are from the *Statistics on Civil Affairs, Taiwan Province, No. 24*, published by Department of Civil

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[2]Please see Tables 8 and 9 on p. 85 and Table 12 on p. 87 in Chapter 4 for the calculated average wage rates for public education and public safety in the cross-section and pooled data sets.

affairs, Taiwan Provincial Government. Data on annual family income, disaggregated at local level, are from the *Report on the Survey of Family Income and Expenditure, Taiwan Province, Republic of China*, various editions, published by Department of Budget, Accounting and Statistics, Taiwan provincial Government.

CHAPTER 4

EMPIRICAL RESULTS[1]

4.1 Introduction

Using employment and average wage rate in public service category *i* as a proxy for output X_i and price P_i, $P_i X_i / M$ in the budget share equations (9), (10) and (11) then becomes labor's share of public spending in service category *i*. This labor share variable is used as the dependent variable in parametric tests. For nonparametric tests, $P_i X_i$, the total wage bill in service category *i*, and $P_i X_j$, the wage bill in service category *j* calculated using service category *i*'s average wage rate, are used instead.

In order to calculate average wage rate for each local service category under this study, an assumption has to be made. Since only the aggregated wage and salary data, which is not broken down by service category, for each locality is available, it is conveniently assumed that the ratio of wage bill to current account expenditures for each local function in each locality is the same as the overall ratio in that jurisdiction. Admittedly, it is a strong assumption. There is, however, no way to get around the data limitation. The extent to which this assumption may be driving the empirical results, however, can be and will be examined later with the technique of sensitivity analysis.

In all of the statistical test procedures performed in this dissertation research, including parametric, nonparametric, sensitivity analysis and probit analysis, whenever

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[1]In order to perform the nonparametric tests, a SAS-IML computer program, shown in Appendix B, was written based on the PASCAL program supplied by Professor Hal R. Varian and the IML program supplied by Professor Lawrence DeBoer. My thanks are due to these two professors.

time-series or pooled data are used, all monetary values are properly adjusted for inflation over time by GNP deflators.

4.2 Parametric Results

As described in Section 3.1.1 in Chapter 3, in performing parametric tests using a translog utility specification, the total number of budget share equations as in equation (9) that can be estimated depends to a large extent on the number of observations. Because there are only twenty-one cross-section observations each year for this study, the maximum number of budget share equations in the model cannot be more than three, with two of these three, such as equations (10) and (11), being actually estimated. With a system of three budget share equations, the total number of parameters to be estimated would be fourteen for the unrestricted model. The number of parameters to be estimated would escalate to be twenty-seven if four budget share equations were specified. Thanks to this limitation, only three local public services are selected for parametric tests: public education, public safety, and all other functions. The selection of the first two public services is obvious: these two are the most important local public sector functions during the period under study. The third service category is otherwise referred to as "residual category" that includes all other public services provided by local governments [Grosskopf and Hayes, (1983)]. Since there are only nine observation points in the time-series data set for each jurisdiction, no time-series analyses are attempted.

The budget share equations were estimated on the nine cross-section data sets and the pooled cross-section and time-series data set using both SAS and SHAZAM nonlinear

maximum likelihood estimation procedures.[2] Although these two statistical packages utilize different algorithms, the former using the GAUSS-NEWTON iteration algorithm while the latter a quasi-NEWTON method, the resultant estimates are similar to the extent that convergence is reachable. Because of the highly nonlinear nature of the budget share equations in a translog utility specification and of the high degree of multicollinearity among the exogenous variables in the equations, however, it has been extremely difficult to obtain consistent estimates of the parameters. The source of multicollinearity comes from the fact that the value of X_3, the residual category, is derived by subtracting X_1, public education employment data, and X_2, public safety employment data, from total employment. Attempts to test the separability assumptions, although highly desirable since many studies in the field of public finance have focused on a single service category (e.g. public education or fire protection), have also failed for precisely the same reason. Therefore, no reports of the separability tests will be presented in this dissertation.

To the extent that it is possible to obtain estimates of the parameters at all, the usefulness of those estimates is highly questionable. Nevertheless, results for 1986, 1994 and the pooled data set are reported in Table 3. Estimates for 1986 are not very precise, judging from the high standard error estimates of the parameters for the unrestricted model. Estimates for the pooled data set are not useful either, because of the obviously biased estimates (e.g. α_1 = 10,999) for all coefficients and the unusually high standard error estimates of the parameters for the restricted model. Estimates for the 1994 date set do

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[2]An example of the SAS program is presented in Appendix A. It is partially annotated, but otherwise quite easy to follow. The SHAZAM program is very similar to the SAS program, so no examples of the former are presented.

Table 3. Estimates of the Parameters of the Direct Translog Utility Function[a]

Parameters	1986		1994		1986-94 Pooled Data	
	Unrestricted Model	Utility-Max Model	Unrestricted Model	Utility-Max Model	Unrestricted Model	Utility-Max Model
α_1	.0660	.0506	-.3861**	-.2205	-.3590**	10,999
	(.7241)	(.2993)	(.0531)	(.1360)	(.0449)	(230,540)
α_2	.7368	-.1118**	-.1638**	-.2012**	-.1585**	-882.36
	(39.21)	(.0322)	(.0072)	(.0361)	(.0107)	(18,490)
α_3	-1.8028[b]	-.9388[b]	-.4501[b]	-.5783[b]	-.4825[b]	-10,117.64[b]
β_{11}	.0989	-.0647	-.0231*	-.0714	-.0020	-3,535.3
	(.2200)	(.0552)	(.0542)	(.0490)	(.0487)	(74,099)
β_{12}	.2708	.0441**	.1013	.0554**	.0384	1,102.8
	(.4231)	(.0208)	(.0525)	(.0204)	(.0339)	(23,115)
β_{13}	-.4104	-.0131	-.0368	.0145	-.0022	-193.35
	(.6931)	(.0343)	(.1047)	(.0236)	(.0546)	(4,053.2)
β_{21}	-1.9987	.0441**	-.0094	.0554**	-.0601**	1,102.8
	(86.46)	(.0208)	(.0116)	(.0204)	(.0214)	(23,115)
β_{22}	-.6874	-.0444**	-.0015	-.0816**	-.0009	-1,627.9
	(29.42)	(.0261)	(.0107)	(.0372)	(.0116)	(34,120)
β_{23}	2.3883	-.0039	.0311*	.0310**	.0810**	-59.10
	(101.89)	(.0104)	(.0159)	(.0135)	(.0295)	(1,238.8)
β_{31}	2.2939	-.0131	.0270	.0145	.1141*	-193.35
	(86.38)	(.0343)	(.0814)	(.0236)	(.0689)	(4,053.2)
	-19.873		-.0957		-.4467**	
	(859.11)		(.0805)		(.1904)	
β_{32}	.6926	-.0039	.0770	.0310**	-.0022	-59.10
	(29.32)	(.0104)	(.0535)	(.0135)	(.0402)	(1,238.8)
	1.4738		-.0125		.0535	
	(81.13)		(.0711)		(.0558)	
β_{33}	-2.6226	.1140*	-.0610	-.0040	-.0712	309.73
	(101.77)	(.0699)	(.1143)	(.0397)	(.0643)	(6,491.5)
	18.6900		.1795		.4794**	
	(784.69)		(.1472)		(.1896)	
Log - Likelihood Function	109.66	103.46	110.52	106.97	727.70	710.80

a : Standard error estimates are in parentheses.
b : Calculated from the formula $\sum_k \alpha_k = -1$.
* : Asymptotically significant at the 10% level.
**: Asymptotically significant at the 5% level.

appear to be acceptable overall. Failure to obtain consistent estimates of the parameters for other years, however, casts serious doubts on the robustness of the estimates reported in Table 3.

If the estimates can be accepted on their face values, then a log-likelihood function ratio test can be performed to test the maintained hypothesis of constrained utility maximization. For instance, the χ^2-statistic for 1986 is calculated to be 12.40, for 1994, 7.10, and for the pooled data, 33.80. The degrees of freedom for this test are determined by the number of restrictions imposed on the utility-maximization model, which in this case is six. The critical values are 12.60 and 16.812 at the 5% and 1% significance levels, respectively. One therefore cannot reject the hypothesis of constrained optimization for 1986 and for 1994. The utility maximization hypothesis, however, would be rejected at the 1% significance level for the pooled data.

It is of interest to note that these results are not consistent with the findings of Grosskopf and Hayes (1983). They also use a translog utility specification for their study of 1977 public sector noncapital expenditures and employment data from 132 Illinois municipalities. In their study, three local public services were chosen: police, fire and residual functions. Their test results reject the utility maximization assumption.

Although the parametric results from this study are not satisfactory overall, they appear to be consistent with the nonparametric results to be reported in the next section.

4.3 Nonparametric Results

In performing nonparametric tests, the number of service categories that can be selected depends only on data availability. Data on public health and environmental

protection are either incomplete or simply not available prior to 1991. Therefore, in cross-section analysis, only three service categories: public education, public safety, and all other services, are selected for 1986 through 1990. Public health and environmental protection are, however, included for analysis for 1991 through 1994. In time-series analysis, only the first three service categories are included.

Results from utility maximization consistency tests using nonparametric techniques are reported in Tables 4 and 5.[3] For cross-section local government employment data, two violations of GARP are found for 1987, with one direct violation of WARP and one violation of transitivity. No violations of GARP are found for 1986, nor are there violations for 1988 through 1994. For time-series local public sector employment data, one direct violation of GARP is found in one jurisdiction (Keelung Municipality) and six violations of GARP are found in another jurisdiction (Taichung Municipality), with three direct violations of WARP and three violations of transitivity. Other than that, no other violations are present for the other nineteen local public sector time-series data.

Nonparametric tests are also performed on a pooled cross-section and time-series local government employment data using the same three service categories that are available for all years as in parametric tests. For this pooled data set, there are a total of 179 observations, with a total of (179x178)/2 = 15,931 possible violations of WARP and a total of at least $179^3 = 5,735,339$ potential violations of the transitive closures.[4] 20

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[3]An example of the nonparametric test program is presented in Appendix B. It is also partially annotated.

[4]See Varian (1982, pp. 971-2).

Table 4. Utility Maximization Consistency Tests for Cross-Section Local Public Sector Employment Data

Year	No. of Violations*
1986	None
1987	2 (Taoyuan H. -D- Taichung H. Taichung H. -T- Taoyuan H.)
1988	None
1989	None
1990	None
1991	None
1992	None
1993	None
1994	None

* "D" denotes violations of direct consistency, i.e. violations of WARP. "T" denotes violations of transitivity. D and T together constitute total number of violations of GARP.

Table 5. Utility Maximization Consistency Tests for Time Series Local Public Sector Employment Data

District	No. of Violations*
Taipei H.	None
Ilan H.	None
Taoyuan H.	None
Hsinchu H.	None
Miaoli H.	None
Taichung H.	None
Changhwa H.	None
Nantou H.	None
Yunlin H.	None
Chiayi H.	None
Tainan H.	None
Kaoshiung H.	None
Pingtung H.	None
Taitung H.	None
Hwalien H.	None
Penghu H.	None
Keelung M.	1 (1986 - D - 1987)
Taichung M.	6 (1989 - D - 1990 1989 - D - 1991 1989 - D - 1992 1990 - T - 1991 1990 - T - 1992 1991 - T - 1992)
Tainan M.	None
Hsinchu M.	None
Chiayi M.	None

* See Table 4.

violations of WARP and 87 violations of transitivity, for a total of 107 GARP violations, are found. These represent 0.13% and 0.0015% of possible violations of WARP and transitivity, respectively. These violations are reported in Table 6.

It is worth noting that prior to the complete data set for the 1986-94 period was collected, the same nonparametric test procedures were performed on the pooled data set excluding the 1986 and 1992 data, and a total of 27 GARP violations, with 11 direct and 16 transitivity violations, were found. The inclusion of the 1986 and 1992 data to the complete pooled data set appears to increase greatly the total number of GARP violations. On closer inspection, this seemingly abnormal jump in the number of GARP violations may be attributable simply to the exponential increase in total potential violations when the number of observations in the data set is increased. In the pooled data set excluding the 1986 and 1992 data, there are 139 observations, indicating a total of (139x138)/2 = 9,591 potential violations of WARP and a total of 139^3 = 2,685,619 potential violations of the transitive closures. The actual violations found in the truncated data set represent 0.11% and .0006% of total possible violations of WARP and transitivity, respectively. These latter figures appear to be in line with those found in the complete pooled data set. Whichever data set is used, it is clear that the actual number of GARP violations represents only a small percentage of total potential violations.

It is of interest to compare the nonparametric results from this study with those of DeBoer (1986). DeBoer performs nonparametric tests on both cross-section and time-series state-level (including the District of Columbia) public sector employment and wage data in the 1970-82 period. He includes education, highways, welfare, hospitals and

Table 6. Utility Maximization Consistency Tests for the 1986-94 Pooled Data Set*

Number	Year	District	Type of Violation	Year	District
1	1986	Taoyuan H.	D	1989	Tainan H.
2	1986	Taoyuan H.	D	1989	Kaoshiung H.
3	1986	Taoyuan H.	T	1991	Kaoshiung H.
4	1986	Taoyuan H.	D	1993	Tainan H.
5	1986	Hsinchu H	D	1987	Ilan H.
6	1986	Miaoli H	T	1986	Taoyuan H.
7	1986	Miaoli H	T	1991	Kaoshiung H.
8	1986	Kaoshiung H.	T	1986	Taoyuan H.
9	1986	Kaoshiung H.	T	1986	Taichung H.
10	1986	Kaoshiung H.	T	1988	Kaoshiung H.
11	1986	Kaoshiung H.	D	1989	Tainan H.
12	1986	Kaoshiung H.	T	1989	Kaoshiung H.
13	1986	Kaoshiung H.	T	1990	Kaoshiung H.
14	1986	Kaoshiung H.	T	1991	Kaoshiung H.
15	1986	Kaoshiung H.	T	1992	Kaoshiung H.
16	1986	Kaoshiung H.	T	1993	Tainan H.
17	1986	Keelung M.	D	1987	Keelung M.
18	1986	Taichung M.	T	1987	Taichung M.
19	1986	Taichung M.	T	1988	Tainan M.
20	1986	Taichung M.	T	1989	Nantou H.
21	1986	Taichung M.	T	1989	Tainan M.
22	1986	Taichung M.	T	1990	Nantou H.
23	1987	Ilan H.	D	1988	Hsinchu H.
24	1987	Kaoshiung H.	T	1986	Taoyuan H.
25	1987	Kaoshiung H.	T	1986	Taichung H.
26	1987	Kaoshiung H.	T	1986	Kaoshiung H.
27	1987	Kaoshiung H.	T	1988	Kaoshiung H.

(table con'd.)

* See Table 4.

Number	Year	District	Type of Violation	Year	District
28	1987	Kaoshiung H.	D	1989	Tainan H.
29	1987	Kaoshiung H.	T	1989	Kaoshiung H.
30	1987	Kaoshiung H.	T	1990	Kaoshiung H.
31	1987	Kaoshiung H.	T	1991	Kaoshiung H.
32	1987	Kaoshiung H.	T	1992	Kaoshiung H.
33	1987	Kaoshiung H.	T	1993	Tainan H.
34	1987	Kaoshiung H.	T	1994	Pingtung H.
35	1987	Taichung M.	T	1989	Tainan M.
36	1987	Taichung M.	T	1990	Nantou H.
37	1987	Tainan M.	T	1986	Taichung M.
38	1987	Tainan M.	T	1987	Taichung M.
39	1987	Tainan M.	T	1988	Tainan M.
40	1987	Tainan M.	D	1989	Nantou H.
41	1987	Tainan M.	T	1989	Tainan M.
42	1987	Tainan M.	D	1990	Nantou H.
43	1988	Taoyuan H.	D	1993	Kaoshiung H.
44	1988	Taoyuan H.	D	1994	Tainan H.
45	1988	Hsinchu H.	T	1986	Hsinchu H.
46	1988	Nantou H.	T	1987	Tainan M.
47	1988	Nantou H.	T	1988	Tainan M.
48	1988	Nantou H.	T	1989	Nantou H.
49	1988	Nantou H.	T	1989	Tainan M.
50	1988	Kaoshiung H.	T	1986	Taoyuan H.
51	1988	Kaoshiung H.	T	1986	Taichung H.
52	1988	Kaoshiung H.	T	1989	Kaoshiung H.
53	1988	Kaoshiung H.	T	1990	Kaoshiung H.
54	1988	Kaoshiung H.	T	1991	Kaoshiung H.

(table con'd.)

Number	Year	District	Type of Violation	Year	District
55	1988	Kaoshiung H.	T	1992	Kaoshiung H.
56	1988	Kaoshiung H.	T	1993	Tainan H.
57	1988	Tainan M.	T	1987	Taichung M.
58	1988	Tainan M.	T	1989	Nantou H.
59	1988	Tainan M.	T	1989	Tainan M.
60	1988	Tainan M.	D	1990	Nantou H.
61	1989	Hsinchu H.	D	1992	Ilan H.
62	1989	Tainan H.	T	1986	Taichung H.
63	1989	Tainan H.	T	1988	Kaoshiung H.
64	1989	Tainan H.	T	1989	Kaoshiung H.
65	1989	Tainan H.	T	1990	Kaoshiung H.
66	1989	Tainan H.	T	1991	Kaoshiung H.
67	1989	Tainan H.	T	1992	Kaoshiung H.
68	1989	Tainan H.	T	1993	Tainan H.
69	1989	Tainan H.	T	1994	Pingtung H.
70	1989	Kaoshiung H.	T	1986	Taichung H.
71	1989	Kaoshiung H.	T	1991	Kaoshiung H.
72	1989	Kaoshiung H.	T	1993	Tainan H.
73	1989	Taichung M.	D	1990	Taichung M.
74	1989	Taichung M.	D	1991	Taichung M.
75	1989	Taichung M.	D	1992	Taichung M.
76	1989	Taichung M.	D	1992	Tainan M.
77	1989	Tainan M.	D	1990	Nantou H.
78	1990	Nantou H.	T	1988	Nantou H.
79	1990	Nantou H.	T	1989	Nantou H.
80	1990	Kaoshiung H.	T	1986	Taoyuan H.
81	1990	Kaoshiung H.	T	1986	Taichung H.

(table con'd.)

Number	Year	District	Type of Violation	Year	District
82	1990	Kaoshiung H.	T	1989	Kaoshiung H.
83	1990	Kaoshiung H.	T	1991	Kaoshiung H.
84	1990	Kaoshiung H.	T	1993	Tainan H.
85	1990	Taichung M.	T	1990	Taichung M.
86	1990	Taichung M.	T	1992	Tainan M.
87	1991	Kaoshiung H.	D	1993	Tainan H.
88	1991	Taichung M.	T	1990	Taichung M.
89	1991	Taichung M.	T	1992	Taichung M.
90	1991	Taichung M.	T	1992	Tainan M.
91	1992	Kaoshiung H.	T	1986	Taoyuan H.
92	1992	Kaoshiung H.	T	1986	Taichung H.
93	1992	Kaoshiung H.	T	1989	Kaoshiung H.
94	1992	Kaoshiung H.	T	1990	Kaoshiung H.
95	1992	Kaoshiung H.	T	1991	Kaoshiung H.
96	1992	Kaoshiung H.	T	1993	Tainan H.
97	1992	Tainan M.	T	1992	Taichung M.
98	1993	Tainan H.	T	1986	Taichung H.
99	1993	Kaoshiung H.	T	1994	Tainan H.
100	1994	Pingtung H.	T	1986	Taoyuan H.
101	1994	Pingtung H.	T	1986	Taichung H.
102	1994	Pingtung H.	T	1988	Kaoshiung H.
103	1994	Pingtung H.	T	1989	Kaoshiung H.
104	1994	Pingtung H.	T	1990	Kaoshiung H.
105	1994	Pingtung H.	T	1991	Kaoshiung H.
106	1994	Pingtung H.	T	1992	Kaoshiung H.
107	1994	Pingtung H.	T	1993	Tainan H.

residual categories in his study, and finds a small number of GARP violations for both the cross-section and time-series data set. He concludes that since the number of violations is so small that the assumption of utility maximization in the public sector could probably be accepted. The nonparametric results from this study appear to be consistent with those of DeBoer.

In a strictly theoretical sense, as long as a single violation of GARP is found, the data set cannot be described as the outcome of constrained utility maximization [Varian (1982), p. 949]. Varian(1985), however, contends that if the data fails the tests by "only a small amount" which is attributable to measurement error, omitted variables, or other stochastic influences, one may not want to reject the maintained hypothesis outright. Viewed in this light, given the extremely small number, and also extremely small percentage, of GARP violations in either cross-section or time-series or pooled data in this study, one is tempted to conclude that the data set provides strong evidence of bureaucratic constrained utility maximization in Taiwan's local public sector fiscal behavior.

Note that in testing the local government utility maximization assumption, both Grosskopf and Hayes (1983), using the parametric technique, and DeBoer (1986), using the nonparametric technique, rely on U. S. data that reflect the strong interactions of voters/taxpayers and public sector bureaucracies. Their studies are therefore unable to isolate bureaucratic preferences. In contrast, this dissertation study uses Taiwan's data that better reflects bureaucratic preferences, as noted earlier. So although the nonparametric results from this study are consistent with those of DeBoer, this study provides a better test of the bureaucratic utility maximization assumption.

To sum up the nonparametric results: The small number of GARP violations in the time-series tests suggests that the local bureaucracies in general have well-defined preferences over local public sector employment and spending patterns. The small number of GARP violations in the cross-section tests further indicates a surprising amount of intertemporal stability in the preference structures across local bureaucracies in Taiwan. The consistent outcomes from the cross-section, time-series and pooled data tests together provide a strong support for the assumption of bureaucratic utility maximization in the literature.

4.4 Sensitivity Analysis

Recall that the labor shares for individual local services are assumed earlier to be equal to the overall labor share at the local level in order to facilitate calculations of average wage rates for each service category, thanks to data limitations. In order to assess the extent to which the method used for calculating average wage rates may be affecting the results, additional tests were performed. As a start, the average wage rates are recalculated based upon Borcherding and Deacon's (1972, p.895) labor share estimates for education (ranging from .6449 to .7899), police (.7947), fire (.7487), health-hospitals (.5677), and sewers-sanitation (ranging from .2775 to .4175). Interestingly, no GARP violations can be found for wage rates constructed using these estimates. Violations of GARP in the data set can only be found when extreme labor share values, like .3 for public education and/or .2 for public safety, are used in the wage rate calculations. This exercise is, however, arbitrary at best.

In an attempt to perform the tests in a more systematic fashion for the purpose of establishing an upper and a lower bound for labor share in the two public service categories (i.e. public education and public safety) within which violations of GARP can be found, an iterative procedure was added to the SAS-IML program shown in Appendix B. This iterative procedure was specified in such a way that the GARP calculations would be performed starting from a value of 0.01 (i.e. 1%), with an increment of 0.01 after each iteration up to 1 (i.e. 100%), for labor share in public education against each value between 0.01 to 1, also with an increment of 0.01, for labor share in public safety. Therefore, there are a total of 10,000 iterations of the GARP procedures that were applied to the cross-section data for each year from 1986 to 1994.

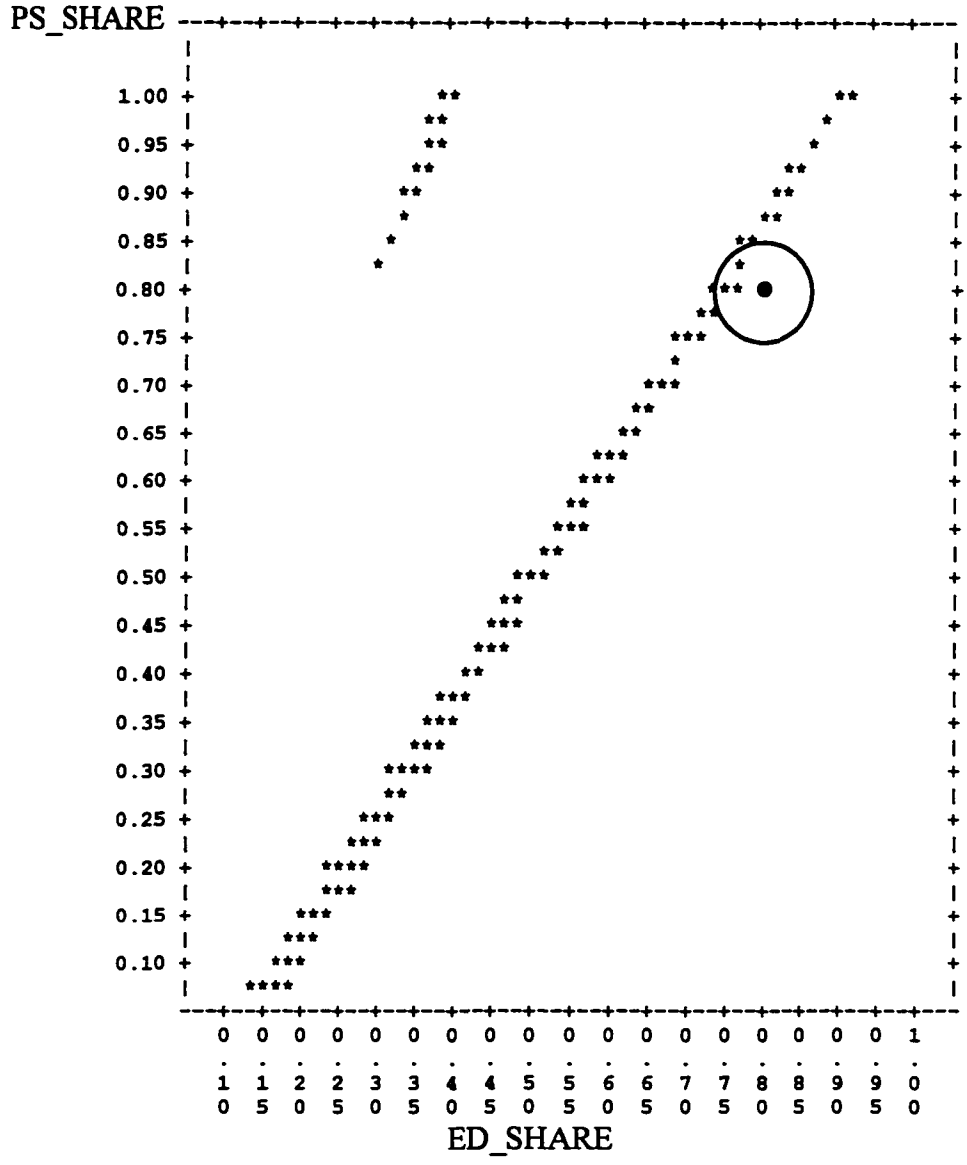
Two things should be noted at this point. First, in earlier nonparametric tests, labor share for each service category is assumed to be the same as the overall labor share at the local level, which varies across all jurisdictions each year. In performing this sensitivity analysis, labor shares for public education and public safety are assumed to be identical for all jurisdictions, varied by the increment of one percentage point in each iterative procedure. Second, in the sensitivity analysis, labor share in the residual service category is assumed to be constant at each iterative step, equal to the overall share at the local level, which, as noted above, varies across all jurisdictions. That is to say, the residual service category is excluded from the analysis.

While it may seem desirable to also include the residual service category in this sensitivity analysis, the attempt is aborted eventually due to three practical considerations. The first is that, as reported earlier, the services amalgamated into the residual service

category are not very important in terms of either current account expenditures or public sector employment as compared with public education and public safety. Besides, since this residual service category is an aggregate of all other local services put together, no insight about each specific service would be gained even if it is included in the analysis. The third consideration is concerned with the demand on computer time this iteration procedure requires. For each cross-section data, it took an average of 370 minutes for a mainframe computer to process the 10,000 iterations just outlined above. If a third service category is included in the analysis, there would be a total of 100^3=1,000,000 iterations of the GARP procedures. This would mean an average of 37,000 minutes (more than 600 hours!) of computer time for each cross-section data. While this is not impossible with a modern-day mainframe computer, this is hardly practical.

For public education and public safety, each pair of labor shares between 1% to 100 % that produces violations of GARP is identified for the cross-section data in each year. For each year, these pairs then form a sample set with which further statistical procedures are performed. Specifically, these pairs are plotted against each other to produce a scatter diagram, one for each year between 1986 and 1994, as shown in Figure 4. In each panel, labor share in public education is represented by the horizontal axis, whereas that of public safety by the vertical axis. The lines (not shown) that trace along the outer edges of the starred area represent the upper and lower bounds of labor shares in these two service categories that would cause the data set to show violations of GARP.

For purposes of cross reference and in conjunction with the reading of Figure 4, several tables containing descriptive statistics of the data set about labor shares, average

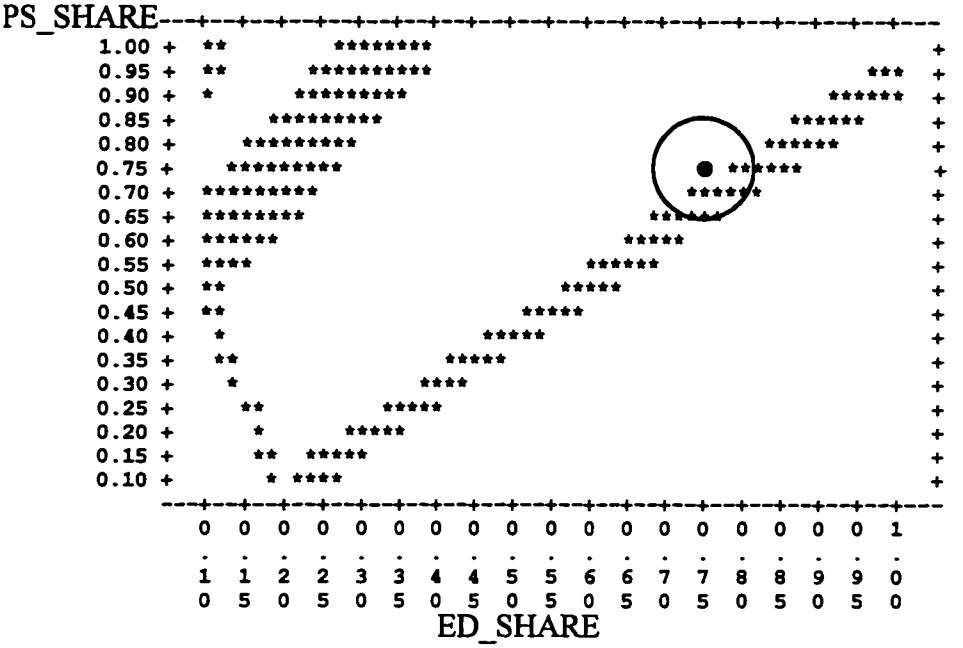


(Panel A - 1986 Data, 281 obs.)

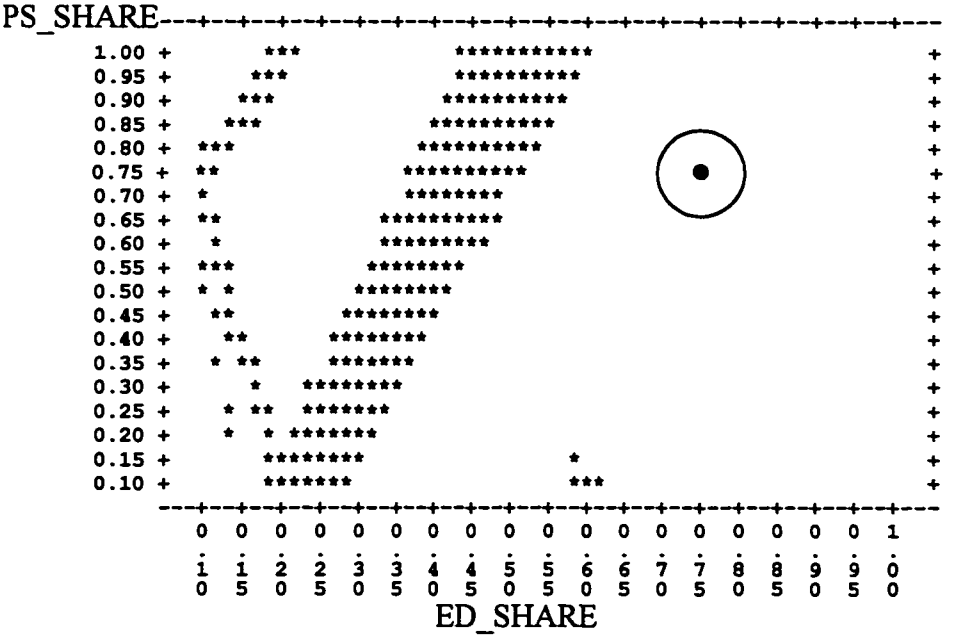
(figure con'd.)

Figure 4. Sensitivity Analysis of Labor Shares in Public spending

Note: In each panel, ED_SHARE is labor share in public education, and PS_SHARE stands for labor share in public safety.

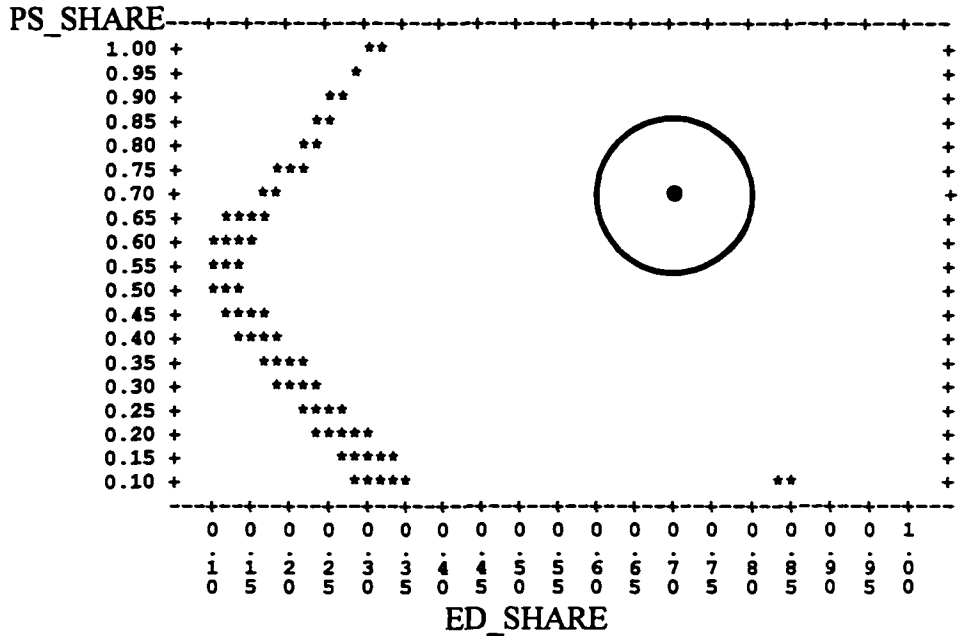


(Panel B - 1987 Data, 1,269 obs.)

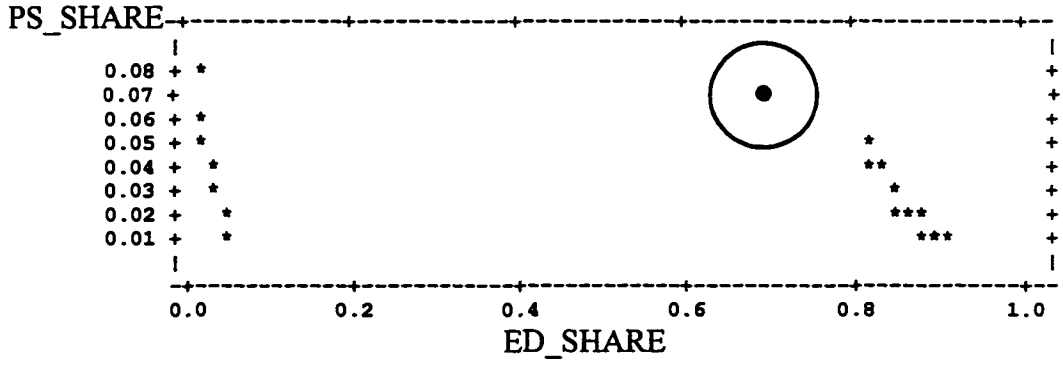


(Panel C - 1988 Data, 1,521 obs.)

(figure con'd.)

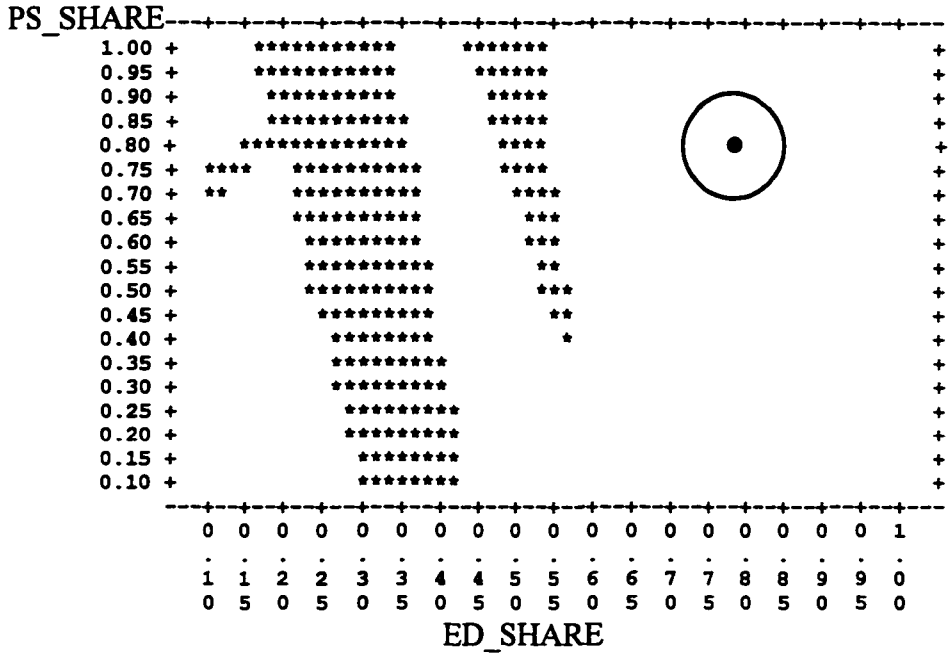


(Panel D - 1989 Data, 559 obs.)



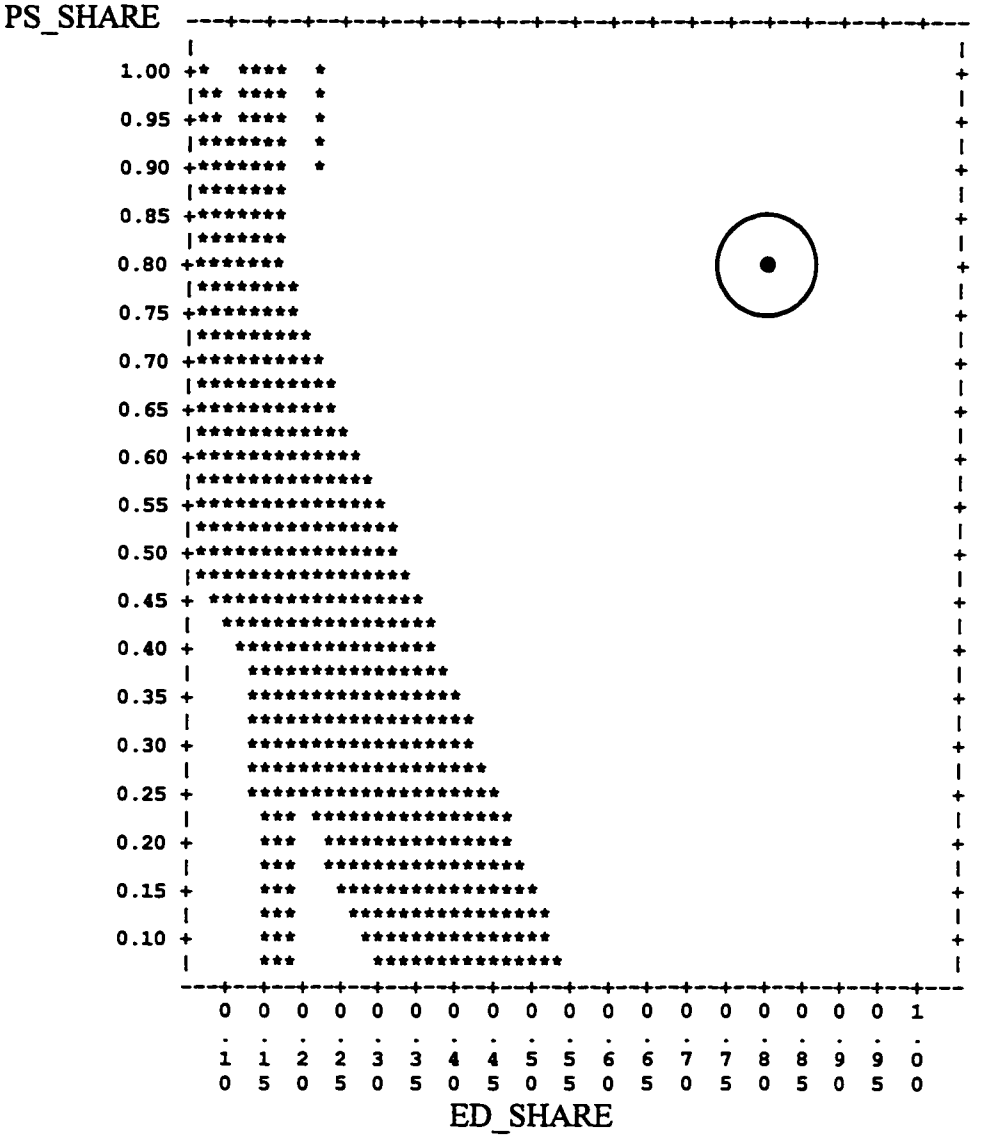
(Panel E - 1990 Data, 19 obs.)

(figure con'd)



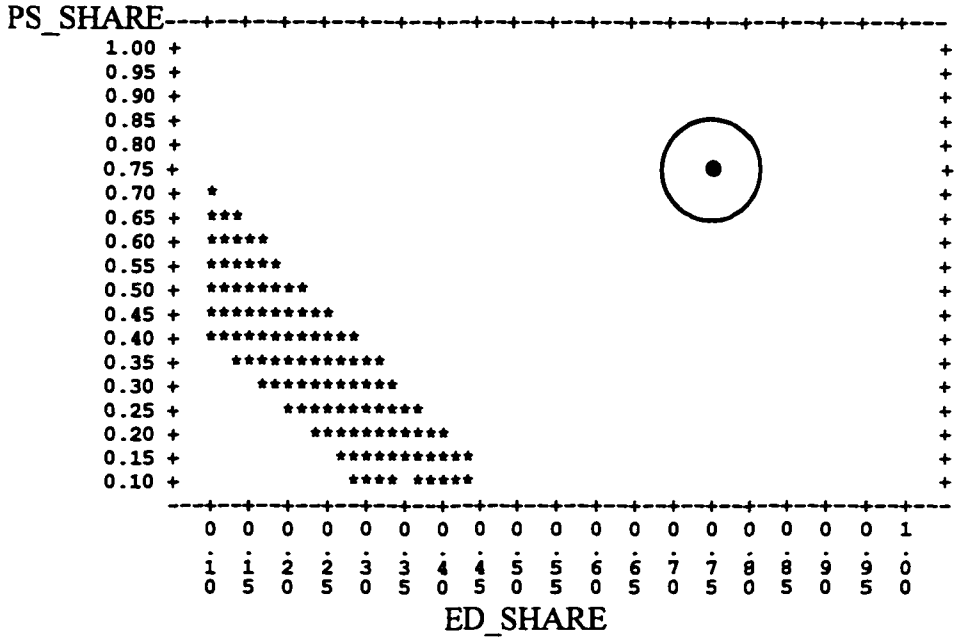
(Panel F - 1991 Data, 1,976 obs.)

(figure con'd.)

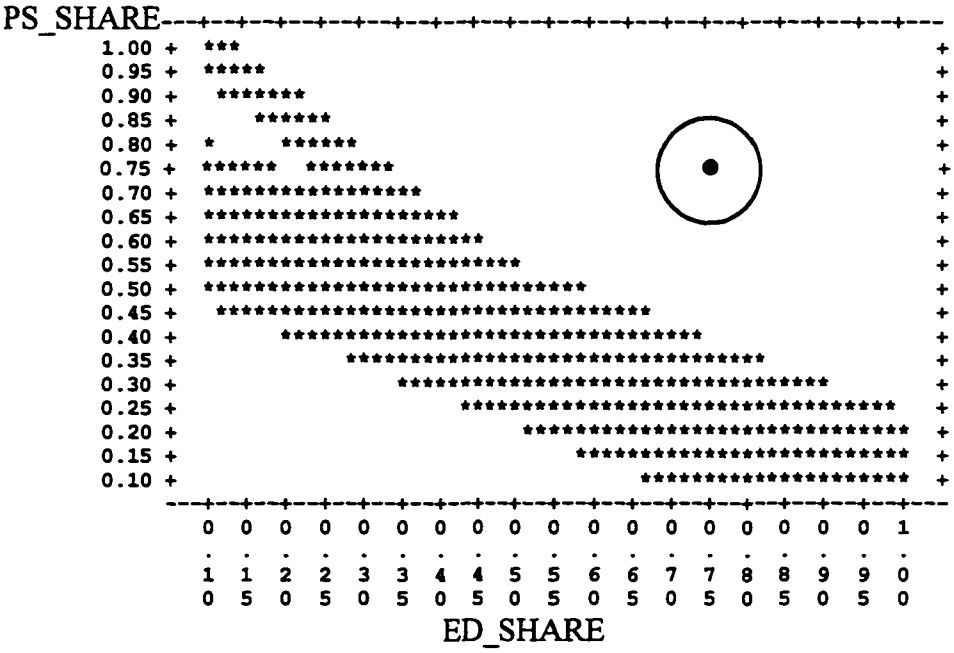


(Panel G - 1992 Data, 2,434 obs.)

(figure con'd.)



(Panel H - 1993 Data, 1,151 obs.)



(Panel I - 1994 Data, 3,332 obs.)

wage rates and employment are also included in this chapter. Table 7 presents the maximum, minimum, mean and standard deviation of overall labor share at the local level from the original cross-section data set. Sample statistics of the calculated average wage rates for public education and public safety from cross-section data are reported in Tables 8 and 9, respectively. Tables 10 and 11 present sample statistics of employment in these two local public services. Sample statistics of labor share, average wage rates and employment for the pooled data set is reported in Table 12.

In each panel of Figure 4, the dot "●" indicates, approximately, the location of the mean value of local overall labor share. The circle around the dot "●" represents, again approximately, an area that is one standard deviation away from the mean value. For the 1986 and 1987 data, it is shown that the mean values of labor share are close, within one standard deviation, to the starred area. For all other cross-section data, the dot "●" is nowhere near the starred area.

Three interesting observations can be made about these scatter diagrams in Figure 4. First, on the average, the starred area represents a small portion of total possible labor share pairs, indicating a strong tendency for the observed data set to conform to the constrained optimization principles. Second, although there are no uniform patterns of the starred areas for all the diagrams, some similarities do stand out. For both very high and very low values of the labor share pairs, with a few exceptions as shown in Panels A and B, no violations of GARP can be found in the observed data set. Since labor share is an indicator of labor intensity in the production of the particular public service in question, this would mean that when the provisions of public education and public safety use either

Table 7. Sample Statistics of Labor Share in Local Public Expenditure, Cross-sectional Data*

Year	Maximum	Minimum	Median	Mean	Std. Dev.
1986	0.96	0.64	0.77	0.79	0.07
1987	0.88	0.62	0.75	0.76	0.07
1988	0.87	0.62	0.74	0.75	0.06
1989	0.83	0.36	0.72	0.70	0.10
1990	0.84	0.52	0.68	0.69	0.09
1991	0.89	0.60	0.76	0.78	0.08
1992	0.91	0.59	0.79	0.80	0.07
1993	0.86	0.55	0.77	0.75	0.07
1994	0.91	0.59	0.78	0.76	0.08

*: Sources: See Table 1.

Table 8. Sample Statistics of Average Wage Rates for Public Education at Local Level[a, b]

Year	Maximum	Minimum	Median	Mean	Std. Dev.
1986	325.60	244.01	292.23	289.05	21.93
1987	325.40	230.48	286.52	284.91	22.81
1988	377.07	272.12	314.12	320.40	26.73
1989	416.16	163.89	331.43	330.60	54.11
1990	493.79	286.48	402.87	390.26	48.35
1991	643.43	452.85	567.26	553.41	50.25
1992	828.19	501.30	673.66	668.89	73.36
1993	895.43	504.89	721.27	702.43	96.30
1994	894.82	569.64	758.09	719.54	91.60

a: Sources: See Tables 1 and 2.
b: These figures are in current dollars. Each unit represents one thousand New Taiwan Dollars (NT$1,000).

Table 9. Sample Statistics of Average Wage Rates for Public Safety at Local Level[a, b]

Year	Maximum	Minimum	Median	Mean	Std. Dev.
1986	394.40	276.55	324.88	323.87	31.18
1987	374.67	270.02	327.26	325.93	28.45
1988	435.08	192.59	326.07	337.50	58.23
1989	474.15	260.75	362.77	365.55	61.92
1990	619.10	274.82	415.76	440.07	101.7
1991	1084.38	128.27	608.01	627.67	188.24
1992	753.14	261.32	583.87	594.90	101.97
1993	743.51	455.69	584.31	586.83	72.72
1994	823.98	504.20	655.59	675.55	80.93

a: Sources: See Tables 1 and 2.
b: See Table 8 above.

Table 10. Sample Statistics of Public Education Employment at Local Level*

Year	Maximum	Minimum	Median	Mean	Std. Dev.
1986	15,828	930	3,937	5,032	3,304
1987	16,462	903	4,069	5,081	3,439
1988	16,805	884	4,238	5,099	3,515
1989	17,259	869	4,438	5,172	3,615
1990	17,667	851	4,521	5,225	3,716
1991	17,607	832	3,607	4,849	3,654
1992	17,426	818	3,560	4,802	3,623
1993	17,433	836	3,608	4,834	3,606
1994	20,379	876	4,421	5,458	4,254

*: Sources: See Table 2.

Table 11. Sample Statistics of Public Safety Employment at Local Level*

Year	Maximum	Minimum	Median	Mean	Std. Dev.
1986	3,633	369	1,115	1,239	664
1987	3,749	395	1,093	1,262	686
1988	4,119	673	1,097	1,344	745
1989	4,034	758	1,095	1,352	725
1990	4,452	727	1,068	1,377	820
1991	4,972	620	1,052	1,344	918
1992	5,186	637	1,239	1,575	966
1993	5,899	697	1,345	1,749	1,100
1994	6,033	693	1,365	1,772	1,122

*: Sources: See Table 2.

Table 12. Sample Statistics of the Pooled Data Set, 1986-94[a, b]

Variable	Maximum	Minimum	Median	Mean	Std. Dev.
Labor Share	0.91	0.36	0.76	0.75	0.08
Employment in Public Education	20,379	818	4,069	5,058	3,575
Employment in Public Safety	6,033	369	1,203	1,453	885
Average Wage in Public Education	739.05	156.44	387.82	426.22	135.59
Average Wage in Public Safety	959.71	113.52	419.78	429.93	122.94

a: Sources: See Tables 1 and 2.
b: Wage rates are expressed in units of per thousand New Taiwan Dollars (NT$1,000), and are properly adjusted for inflation. Given the current exchange rate of approximately US$1 for NT$27, the annual mean average wage in public education of, say, 426.22 is equivalent to about US$15,786.

labor intensive or capital intensive technology, the public expenditure results can normally be viewed as the constrained optimization outcomes. And finally, the dot's position relative to the starred area in each panel of Figure 4 helps to explain why there are so few GARP violations in the observed data set in the 1986-94 period. It also helps to validate the assumptions made earlier about labor share for public education and public safety in the nonparametric tests. As shown by this sensitivity analysis, the assumptions used to construct the wage rates do not appear to be crucial to the empirical results.

In sum, the conclusion from this sensitivity analysis exercise is that, overall, the conclusions made about local bureaucracies' utility functions based on GARP principles appear to be quite robust, and the results found in this study are not driven by the

assumptions used to calculate the wage rates. Even if actual labor shares differ considerably from the values assumed in the earlier part of this study, the GARP calculations will not be affected in any important way.

4.5 Probit Analysis

As reported above, the cross-section data shows 2 violations of GARP for 1987 and the time-series data shows 1 violation for Keelung Municipality and 6 violations for Taichung Municipality. And when the pooled data set is tested, 107 violations of GARP are found. Although the total number of violations is relatively small, and may perhaps be attributable to measurement error, it is tempting to see if these violations are caused by some underlying systematic socio-politico-economic changes during the 1986-94 period. When the 107 pairs of violations of GARP in the pooled data set are plotted against each other, there seems to be a pattern: the majority of them cluster within the 1986-90 period.

In order to investigate potential determinants of GARP violations, the probit analysis technique is applied to the pooled data set to examine the factors affecting whether or not the Hsien and Municipality is likely to exhibit a GARP violation by using the violation status, V_i (V=0 if no violation, V=1 if a violation), as the binary dependent variable in an empirical model with a variety of socio-politico-economic variables as independent variables. As with both the parametric and nonparametric tests, the choice of variables is constrained by data availability during the period under study. This exercise is expected to enable us to identify the underlying socio-politico-economic factors that may have an effect on bureaucratic behaviors in Taiwan during the 1986-94 period.

4.5.1 The Probit Model

Under the standard probit analysis, the model is so specified as to determine the probability that, given the jurisdiction-specific socio-economic characteristics, the bureaucracy in a particular jurisdiction will choose the public expenditure mix that violates GARP principles. This probability is a function of an index of the bureaucracy's propensity to select the expenditure patterns that are not consistent with GARP. The index is in turn assumed to be a linear function of the jurisdiction's socio-economic characteristics.

Using the random utility model approach,[5] this index can be expressed as:

(17) $$\mathbf{I}_i = \mathbf{X}_i'\mathbf{B}$$

where $\mathbf{I}_i$ is the index or propensity for the bureaucracy in jurisdiction *i* to choose the public expenditure mix that violates GARP, $\mathbf{X}_i$ is a (kx1) vector of variables measuring the attributes of the socio-economic characteristics pertaining to jurisdiction *i*, $\mathbf{X}_i'$ represents the transpose of $\mathbf{X}_i$, and **B** is a (kx1) vector of unknown parameters to be estimated. In this context, k is the total number of the explanatory variables, including the intercept term.

The probability that the bureaucracy of a particular jurisdiction chooses an expenditure mix that is not consistent with GARP can be written as:

(18) $$\mathbf{P}(\mathbf{V}_i = 1) = \mathbf{P}(\mathbf{I}_i^* \leq \mathbf{I}_i)$$

where $\mathbf{P}(\cdot)$ denotes the probability, $\mathbf{V}_i$ is the violation status binary choice variable for jurisdiction *i* with a value of 1 for GARP violations and a value of 0 otherwise, and $\mathbf{I}_i^*$ the

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[5]For a more thorough treatment of the random utility model in probit analysis, please see Judge, Griffiths, Hill, Lütkepohl and Lee (1985, pp. 753-68).

i^{th} jurisdiction's threshold for GARP violations. $\mathbf{I_i^*}$ is assumed to be a standard normal random variable, which, like $\mathbf{I_i}$, depends on those socio-economic factors pertaining to jurisdiction *i*. Therefore, the above equation becomes:

(19) $$\mathbf{P}(\mathbf{V_i} = 1) = \mathbf{P}(\mathbf{I_i^*} \leq \mathbf{I_i}) = \mathbf{F}(\mathbf{I_i})$$

where $\mathbf{F}(\mathbf{I_i})$ is the cumulative probability distribution function (c.d.f.) for $\mathbf{I_i^*}$ evaluated at the Index $\mathbf{I_i}$.

The probit model can then be expressed as:

(20) $$\mathbf{V_i} = \mathbf{I_i} + \mu_i = \mathbf{X_i'B} + \mu_i$$

where $\mathbf{V_i}$ can be called the "observed" probit, and $\mathbf{I_i}$ the "true" probit. μ_i is the random disturbance term having a zero mean.[6]

Equation (20) can be estimated using the PROBIT procedure in either SHAZAM or SAS program package. The empirical probit model is specified as follows, suppressing subscripts *i*, for jurisdiction identification, and *t*, for time periods:

(21) $$\begin{aligned} V = {} & \beta_1 + \beta_2\,\text{INCOME} + \beta_3\,\text{NONPARTY} + \beta_4\,\text{VOTE} \\ & + \beta_5\,\text{DENSITY} + \beta_6\,\text{CITY} + \beta_7\,\text{EMP/POP} + \beta_8\,\text{EMP/VOTER} \\ & + \beta_9\,\text{SOUTH} + \beta_{10}\,\text{EAST} + \beta_{11}\,\text{WEST} + \varepsilon \end{aligned}$$

In the above empirical model specification, V is the dependent dummy variable assuming a value of 1 if jurisdiction *i* is found to have a violation of GARP at time *t* in the

---

[6]The variance of μ_i is $[P_i(1-P_i)]/n_i[f(F^{-1}(P_i)]^2$, where n_i is the *n* repetitions of the same choice situation for jurisdiction *i*, P_i the proportion of jurisdiction *i* choosing the expenditure patterns that violate GARP in n_i trials, f the probability distribution function of a standard normal random variable, and F^{-1} the inverse function of the normal c.d.f. See Judge et al, *op. cit.* pp. 762-3.

pooled data set, and a value of 0 otherwise. β_i's are the coefficients to be estimated, and ε is the random disturbance term.

INCOME is a measure of annual family income at the local level. It is included in the probit model as a socio-economic control variable. There are no *a priori* reasons to expect what kind of effect this variable would have on the local bureaucracy's spending behavior in Taiwan. One could conjecture, however, that various attributes of so-called "quality of life" are normal goods so that people's concern over these issues rises with income. This appears to be true in Taiwan where the citizens are becoming increasingly vocal in recent years on a host of social welfare issues such as environment, social security, health, education, public transportation, leisure, etc. at the same time their living standards measured in traditional economic progress indices, i.e. GNP growth rates and per capita income, are rising. The government, however, has been slow in adjusting its traditional economic development policies that are not consistent with social goals, such as industrial production vs. conservation of the environment, and so on. To the extent that local public sector spending patterns reflect the preferences of the public sector bureaucracy, and to the extent that the voters/taxpayers are successful in influencing local politics as incomes rise, one would expect the sign of the INCOME coefficient to be positive.

NONPARTY is a dummy variable, taking a value of 1 if the elected magistrate or mayor is *not* a member of the ruling party, and 0 otherwise. The central bureaucracy likely reflects the long time dominance of the KMT as the single ruling party. If local public sector spending patterns reflect the central bureaucracy's preferences, then a magistrate or mayor who is not a member of the ruling party may have a stronger tendency than a party

member official to depart from the prevailing party line. The jurisdiction that elected a non-party member as its head of administration is therefore more likely to exhibit violations of GARP. The sign of this variable's coefficient is therefore expected to be positive.

VOTE is a measure of voter turnouts for the three elections of the sixteen magistrates and five mayors that were held in 1985, 1989 and 1993. It is a ratio of the number of ballots to total number of eligible voters in each Hsien and Municipality. Since there are only three data points for the VOTE variable, to construct a measure for this variable, the 1985 election data is used for 1986-88, the 1989 election data for 1989-92, and the 1993 election data for 1993 and 1994. Voter turnouts differ significantly across jurisdictions. For example, this ratio was as low as 56.6% for one Hsien (Taitung) and as high as 84.6% for another (Hsinchu) in the 1989 election. There are no *a priori* reasons to expect how this factor may affect GARP violations in the pooled data set. On the one hand, one may argue that a high voter turnout may be the result of the ruling party's ability to mobilize voters to go to the voting booth both as a demonstration of party support and as an indication of the party's hold over the jurisdiction's political affairs. If this were the case, one would expect the VOTE coefficient to be negative. On the other hand, one may also argue that higher rates of ballots indicate voters' greater motivation to register their dissatisfaction with the ruling party through the voting process. If this were the case, a high voting percentage indicates a stronger voter input into how the local governments will fulfill their policies. To the extent that the interests of the citizenry are not coincident with the bureaucracy's preferences, the jurisdictions having higher voter turnouts will exhibit

characteristics that increase the probability of GARP violations, and one would expect the VOTE coefficient to be positive.

DENSITY is a measure of locality population density per square kilometer, and CITY is a dummy variable taking a value of 1 if jurisdiction *i* is an urban center, that is, a Municipality, and 0 otherwise. These two variables are admittedly highly correlated, but population density also varies greatly even among the sixteen Hsiens. For instance, the 1986 data shows that two Hsiens, Hwalien and Taitung, have population densities as low as 78 persons per square kilometer, while the most populous Hsien (Taipei) has a density as high as 1,329 persons per square kilometer. The density in Taipei Hsien has increased to 1,589 persons per square kilometer in 1994, whereas the density in Hwalien Hsien remains constant during the period, and the density in Taitung has decreased to 73 persons per square kilometer. Because of this demographic differences among Taiwan's Hsiens and Municipalities, these two are included as separate variables in the empirical model. It is a general perception in Taiwan that the educational level of voters is positively correlated with the degree of urbanization of a locality and that the influence of the ruling KMT party is stronger in the more rural areas than in an urban center or a more densely populated locale. If the bureaucratic utility function reflects the preferences of the ruling party, then local bureaucracies in the more urbanized jurisdictions, facing better educated citizens and weaker control from the top, are conceivably more likely to heed voters' preferences rather than merely following the party line. The signs of both variables are therefore expected to be positive.

EMP/POP measures the ratio of public sector employment to population in each jurisdiction and EMP/VOTER measures the ratio of public sector employment to the number of eligible voters in each of the three elections. Both of these variables are included in an attempt to capture how the relative size of civil service may affect local bureaucrats' fiscal behavior. There are no prior expectations about signs of the coefficients associated with these two variables. Note that the EMP/VOTER measure is constructed using data on voters in the same way as in VOTE.

Several regional dummy variables are also included in the empirical model to capture any geographical differences that might exist. Following standard practices, the sixteen Hsiens and five Municipalities in Taiwan are grouped into four regions: north, south, east and west. The northern region, where the central bureaucracy is located, may have less tendency to display characteristics that affect GARP violations. If political control is inversely related to the distance between the local administrative unit and the central political machine, then it is not unreasonable to expect that regions that are farther away from the central bureaucracy would have greater tendency to exhibit characteristics that violates GARP. Traditionally, the ruling party has, however, had a stronghold of the eastern region. Given these considerations, it is expected that the sign of the coefficient of EAST will be negative, meaning that the jurisdictions in the eastern region are less likely to have GARP violations, while the signs of the coefficients of WEST and SOUTH will be positive, meaning that the jurisdictions in these regions are more likely to violate GARP.

To test the overall significance of the socio-economic characteristics included in the probit model in explaining GARP violations, a null hypothesis that none of the factors

included in the probit model have any effects on bureaucratic behaviors against the alternative hypothesis that at least one of these jurisdiction-specific characteristics has an effect on bureaucratic behaviors can be constructed as follows:

(22) $H_0: \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$

Vs. H_1: Not all β_i's are zero

The likelihood ratio test, similar to that described earlier, is employed to test this hypothesis.[7] Specifically, the test statistic LR is a χ^2 random variable with degrees of freedom equal to (k-1) = 10. The same likelihood ratio test procedure can also be applied to any subset of the independent variables in the probit model to test whether the coefficients associated with these specific variables are jointly different from zero. For example, it is easy to set up a null hypothesis that none of the regional dummy variables have any effects on bureaucratic behaviors that lead to GARP violations against the alternative hypothesis that at least one of the regional variables has some effect on bureaucratic behaviors. Similarly, the degrees of freedom for χ^2-test would be the number of coefficients included in the null hypothesis. For the significance of each individual socio-economic characteristic affecting bureaucratic behaviors, a test based on the asymptotic property of the t-distribution, which approximates a standard normal distribution, is used.

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[7]Please see equations (12) and (13) and the likelihood ratio test procedure described on p. 43 in this dissertation.

4.5.2 The Probit Results

Since per capita GNP data at the local level is not available, two different measurements of the variable INCOME are used. The first set of models uses per capita family income (PY), defined as the grand total family income at the local level divided by local population, is used. The second set of models uses average household income (FY), defined as the grand total family income divided by the number of households. Several variants of equation (21) are estimated for each income definition. Altogether, a total of fourteen models are fitted to the 1986-94 pooled data set.

The probit results are reported in Table 13. Columns labeled (1) through (7) are results from probit models that use PY for the variable INCOME, while those labeled (8) through (14) are results from models that use FY to measure INCOME. As before, $L(\theta^*)$ represents the maximum likelihood estimator of the unrestricted log-likelihood function, whereas $L(\theta_0)$ is the maximum likelihood estimator of the restricted (i.e. intercept only) log-likelihood function, that is, under the hypothesis that $\beta_2 = ... = \beta_{11} = 0$. The pseudo-$R^2$, also known as Likelihood Ratio Index (LRI) or McFadden's R^2, is computed as:

$$\text{pseudo-}R^2 = 1 - [L(\theta^*) / L(\theta_0)] \tag{23}$$

This statistic has a value of 1 when the model is a perfect predictor, and a value of 0 when $L(\theta^*) = L(\theta_0)$. Obviously, $0 \leq \text{pseudo-}R^2 \leq 1$. Although this measure is analogous to the coefficient of determination R^2 in linear regression models, the value of pseudo-R^2 between 0 and 1 has no intuitive meaning [Judge et al., (1985), p. 767; Judge et al., (1988), p. 794]. Nevertheless, it is reported together with other summary statistics, following standard practices.

Table 13. Estimates of the Parameters of the Probit Models for Determining GARP Violations[a]

Variables	Probit Models With Per Capita Family Income						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CONSTANT	-3.2707	-3.4909	-3.6954*	-3.3033	-2.941	-3.1303	-5.3195***
	(-1.405)	(-1.541)	(-1.681)	(-1.418)	(-1.254)	(-1.347)	(-3.003)
PY	-.0057	-.0078*	-.0075	-.0092**	-.0085**	-.0073	-.0084**
	(-1.152)	(-1.698)	(-1.539)	(-2.153)	(-2.037)	(-1.626)	(-2.114)
NONPARTY	.5305*	.4976*	.4008	.5373*	.5248*	.5839**	.6240**
	(1.771)	(1.693)	(1.406)	(1.817)	(1.769)	(2.007)	(2.246)
VOTE	.0512**	.0536**	.0535**	.0576**	.0561**	.0576**	.0684***
	(1.975)	(2.104)	(2.142)	(2.247)	(2.181)	(2.351)	(3.019)
DENSITY	-.0003		.0003**	-.0001	-.0002	-.0003	
	(-1.068)		(2.238)	(-.441)	(-.689)	(-.969)	
CITY	2.0081**	1.0133***		1.5173	1.7286*	1.9789**	1.1793***
	(1.994)	(2.803)		(1.616)	(1.745)	(2.014)	(3.508)
EMP/POP	-406.74	-241.34	-177.32		-113.96	-295.90	
	(-1.363)	(-.949)	(0.658)		(-1.205)	(-1.092)	
EMP/VOTER	203.70	110.33	77.919	-55.097		113.50	
	(1.036)	(.633)	(.429)	(-1.022)		(.648)	
SOUTH	.2553	.1390	.1104	.0554	.0943		
	(.748)	(.434)	(.336)	(.180)	(.310)		
EAST	-1.4208	-1.4501	-1.4801	-1.4091	-1.3286		
	(-.587)	(-.597)	(-.607)	(-.574)	(-.544)		
WEST	.0628	-.0631	-.1443	.0055	.0065		
	(.184)	(-.198)	(-.450)	(.016)	(.019)		
$L(\theta^*)$[b]	-72.96	-73.54	-75.03	-73.89	-73.49	-73.59	-75.20
$L(\theta_0)$[c]	-88.45	-88.45	-88.45	-88.45	-88.45	-88.45	-88.45
χ^2-statistic	30.97***	29.82***	26.84***	29.12***	29.92***	29.72***	26.50***
pseudo-R^2	.1751	.1686	.1517	.1647	.1691	.1680	.1500
Percentage of Right Predictions	.83	.82	.80	.82	.82	.82	.79

(table con'd.)

a: Asymptotic t-values are in parentheses.
b: Estimated log-likelihood function values for the unrestricted models.
c: Estimated log-likelihood function for the restricted (i.e. intercept only) models.
*: Asymptotically significant at the 10% significance level.
**: Asymptotically significant at the 5% significance level.
***: Asymptotically significant at the 1% significance level.

Variables	Probit Models With Average Household Income						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
CONSTANT	-2.9232	-3.1605	-3.3626	-2.9501	-2.7068	-3.0125	-5.2176***
	(-1.255)	(-1.392)	(-1.526)	(-1.265)	(-1.158)	(-1.310)	(-2.969)
FY	-.0024*	-.0029**	-.0029**	-.0032***	-.0030**	-.0026**	-.0029**
	(-1.659)	(-2.120)	(-1.999)	(-2.583)	(-2.448)	(-2.097)	(-2.517)
NONPARTY	.5776*	.5510*	.4544	.5916**	.5787*	.6024**	.6495**
	(1.906)	(1.843)	(1.568)	(1.967)	(1.918)	(2.048)	(2.309)
VOTE	.0543**	.0572**	.0574**	.0603**	.0586**	.0616**	.0730***
	(2.072)	(2.224)	(2.270)	(2.344)	(2.273)	(2.506)	(3.216)
DENSITY	-.0003		.0003**	-.0001	-.0002	-.0003	
	(-.950)		(2.492)	(-.489)	(-.696)	(-.921)	
CITY	1.9457*	1.0151***		1.5565*	1.7343*	1.9413**	1.1794***
	(1.924)	(3.010)		(1.664)	(1.767)	(1.972)	(3.652)
EMP/POP	-321.61	-173.98	-99.175		-104.90	-263.92	
	(-1.061)	(-.669)	(0.362)		(-1.158)	(-.984)	
EMP/VOTER	148.68	66.596	26.989	-54.755		94.89	
	(.750)	(.375)	(.146)	(-1.031)		(.555)	
SOUTH	.1252	.0124	-.0267	-.0524	-.0055		
	(.351)	(.037)	(-.077)	(-.166)	(-.018)		
EAST	-1.5319	-1.5722	-1.5974	-1.5453	-1.4836		
	(-.635)	(-.650)	(-.658)	(-.634)	(-.611)		
WEST	.0466	-.0635	-.1547	.0055	.0101		
	(.136)	(-.198)	(-.480)	(.016)	(.030)		
$L(\theta^*)^b$	-72.20	-72.66	-74.14	-72.76	-72.48	-72.63	-74.15
$L(\theta_0)^c$	-88.45	-88.45	-88.45	-88.45	-88.45	-88.45	-88.45
χ^2-statistic	32.50***	31.58***	28.62***	31.38***	31.94***	31.64***	28.60***
pseudo-R^2	.1837	.1786	.1618	.1774	.1806	.1788	.1617
Percentage of Right Predictions	.84	.82	.80	.81	.82	.83	.80

As can be seen from the results reported in Table 13, several jurisdiction-specific socio-economic characteristics stand out as statistically significant determinants of GARP violations across the various models for both the PY or FY specifications. Specifically, PY is asymptotically significant at the 10% level in model (2) and asymptotically significant at the 5% level in models (4), (5) and (7). Similarly FY is asymptotically significant at the 10% level for model (8), asymptotically significant at the 5% level for models (9), (10), (12), (13), and (14), and asymptotically significant at the 1% level for model (11). It is interesting to note the stability of these coefficient estimates across all of the models. It is also noteworthy that the estimated signs of PY and FY coefficients in the fourteen models are all negative, indicating that higher income is associated with a lower probability of the jurisdiction exhibiting GARP violations, which is contrary to expectation. Perhaps higher income is just a manifestation of a relatively larger middle-class base in a given jurisdiction. The middle class , as a group, are usually believed to be more conservative, hence more likely to identify with the status quo. If such were the case, then the negative income factor estimates are perfectly justifiable.

Party membership (or rather, non-membership) of the elected magistrates and mayors appears to be a significant and positive determinant of GARP violations within the 1986-94 sample. Except for models (3) and (10), in which the variable CITY is excluded, the NONPARTY coefficient estimate is asymptotically significant either at the 10% or 5% level in all other twelve model specifications. The positive estimates are consistent with prior expectation.

Voter turnout (VOTE) is found to be another significantly positive factor affecting the likelihood of a jurisdiction's exhibiting violations of GARP. In all fourteen models the estimated coefficient of this variable is asymptotically significant either at the 5% or 1% level. The positive sign of the estimate of this variable indicates that the higher the voting percentage, the greater the probability of the jurisdiction exhibiting GARP violations. As noted earlier, there are no prior expectations as to what effect this jurisdiction-specific characteristic may have on bureaucratic behaviors. The probit results, however, show that higher rate of ballots is probably an indication of voters' greater motivation in expressing their preferences through voting processes, rather than a result of the ruling party's ability to mobilize voters. This observation is consistent with the expected effect of greater democratization.

DENSITY is found to be a significant determinant only when the variable CITY is excluded from the model. The estimated coefficient of DENSITY is always found to be statistically insignificant and of the wrong sign when both are included in the model. The estimated coefficient of CITY is always asymptotically significant and positive except for model (4), which is consistent with prior expectation. The probit results confirm the high correlation between DENSITY and CITY. In model (2) in which DENSITY is excluded from the basic model of equation (21), the maximum likelihood estimator of the log-likelihood function is -73.54, which is also the log-likelihood function estimator of the restricted model of equation (21) under the hypothesis that β_5 (i.e. coefficient of DENSITY) = 0. The unrestricted estimator of the log-likelihood function for equation (21) [i.e. model (1)] is -72.96, the test statistic is therefore $2^*|(-73.54) - (-72.96)| = 1.16$. The

critical value at the 5% significance level with 1 degree of freedom is 3.841. Therefore, the hypothesis that $\beta_5 = 0$ cannot be rejected at the 5% level. When model (3), in which CITY is excluded but DENSITY is included, is compared against model (1), the likelihood ratio is 2*| (-75.03) - (-72.96) | = 4.14, which is greater than the critical value at the 5% level, so the hypothesis that β_6 (i.e. coefficient of CITY) = 0 is rejected. Comparisons of model (8) with (9) and of (8) with (10) also show that CITY is a better explanatory variable than DENSITY in the probit model.

Surprisingly, none of the employment and regional variables are found to be significant determinants of GARP violations in the various specifications of equation (21). When DENSITY, EMP/POP, EMP/VOTER, and the three regional variables are dropped from the model [i.e. models (7) and (14)], the remaining variables all have statistically significant estimates of the coefficients. Model (7) is essentially a restricted version of model (1) under the hypothesis that $\beta_5 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$, so again a likelihood ratio test can be applied to test the null hypothesis. The test statistic is 2*| (-75.20) - (-72.96) | = 4.48 and the critical value at the 5% significance level with 6 degrees of freedom is 12.592, so that the null hypothesis cannot be rejected. Comparisons of model (8) with (14), in which average household income is used in the place of per capita family income, yielded a similar result.

The likelihood ratio test is performed for each one of the fourteen variant models of equation (21) to test the overall significance of the probit model in explaining GARP violations. In all cases the null hypothesis of no effects is rejected at the 1% significance level, indicating an overall relevance of the variables included in the probit model for the

explanation of GARP violations. These results are summarized in Table 14. The overall significance of the probit model is again confirmed by the rates of successful predictions that are reported in Table 13. In all of the fourteen cases, the percentage of correct predictions based on each of the specified models is about 80%, which is generally a very good result.

In sum, the probit model of equation (21) is a robust specification. Moreover, for the 1986-94 sample of Taiwan's local public sector fiscal behavior, family income, party membership of the elected administrators, voting percentage and the status as a provincially designated municipality are all important determinants of GARP violations by local governments. The probit results also imply that the bureaucratic preference structure found to hold under the nonparametric tests reflects to some extent the preferences of the ruling KMT party. In general terms then, greater democratization and greater urbanization both appear to have a negative effect on the ruling party's continued dominance in Taiwan.

Admittedly there may be other jurisdiction-specific socio-economic characteristics that are not captured by equation (21); identifying the additional factors affecting a locality's tendency to violate the constrained optimization principles should be an interesting topic for future research.

Table 14. Critical Values and Test Statistics

Model	Critical Value[a]	Degrees of Freedom	χ^2-Statistic[b]	Hypothesis Testing[c]
(1)	23.209	10	30.97	Reject H_0
(2)	21.666	9	29.28	Reject H_0
(3)	21.666	9	26.84	Reject H_0
(4)	21.666	9	29.12	Reject H_0
(5)	21.666	9	29.92	Reject H_0
(6)	18.475	7	29.72	Reject H_0
(7)	13.277	4	26.50	Reject H_0
(8)	23.209	10	32.50	Reject H_0
(9)	21.666	9	31.58	Reject H_0
(10)	21.666	9	28.62	Reject H_0
(11)	21.666	9	31.38	Reject H_0
(12)	21.666	9	31.94	Reject H_0
(13)	18.475	7	31.65	Reject H_0
(14)	13.277	4	28.60	Reject H_0

a: Critical values are from the χ^2 distribution table at the 1% level of significance.
b: Source: Table 13.
c: For the overall relevance of the probit model.

CHAPTER 5

SUMMARY AND CONCLUSION

There exist a number of competing choice-theoretic economic structural models of state and local government fiscal behavior in public finance literature, yet no single tractable framework has gained wide acceptance as *the* structural model of local fiscal behavior. The popular median voter model provides a foundation for demand aggregation under majority rule which conveniently circumvents the difficulty in aggregating unrestricted individual preferences, but is totally mute about the supply of goods and services in the public sector. Niskanen's bureaucratic monopoly model, on the other hand, builds a supply-side framework for publicly provided goods and services. The public sector expenditure outcome predicted by the model, however, deviates from the median voter result. The Romer-Rosenthal bureaucratic agenda control model extends Niskanen's concept of bureaucrats as budget maximizers to the median voter framework in the referendum setting, leading to a result that is also at odds with the outcome implied by the median voter model.

All of these models of public sector fiscal behavior can be, and have been, criticized one way or the other as being unrealistic in describing the real, and no doubt much more complex, world. The literature review in Chapter 2 points out that the theoretical validity of the median voter model critically hinges upon the single-peakedness of voters' preferences; without single-peakedness voting cycling is the likely result. The Niskanen model is questioned for its characterization of bureaucrats as budget maximizing agents. While the underlying logic of the Romer-Rosenthal model is not challenged, the

development of the model within a referendum setting is deemed incomplete in view of the various forms of the public sector expenditure decision-making process, for instance, a committee setting or when no referendum is required [Holcome, (1989), p. 117]. One common feature of those public choice models that incorporate electoral process into analysis is that strategic voting is simply assumed away. In reality, however, voters often have incentives to misrepresent their true preferences [Dixit and Nalebuff, (1991), pp. 259-85]. In the final analysis, none of these public choice models truly describe the real world. But then, none are intended to be accurately descriptive; the real test of a model lies in its empirical relevance.

The median voter model utilizes the indifference curve analysis for individual voters as both taxpayers and service recipients whose utilities are positive functions of private and public goods consumption. The assumption of utility maximization subject to a budget constraint for voters/taxpayers follows directly from the application of received microeconomic theory and underlies much of public choice theory since the 1970s. Bureaucratic models, such as that of Niskanen and of Romer and Rosenthal, typically assume that bureaucratic utility is a positive function of budget size, the number of employees, or other measures of "power" and "prestige" of the office. The utility maximization assumption for bureaucrats, or more precisely, for the bureaucracy as a whole, has not received the same rigorous treatment by public finance economists as the consumer choice-based models. To treat state and local expenditure results "as if" they were the outcomes of bureaucratic constrained maximization is an ingenious invention, yet

the appropriateness of making such an assumption and the empirical relevance of the model has not been directly addressed in the literature.

The current lack of definitive evidence regarding the validity of the bureaucratic utility function assumption represents a significant gap in the public choice literature. To fill this gap, this dissertation research directly tested the assumption that bureaucrats or the bureaucracy operates as if they have well-defined preferences over budgetary outcomes by analyzing local government spending and employment data from Taiwan during the 1986-94 period. Because of a long tradition of a single party dominance, Taiwan's public sector data allows a researcher to isolate resource allocation decisions made by local bureaucracies with limited constraints from voters/taxpayers, thereby providing a unique opportunity for direct tests of bureaucratic utility function assumption.

Both parametric and nonparametric test techniques have been employed to analyze the data set. The parametric tests used a translog utility function specification for the nine cross-section and the pooled cross-section and time-series data sets. Consistent estimates of the parameters have been difficult to obtain, except for the 1994 cross-section data. Failure to obtain satisfactory results prevented direct tests of the utility maximization assumption. This illustrates the shortcoming of the test procedure based on specific functional form assumptions.

The nonparametric tests based on the theory of revealed preference were performed on the cross-section, time-series, and pooled data sets separately. For the nine cross-section local government data, all but the 1987 data set passed the GARP consistency tests. Even when the 1987 data set was found to violate GARP, the total number of violations

were small relative to total potential violations. For the twenty-one time-series data sets, one for each local jurisdiction, all but two jurisdictions passed the GARP tests. And again, the number of violations of GARP were small relative to total possible violations. For the pooled cross-section and time-series panel data set, 107 violations of GARP were found, representing 0.13% and 0.0015% of possible violations of WARP and transitivity, respectively.

Although the parametric tests fail to provide guidelines for accepting or rejecting the assumption of utility maximization, it is possible to draw several meaningful conclusions based solely on the nonparametric results. Since the number of GARP violations in either the cross-section or time-series or pooled data set is really small relative to total possible violations, which may be attributable to measurement errors, omission of relevant variables or stochastic disturbances, this dissertation concludes that the observed data set strongly supports the hypothesis that the bureaucracies have well-defined preferences over public employment patterns. The cross-section and time-series results together strongly indicate the intertemporal stability in the preference structures across individual bureaucracies. Furthermore, the pooled data test results show a strong support for the assumption of bureaucratic utility maximization in Taiwan's local government fiscal behavior.

The sensitivity analysis enabled this study to identify labor share values that would cause the observed data set to display inconsistency with GARP. The results from this sensitivity analysis greatly strengthen the conclusion of bureaucratic utility maximization in Taiwan's local bureaucracies.

The probit analysis using violation status found in the pooled data GARP test as the binary dependent variable further enabled this study to identify potential socio-politico-economic determinants of GARP violations. The level of income was found to have a negative effect on the likelihood that the local bureaucracy would deviate from utility maximization. More importantly, degree of urbanization, voter turnout and party membership of the elected chief administrator in a jurisdiction were found to be significant determinants of local public sector bureaucratic behavior. Greater degree of urbanization, greater voting percentage as a result of democratization, and elected bureaucrats not belonging to the dominant ruling party all appear to increase the probability that the locality's fiscal behavior will digress from that which maximizes bureaucratic utility.

Pooling all of the empirical evidence, this dissertation concludes that the local bureaucracy does have well-defined preferences and that the bureaucratic utility is an increasing function of public sector budget. This dissertation further concludes that the "as if" proposition used in the public choice literature is justified. The probit results also suggest that researchers should take precautions when modeling the public sector fiscal behavior in emerging democracies via the bureaucratic approach, for although the assumption of constrained optimization is justified, the likelihood that it is not increases with each successful democratization process.

This dissertation study also points to a few avenues for future potential research. For example, it would be of great interest to see if the jurisdiction-specific socio-political factors found to have an effect on bureaucratic behavior continue to hold in Taiwan after five or ten years have elapsed. For an emerging democracy such as Taiwan, one would

expect to find more and more GARP violations in each subsequent cross-section local public sector fiscal data if those socio-political determinants found in this study are truly relevant. It would also be interesting to identify additional jurisdiction-specific socio-political factors affecting local bureaucracy's fiscal behavior. Another possible area of research is to test the international relevance of the bureaucratic utility hypothesis by performing GARP tests on public sector spending and employment data drawn from countries with distinctive political traditions.

This dissertation study focused on providing direct empirical evidence to shed some light on the appropriateness of the assumption of constrained utility maximization in the local public sector. It has argued that the relevance of a theoretical model lies in its predictive power regardless the descriptive accuracy of the underlying assumptions. With the advent of GARP, it is now possible to test the "as if" depiction of decision-making in utility-maximization framework. Moreover, the concept of GARP is both simple to understand and easy to use. It would therefore seem prudent for researchers to check data consistency before modeling so that the underlying assumptions regarding the agent's preferences would not become questionable. The empirical evidence from this dissertation research in no small way lends strong support to using the utility-maximization models as predictive models in general.

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APPENDIX A

AN EXAMPLE OF THE SAS PROGRAM FOR PARAMETRIC TESTS

```
*|----------------------------------------|
      PARAMETRIC TESTS
 |----------------------------------------|;

****TRANSLOG UTILITY FUNCTION****;

data d1994;
 infile 'a:\sas\d94.dat';
 input year ID district $ allem allex allw edem edex psem psex
     phem phex epem epex;
     allwex=allw/allex;
     edw=allwex*edex;
     edaw=edw/edem;
     psw=allwex*psex;
     psaw=psw/psem;
     phw=allwex*phex;
     phaw=phw/phem;
     epw=allwex*epex;
     epaw=epw/epem;
     misem=allem-edem-psem-phem-epem;
     misex=allex-edex-psex-phex-epex;
     misw=allwex*misex;
     misaw=misw/misem;
 run;

*Note  = ALL EXPENSES ARE IN NT$1,000;
*Note  = Assuming wage expenses as a percentage of current account
          expenditures in each service category is the same as the
          wage/expenditures ratio at the local level;
*allem  = total employment;
*allex  = total current account expenditures;
*allw   = total wage expenses;
*allwex = total wage expenses as a percentage of ALLEX;
*edem   = employment in public education;
*edex   = current account expenditures in public education;
*edw    = wage expenses in public education;
*edaw   = average wage rate in public education;
*psem   = employment in public safety (police and fire protection);
*psex   = current account expenditures in public safety;
```

```
*psw   = wage expenses in public safety;
*psaw  = average wage rate in public safety;
*phem  = employment in public health;
*phex  = current account expenditures in public health;
*phw   = wage expenses in public health;
*phaw  = average wage rate in public health;
*epem  = employment in environmental protection;
*epex  = current account expenditures in environmental protection;
*epw   = wage expenses in environmental protection;
*epaw  = average wage rate in environmental protection;
*misem = employment in all other functions;
*misex = current account expenditures in all other functions;
*misw  = wage expenses in all other functions;
*misaw = average wage rate in all other functions;

proc print data=d1994;
  var id district allem edem psem phem epem misem allex edex psex phex epex
      misex allw allwex edw edaw psw psaw phw phaw epw epaw misw misaw;
run;

data d1994_1;
 set d1994;
 y1 = edw/allw;                          /*This is P1X1/M in equation (10)*/
 y2 = psw/allw;                          /*This is P2X2/M in equation (11)*/
 y3 = (allw - edw - psw)/allw;
 mis = allem - edem - psem;
 lnedem = log(edem);                  /*This is lnX1 in equations (10), and (11)*/
 lnpsem = log(psem);                  /*This is lnX2 in equations (10), and (11)*/
 lnmis = log(mis);                    /*This is lnX3 in equations (10), and (11)*/
run;
**;
** To obtain initial values for the parameters;
**;
proc reg data=d1994_1;
   model y1 = lnedem lnpsem lnmis;
   model y2 = lnedem lnpsem lnmis;
   model y3 = lnedem lnpsem lnmis;
run;

title1 'Parametric Tests --- Translog Utility Function';
title2 'Unrestricted Nonlinear Maximum Likelihood Procedures';
**;
** y1 = education labor's share  in total expenses;
** y2 = public safety labor's share in total expenses;
```

```
**;
** SAS Nonlinear Maximum Likelihood Estimating Procedures;
** The following is for Unrestricted NML;
**;
proc model data=d1994_1;

 var y1 y2 lnedem lnpsem lnmis;
 parms a1 a2 b11 b12 b13 b21 b22 b23
       b31 b32 b33 b231 b232 b233;
 b1m1 = b11+b21+b31;
 b1m2 = b12+b22+b32;
 b1m3 = b13+b23+b33;
 b2m1 = b11+b21+b231;
 b2m2 = b12+b22+b232;
 b2m3 = b13+b23+b233;
 y1=(a1+b11*lnedem+b12*lnpsem+b13*lnmis)/(-1+b1m1*lnedem
                                    +b1m2*lnpsem+b1m3*lnmis);
 y2=(a2+b21*lnedem+b22*lnpsem+b23*lnmis)/(-1+b2m1*lnedem
                                    +b2m2*lnpsem+b2m3*lnmis);
**;
** Arbitrary starting values for the parameters;
**;
 fit y1 y2
    start=(a1 .05 b11 -.05 b12 .78 b13 .2
           b21 .44 b22 1.0 b23 -.8 a2 -.49 b31 .006 b32 .01
           b33 -.57 b231 .03 b232 .62 b233 .41)/itsur
           maxiter=100 converge=.00001;
run;

title2 'Restricted (symmetry and equality) Nonlinear ML';
**;
** The following is for Restricted NML;
**;
proc model data=d1994_1;
 var y1 y2 lnedem lnpsem lnmis;
 parms a1 a2 b11 b12 b13 b22 b23 b33;
 bm1 = b11+b12+b13;
 bm2 = b12+b22+b23;
 bm3 = b13+b23+b33;
 y1=(a1+b11*lnedem+b12*lnpsem+b13*lnmis)/(-1+bm1*lnedem
                    +bm2*lnpsem+bm3*lnmis);

 y2=(a2+b12*lnedem+b22*lnpsem+b23*lnmis)/(-1+bm1*lnedem
                    +bm2*lnpsem+bm3*lnmis);
```

```
**;
** Arbitrary starting values of the parameters;
**;
 fit y1 y2
  start=(a1 .05 b11 -.05 b12 .78 b13 .2 b22 1.0 b23 -.8
         a2 -.49  b33 -.57) /itsur maxiter=100
        converge=.00001;
run;
```

APPENDIX B

AN EXAMPLE OF THE SAS-IML PROGRAM FOR NONPARAMETRIC TESTS

```
/* This SAS-IML program for checking GARP is capable of:
  (1) identifying violations (in pairs) of direct revealed preference (WARP);
  (2) identifying violations (in pairs) of GARP;
  (3) calculating and printing Varian's "R" and "V" matrices; and
  (4) calculating and printing Varian's violation index.                    */

*|----------------------------------------------|
        NON-PARAMETRIC TESTS
          ACCORDING TO GARP
  |----------------------------------------------|;

proc IML;
  use d1994;
    read all var{id edaw psaw phaw epaw misaw                  /* See Appendix A for*/
              edem psem phem epem misem} into m;               /* variable names    */
    p = m[,2:6];                                              /* The wage matrix   */
    x = m[,7:11];                                             /* The employment matrix*/
    n = nrow(p);
    y = p*x`;                                                 /*The matrix of P^iX^i and P^iX^j*/
    z = vecdiag(y)*j(1, n);
    mm = z >= y;
    id = m[,1];
    col={ "obs1" "obs2" };

 start program;                          /*Beginning of IML module called "program"*/

*************************************
        Testing Direct Consistency
*************************************;
    test = y#0;
    list1 = j(1,2,0);
       do I = 1 to n;
          do j = (i+1) to n;
             if  y[i,i] >= y[i,j] & y[j,j] < y[j,i]
               | y[i,i] <= y[i,j] & y[j,j] > y[j,i]
               | y[i,j] >= y[i,i] & y[j,i] >= y[j,j]
             then go to aa;
             test[i,j] = 1;
```

```
            list1 = list1//(id[i,]||id[j,]);
          aa:
        end;
      end;
  print,, "Nonparametric Tests --- 1994 Data";
  print,, "Identification="; print id;
  print,, test;
  print,, "Violations of direct consistency (pairs)=";
  print list1 [colname=col];


**********************************
      Computing Transitivity
**********************************;

  v = y/z;                                        /* Varian's value matrix     */
  pr = (z > y);                                   /* Varian's 'PR' matric      */
  vv = pr`;
  mt = mm;

  do  k = 1 to n;                                 /* This do-loop procedure follows*/
     do i = 1 to n;                               /* Varian's (1982, p.972) algorithm*/
        do j = 1 to n;
         var = mt[i,k] & mt[k,j];
         mt[i,j] = var <> mt[i,j];                /* Varian's 'R' (= MT) matrix */
         if mt[i,j] - mm[i,j] = 0 then go to aaa;
         aaa:
        end;
     end;
  end;


  check = mt # vv;
  if sum(check) > 0 then go to bbb;
   list2 = j(1,2,0);
   vindex = j(1,1,0);
  print,, "This data set is consistent with transitivity";
  print "************************************";
  print,, "    Violations of GARP="; print list2 [colname=col];
  print,, " Varian's violation index=" vindex;
  go to ccc;
```

```
   bbb: print,, "This data set violates transitivity";
      print "*******************************";
      print,, check;
      list2 = j(1,2,0);
      vindex = j(1,1,0);
      do i=1 to n;
         do j=1 to n;
          if check[i,j]=1 then list2=list2//(id[i,]||id[j,]);
          if check[i,j]=1 then vindex=vindex + v[j,j] - v[j,i];
         end;
      end;
      print,, "    Violations of GARP="; print list2 [colname=col];
      print,, " Varian's violation index=" vindex;

   ccc: print,,,"Matrices used to check utility maximization";
      print "*********************************************";
      print  "Price Matrix=";      print p;
      print,, "Quantity Matrix=";    print x;
      print,, "Expenditure Matrix=";   print y;
      print,, "Matrix formed by diagonal elements=";   print z;
      print,, "Varian's value matrix=";    print v;
      print,, "Direct revealed preference, '1' indicates
               Varian's 'R^0' (see Varian (1982))";     print,, mm;
      print,, "Varian's 'R' matrix, '1' indicates Varian's
               transitive closure, 'R' (see Varian (1982))";    print mt;
      print,, "Varian's 'PR' matrix, '1' indicates Varian's
            'P^0' (see Varian (1982))";     print pr;
      print,, "Transpose of 'PR'=";    print vv;

   finish;
  run program;
quit;
```

```
*|----------------------------------------|
        SAS-IML FOR
     SENSITIVITY ANALYSIS
 |----------------------------------------|;
```

NOTE: To run the sensitive analysis, the above IML program is revised to include the iterative procedures as following:

```
proc IML;
  use d1994;
    read all var{id} into id;
    read all var{edem} into edem;
    read all var{psem} into psem;
    read all var{phem} into phem;
    read all var{epem} into epem;
    read all var{misem} into misem;
    read all var{edex} into edex;
    read all var{psex} into psex;
    read all var{phex} into phex;
    read all var{epex} into epex;
    read all var{misex} into misex;
    read all var{allw} into allw;
    read all var{allex} into allex;

    allwex=allw/allex;
    phw=allwex#phex;
    phaw=phw/phem;
    epw=allwex#epex;
    epaw=epw/epem;
    misw=allwex#misex;
    misaw=misw/misem;

start program;

    C=0;                          /* Beginning of the iterative procedures */
    do a=1 to 100;                /* for the sensitive analysis            */
        C=C+1;
        G=C/100;
        D=0;
       do b=1 to 100;
          D=D+1;
          H=D/100;
```

```
        edw=G*edex;                          /* Calculation of labor share in education*/
        edaw=edw/edem;
        psw=H*psex;                          /* Calculation of labor share in public safety*/
        psaw=psw/psem;
        p = edaw||psaw||phaw||epaw||misaw;
        x = edem||psem||phem||epem||misem;
        n = nrow(id);
        y = p*x`;
        z = vecdiag(y)*j(1,n);
        mm = z >= y;
        col={ "obs1" "obs2" };

************************************
      Testing Direct Consistency
************************************;
                    .
                    .
                    .
(same as the above IML example from the line
of "start program" down to the end of the "ccc"
subroutine.)
                    .
                    .
                    .
       end;
     end;                                  /* End of the iterative procedures for the */
   finish;                                 /* sensitive analysis.  There are 10,000  */
 run program;                              /* iterations for the tests of GARP       */
quit;
```

VITA

Chinkun ("C. K.") Chang is a native of Taiwan, officially Republic of China. He holds a Bachelor's degree in Economics from Feng-Chia University. In 1974, upon graduation from college, he was drafted to serve two years as a second lieutenant in Chinese Marine Corps. He came to the United States in 1976 to pursue advanced degrees and earned a Master of Art in Economics from North Dakota State University in 1978. From 1978 to 1983, he was a doctoral student in the Department of Economics at Louisiana State University. Without finishing his dissertation, he went off to become a full-time instructor in the Department of Economics at Memphis State University, in Memphis, Tennessee, during the 1983-4 academic year. In 1984, he returned to Taiwan and was employed as an associate research fellow at Taiwan Institute of Economic Research, a privately funded major think tank in Taipei. In the subsequent years until his return to the United States in 1993, he served, concurrently, as a special assistant to the chairman of one of the major conglomerates, the China Trust Group, in Taiwan and was substantially involved in the nascent movements of economic cooperation and integration for the Pacific Rim countries, which eventually led to the founding of the intergovernmental Asia-Pacific Economic Cooperation Ministerial Meetings (better known as "APEC") in 1990. He returned to Louisiana State University and the Department of Economics, in 1993, to resume his pursuit of a doctorate. He is married to the former Ms. Hsueh-Fen Lai and they have two sons, Yuan and Soong.

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